# GRAZING EFFECTS ON OAK DISTRIBUTION IN JASPER RIDGE AND ADJACENT AREAS

A THESIS

SUBMITTED TO THE DEPARTMENT OF BIOLOGICAL SCIENCES

AND THE COMMITTEE ON GRADUATE STUDIES

OF STANFORD UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SCIENCE

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August 1976

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## ACKNOWLEDGMENTS

To Dr. John H. Thomas for his guidance and assistance in conducting this study, and for his suggestions in preparing this manuscript.

To my husband for his encouragement.

TABLE OF CONTENTS

## Abstract

In this work the effect of cattle grazing on Jasper Ridge and SLAC-area has been studied.

Aerial photographs and an orthophatomap were used as sources of information on oak trees distribution during the period between 1928 and 1970 on Jasper Ridge and SLAC-Area. Jasper Ridge trees have disappeared and new trees appeared but replacement level was reached only after 1960. On the SLAC-area trees have disappeared and not been replaced.

A survey on seedlings present on Jasper Ridge was conducted showing numerous seedlings less than 15 years old. No seedlings were found on SLAC-area.

A brief age study was carried out on Q. douglasii indicating the major group to be about 100 years old.

Cattle grazing appears to be the major cause preventing oak trees to regenerate in the SLAC-area.

# GRAZING EFFECTS ON OAK DISTRIBUTION IN JASPER RIDGE AND ADJACENT AREAS

## Introduction

It is known that the kind of land use may affect plant distribution, interfering with the ecological balance. The use of fires for clearing forests in primitive agriculture, or for enlarging the area available for grazing has lead to the creation or extension of grasslands, or in some circumstances to deterioration of land and plant cover at such a level to cause establishment of deserts or enlargement of those already existant. Once such practices are halted, there is evidence that, if the damage done is not excessive, and where climate and soild conditions permits, the original vegetation may be restored. Although maintenance of grasslands is supposed to be dependent on periodic fires, such fires are not always man made, other sources, such as lightening, are considered capable of preventing grasslands from being reseeded by woody plants (Stewart, 1955; Bartlett, 1955).

Grazing by cattle, sheep or sometimes by deer has an effect comparable to fire on maintenance of grassland, or, if heavy enough, its depletion and following erosion. The reason is evident since cattle eat seeds and seedlings of woody plants, as well as any other understory vegetation, preventing them from taking over the area.

If the situation is maintained for a long time, even without concurrence of fire, scattered trees present in the region eventually grow old and die with no possibilities of replacement. This seems to be the case of the oak savanna near Jasper Ridge.

Actually, oak regeneration faces other than domestic animal

grazing problems such as grass competition, rodent, insect and bird damage to acorns and seedlings, browsing by deer, etc. On the other hand, animals may be agents in improving germination conditions. Squirrels and some birds are known to bury acorns, and those not found and eaten are protected from excessive heat and germinate (Griffin, 1971 and 1976).

Knowing tree ages in certain regions permits an evaluation of what to expect for the vegetation composition concerning those trees in the future. If most of them are old and fewer younger trees are present, one can expect their number to diminish, and vice versa. Generally, with oaks, increment boring is not practicable for it is very hard work, thus tree ring analysis, for detecting tree age, is not feasible. What has been done is to count growth rings in all cut trees available, measure their diameter and plot diameter versus ring number, obtaining this way a manner of interpolate whatever diameter is found on uncut trees and deduce the age (White, 1966). However, the variation in diameters and corresponding number of rings is frequently very high, thus data obtained are only approximations. Data on life span may also be useful for the mentioned purpose, mainly when aerial photography or maps of trees in the studied region are available and are old enough to cover considerable portions of the average length of life.

More valuable information about vegetation stability of the place being studied is furnished by gathering data on presence or absence of seedlings and saplings. If no seedlings are present, and no saplings are visible, one can deduce that if the situation persists, the considered plant will be extinct in that given place as individuals

become old, die, and no replacement occurs.

The purpose of this work is to determine the response to the halting of domestic animal grazing on three species of oak occurring in Jasper Ridge grasslands, namely Quercus lobata Nee, Quercus agrifolia Nee, and Quercus douglasii Hooker & Arnott. A comparable adjacent area, where grazing is still proceeding, is also studied in order to emphasize eventual differences in oak tree regeneration due to grazing effects.

Jasper Ridge Biological Experimental Area

Jasper Ridge Biological Experimental Area is on a low foothill of the Santa Cruz Mountains located about five miles southwest of Palo Alto. Its average height is about 600 feet. The highest elevation is 800 feet and the lowest is 200 feet.

Within an area of approximately one square mile, Jasper Ridge contains seven plant communities: chaparral, mixed evergreen forest, foothill woodland, fresh water marsh, streambank vegetation, redwood forest and grasslands.

The grasslands with scattered oak trees occupy the flattened top of the ridge and gentle slopes. The dominant grasses are Avena fatua and Avena barbata, but several others are also present; 120 species of native herbs have been identified by researchers under the cover of the taller wild oaks. Oak trees occurring in this association are mainly Q. agrifolia, Q. douglasii and a small number of Q. lobata. Where grasslands are in contact with forest or chaparral, a transition area appears, with plants characteristic of both communities intermingled.

Part of the grasslands is on soil formed over the serpentine ground rock, which is moderately toxic, presenting, for this reason, a number of plants growing exclusively in this place, being better able to tolerate this condition. However, plants occurring in the surrounding areas also appear in the serpentine section (Jasper Ridge at Stanford University, 1968; Elliot, 1958).

Records show that Jasper Ridge land has been used for cattle grazing, sometimes interrupted with periods of no grazing, since 1920. But it is known that it has happened, in the whole area, since early 18th century. The practice was halted in 1960 and public access was also stopped. (Information obtained from Stanford Planning Office and Mr. A. Grundmann, director of Jasper Ridge.)

Stanford Linear Accelerator Center Area (SLAC-Area)

The area examined in this study is adjacent to Jasper Ridge and corresponds to both sides of the SLAC building. This land has been used for cattle grazing since 1922, as shown on records, but certainly earlier, as mentioned for Jasper Ridge. The vegetation cover is basically similar to the Jasper Ridge grasslands.

Characteristics of the Oak Trees Being Studied

Oak trees belong to the family Fagacede which has three genera: Quercus, Pasania and Castanopsis.

The three species that this study is concerned with are included in the genus Quercus. Its characteristics are presented below:

Quercus L.-Oak

"Trees as shrubs of slow growth, hard wood and usually contorted

branches. Flowers greenish or yellowish. Staminate catkins pendulous, one or several from the lowest axils of the season's shoots. Pistillate flower 1 in an involucre; involucres 1 or 2, rarely several, borne in the upper axils of the season's shoot sessile, less commonly pedunculate, or when several sometimes scattered on a short catkin-like spike; ovary with 3 to 5 styles or stigmas. Fruit an acorn, the nut set in a scaly cup. Abortive ovules often discernible in the ripe or nearly ripe acorn -- about three hundred species distributed over the northern hemisphere." California has fourteen species, nine trees and five shrubs (Jepson, 1910).

Quercus lobata Nee

Also called valley oak or California white oak. "Graceful tree, commonly 40 to 75, but not rarely 100 feet tall, with a great crown which, in typical form, is broader than high, and whose spreading limbs finally end in long and slender pendulous branchlets reaching nearly or quite to the ground; trunk 2 to 10 feet in diameter, bark on the main trunk 1 to 4½ inches thick, dark brown or sometimes ashen gray, and checked nearly to the wood into plates 1 or 2 inches across; plates on typical trunks cuboid but often rectangular or narrow; leaves 3 to 4 (rarely 6) inches long, 2 to 3 inches broad, green aboree paler beneath with a thin but close covering of short hairs, yellow-veined, parted to the middle or nearly to the midrib into 3 to 5 pairs of lobes; lobes most commonly broadened towards the end, less frequently pointed, coarsely 2 or 3 toothed at apex or sometimes entire; leaves of the sterile pendulous shoots smaller and more deeply loked than the ordinary leaves, staminate catkins 1 to 3 inches long; calyx-

lobes 6 to 8 linear; stammens 8 to 11; pistillate flowers mostly solitary and sessile; producing acorns which mature in the first autumn; cup drab-brown, with a dull reddish tint, deeply hemispherical and very warty or tuberculate, ½ to 3/4 inch deep or more, and of greater diameter than the nut; nut long conical, at first bright green, later mahogany or chestnut brown, 1½ to 2¼ inches long and ½ to 3/4 inch in diameter " (Jepson, 1910).

This deciduous white oak species is very prolific bearing more abundant crops of acorns than any other Western oak. Reproduction is almost exclusively by seed, but it is poor, being well succeeded more frequently in protected situations. Its wood is little valued, being used only for fuel. It is the largest and the fastest growing of the three species considered in this work (Jepson, 1910).

Quercus douglasii Hooker & Arnott -- blue oak

"Tree commonly 20 to 60 feet high, typically with rounded crown and with a trunk ½ to 2 or sometimes 4 feet in diameter; bark white, shallowly checked into small thin plates, only slightly roughened but with the characteristic roughness extending up the links well into the branches; leaves minutely pubessent, bluish green above, pale beneath, 1 to 3 inches long, ½ to 2½ inches broad, mostly oblong to obovate, entire, or coarsely and often unequally few-toothed, or shallowly lobed; staminate catkins about 1 inch long; calyx yellow or green, with lacimintely cleft segments and about 9 stamens; acorns ripe

in the first autumn; cup 4 to 6 lines broad, of less diameter than the nut and very shallow, the scales developing small wart-like processes, nut 3/4 to 1½ inches long, 6 to 10 lines in diameter, dark or light brown, oval in outline but variable, often much swollen just below or at the middle or only on one side, or again narrow and tapering to apex " (Jepson, 1910).

The blue oak, a deciduous member of the white oak group, is the most frequent oak tree in the grasslands of Jasper Ridge and SLAC area. It is well adapted to dry slopes and cannot tolerate excess moisture. Its wood is hard, though brittle, and is used only as fuel or for post making. Quercus douglasii is a slow growing species. Its reproduction is done by seeds which are abundantly produced, and sometimes an adult trunk if not cut too low may send up sprouts (Jepson, 1910).

The blue oak once was thought of as a "weed tree" in whose shade scarce forage would grow, and for this reason, the procedure of reducing its number was considered sound in order to obtain more forage yield from each acre. More recent research has found that blue oak, instead of being prejudicial, is indeed beneficial, since it improves and enriches the rangeland soils. It has been determined that the forage under the blue oaks is not only more productive, it is also of higher nutritional value (Holand, 1976).

Quercus agrifolia Nee

It is also called coast live oak or Encina. "Low broad trees, with open or as often very dense crowns, as much as 60 or 70 but usually 20 to 35 feet high, the short trunk parting into erect limbs or more

commonly into crooked, widely spreading branches, which often touch or even trail along the ground; bark smooth and beech-like, or sometimes fissured, dark brown or gray on the surface, reddish or pink inside, very brittle when fresh, 1 to 2¼ inches thick and clothing a trunk 1 to 4 feet in diameter; leaves roundish, elliptic, sometimes ovate or oblong, usually with spine-tipped teeth or entire, commonly 1 to 2½ inches long but varying from ½ to 4 inches, usually convex above; staminate catkins 1 to 1½ inches long, deep red, stamens 4 to 8; pistillate flowers set in the upper axils of the season's shoot; styles 4 or sometimes 3; acorns 1 in a place or in clusters of 2 to 5, maturing in the first autumn; cup broadly turbinate, 4 to 7 lines deep, embracing the base of the pointed nut; nut 1 to 1½ inches long, 5 to 7 lines thick " (Jepson, 1910).

This evergreen species, member of the black oak group, appears to favor valleys or shelf-like flat regions on the hills; it is quite common in the hill country although frequently reduced to a shrub-like form. Reproduction by stump sprouts is frequent except for old trees. Acorn production is abundant but not all trees participate in any one season. Seeds germinate readily but seedlings are very sensitive to dryness; few or none remain after the first rains that are interrelated with short dry periods. Its wood is hard and heavy; it is little valued for constructive purposes, being more commonly used for fuel (Jepson, 1910).

## MATERIALS AND METHODS

### Tree Distribution - Aerial Photographs

Data on present and past oak trees distribution in Jasper Ridge and the Stanford Linear Accelerator Center adjacent area, were obtained from aerial photographs and an orthophoto map (Figures 1, 2, 3 and 4) being possible to follow appearance and disappearance of oaks from 1928 until 1970. The sources of such aerial photographs are the following:

1928 -- Courtesy of Prof. H. Mooney of Biological Sciences Department, Stanford University

1948 and 1960 -- United States Geological Survey

1970 -- Orthophoto map obtained from the Engineering and Road Department of San Mateo County.

From these photographs maps were made showing differences in number and distribution corresponding to each mentioned year. These maps may be overlayed, and doing so, dissimilarities are promptly observable. Maps showing Jasper Ridge and the SLAC-area were made separately.

### Seedling Study

A local survey in the study areas were made in order to determine the number of seedlings of each oak species. The survey was conducted in late April and May of 1976. Annual growth ring count was made on two specimens found in Jasper Ridge; one *Q. agrifolia* and the other *Q. lobata*, both seedlings.

Literature Search

Literature was searched for data on oak tree relationship between diameter and number of growth rings in order to obtain some insight on the age composition of the population of oaks being studied. A few data on age of Q. douglasii and Q. lobata were found, and none for Q. agrifolia were available. Since, with oaks, increment boring is impracticable, and no stumps in reasonable conditions were present in the area studied, few conclusions can be drawn based only on this information.

## RESULTS AND DISCUSSION - OAK DISTRIBUTION

### Jasper Ridge

Oak tree distribution in Jasper Ridge has varied in the period between 1928 and 1970. Maps 1, 2, 3 and 4 show the alterations that occurred in tree number and the local where it happened.

By overlaying the maps conservatively it can be observed that new trees tend to appear near to oak clusters, or at least where there exists one or two trees. This is to be expected considering that acorns are heavy and generally remain close to the tree that they came from, unless carried away by an animal. Also, trees provide a more protected environment making it easier for acorns to germinate; and once seedlings are established under such conditions they have more protection against dryness.

Jasper Ridge had been grazed until 1960. However, it is not likely that grazing had been too heavy where most of the new trees appeared before this date. Supporting this statement we may mention that information obtained on Jasper Ridge land use stated that grazing occurred on an "on and off basis" between 1920 "or perhaps earlier" until 1955; this suggests that vegetation could partially recover in the "off" periods. Naturally, there is no "off" period for grazing by deer which always happened and is still occurring. Also, when trees are too close together forming a group, it is logical to think that some spaces would exist which are not available to cattle, providing ground for a relatively undisturbed recovery.

The relative seedling and acorn protection is, of course, also a function of their number; if their germination and seedling

establishment rates are high, there are better chances that eventually one finds the conditions to become an adult.

The quantitative variation of oaks in Jasper Ridge is described in Table 1 below.

TABLE 1

Quantitative Variation of Oaks in Jasper Ridge from 1928 to 1970

| Year | Number of dead trees | Number of new trees | Total number of trees present | Probable disappearance cause |
|---|---|---|---|---|
| 1928 | - | - | 282 | - |
| 1948 | 33 | 27 | 276 | old age |
| 1960 | 9 | 8 | 275 | old age |
| 1970 | 0 | 15 | 290 | old age |

Trees have disappeared and have been replaced by new others. In 1948 and less in 1960 there was a slight trend of reducing the total number of trees. In 1970 the number was higher than 42 years earlier, showing a reverse trend after grazing was halted. However, the evidence for regeneration after the halting of cattle grazing is weak considering only these numbers; but if we think of the number of new trees/year, we have 1.35 trees/year during the period of 1928 to 1948, and 1.50 trees/year for the period 1960-1970. Although the difference is still small, it seems reasonable since grazing was done with interruptions. Data show regeneration occurring in Jasper Ridge.

Stanford Linear Accelerator Center-area

Maps 5, 6, 7 and 8 show steady declining in the number of oak trees present in the region. Since there are no, or few, oak clusters

in the region, there is only a few preferencial places for new trees to arise. When it happened, it was in the same pattern as Jasper Ridge.

There is no data on how heavy grazing has been in the SLAC-area; but recently it has been intensive, and the land is now entirely covered by a thin layer of grass with much of the soil exposed, which is a sign of heavy grazing. Sporatically the land is disked and hay harvested.

Table 2 below shows the quantitative variation in the number of trees in this area.

TABLE 2

Quantitative Variation of Oaks in the SLAC-area From 1928-1970

| Year | Number of dead trees | Number of new trees | total number of trees present | Probable disappearance cause |
|---|---|---|---|---|
| 1928 | - | - | 335 | - |
| 1948 | 51 | 7 | 291 | Agricultural land use: less 8 trees<br>Road alteration: less 5 trees<br>Old age: less 38 trees |
| 1960 | 24 | 2 | 269 | Road alteration: less 15 trees<br>Old age: less 9 trees |
| 1970 | 47 | 0 | 222 | SLAC construction: less 32 trees<br>Old age: less 15 trees |

Any period of time observed shows that the number of new trees cannot replace those lost by natural death. Thus, in this area, oak trees appear not to be regenerating.

Further evidence supporting the statements above on oak regeneration, both in Jasper Ridge and the SLAC-area, are furnished through the seedling study.

Seedling Study

A local survey in Jasper Ridge showed the presence of numerous seedlings and saplings. Data are condensed in Table 3.

The areas designated by letters in this table correspond to areas shown in Map 9.

Apparently the most successful regeneration happening is that of Quercus douglasii. But considering the overall adult tree number of each species in the area surveyed, and the proportion between adult and seedlings number, we may have better conditions for an evaluation (see Table 4).

These data seem to indicate that Q. lobata regeneration is very weak, and we may expect its number to decrease in the decades to come as adult trees grow old and die. Quercus agrifolia and Q. douglasii appear to be spreading over the respective preferential areas. Considering the total number of seedlings per adult tree, Q. douglasii seems to be in better condition. However not all seedlings become established saplings, disappearing due to many possible reasons such as dought, deer browsing, insect attacks, disease, etc., thus a better indication of success is the ratio between the number of well established saplings (1 to 4 inches of diameter) and the number of adult trees. The latter ratio in this case shows similar possibilities of increasing number for both Q. agrifolia and Q. douglasii.

TABLE 3

Seedling and Sapling Distribution in Jasper Ridge Grasslands
(See corresponding map no. 9)

| | | Diameter classes (inches) | AREA a | b | c | d | e | f | g | h | i | j | All areas Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quercus agrifolia | Number of Seedlings per Diameter Class | 0-½ | 5 | - | 5 | 1 | 11 | - | 8 | 10 | - | - | |
| | | ½-1 | 4 | - | 0 | 1 | 1 | - | 9 | 5 | - | - | |
| | | 1-4 | 10 | - | 3 | 0 | 9 | - | 0 | 6 | - | - | |
| | Total Number of Seedlings | | 19 | 0 | 8 | 2 | 21 | 0 | 17 | 21 | 0 | 0 | 88 |
| Quercus douglasii | Number of Seedlings per Diameter Class | 0-½ | 58 | - | 20 | - | 10 | 2 | - | 9 | - | 2 | |
| | | ½-1 | 47 | - | 7 | - | 11 | 7 | - | 10 | - | - | |
| | | 1-4 | 33 | - | 2 | - | 20 | 2 | - | 3 | -- | - | |
| | Total Number of Seedlings | | 138 | 0 | 29 | 0 | 41 | 11 | 0 | 22 | 0 | 2 | 243 |
| Quercus lobata | Number of Seedlings per Diameter Class | 0-½ | - | - | - | - | - | - | - | 3 | - | - | |
| | | ½-1 | - | - | - | - | - | - | - | 1 | - | - | |
| | | 1-4 | - | - | - | 0 | - | - | - | 2 | - | - | |
| | Total Number of Seedlings | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 0 | 6 |
| | | | | | | | | | | | | Total number for the 3 species in all areas | 337 |

TABLE 4

Relationship Between Adult and Seedling Number for 3 Oak Species in Part of Jasper Ridge Grasslands

| Species | Q. lobata | Q. agrifolia | Q. douglasii |
|---|---|---|---|
| No. of adult trees | 15 | 28 | 64 |
| Total no. of seedlings and saplings | 6 | 88 | 243 |
| No. of saplings with diameter 1-4 inches | 2 | 28 | 60 |
| Total seedling no. / Adult number | 0.40 | 3.14 | 3.80 |
| No. of saplings (Diam. 1-4 inches) / Adult number | 0.13 | 1.00 | 0.94 |

The SLAC-area was also observed locally, and no seedlings or saplings were found. Thus in this region oak trees are not being replaced.

Age Study

In order to know the age of the seedlings present on Jasper Ridge, annual rings were counted on two specimens, Q. agrifolia and Q. lobata. The first presented a diameter measuring 3/8 inch and 7 annual rings; the latter had a ½ inch diameter and 6 annual rings. Since the diameters of the seedlings present in the area measure more or less ½ inch with considerable variation, the data obtained will only tell that the most frequent seedlings of the considered species are less than 15 years old, meaning that the majority appeared possibly less than 15 years ago, which is after cattle grazing was halted (in 1960).

Data on diameter and number of annual rings were found in the literature concerning the Q. douglasii. Trees with 13 inches of diameter average 97, and with 15 inches average 126 annual rings.

The diameter of adult blue oaks occurring on Jasper Ridge were measured and its frequency distribution is seen in Figure 5.

The largest group has a mean diameter of 13.5 inches. Calculating from Whites data, it is obtained an average number of 101 annual rings, which correspond to the same age.

Diameters of Q. douglasii on Jasper Ridge which, for appearing far from other trees, could be compared to those occurring in the SLAC-area are 21, 25½, 27, 34 and 41 inches. A rough approximation on their ages would be a range between 150 and 270 years, except for the last mentioned (41 inches) which cannot be compared to those on the White's work for having a much larger diameter. Jepson (1910) gives an average age of 80 to 300 years for mature Q. douglasii, thus these mentioned Jasper Ridge blue oaks and the comparable ones occurring on SLAC-area are mature to old trees.

Conclusions

Both Jasper Ridge and SLAC-area are subject to quite similar environmental factors, such as climate, insect and other animal populations, etc., except for cattle grazing which no longer occurs in Jasper Ridge, but is still occurring in the SLAC-area. Fire, which could be a major factor in preventing oak trees from regenerating, has not occurred on Jasper Ridge because of the difficulty in getting permission to have a controlled burn, and has also been absent in the SLAC-area because no herbaceous cover is present in enough quantity to

provide fuel for summer fires.

Since no other influencing circumstances are left, it is logical to assume that cattle grazing is the factor preventing oak regeneration in the SLAC-area; and that after it was halted in Jasper Ridge, better conditions for regeneration were provided.

Figure 1

Aerial photograph of Jasper Ridge and Stanford Linear Accelerator Center-area in 1928. Light areas are grasslands and scattered dark spots are oak trees. Courtesy of Prof. Dr. H. Mooney.

Figure 2

Aerial photograph of Jasper Ridge and Stanford Linear Accelerator Center-area in 1948 (copy). The original is from the United States Geological Survey.

Figure 3

Aerial photograph of Jasper Ridge and Stanford Linear Accelerator Center-area in 1960 (copy). The original is from the United States Geological Survey.

Figure 4

Photographic reproduction of an orthophotomap showing Jasper Ridge and Stanford Linear Accelerator Center-area in 1970. Ortophotomap from Engineering and Road Department of San Mateo County

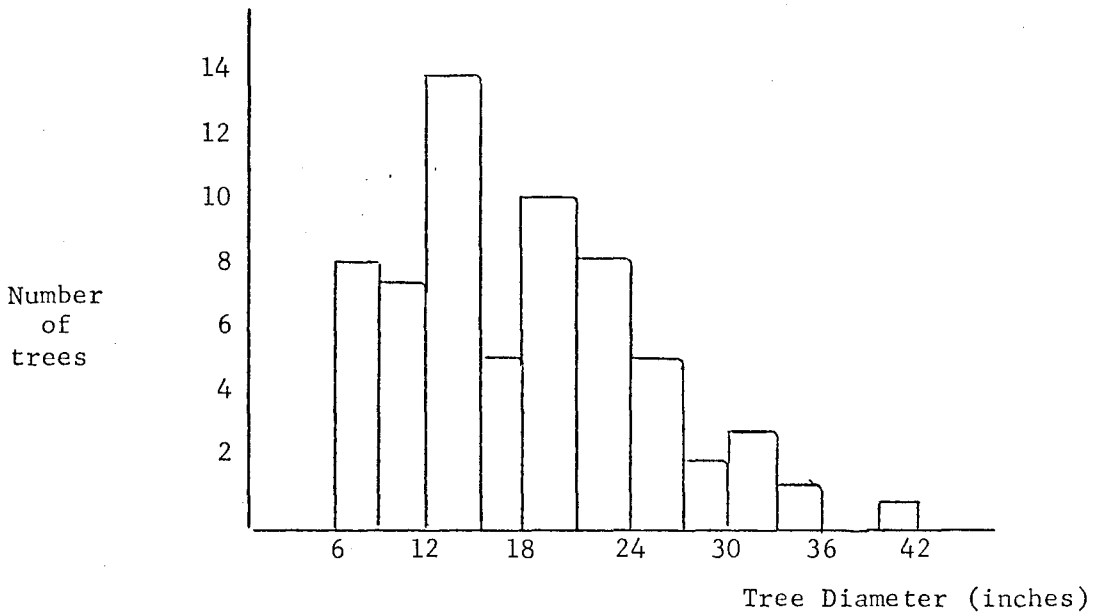
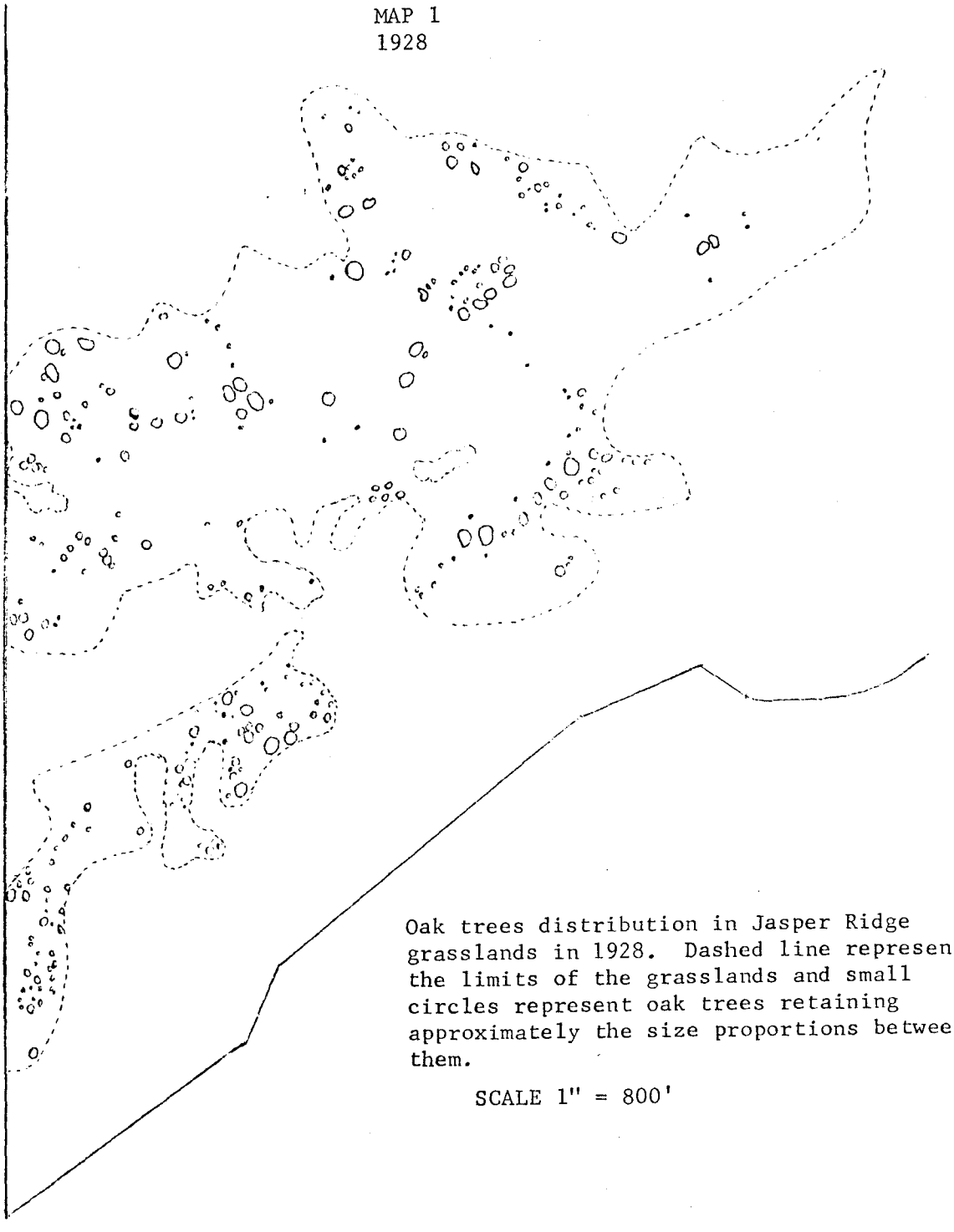



Figure 5

Frequency distribution of diameters of 64 blue oaks occurring on Jasper Ridge

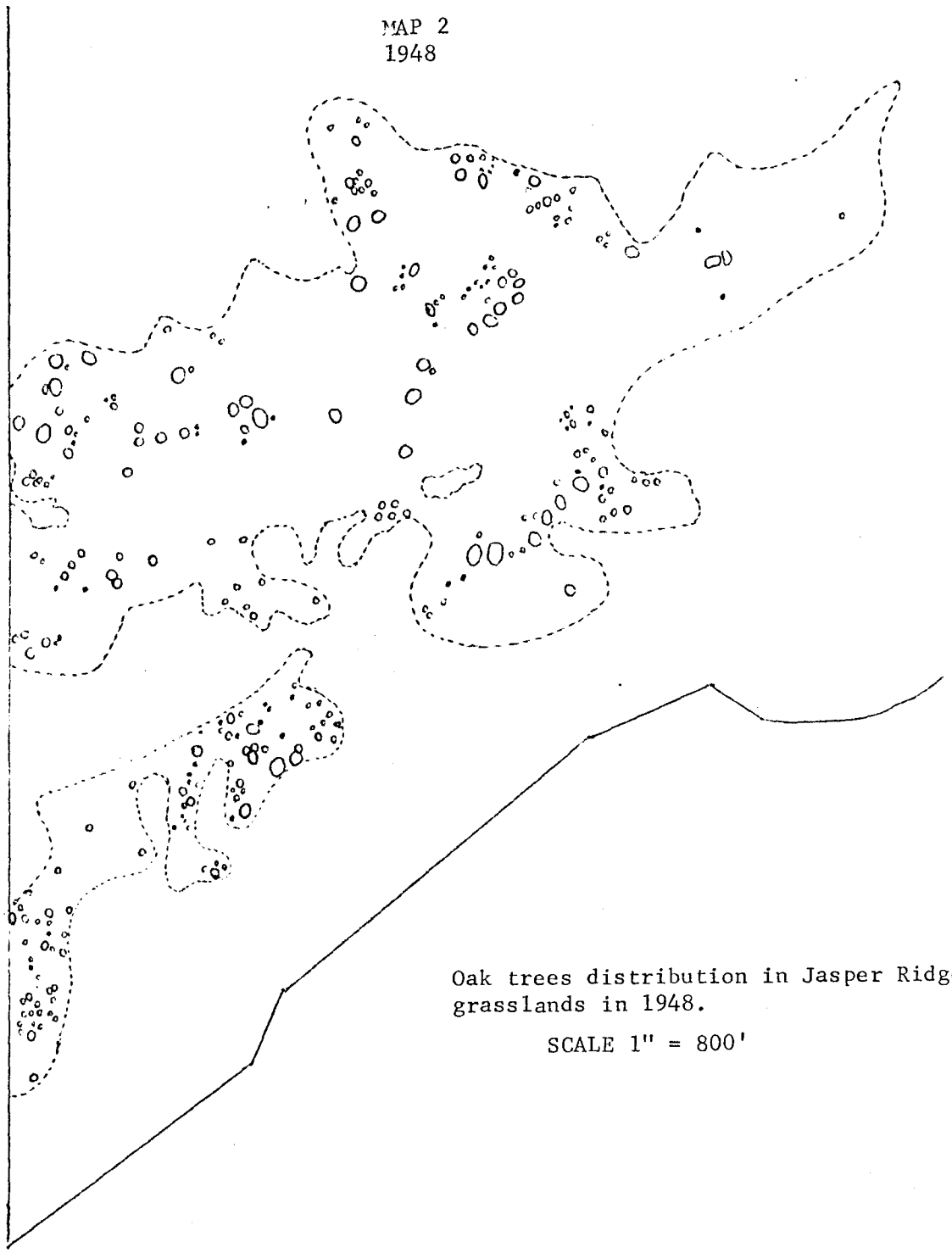
MAP 1
1928



Oak trees distribution in Jasper Ridge grasslands in 1928. Dashed line represents the limits of the grasslands and small circles represent oak trees retaining approximately the size proportions between them.

SCALE 1" = 800'

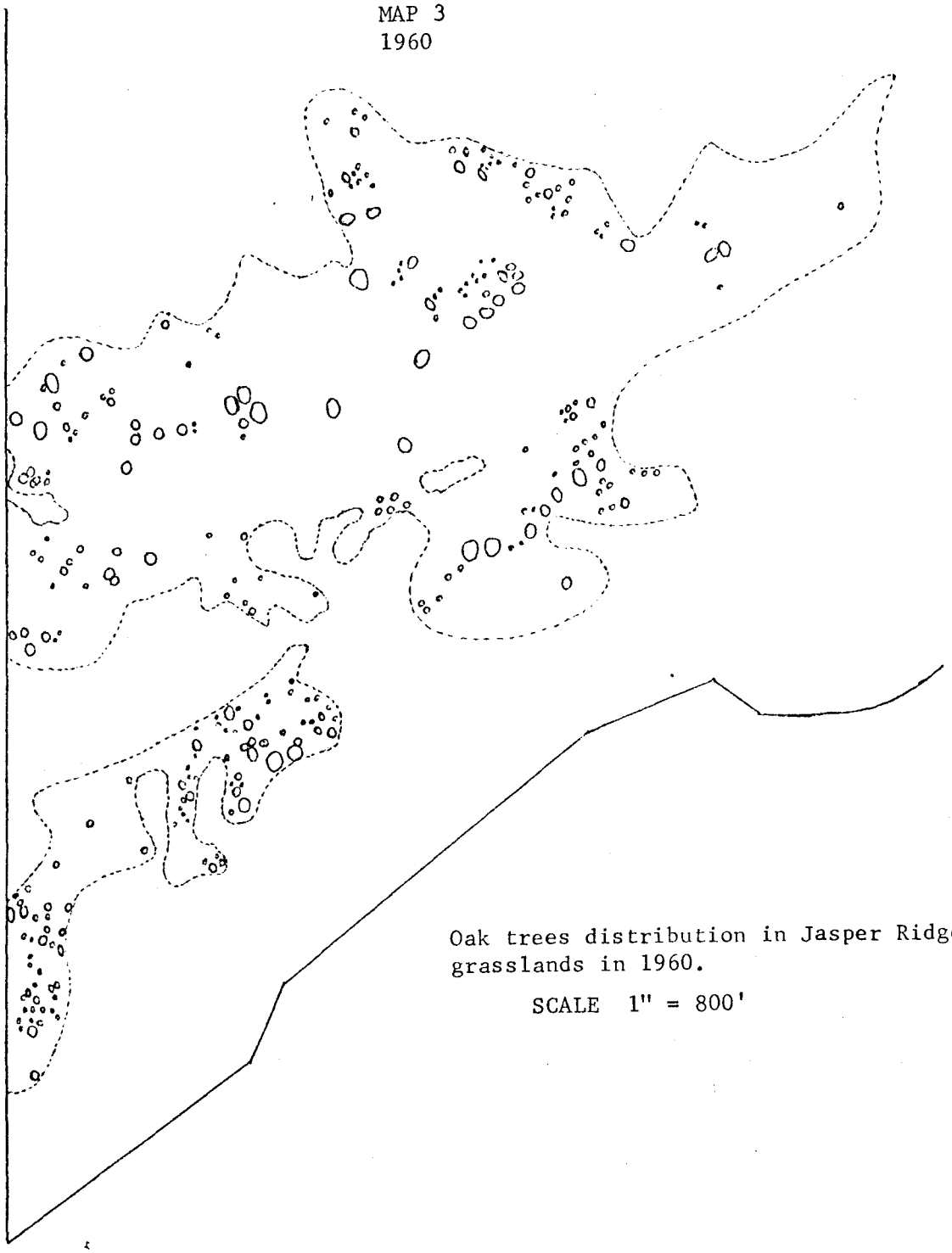
MAP 2
1948



Oak trees distribution in Jasper Ridge grasslands in 1948.

SCALE 1" = 800'

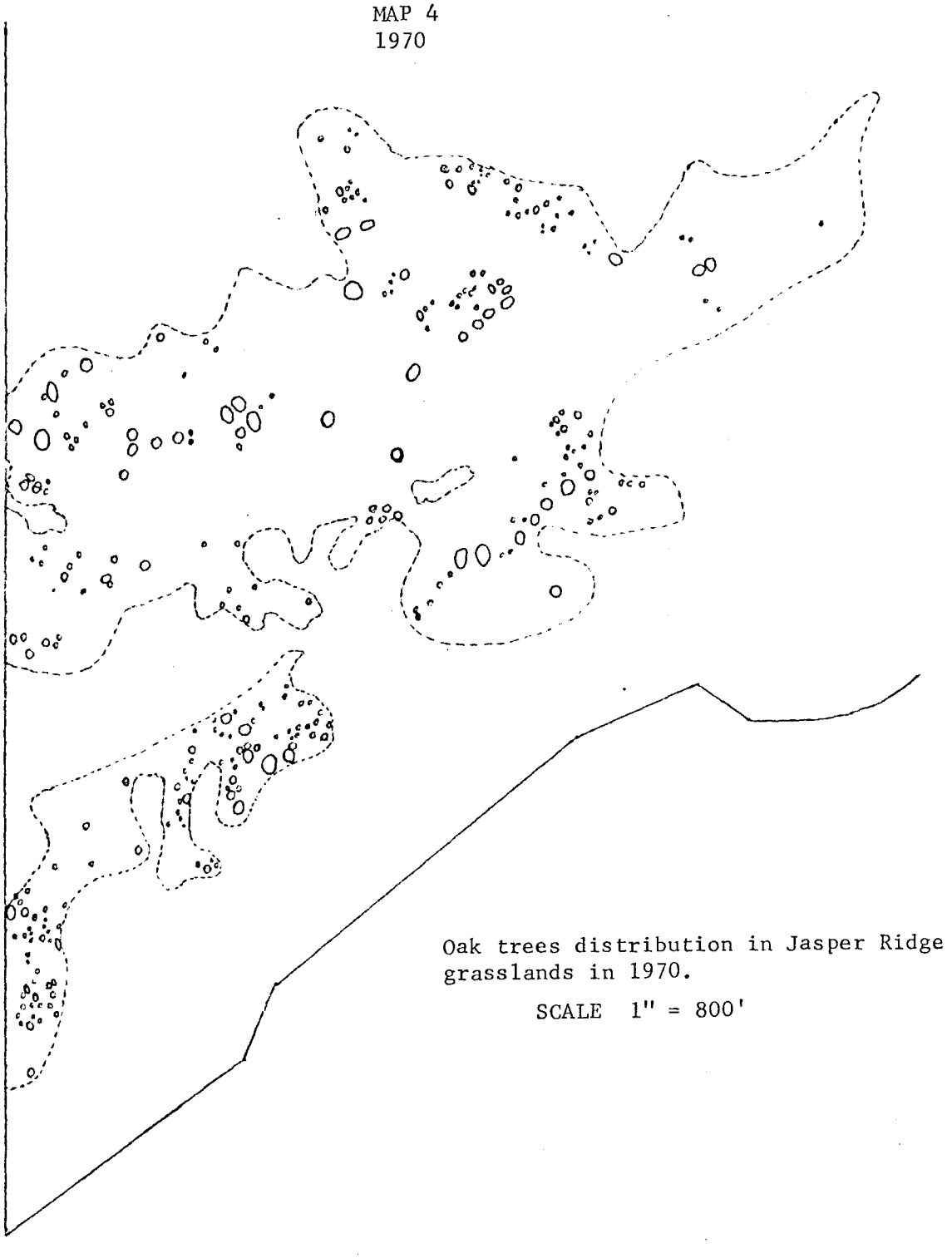
MAP 3
1960



Oak trees distribution in Jasper Ridge grasslands in 1960.

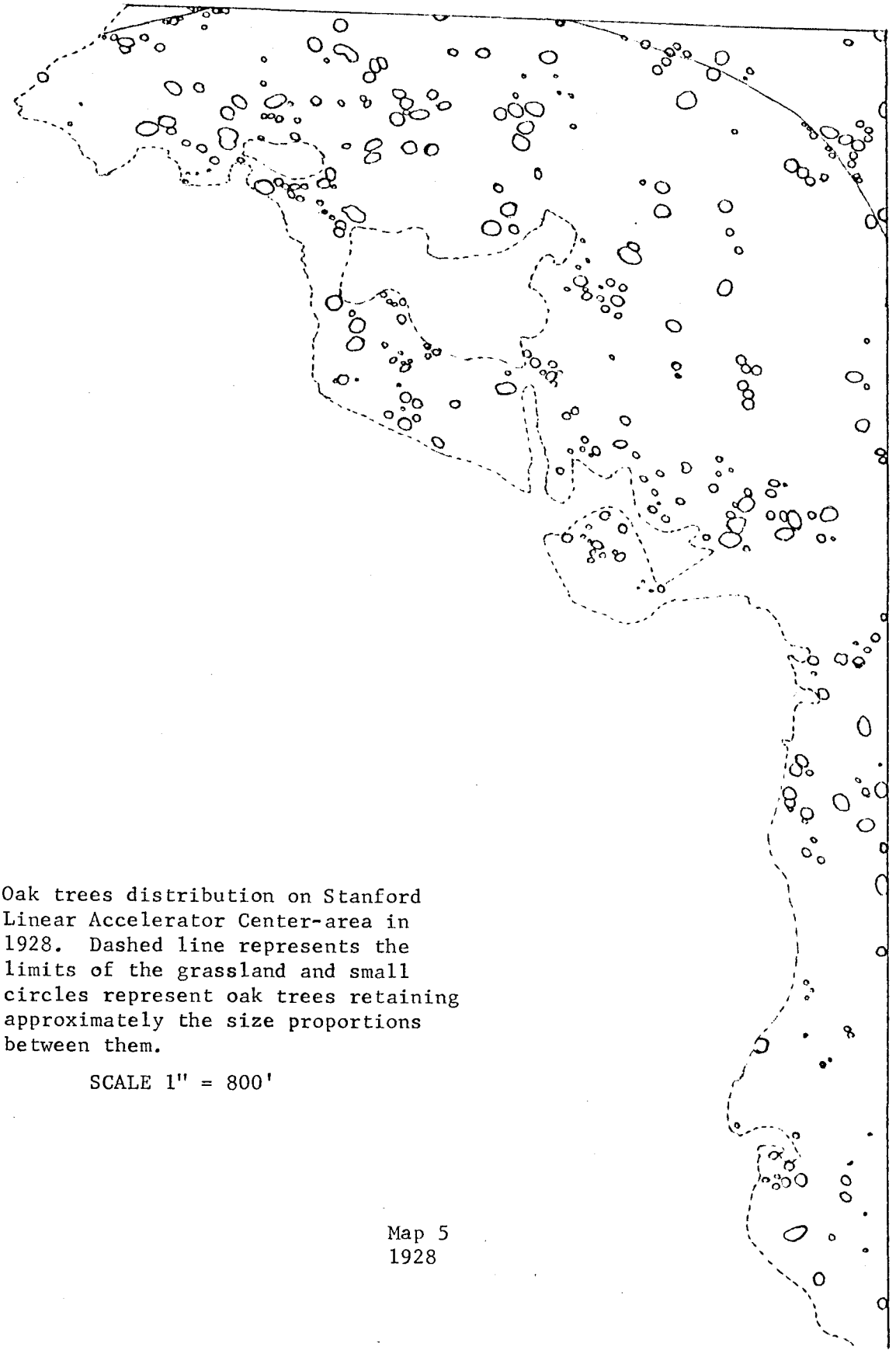
SCALE 1" = 800'

MAP 4
1970



Oak trees distribution in Jasper Ridge grasslands in 1970.

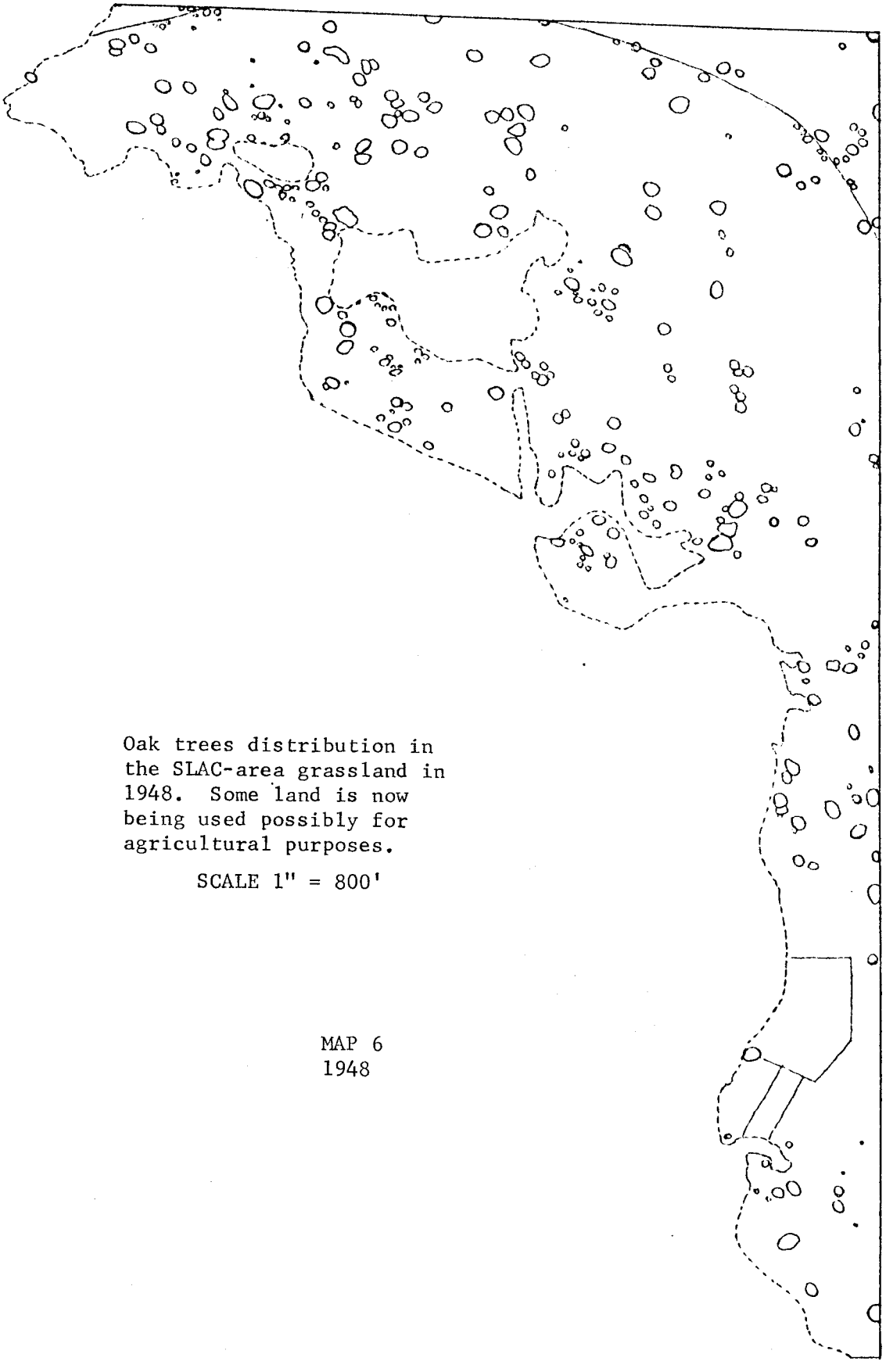
SCALE 1" = 800'



Oak trees distribution on Stanford Linear Accelerator Center-area in 1928. Dashed line represents the limits of the grassland and small circles represent oak trees retaining approximately the size proportions between them.

SCALE 1" = 800'

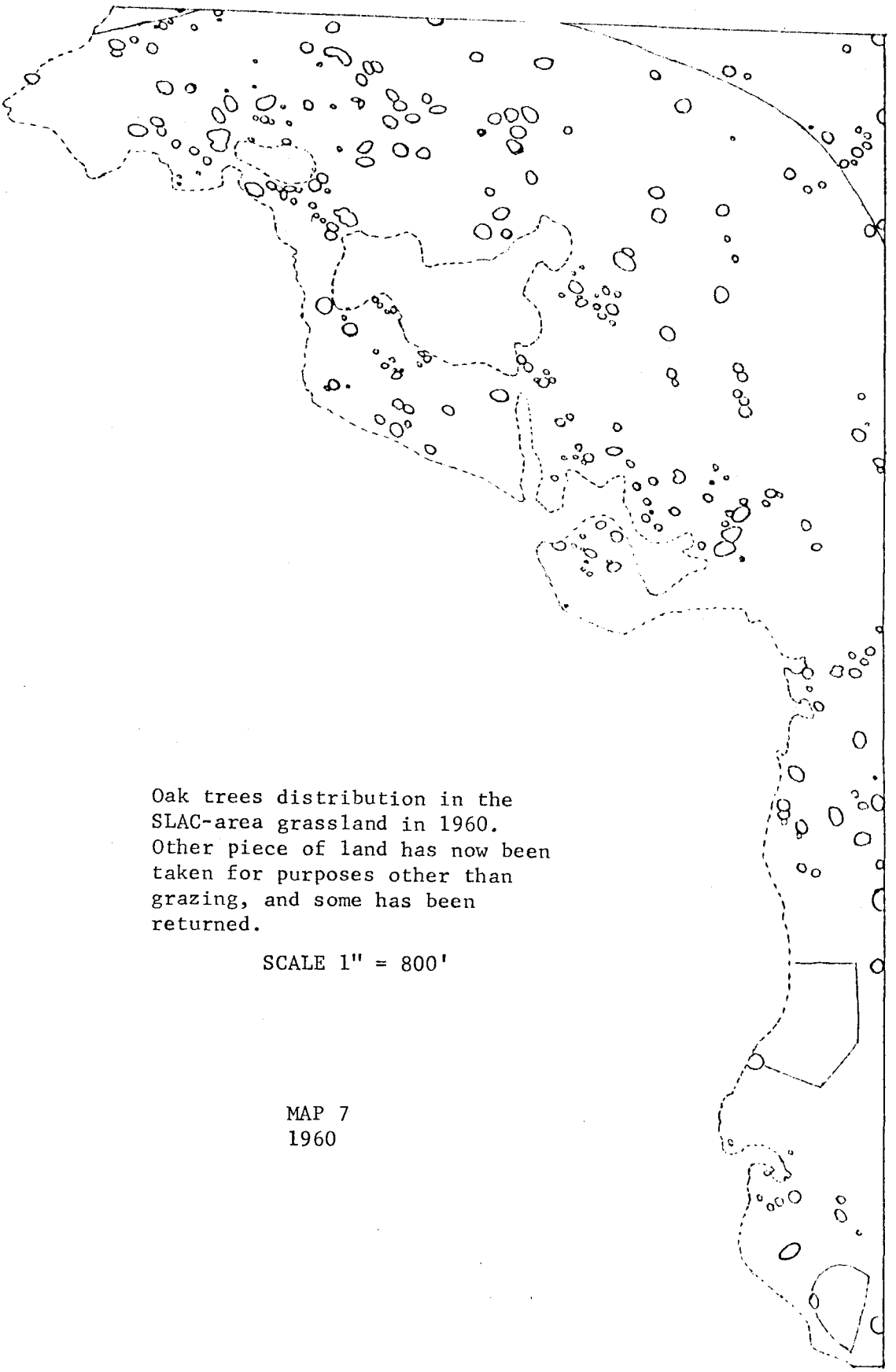
Map 5
1928



Oak trees distribution in the SLAC-area grassland in 1948. Some land is now being used possibly for agricultural purposes.

SCALE 1" = 800'

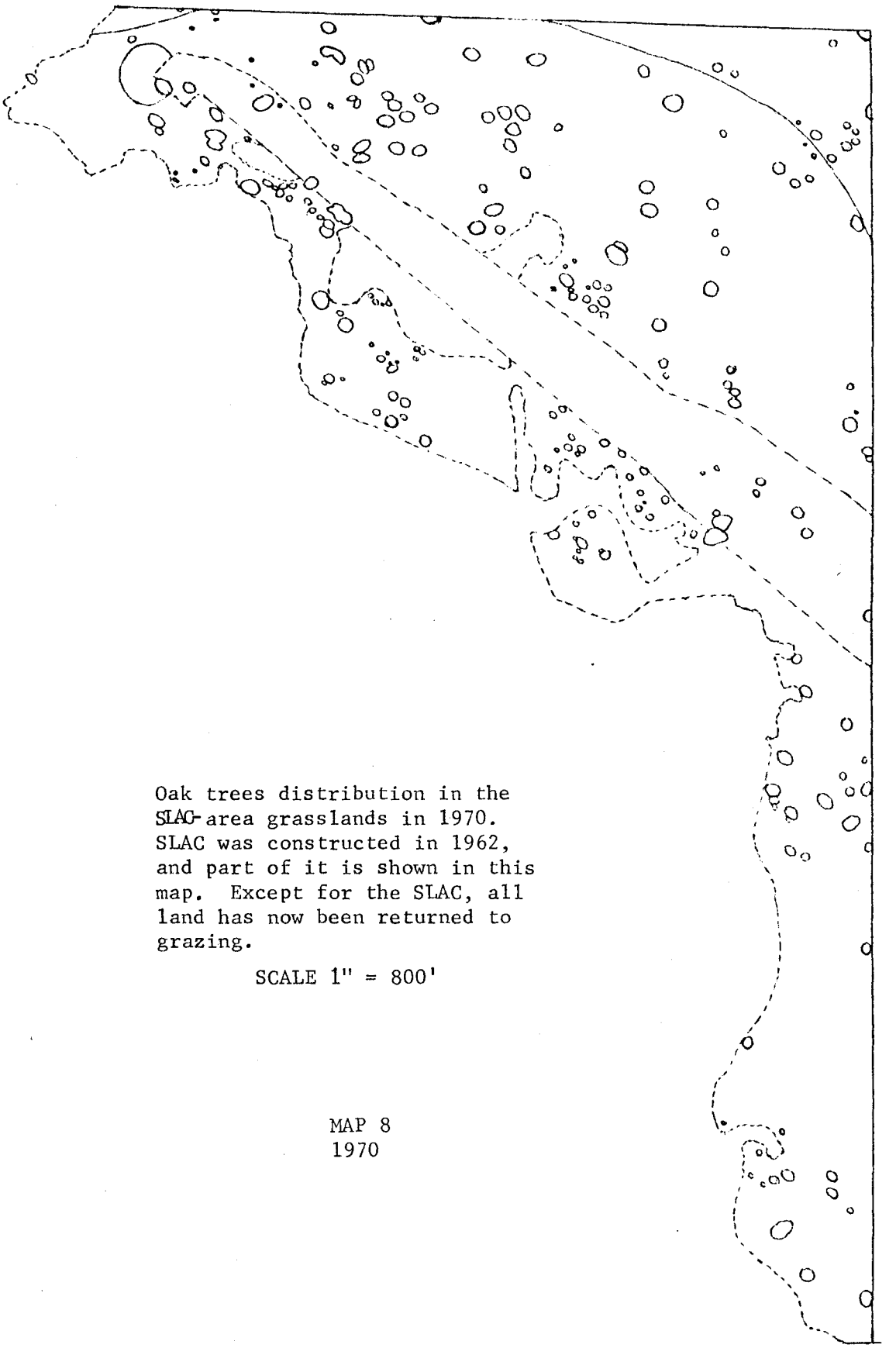
MAP 6
1948



Oak trees distribution in the SLAC-area grassland in 1960. Other piece of land has now been taken for purposes other than grazing, and some has been returned.

SCALE 1" = 800'

MAP 7
1960

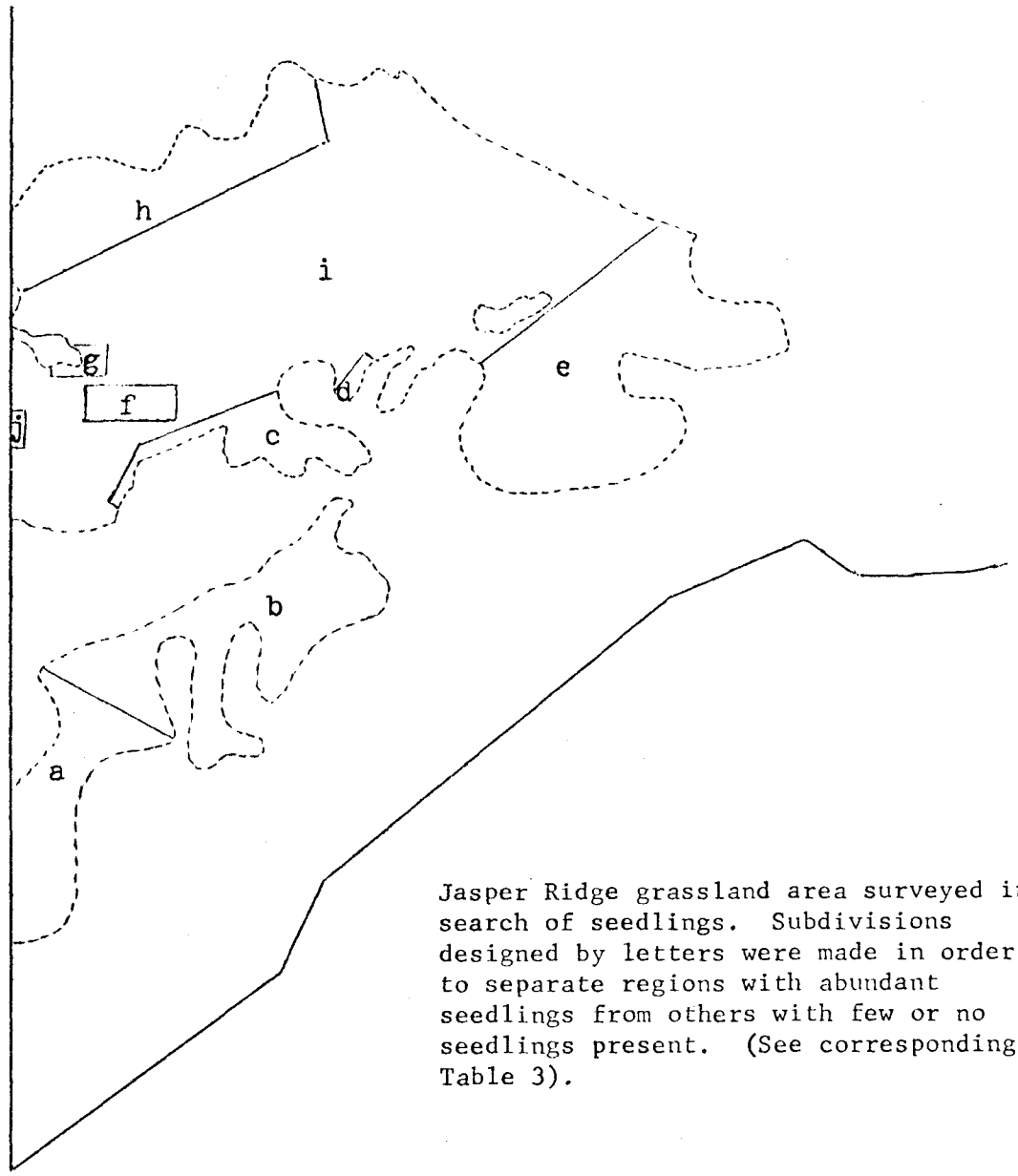


Oak trees distribution in the SLAC-area grasslands in 1970. SLAC was constructed in 1962, and part of it is shown in this map. Except for the SLAC, all land has now been returned to grazing.

SCALE 1" = 800'

MAP 8
1970

MAP 9




Jasper Ridge grassland area surveyed in search of seedlings. Subdivisions designed by letters were made in order to separate regions with abundant seedlings from others with few or no seedlings present. (See corresponding Table 3).

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