

Botany  
Honours



A PRELIMINARY REPORT  
ON THE  
RE - SURVEY OF ALIEN VEGETATION  
IN THE  
CAPE PENINSULA

by

DUNCAN McLACHLAN

(Botany Department, University of Cape Town)

OCTOBER 1976.

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

## C O N T E N T S

Abstract.

Introduction.

Sampling Methods.

Distribution Patterns.

Distribution in Relation to Ecology.

Rate of Infestation.

Cutting of Pinus Pinaster.

Fire.

Discussion.

Management Proposals and Recommendations.

Summary.

Acknowledgements.

References.

A B S T R A C T

Distribution studies of introduced trees and shrubs in the Cape Peninsula were done in 1959/60, by Hall (1961).

The same sample sites were revisited in 1976 to assess the change in the distribution and infestation over the 16 year period.

The effects of clearing and burning were examined and control management proposals of pest plants are suggested.

## I N T R O D U C T I O N

### Initiation of the Project

Concern has been expressed by several people and organisations, over many years, about the invasion of introduced trees and shrubs into the indigenous flora of the South-Western Cape. Wicht (1945), reported that "One of the greatest, if not the greatest, threat to which the Cape vegetation is exposed, is suppression through the spread of exotic plant species". Between May 1959 and May 1960, an extensive survey was made on the distribution of alien species (1) in the Cape Peninsula (Hall 1961). The area studied extended from Table Mountain southwards to the Muizenberg Mountains (see Map 1). Data on the distribution patterns were extracted from sites located from intersecting points of a grid, lines 1,000 yards apart on a Trigonometrical Survey map. In the present project, 73% of the 87 sites were revisited to monitor the changes in the alien populations after a 16 period year. The increase or decline of populations, the change in distribution patterns, the various effects of alien control measures and natural fires, were noted, with the aim of establishing recommendations for management control.

### NOTE

(1) "Pe<sup>s</sup>nt Plants" has been a promoting term in recent years in preference to alien vegetation. In this project, I have used the term alien vegetation as I feel this is more descriptive.

### The Introduction and Establishment of Alien Species

These species were originally introduced for economic purposes, mainly for the production of timber and for the stabilizing of sand dunes on the Cape flats. (Lückoff 1951). Pinus pinaster, the cluster

pine, was probably brought to the Cape at the turn of the 17th Century and plantations were established in 1892 at Tokai and on the southern slopes of Constantia Berg, and later on the Back Table of Table Mountain. Plantations of Pinus radiata and P. canariensis were being grown at Tokai in 1886 (Zahn & Neethling 1929). P. radiata was later planted on the northern slopes of Devils Peak in an anti-erosion programme (Lückoff 1951) and was later established on many of the south-east facing slopes of Table Mountain. P. pinea was introduced and planted mainly for ornamental reasons.

P. pinaster has the widest distribution of all the exotic species and is by far the most aggressive invader (Moll & Campbell 1976). P. halepensis, the Aleppo pine, is restricted to localized areas on the lower northern slopes of Table Mountain where it was originally planted and the other three species are not important as invaders.

The Australian Acacia species are A. cyclops, A. saligna, A. longifolia, A. melanoxylon and A. mearnsii. A. cyclops and A. longifolia are morphologically similar outside the flower season. A. cyclops, rooikranter<sup>2</sup>, is the most widely spread of the five species. A. melanoxylon was originally introduced in the late 1800's and is scattered in isolated sections of the mountain.

The three Hakea species from Australia are H. gibbosa, H. sericea and H. suaveolens. They have formed clumped stands all over the study area and especially on the drier western slopes of Table Mountain and on Skoorsteenkop. It is known that Hakea species are spread rapidly by fire or mechanical damage as the seeds held in a thick protective coat, are usually only released after the plant is damaged.

Albizia lophantha was probably introduced to the Cape in about 1834, (Taylor 1975). It can form dense thickets and is scattered over the study in usually mesic areas with clay soils. A number of Eucalyptus species are found in the study area. They are planted mainly as windbreaks and in plantations.

## S A M P L I N G     M E T H O D S

### The 1959 / 60 Survey

The area selected for the survey consisted of a 40 square mile (about 102 square km) tract of the mountains in the northern part of the Cape Peninsula, extending from Table Mountain southwards to the Muizenberg Mountains (Hall 1961). Throughout the area, intersections of the thousand yard grid lines on the 1:25,000 Trigonometrical Survey Map (1951) were chosen for sampling. Only those points above the 500 foot contour were examined. The points were located in the field by reference to the map, using an altimeter and a prismatic compass.

At each sample site, details were recorded on duplicated forms showing position, altitude of site, numerically and physiognomically dominant indigenous species, average cover height and density, post-burn age, soil type, soil moisture and aspect. Introduced species were recorded in terms of the approximate number of plants within a radius of 200 yards of the sample point. Where high frequencies were encountered, a circular area of 100 square metres was examined at the sample site to gain some information of the densities attained in such communities. In addition, photographs were taken of the vegetation at most of the sample points. The survey was restricted to those species whose aborescent life-form would likely cause changes in the structure and species content of the local flora. Thirteen species were included, and the survey was carried out in the period of May 1959 to May 1960 (Hall 1961).

### 1976 Survey Methods

The sample points were located in the same manner as in 1959/60, at the intersections of the grid lines, except I used 1:18,000

Trigonometrical Survey Map (1958) which shows greater detail.

These sites are referred by the vertical and horizontal co-ordinates of the grid reference. The majority of these sample sites were revisited and similar data were extrapolated from the sites as in 1959/60. These sample points were found by using a prismatic compass and altimeter, but it was found that most of the points could be located more easily using the photographs in 1959/60 and the site location maps drawn by Hall. The intersection point was usually located accurately and in most cases the exact beacon was found.

At each sample point, data were recorded on specially prepared field sheets, (see Appendix) as follows : A detailed local map was drawn in most cases showing the geographic and physiognomic features of the site. In areas of infestation, notes were made on alien clearing and the result of burning. At each sample point or beacon, a plot of 100 square metres was examined, as far as could be determined, of the same area as was recorded in 1959/60. Within this plot, aliens were recorded and grouped into three classes (0 - 0,15 m, 0,15 - 2 m and over 2m high), and the density of individuals of each class were compared to those for the 1959/60 survey. The aliens within the radius of a 200 metre circular site (about 125,600 square metres) were also counted or estimated if infestation was greater than 1 tree per 1,200 square metres. The size or age, (which was determined by counting rings on axed plants) of these species, their pattern of distribution, features of habitat and growth, and the effects of fire and cutting were noted. The estimated number of cut aliens were determined where possible to assess the effectiveness of the control practices. Certain indigenous species (those having the highest

cover/abundance values, Werger 1974), cover age, height and density were recorded. In addition, habitat factors such as soil type, moisture, rock cover, aspect, slope and soil disturbance were noted. These data were recorded for every sample in densely infested and lightly infested (near free) areas. Further information on alien populations were recorded as follows : seedling rates, estimated soil seed loads, seedling and adult numbers, mortality rates and mortality factors, regeneration and spreading rates and other points of interest.

At most sites, identical photographs were taken as far as possible to those in 1959/60. The alien species recorded were those chosen in 1959/60 as well as Pinus canariensis and Acacia mearnsii.

Of the 87 samples done in 1959/60, 51 of these were revisited and another 13 observed generally while climbing. (These are shown on Map 1).

In 1959/60, all measurements were in feet and yards. As this project is a repetition of that done by Hall, the slight difference in metric distances was taken into account, and in the field, site radius distances were in yards. The plot and site rise are referred to in metres. The difference in measurement of 200 yards or metres (9%) in rough mountain terrain is almost minimal. The alien distribution maps though, for comparison purposes, remain in imperial units.

## D I S T R I B U T I O N      P A T T E R N S

1. In 1959/60, the percentage occurrence of each alien species in the 87 samples was calculated (see Column I, Table 1) and compared to the occurrence in 1976. Not all the points were re-examined and therefore exact percentage occurrence for each species in 1970 could not be compared accurately to 1959/60. Though, estimated percentages of all 87 sites are given in Column III, Table 1. Percentage infestation increase values for 1976 are given for some of the species. The infestation increase is the percentage of sites which are new areas of infestation over all the sites which previously were infested, (ie. the percentage of sites with recent infestation). (see Table 1).

It is apparent from Table 1 that Pinus pinaster is the most widely dispersed exotic species in the study area and has scarcely extended its range over the 16 years. Hakea gibbosa and H. sericea occur in a greater number of sites than was found in 1959/60. Acacia cyclops and A. saligna have also apparently spread over the years, as has Eucalyptus and P. canariensis. The other species have not changed to any degree and the percentage occurrence is more or less static. The slight increase in Eucalyptus sp. is not only due to the planting of wind breaks.

2. The distribution patterns of the introduced species in 1959/60 and 1976 are summarized and compared in Maps 2 - 13. The aliens are grouped into density classes and the results of both surveys are super-imposed on one another to facilitate comparison.

Five density classes are recognised as follows : +, isolated trees 1 - 19, 20 - 50, 51 - 200, 200 + trees within 200m radius of the sample point.

Pinus pinaster is the most widely dispersed of all the introduced species, and is more or less evenly distributed over the 102 square km of the study area, with occasional dense stands in some areas. The pattern of distribution of the pines has altered over the 16 years. In some of the sites, the populations have drastically increased (sites 90/74, 95/71, and 89/82). 17 sites have decreased in P. pinaster numbers over the 16 years. This decline in pine populations is mainly due to cutting by authorities and individuals. (The sites are 87/84, 88/87, 88/86, 88/78, 89/88, 89/87, 89/86, 89/74, 90/90, 90/89, 90/88, 90/84, 92/73, 93/72, 94/72 and 95/72). P. radiata and P. pinea are found in isolated areas and have not spread. P. canariensis has spread to sites 88/80, 79 and 78, but only isolated trees were found.

Hakea populations have definitely increased over the 16 years, and isolated plants and clumped stands of the different species have been found at previous Hakea-free sites. (eg. 85/84, 88/80, 92/73 and 92/72). Hakea spp. are mainly distributed on the lower drier western slopes of Table Mountain, the north western slopes of Vlakkenberg, Skoorsteenkop and on the Muizenberg Mountains. Large areas of high density Hakea gibbosa and H. sericea were examined at a new plot at 85/86.

Acacia cyclops is extensive on the lower western slopes of Skoorsteenkop, Noordhoek Peak and Spitzkop. The seven plots with

high densities of A. cyclops were not examined and therefore changes in these dense stands are not fully recorded. This species has spread to a number of other sites, especially in soil disturbance areas. A. saligna has also spread to a number of previously uninfested sites at slightly higher altitudes in the Muizenberg Mountains and in Silvernime (eg. 90/74, 91/73, 92/73, 93/71 and 94/72).

Albizia lophantha is found mainly on the mountain slopes surrounding the Houtbaairivier valley and Orange Kloof. Apart from being found in broad-leaved fynbos it also occurs on forest margins and in open forest (Moll & Campbell 1976). Its spread has been checked by clearing in some sites (eg. 89/90). Eucalyptus sp is found in a number of new sites, by planting of windbreaks (89/74, 90/82 and 91/85) and isolated escapes (90/74).

D I S T R I B U T I O N   I N   R E L A T I O N   T O   E C O L O G Y

In 1959/60 "maximum development" attained by alien species in various communities and soil types was tabulated (Hall 1961). This table has been slightly expanded and modified. The majority of the sites (about 85% +) are in the Fynbos community. Some sites were in the scrub and forest.

The forest communities are chiefly confined to ravines, Orangekloof and Newlands, and the important species are Cassine peragua, Rapanea melanophlocos, Podocarpus latifolius, Halleria lucida, Olinia lymsa and Diospyros whyteana. The scrub community lacks many typical fynbos elements and has some features of the forest (Hall 1961, MacKenzie 1975). Characteristic species are Rhus tomentosa, Maytenus oleoides, Olea capensis, Phyllica buxifolia, <sup>Colpou</sup>Osyris compressa, <sup>?</sup>Gymnosporia laurina and other species. They are confined to more open ravines, wetter slopes and forest margins (as in Orange Kloof). The Fynbos consists of a restiod, ericoid and proteoid element. A table was drawn up as in Hall (1961) showing the maximum development or infestation by alien species in Fynbos, scrub and forest communities. In the Fynbos community, the infestation is shown in various habitats and on different soil types, and also in areas of various biotic or soil disturbed and recently burned areas. (see Table 2).

Pinus pinaster occurred in all the habitats examined, although the encroachment of pines into well established true forest patches is almost nil. P. pinaster, although it is only moderately fast growing is able to establish itself anywhere in mountain fynbos except in forests. It appears to vary in growth and vigour according to geographical providence, and the strong Cape winds obviously aid in the dispersion of the winged seeds. This can be noted very clearly

in sites which have young plant escapes scattered in the near free areas adjacent to dense stands or plantations (eg. 91/74, 89/87 and 89/86). Thus with the presence of these P. pinaster plantations on the mountains, the species will continue to be dispersed. The dispersal range of the cluster pine is not known, but it was noted that seeds are easily blown up a slope or cliff in strong winds (92/89). Therefore, even though pines may be eradicated from certain high altitudes, trees would eventually establish themselves on the mountain tops from plantations or stands at lower altitudes (example near 92/89). It is also suggested that P. pinaster tolerates exposure to sea air better than the majority of other alien species (Poynton 1973). Whether this is a factor in its successful establishment in fynbos and contributing to the fynbos feature of susceptibility to invasion is very questionable. The widespread distribution of P. pinaster is undoubtedly a result of its dispersal efficiency and its ability to adapt to various habitats within the mountain fynbos biome.

P. radiata is not considered an important pest, and although isolated trees were found in a number of sample sites, evidence of P. radiata was not found on revisiting the site (eg. 85/84). These trees do not spread rapidly and the isolated trees were probably cut down. Though, on Devils Peak, P. radiata is recorded as an invasive plant (Moll & Campbell 1976).

Hakea spp. are characterised by their habit of forming very dense stands (up to 150 - 250 plants per 100 m<sup>2</sup>). Although they are found mainly on the dry sandy and granite soils, and were documented by Hall (1961) as being rare on moist slopes, their encroachment into new sites might prove otherwise. They are presently found mainly on the drier

western and northern lower slopes of the mountains in the study area, but all species are found in both relatively moist fynbos slopes and scrub vegetation, (eg. sample points on Geelklip buttress, Myburgh's corner and in Orangekloof). The large areas and sites in varying habitats with low densities of Hakea sp show that perhaps these species are capable of higher infestation on moist slopes and at higher altitudes. It is evident that many of the less common species, including Hakea are rare at high altitude and that this is probably due to dispersal rates and the lack of infection sources in these areas and not due to different habitat conditions. Climate, temperatures and the occurrence of mists vary very slightly at low and high altitudes.

<sup>what</sup>  
(This) also applies to Acacia sp. It was noted that a number of new infected sites were formed in 1976 at higher altitudes, (eg. 90/74, 91/73, 92/73, 93/71, 94/72 in A. saligna) suggesting that some species have the potential of spreading to various habitats on the mountains. A. longifolia and A. cyclops have the ability to spread rapidly in previously infested areas after clearing (eg. below Tafelberg Road, Moll & Campbell 1976) and A. longifolia is present in disturbed indigenous forest (eg. 92/86), and both species are common in areas with soil disturbance (eg. 91/72). A. melanoxyton and Albizia lophantha are able to invade scrub and some forest communities. Both are rare on dry slopes and prefer mesic conditions. A. lophantha is most common on clay and granite soils and can form dense stands (near 89/86). A. melanoxyton is probably more common on sandy moist habitats. These two species are limited in their encroachment abilities into the major portion of the mountains and are only a threat on the lower sites to scrub and open forest communities.

TABLE 1

Percentage occurrence of alien species at 87 samples in 1959/60, (Hall 1961) and estimated percentage occurrence in 1976. Percentage infestation increase in the re-examined sites, is in column 2.

Alien species	-% occ. 1959/60	-% infestation incr. 1976	-est. % occ. 1976
<i>Pinus pinaster</i>	83	2	85
<i>p. radiata</i>	11	0	9
<i>P. pinea</i>	6	0	4
<i>P. canariensis</i>	-	2	3
<i>Hakea gibbosa</i>	24	4	27
<i>H. sericea</i>	9	5	14
<i>H. suaveolens</i>	11	0	11
<i>Acacia longifolia</i>	7	0	8
<i>A. cyclops</i>	20	2	23
<i>A. saligna</i>	17	4	21
<i>A. melanoxylon</i>	6	-	6
<i>Albizia lophantha</i>	7	0	6
<i>Eucalyptus species</i>	5	3	8
<i>Acacia mollisima</i>	1	-	1
<i>A. mearnsii</i>	-	1	1

TABLE 2

Maximum development attained by the important alien species in various habitats, modified from Hall (1961)

	P. pinaster	P. radiata	P. pinea	H. gibbosa	H. sericea	H. suaveolens	A. longifolia	A. cyclops	A. saligna	Albizia sp.	Eucalyptus spp.	A. melanoxylon	A. mollissima
<u>Fynbos:</u>													
Dry slopes													
sandy soils	5	3	2	5	5	5	2	5	5	-	1	1	1
clay soils	3	1	-	1	1	3	-	5	1	-	1	-	-
granite soils	3	1	1	5	3	5	-	2	2	-	1	-	-
Moist slopes													
sandy soils	5	4	-	5	1	1	+	+	2	+	4	4	-
clay soils	2	1	-	2	2	2	1	5	2	4	+	2	-
granite soils	2	+	2	2	1	+	+	2	1	4	+	+	-
Cliffs & rocky places													
dry slopes	4	+	-	2	1	+	2	+	2	-	-	+	-
moist slopes	5	1	+	1	1	+	3	+	2	+	+	1	-
<u>Scrub</u>													
open ravines	2	1	+	3	3	1	1	+	4	2	+	2	-
forest margin	2	1	1	+	4	2	1	+	1	3	2	1	-
<u>In Forest</u>													
	+	-	-	-	-	-	-	-	-	-	-	-	-
<u>In cleared areas</u>													
	2	-	-	3	3	3	2	3	2	*	1	1	* R
<u>Eroded areas</u>													
	1	-	-	2	2	*	1	2	2	*	1	*	* R
<u>Soil disturbed a.</u>													
	2	+	-	1	1	*	2	3	3	*	2	*	* R
<u>In burnt areas</u>													
	2	-	-	5	4	3	*	2	3	+	+	*	* R

KEY 5-abundant, 4-common, 3-frequent, 2-occasional  
1-rare, +-very rare, \*-unknown, R- rates of  
infestation.

TABLE 3

Environmental data from 5 relatively undisturbed sites, and Rate of Infestation (Infestation Index) over the 16 year period.

	85/84	86/84	89/81	90/74	91/87
Altitude	1950'	2200'	1700'	1500'	2800'
Slope	10 <sup>o</sup>	5 <sup>o</sup>	15 <sup>o</sup>	8 <sup>o</sup>	15 <sup>o</sup>
Soil type	sandy	"	"	"	"
Moisture	2	3	2	2	3
Aspect	W	E	NW	S	S
Rock cover	2	3	2	2	1
Soil disturbance	nil	"	"	"	"
Evidence of clearing	al. nil	nil	"	al. nil	nil
Cover age	5	5	16+	16+	16+
Infestation Index	3	10	4,5	100	1,5

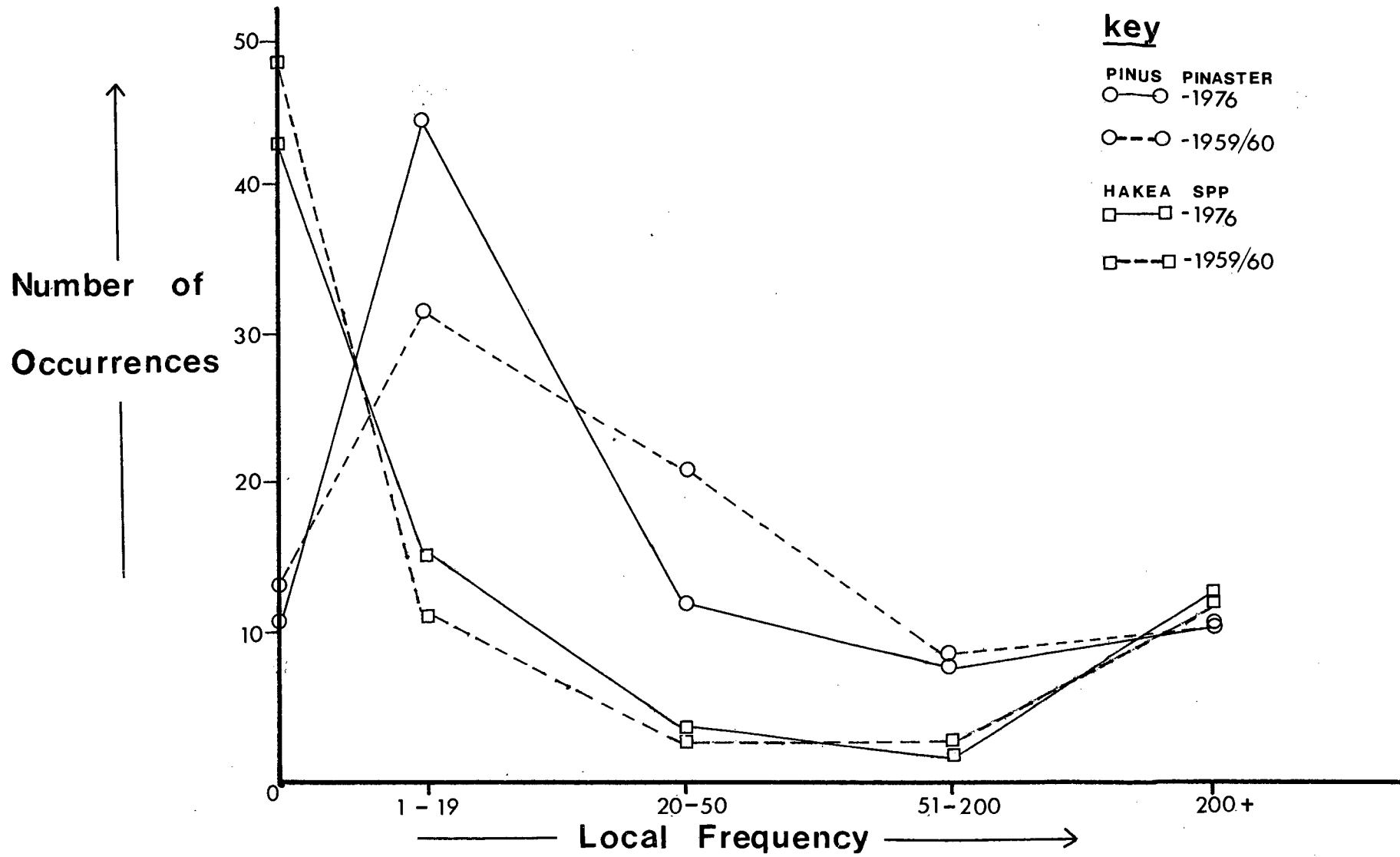


DIAGRAM 1

Graph showing the number of occurrences of Pinus pinaster and Hakea spp., found at the sites, and their various local frequencies in 1959/60 and 1976. Local frequency is expressed as the number of plants within 200m of the sample point.

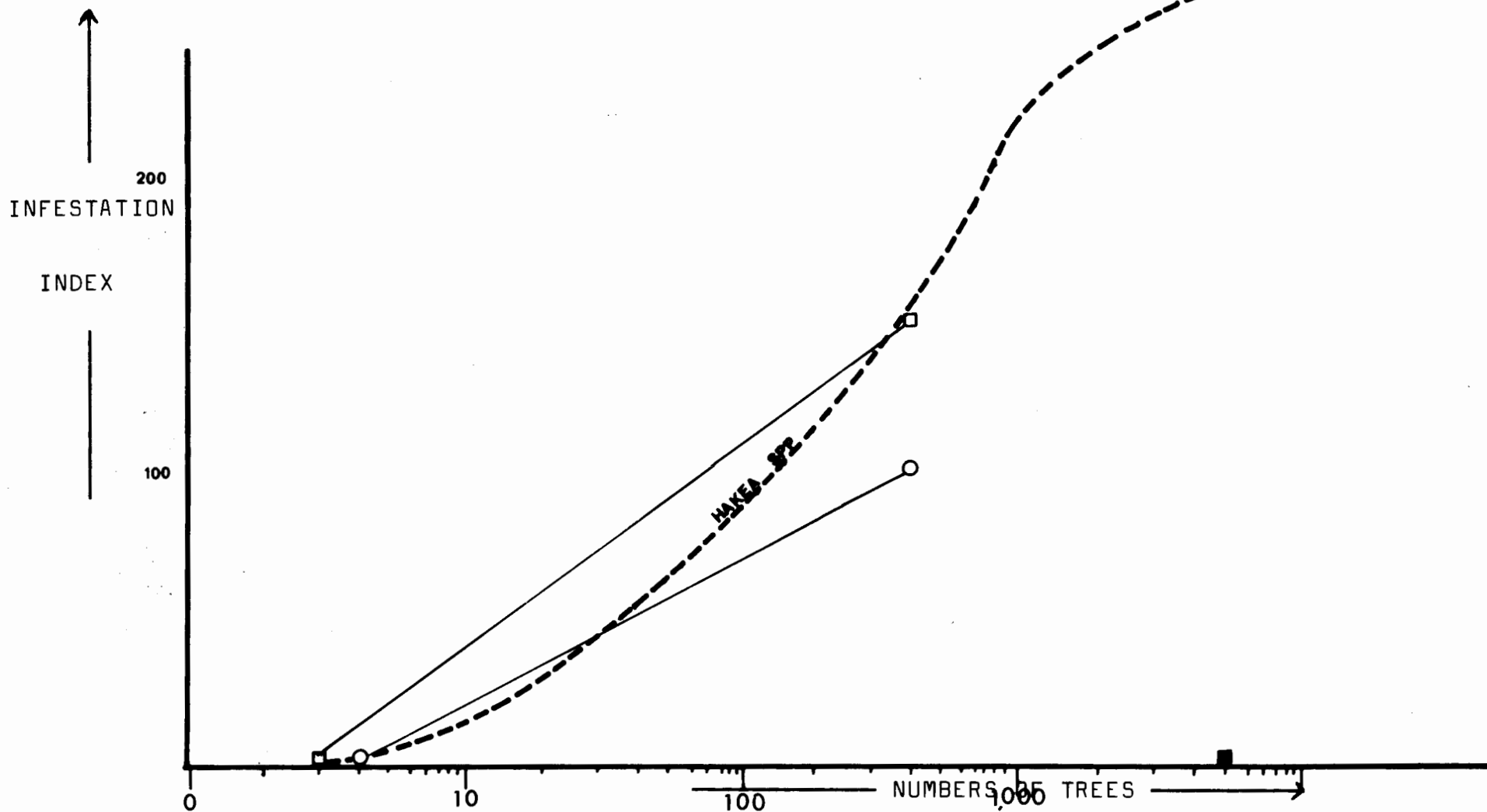


DIAGRAM 9. The increase of Hakea spp (Infestation Index), in an area of 5,000 sq. m. The hypothetical increase (-----)curve, and the rate of density increase at two sites (80/74 & 92/72) are given.

## R A T E   O F   I N F E S T A T I O N

1. A few sites in the study area that had been relatively undisturbed over the last 16 years. Only five sites were chosen, as being undisturbed, to show changes in local density of Pinus pinaster populations. The five sites chosen (85/84, 86/84, 89/81, 90/74, 91/87) all have similar environments (see Table 3).

They are all at high altitudes on mountain tops and have relative similar habitats. Recent cutting of pines at 90/74 and 85/84 were accounted for and except for 86/84 and 85/84, the other sites have not been burnt in the last 16 years. In the two burnt sites, regeneration of seedlings might have been effected, although in adjacent areas of similar age, after burnt vegetation, the trees burnt by fire are still standing and visible and thus the burnt trees were counted as probable survivors.

The Infestation Index was calculated for each P. pinaster population at the five sites. (ie. the Infestation Index is the value obtained by dividing the number of pines found in 1976 by the original number of pines in 1959/60 at each site). The Infestation Index was plotted against the number of trees, to give the rate of increase in P. pinaster populations at the various sites. The rate of increase over 16 years is shown by the slope of the curve on the graph (see Diagram 2, Graph 2a), the number of trees in the graph is represented logarithmically. A second curve was drawn to show the accumulative rate of infestation or increase of one hypothetical undisturbed P. pinaster population, without additional external seed sources.

(This is why site 95/72 was excluded, as the seeds were obviously

blown from an old, relatively dense stand in the adjacent valley). The curve of each site is plotted accumulatively on the previous curve in order to demonstrate the possible increase pattern in one population by using data from sites with different numbers of trees, from one tree to a dense stand or plantation (see Diagram 2, Graph 2b). The final curve (dotted) is the hypothetical rate of increase (infestation) of one P. pinaster tree to form a dense stand of about 16,500 trees per site area (125,600 sq.m.). From the graph, it is apparent that initially, increase is relatively slow, until the population is about 20 trees per 125,600 sq.m. The population increase is then extremely rapid until the number of trees is about one tree per 40 sq.m. Once the pines have formed dense stands, the infestation index is low (ie. about 1,1 - 1,5 for every 15 years) as maybe expected, until the area is at maximum development. It is estimated from the graph, that the time needed (time also accumulates) for one tree to form a dense population of P. pinaster will take about 35 - 45 years, without external influences. This has far-reaching consequences if this alien species is not controlled.

Hakea sp on the other hand, have a greater potential for increase in population size; Two sites 89/74 and 92/72 were taken. At both sites, the young plants, all the same age; seeded from two or three adult plants that had been damaged by mechanical injury (ie. axed). The infestation index of these species is extremely high and they can form very dense stands in a short period of time. The graph shows the hypothetical increase in a Hakea population, until it reaches about 1 - 1,6 trees per sq.m.

Though the population may remain static for a number of years if

the area is left undisturbed (see Diagram 3).

2. High percentage of seedlings of P. pinaster and Acacia saligna and Hakea sp were found in near free areas at about 11 sites (see Map 16). This was attributed to high seedling rates and seed loads from nearby dense stands in P. pinaster, and cutting of isolated plants in Hakea sp. This indicates that the highest rate of infestation of P. pinaster in near free areas is near dense stands.
  
3. Another feature of most alien species found in the study area is the development of clump or scattered stands of the same age. In Hakea sp, this is obvious as the populations are usually always the same age as seed dispersal is induced by fire or injury. In about 8 sites in the study area, (see Map 16) P. pinaster was noted to have scattered areas of similar age groups. In 95/71, the infested area (about 1 tree per 600 sq.m.) had not been burnt over the 16 years and yet all the plants are of a similar age (2½ - 3 m high). This pattern was repeated at several sites. This tends to indicate that dispersal of P. pinaster seed is not only random, but that seedling rates or seedling regeneration respond to specific and various environmental and physiological factors.

## C U T T I N G   O F   P I N U S   P I N A S T E R

At each site, the evidence of felling by authorities and individuals, and the approximate numbers of axed trees noted. There was evidence of cutting at 40 of the sites visited. The data in each of the 40 sites was analysed on the change in the population, over the 16 years and the effects of cutting during that period. These are summarized on Map 15.

At 12 sites, there was evidence of a few isolated trees being cut down, and at the other 28 sites, there was evidence of heavy cutting (+ 25 trees in the site area) and very heavy cutting (+100). Very heavy cutting was found at 88/86, 90/88, 91/89, 92/73 and 95/72 (see Photographs). Out of the 28 sites with heavy cutting, 14 of these showed that cutting of P. pinaster has been effective in drastically reducing the population and the spread of this species. In some cases, the population had been recently cut as in 91/88, 90/74, 88/86 and 89/86. In very densely cut areas, where 45%+ of the cover is cut material, the regeneration of the indigenous flora is slow, (eg. 90/74 and 91/88). Though in other areas where heavy cutting has taken place after 1959/60, but probably before 1968, the regeneration of indigenous flora is almost unaffected or apparently so, if the previous population of pines was about one tree per 300 - 420 sq.m. (about 300 pines in the site area (eg. 89/88, 92/73 and 95/72). In 95/72, it had been burnt after cutting and thus nearly all evidence of previous pine infestation in the area was eliminated. The fynbos appeared to be almost completely unaffected with similar floristic composition at the previous infested areas as compared to previous near free areas seen from the +Local Map drawn in 1959/60. This survey demonstrates that cutting of P. pinaster has been effective in control.

## F I R E

Fire is of some significance in both the increase and decline of alien populations. It is well documented that Hakea sp, and to a lesser degree, Acacia cyclops, that fire aids in their invasive potential into the fynbos. In Hakea sp, the hard seed coats open, to release the seed after fire. The spreading of Hakea sp over the last 16 years is on the lower western slopes of Table Mountain, are at sites 85/85, 85/86.

The system is more complex with regard to P. pinaster. Adamson (1935) mentions that the invasive ability of P. pinaster is greatly assisted by the reduced competition from the fynbos brought about by frequent fires. In the sites examined, this does not seem to be the case. About 35% of the sites had been burnt in the last five years. Of these, there was evidence in 9 of the sites of fire destroying P. pinaster trees. In 4 of these, between 15 and 150 trees, of 2 - 4 m high, were killed in the fires and demonstrated that fire is an important controlling factor in the spreading of P. pinaster seedlings and young plants.

At one sample 95/71, half of the site had been recently burnt in a controlled fire. The other half had not been burnt for at least 20 - 30 years and was infested with P. pinaster at about one tree per 250 sq.m. In the burnt area, which had groves of Mimetes present, not one pine seedling or tree was found.

It was also noted that in a firebreak which was burnt through very dense Hakea sp on the lower western slopes of Table Mountain (near 85/86), that very few seedlings were found in the burnt area. This is unusual, and is probably due to authorities removing alien regeneration in these cleared areas.

## D I S C U S S I O N

In general, there has been a slight increase in the area of infestation in Pinus pinaster, Hakea gibbosa, Hakea sericea, Acacia cyclops, Acacia saligna and Eucalyptus sp. There has also been a marked increase in the density of Pinus pinaster populations at various sites. Although P. pinaster is found in slightly more samples than before, the actual numbers in most of the samples have declined. The cutting down of many dense stands of P. pinaster (see Photographs) has without doubt, decreased drastically the rate of spreading through the mountains of the study area. From Diagram 1, the number of occurrences of P. pinaster and Hakea spp found at various density classes at the sites can be compared over a 16-year period. Hakea spp have not changed very much. The number of sample sites with high densities (200 +) are about the same. Though, some previously lightly infested sites have grown up over the period (ie. 91/88 and 90/74 respectively - see Photographs). The number of sites with 20 - 50 trees have decreased. This is due to extensive clearing, and as a result, many of the sites that were previously relatively densely infested (20 - 50 trees) now only have a few isolated trees.

### Value of the Survey

The re-examination of the exact sample sites has given valuable data on alien vegetation spreading, clearing and interesting results on distribution patterns. These results would have been impossible to obtain without the foresight of Hall (1961) in locating sites, taking photographs and recording data from which these data were compared.

The method of sample location was objective, which resulted in many similar sample sites and plots, many of these being information

useless as entities, but not in the distribution pattern change. Subjective sampling might have improved the value / time procedure. Through grid-reference objective sample location, there has been no bias in the location and thus in the distribution patterns, although similar results might have been obtained with fewer subjective samples. The importance of the method is the relocation and re-examination of the exact plot (100 sq.m.) and site (125,000 sq.m.).

## MANAGEMENT PROPOSALS & RECOMMENDATIONS

The important pest plants are listed below in order of existing menace and potential danger to the indigenous flora of the mountains in the study area :-

- a. Pinus pinaster
- b. Hakea gibbosa  
Hakea sericea
- c. Acacia cyclops  
Acacia saligna
- d. Other alien species.

P. pinaster is the most widespread and is at present the greatest danger to the indigenous flora. Although large areas have been cleared, isolated trees still remain in most areas. Many of these trees are in inaccessible places. Thus, P. pinaster has the potential to infest densely all areas of the mountain. As can be seen from Diagram 2, the greatest rate of increase in infestation is after the density is one tree per 6,200 sq.m. (20 trees in the site). Initially, the increase of infestation from isolated trees is low, though this is definitely not always the case. Once the density is about one tree per 60 sq.m. the rate of infestation decreases. Ratiocinatively, clearing of isolated trees and lightly infested areas is more effective initially in preventing the further infestation of the cluster pine into other areas. Once the lightly infested areas and escapes from dense stands have been cleared, then it is only logical to clear dense stands..

Problem arises in the clearing of isolated Hakea spp. Injury to the plant initiates seed liberation and thus increased local infestation. Areas of lightly infested Hakea spp., and isolated plants should be cut

↑  
Infestation  
Index

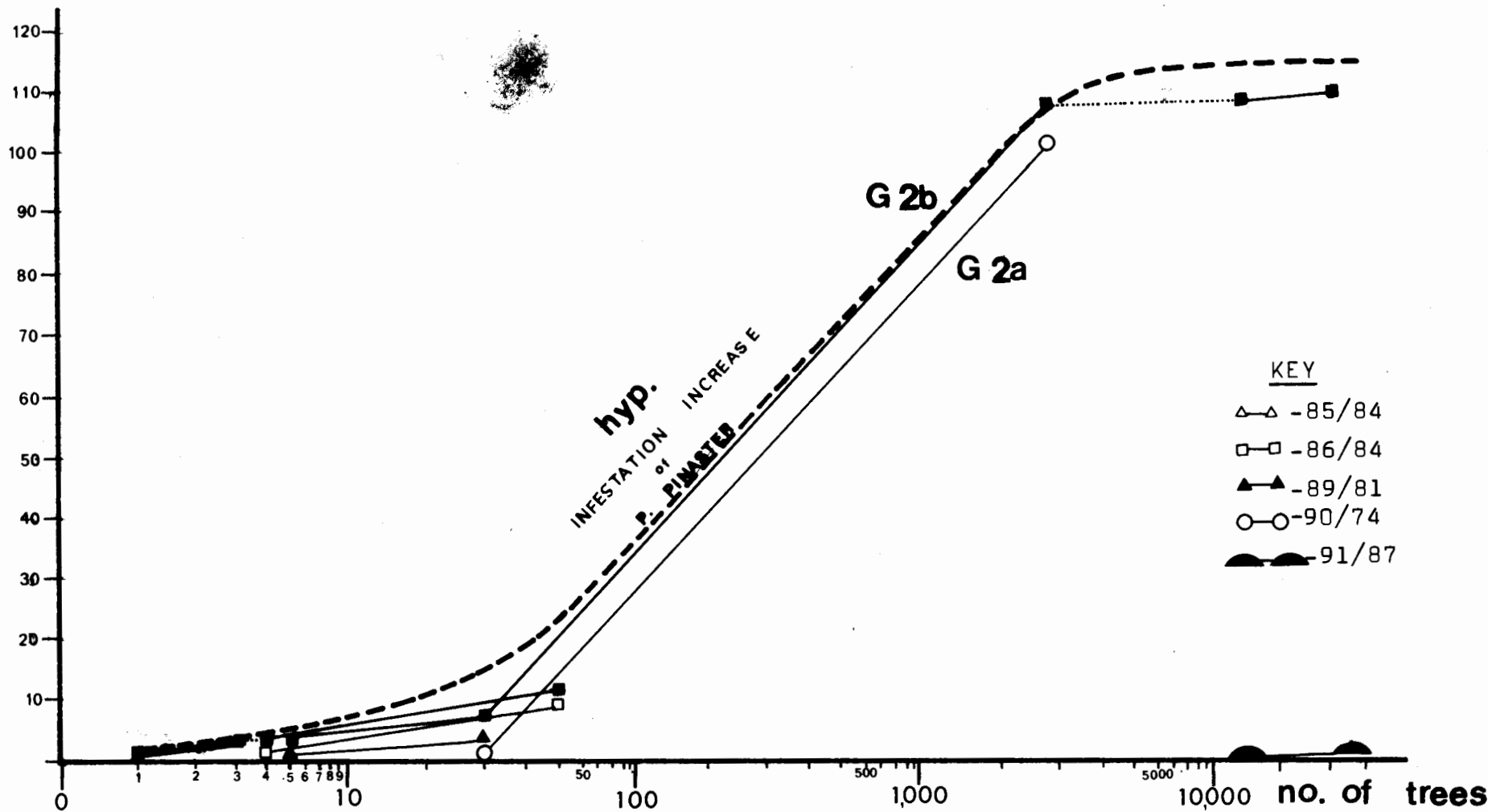


DIAGRAM 2 GRAPH 2a: The rate of increase in the number of P. pinaster trees at various relatively undisturbed sites. The rate of increase is shown by the INFESTATION INDEX.

GRAPH 2b Accumulative rate of infestation increase of a pine populations at various densities

## SUMMARY

The re-examination of the exact sample sites has given valuable data on alien vegetation spreading, clearing and interesting results on distribution patterns. These results would have been impossible to obtain without the foresight of Hall (1961) in locating sites, taking photographs and recording data from which these data were compared.

and piled together, and the area revisited 18 months later to remove seedlings. Dense areas (one tree per 0,5 - 3 sq.m.) should be confined and protected from fire. Controlled annual fire strips through dense stands may be a method of control. In this method, strips of the area are burnt and weeded of seedlings, until eventually the whole area is free. Although fire is the cause of the rapid encroachment of Hakea, it may also be a method of control.

Fire control of P. pinaster seedlings may also be effective. The seedlings and young plants are susceptible to burning and thus, if an area is cleared of pines, it may be effective to burn the same area 2 - 3 years later to eliminate further regeneration. This has appeared to be very effective at site 95/71 (see Photograph).

The findings of this survey, in that outlying infestations should be cleared first and that these areas should be re-cleaned regularly, are suggested by Moll & Campbell (1976). They suggested three control phases (i) Containing action (ii) Main assault and (iii) Mopping-up operations.

Initially, all areas lightly infested by pest plants should be cleared and re-cleaned continually. In many cases, eg. Acacia spp and Albizia, which have very long living seeds, re-weeding of areas is all the more important. Burning of areas should be planned according to clearing operations, as already mentioned (if the fynbos has not been burnt for at least 15 years).

The control of pest plants should be under co-ordinate management, as suggested by Moll & Campbell (1976) and in Veld and Flora (1976).

In this way, management control of pest plants can be more effective, if the different authorities responsible are co-ordinating to one management plan.

## S U M M A R Y

The status in respect to distribution patterns and ecology of a number of alien species on Table Mountain, Constantiaberg and Muizenberg Mountains were re-examined from 73% of the same sample sites examined in 1959/60 by Hall (1961).

Alien species were found in 96% of these sites. Pinus pinaster is by far the most widespread of all the species, occurring in 85% of the sample sites. Hakea gibbosa, H. sericea and Acacia cyclops are the next most common species, occurring usually as dense stands, whereas in P. pinaster, 60 - 70% of the sites have only isolated or scattered trees. The other ten alien species, found in 40% of the sites re-examined, have remained more or less static in their distribution. Isolated plants and clumps of seedlings of Hakea spp have spread into new areas and are potentially dangerous in the event of fires of forming dense colonies in these areas.

The control measures, by clearing, have only been effective in P. pinaster. Of the sites re-examined, the numbers of densely populated stands have decreased drastically, although the numbers of sites with isolated trees have as a result increased (see Diagram 1). The clearing of pines has only temporarily decreased the infestation of P. pinaster. P. pinaster is widespread although in fewer numbers, has the potential to infest densely all areas of the mountains in the study area.

From these data (ie. infestation rates, effects of clearing and distribution) of P. pinaster, it can be established that it is essential to clear isolated trees and lightly infested areas first, before heavily infested areas. If not, P. pinaster will increase.

This also applies to Hakea spp and Acacia spp.

Young plants of P. pinaster are susceptible to fire and Hakea spp are spread rapidly by burning. Thus it is essential that burning management and clearing management on the mountains are co-ordinated.

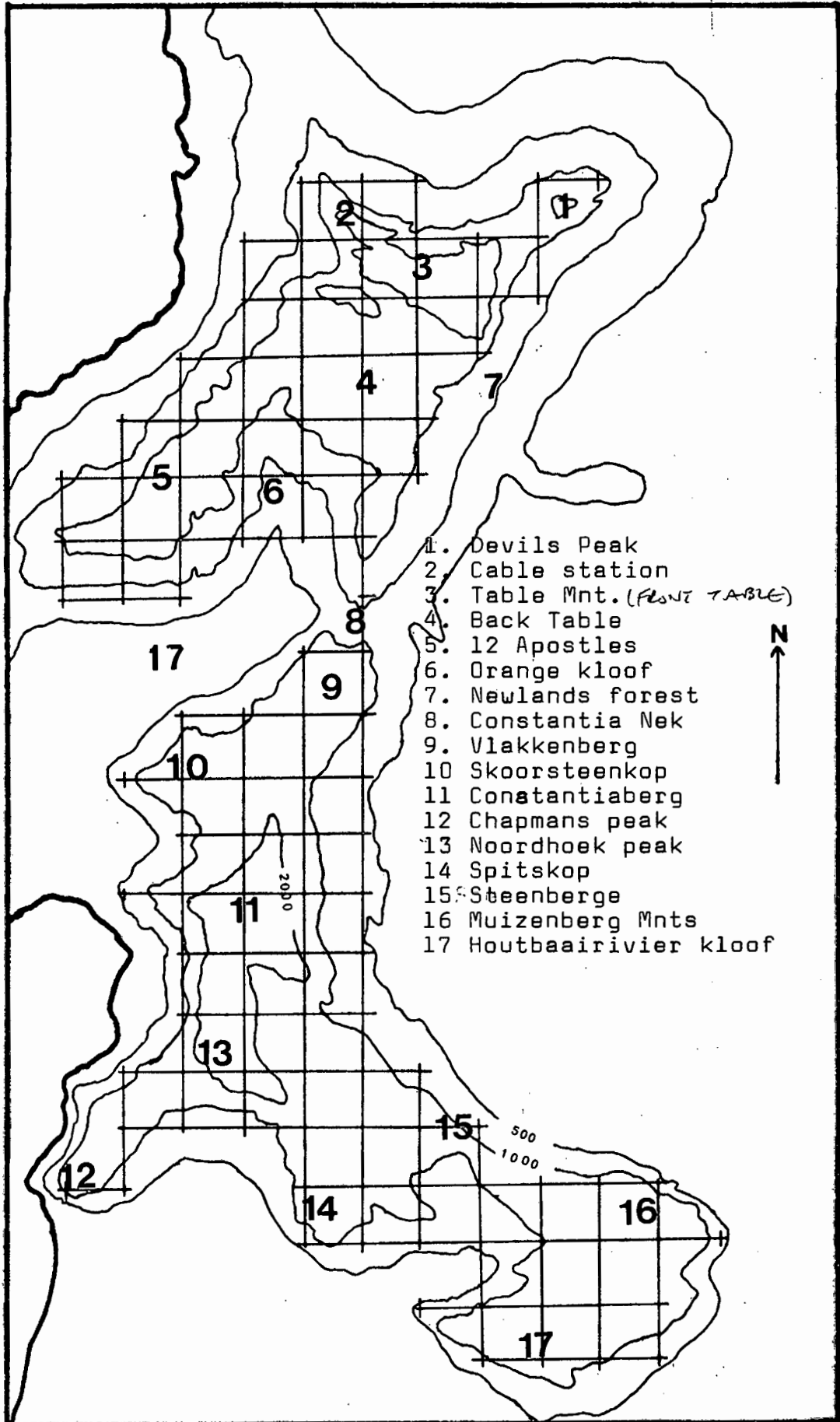
Areas lightly infested by Hakea spp should be protected from fire, before clearing operations, and maybe burnt about 18 months after clearing (if the indigenous vegetation is 15 + years - McLachlan 1974, Moll & Campbell 1976). to help eliminate seedlings.

Re-clearing of these areas is also necessary at intervals depending on the longevity of the seeds. Strip-burning in dense stands of Hakea spp may be a control method.

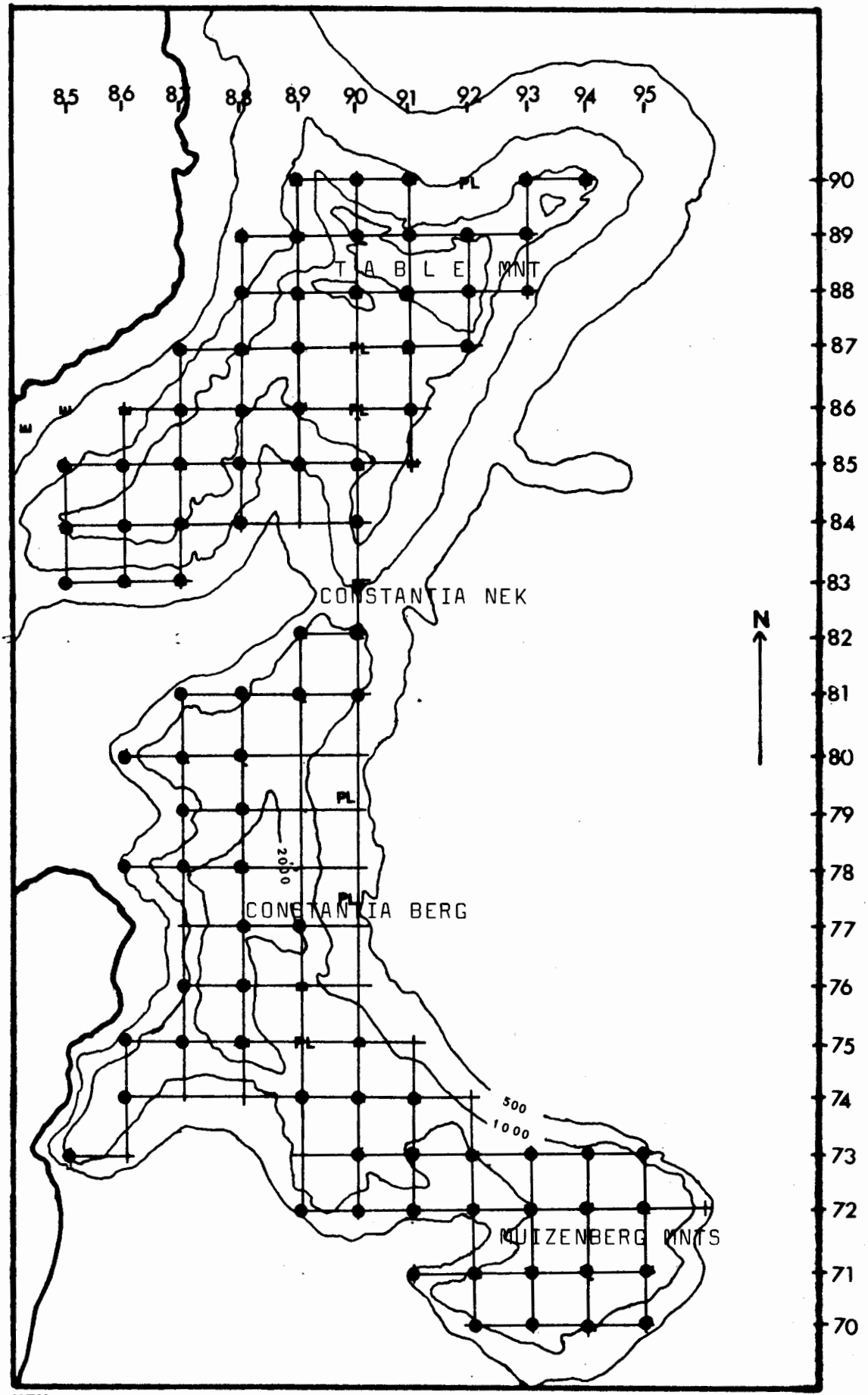
Isolated and lightly infested areas of P.pinaster should first be cleared, and these areas should have planned burning programmes, in order to minimise regeneration.

A co-ordination for management control of pest plants should be adopted in the mountains of the study area.

REFERENCE MAP



MAP 1 SAMPLE SITE DISTRIBUTION and GRID REFERENCE

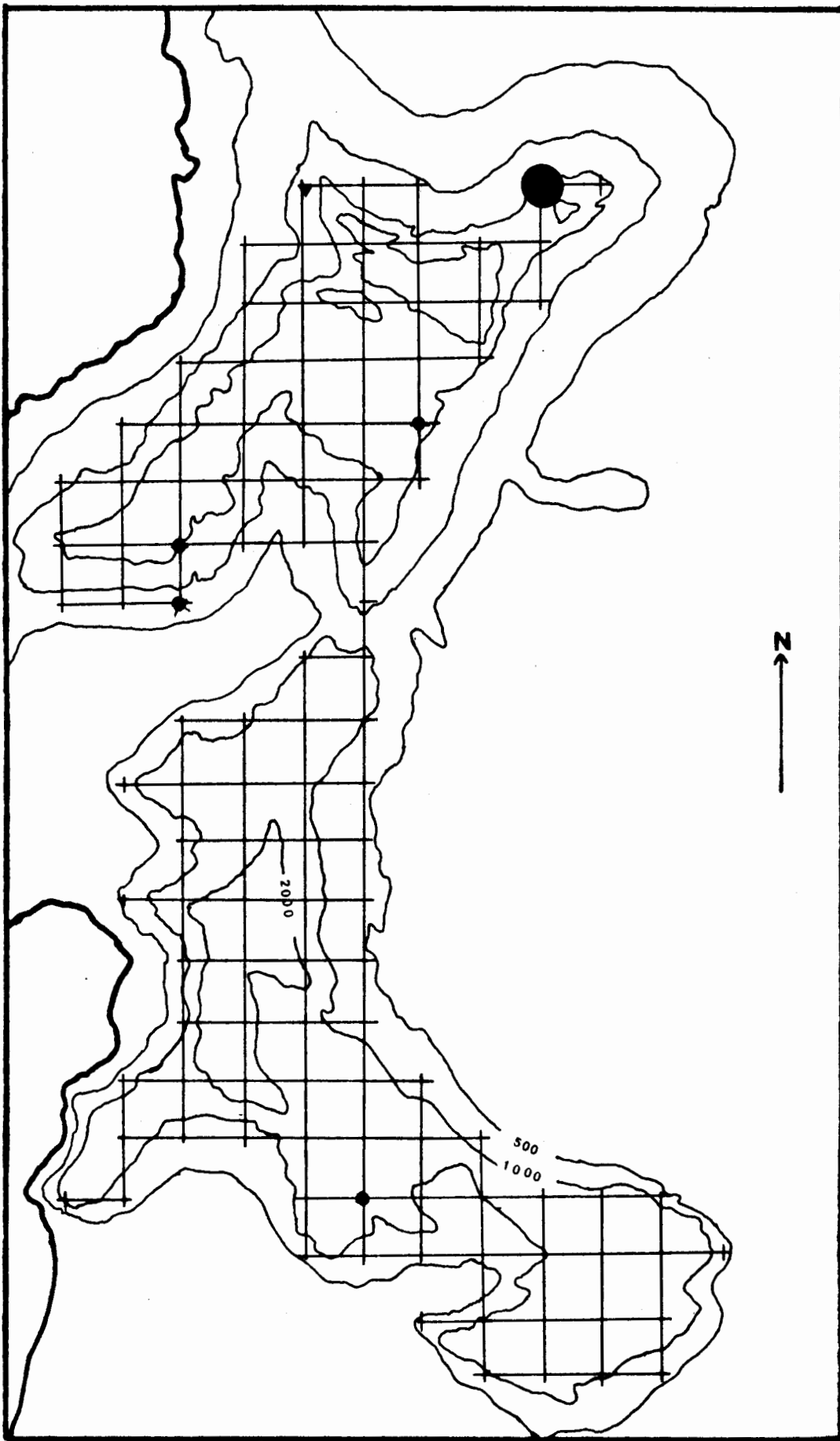


KEY

KEY

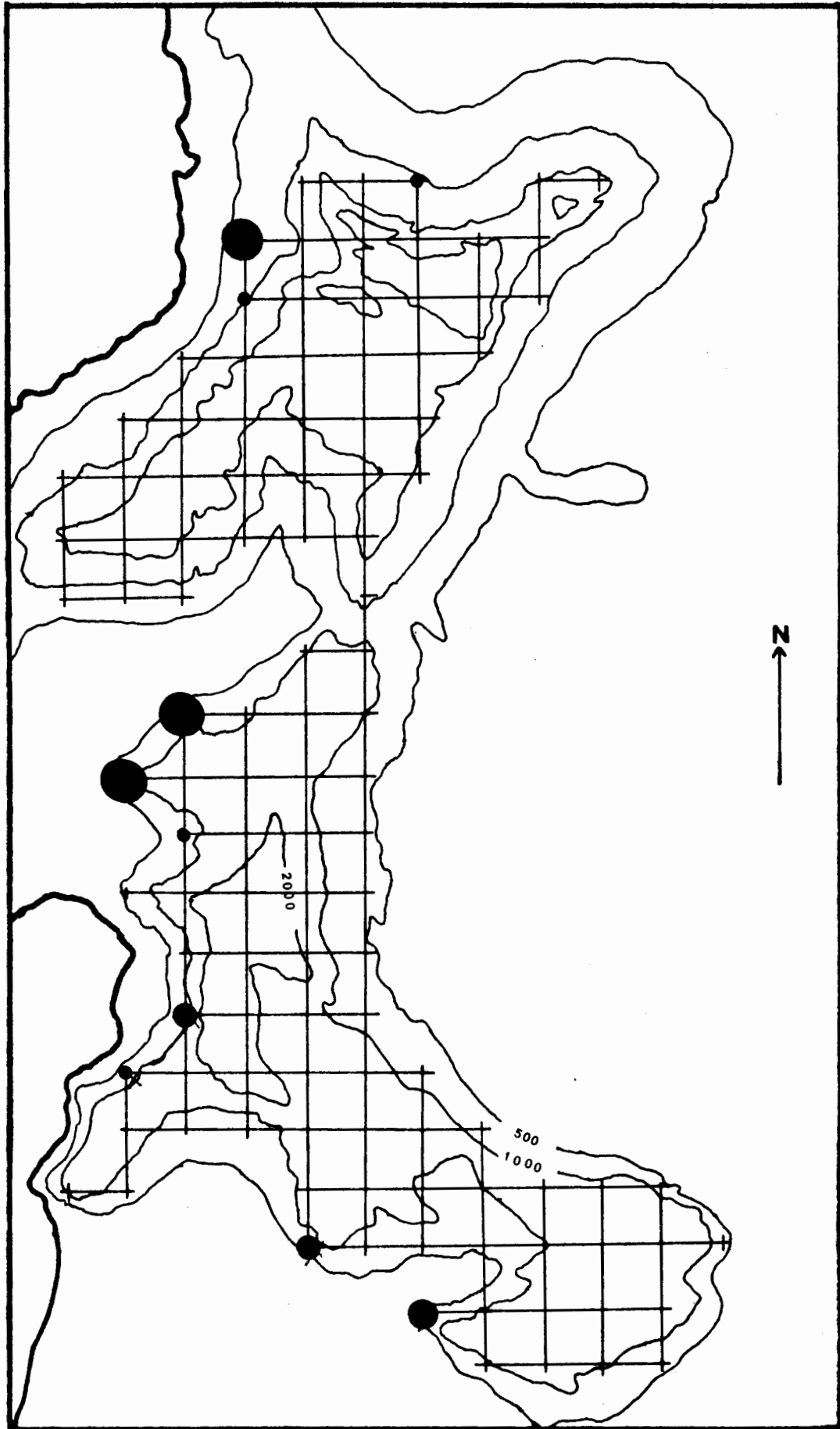
- Points done in 1959/60
- w Points done in 1976
- Points observed (1976)

MAP 11 DISTRIBUTION of ACACIA MELANOXYLON and  
ACACIA MEARNSII in 1959/60 and 1976



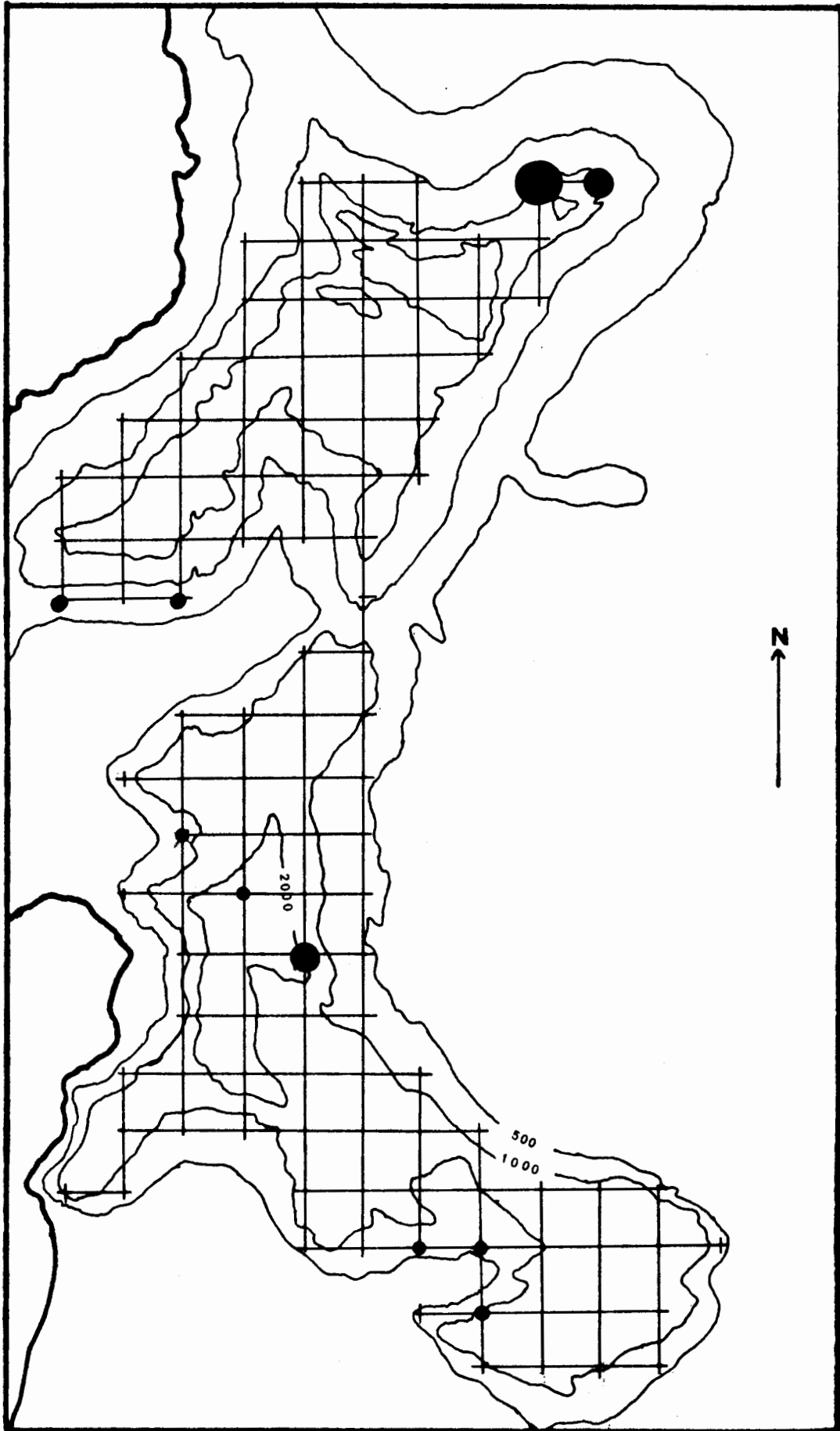
KEY *A. melanoxyton* ● 1959/60 ○ 1976 *A. mearnsii* (▼)

MAP 7 DISTRIBUTION of HAKEA SUAVEOLENS  
in 1959/60 and 1976



KEY ● 1959/60  
○ 1976

MAP 3 DISTRIBUTION of PINUS RADIATA  
in 1959/60 and 1976

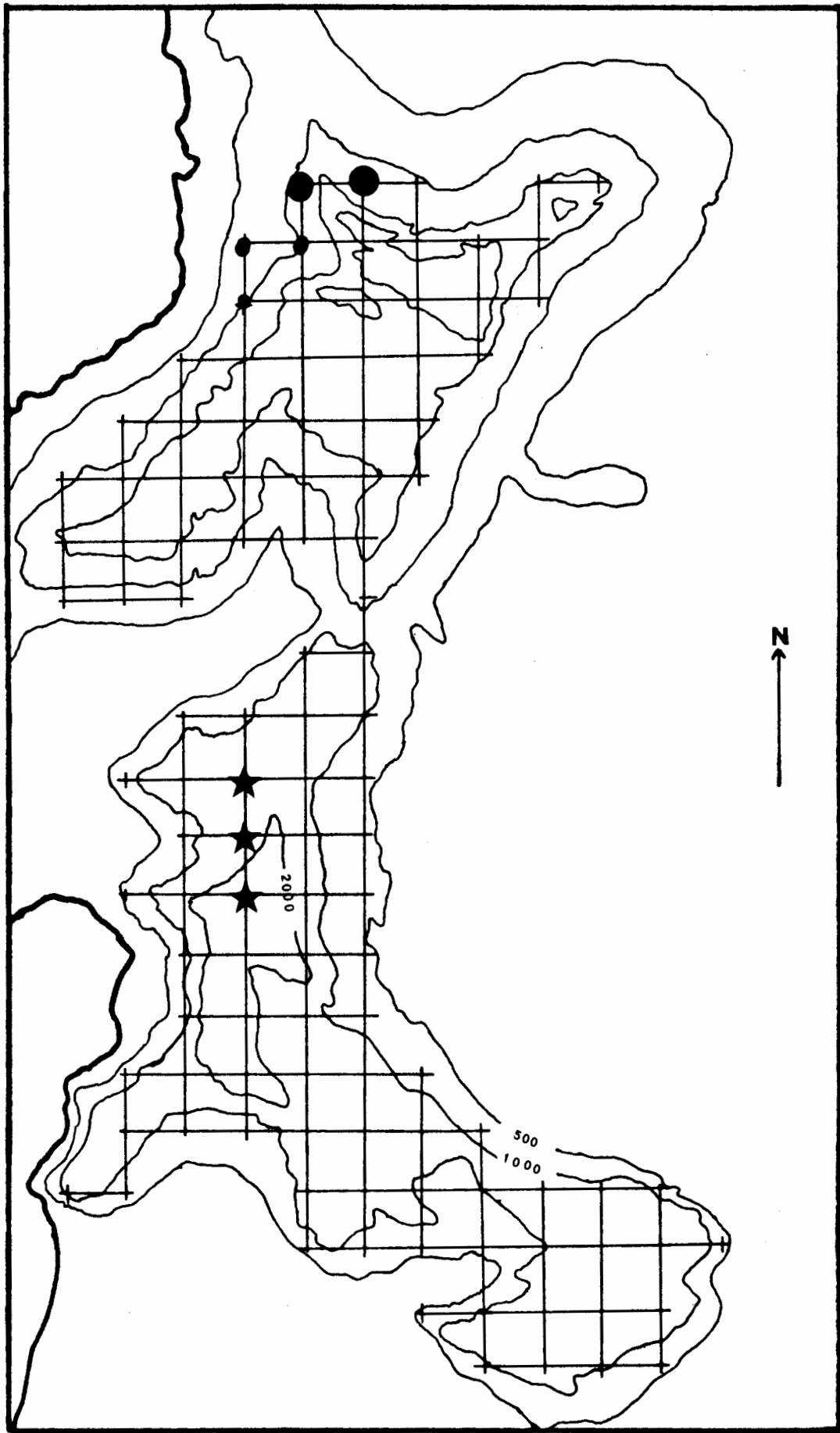


KEY

● 1959/60

○ 1976

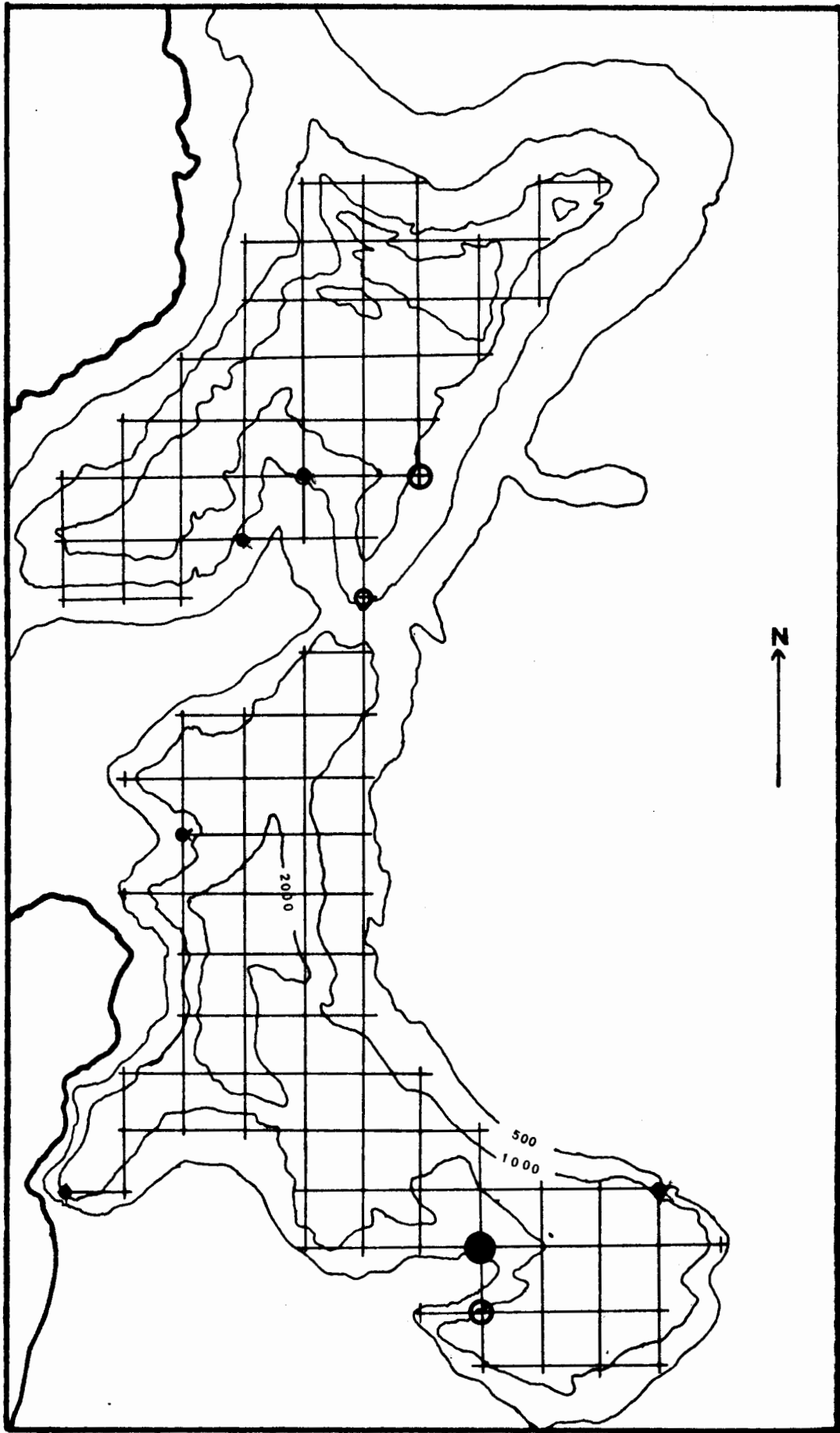
MAP 4 DISTRIBUTION of PINUS PINEA and P. CANERIENSIS  
in 1959/60 and 1976



KEY ● 1959/60  
○ 1976

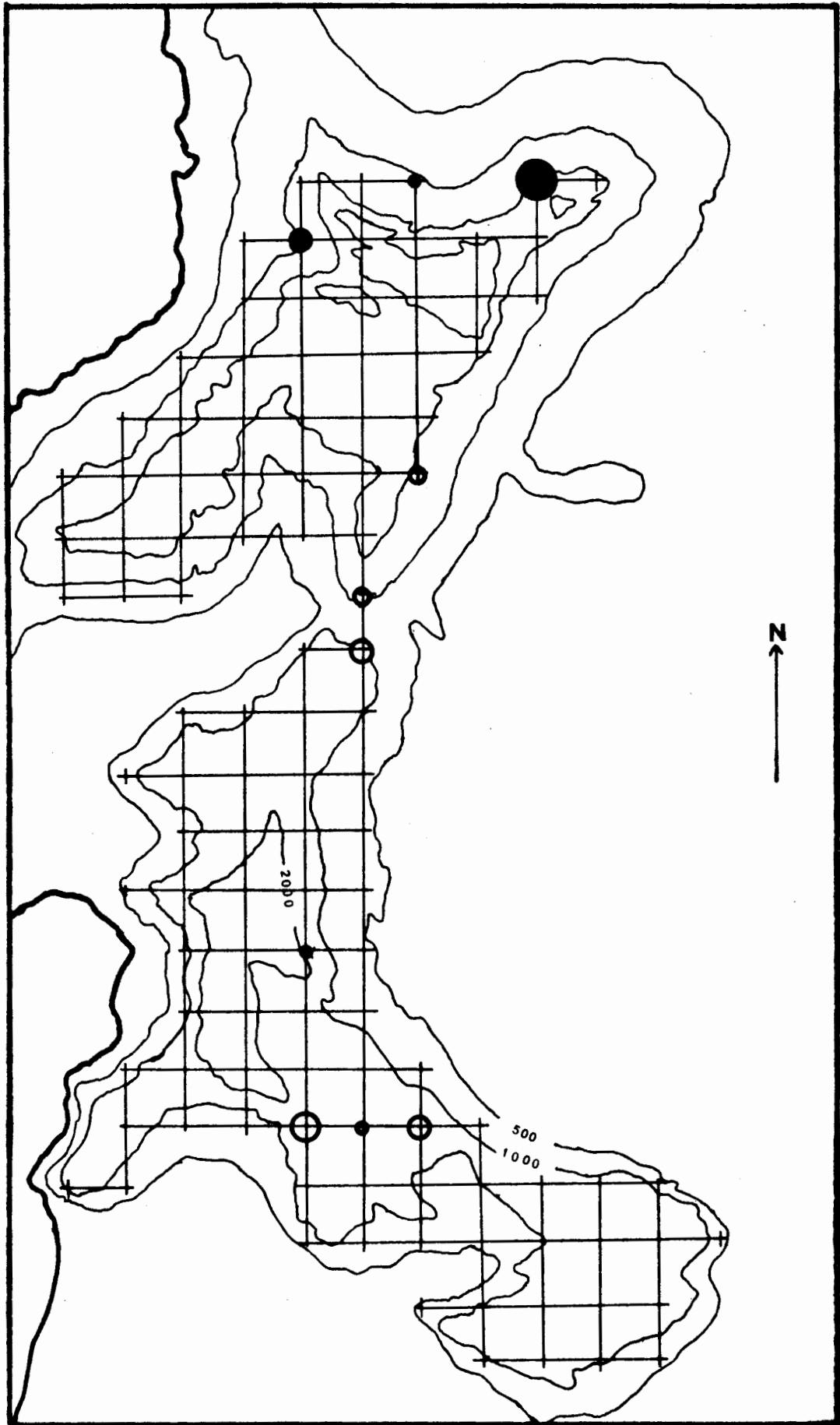
★ Isolated trees of  
Pinus canariensis

MAP 8 DISTRIBUTION of ACACIA LONGIFOLIA  
in 1959/60 and 1976



KEY ● 1959/60  
○ 1976

in 1959/60 and 1976

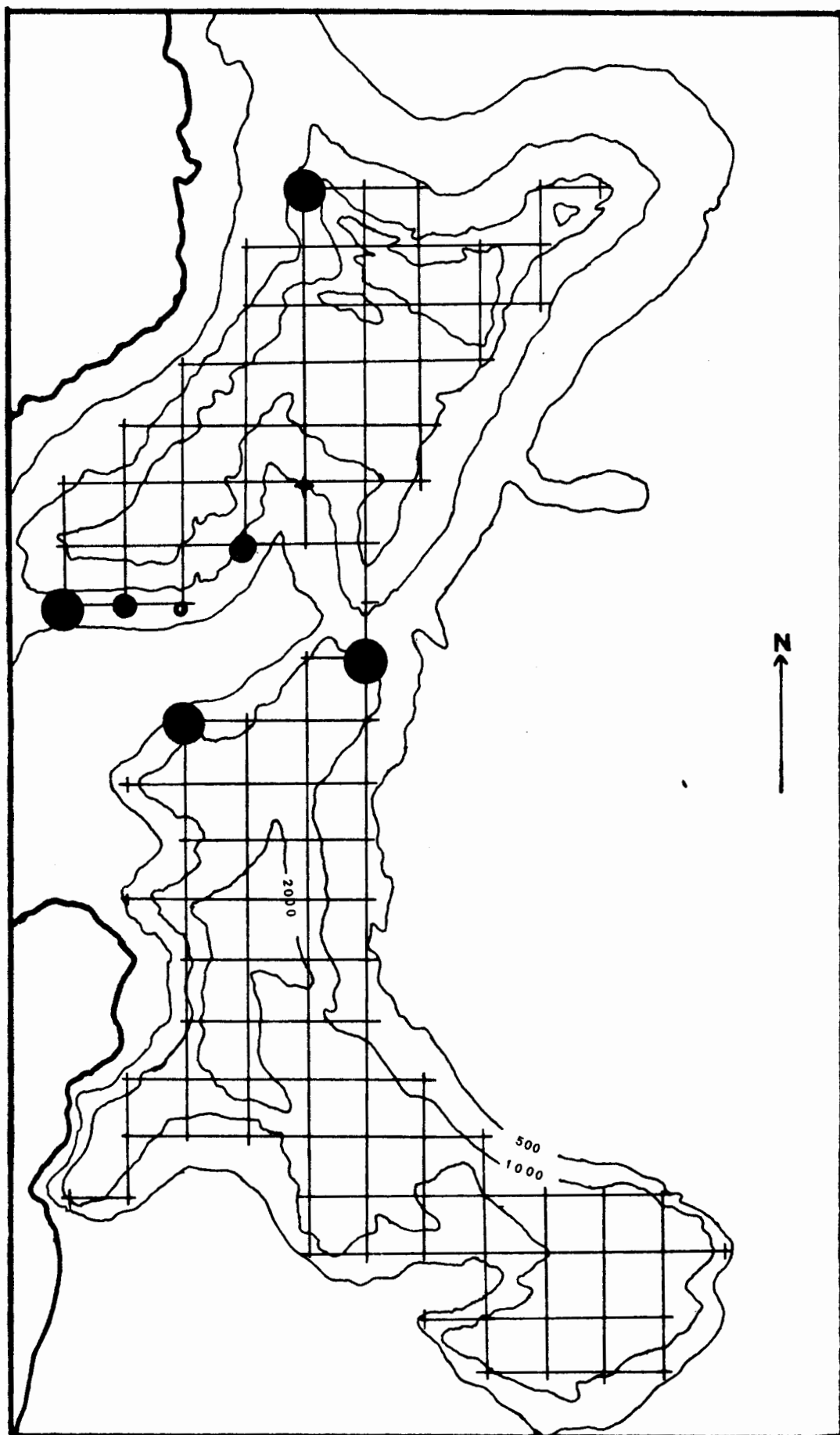


KEY

● 1959/60

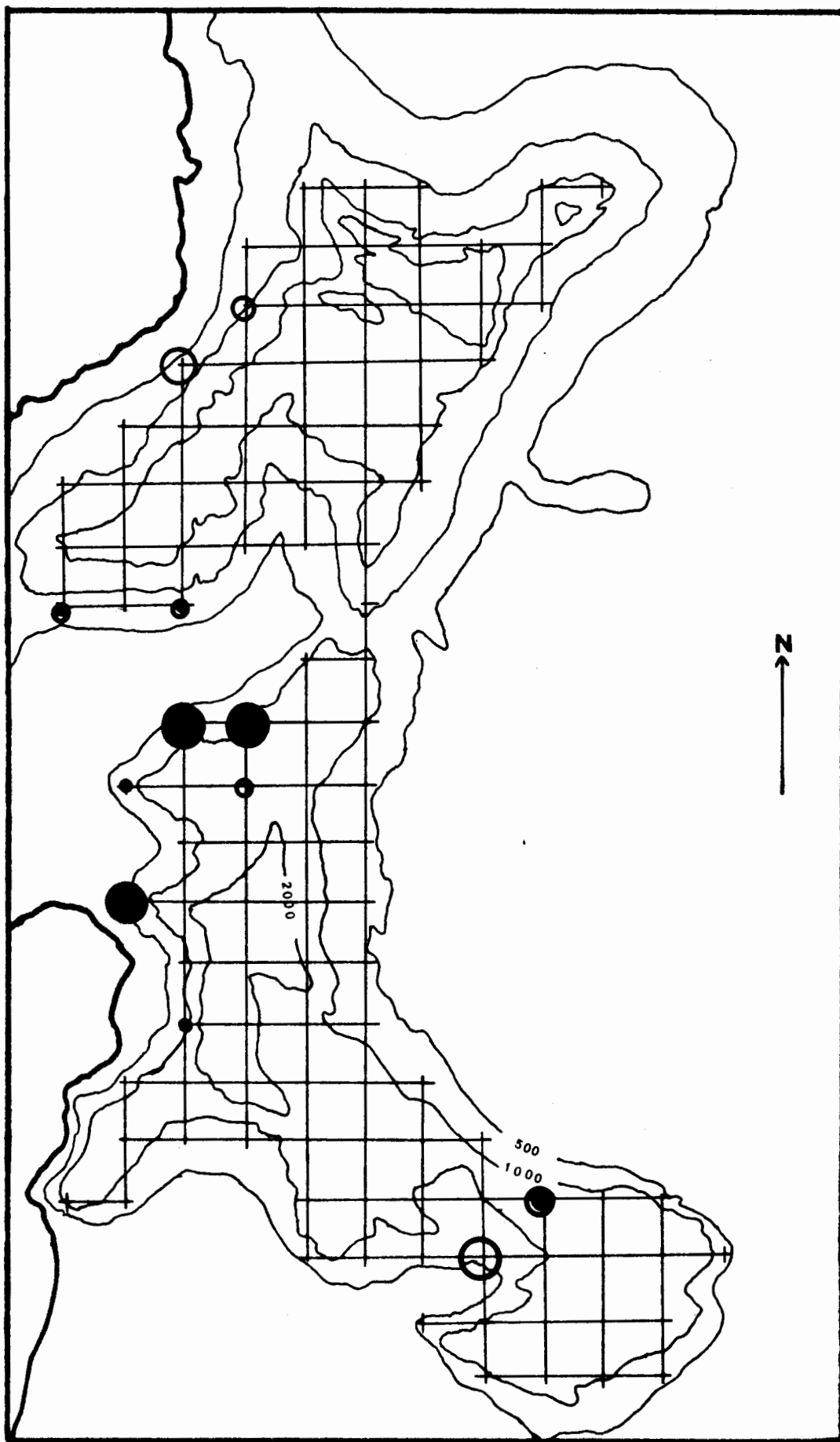
○ 1976

MAP 12 DISTRIBUTION of ALBIZZIA SPP.  
in 1959/60 and 1976



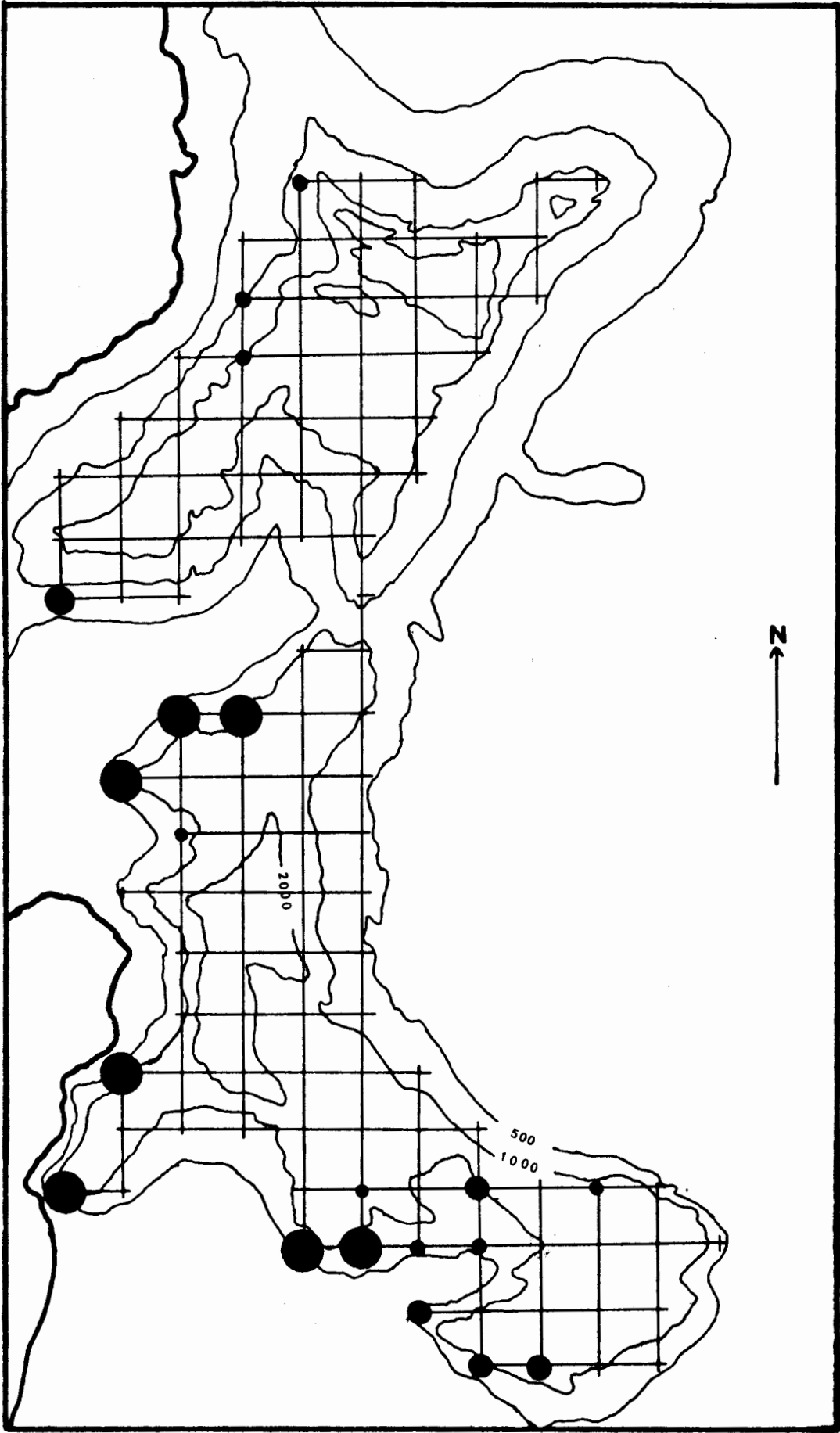
KEY      ● 1959/60  
            ○ 1976

MAP 6 DISTRIBUTION of HAKEA SERICA  
in 1959/60 and 1976



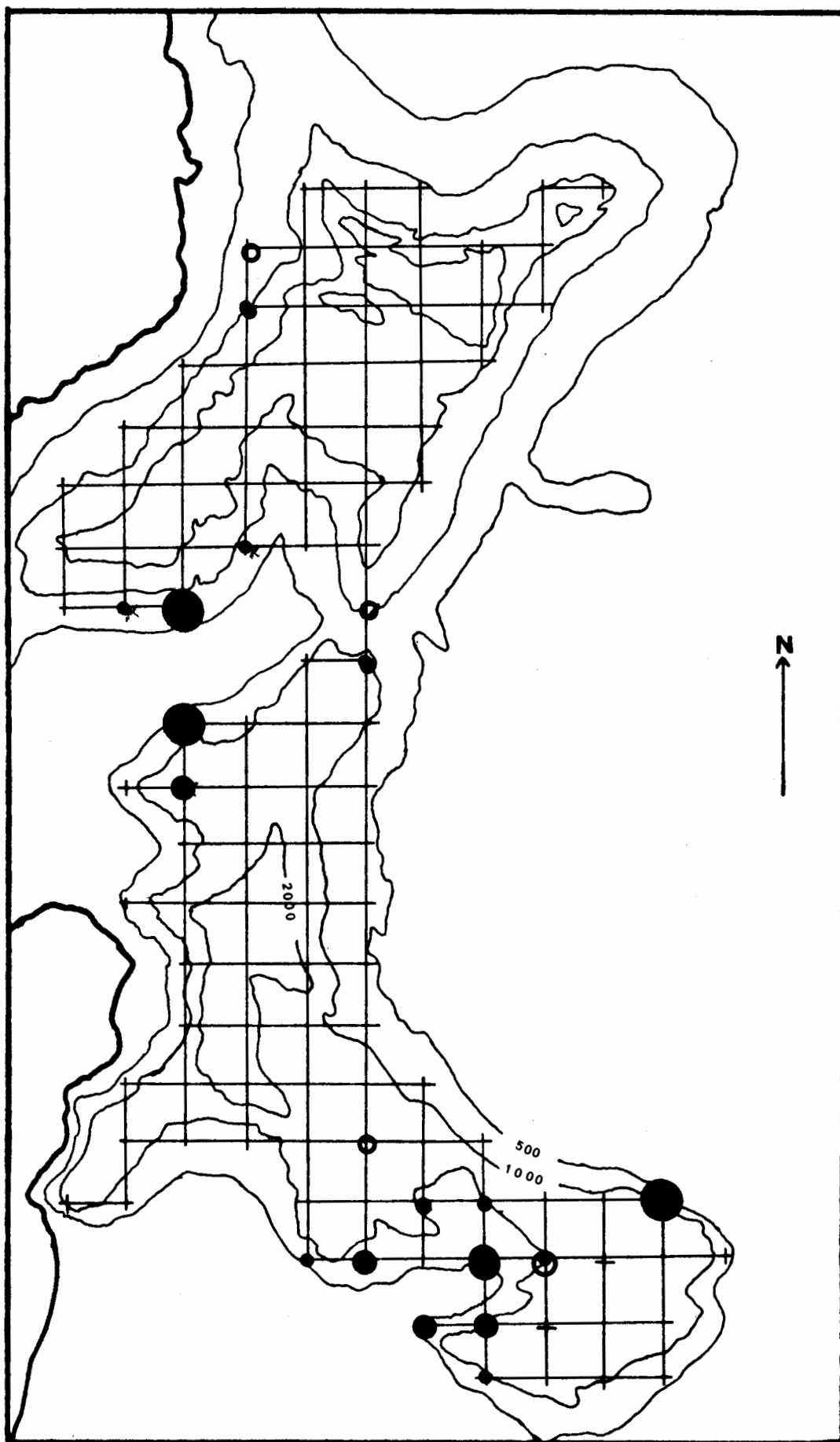
KEY      ● 1959/60  
         ○ 1976

MAP 9 DISTRIBUTION of ACACIA CYCLOPS  
in 1959/60 and 1976



KEY      ● 1959/60  
            ○ 1976

MAP 10 DISTRIBUTION of ACACIA SALIGNA  
in 1959/60 and 1976



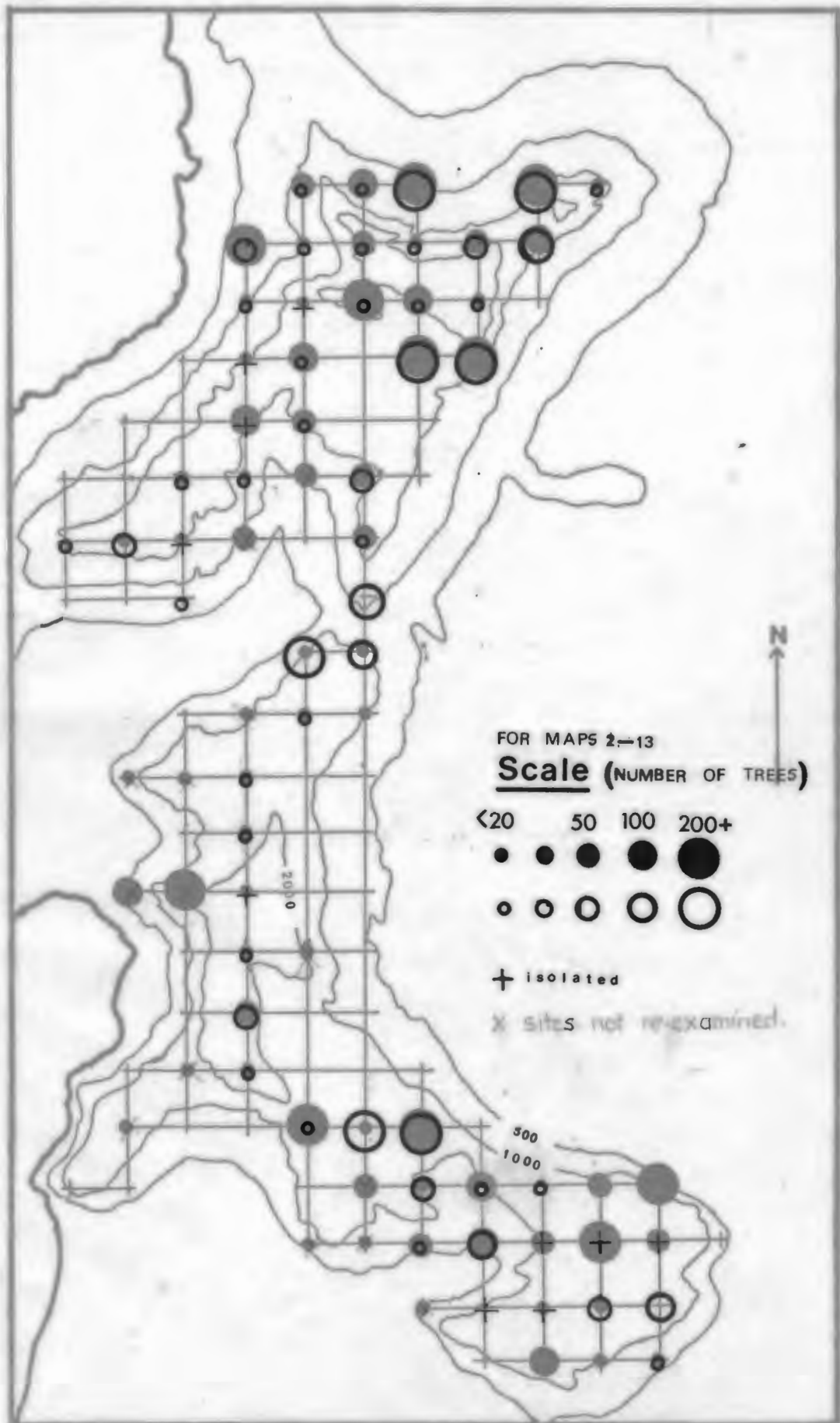
KEY ● 1959/60  
○ 1976

MAP 5 DISTRIBUTION of HAKEA GIBBOSA  
in 1959/60 and 1976



KEY      ● 1959/60  
            ○ 1976

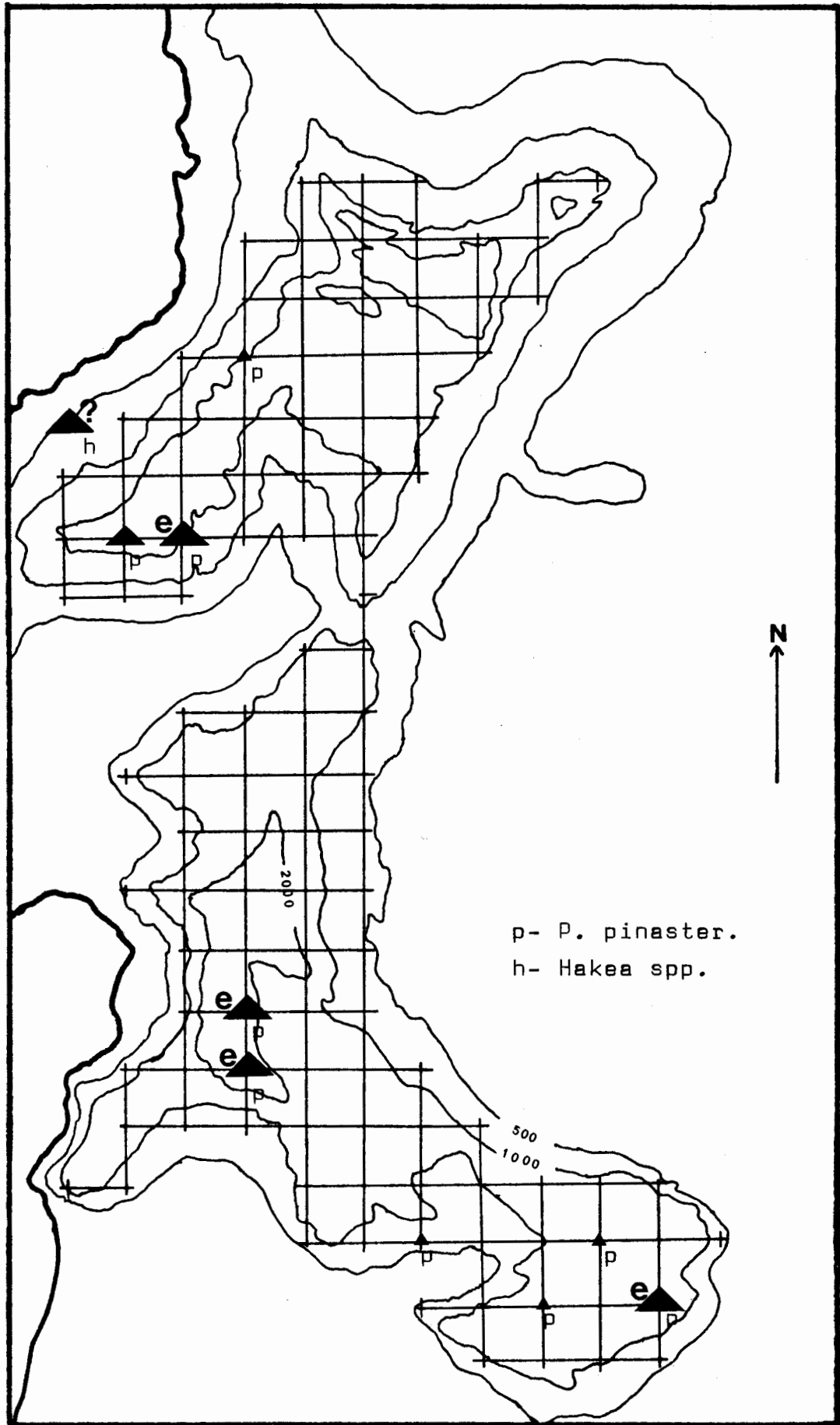
in 1959/60 and 1976



KEY

- Distribution in 1959/60
- Distribution in 1976

MAP 14 NUMBER OF TREES KILLED BY FIRE AT DIFFERENT SITES (of PINUS PINASTER) and HAKEA spp)

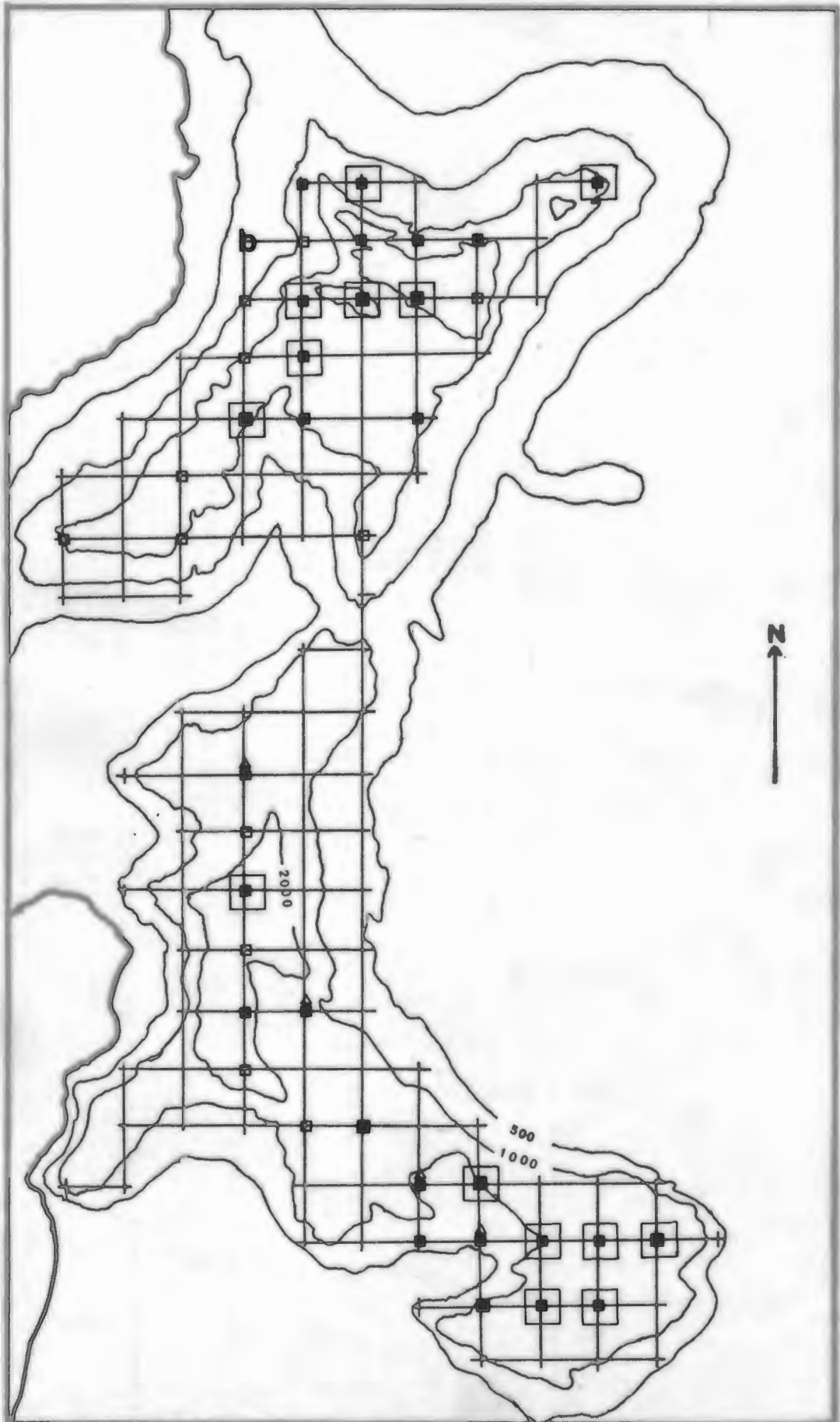


p- P. pinaster.  
 h- Hakea spp.

- ▲ Isolated trees
- ▲ 3-15 trees
- ▲ 15+ trees
- ▲ Sites at which fire effectively controlled alien numbers.

MAP 15

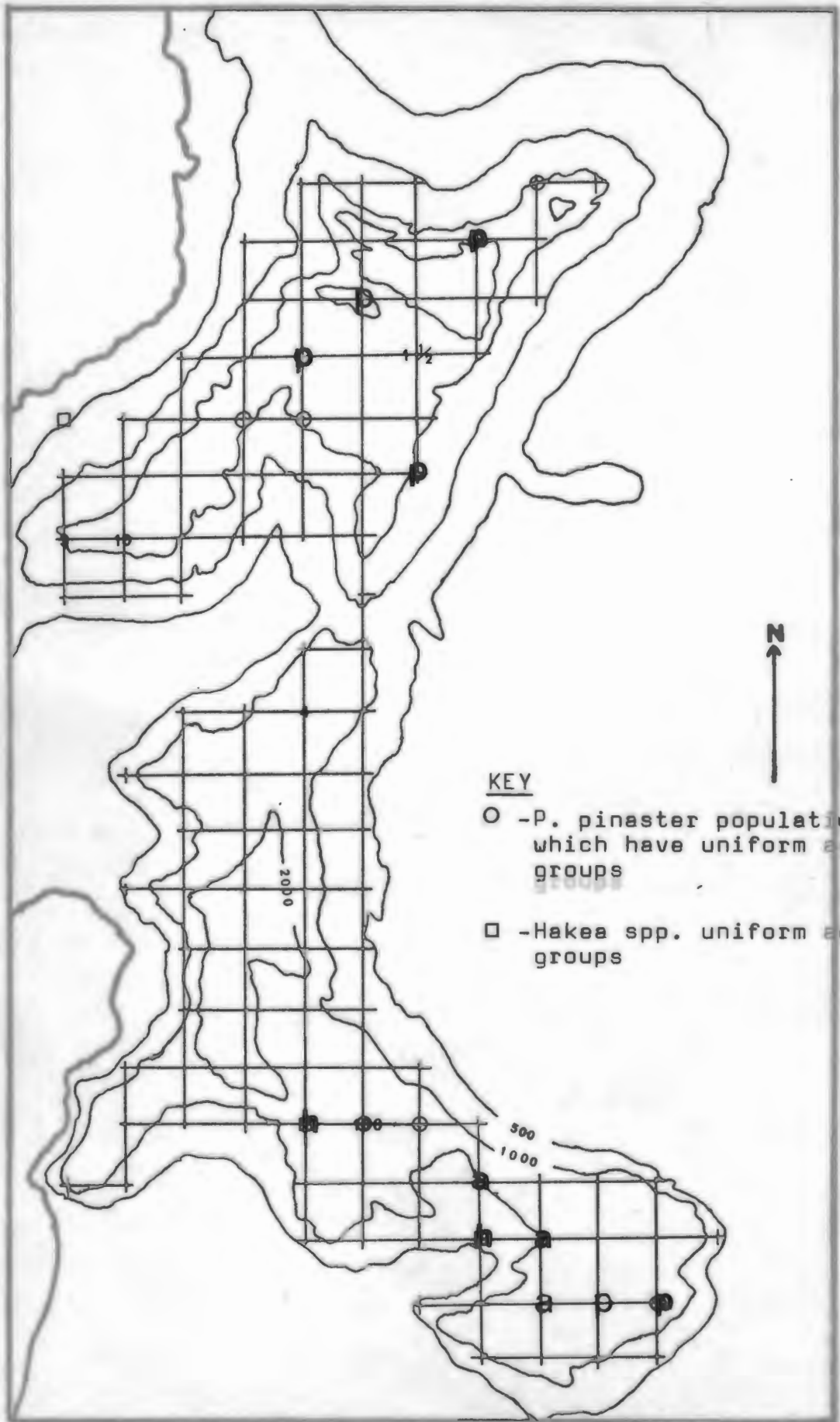
MECHANICAL REMOVAL (ie: CUTTING) of PINUS PINASTER AT VARIOUS SITES, AND THE EFFECT ON INFESTATION



KEY

- -isolated cut trees
- -heavy cutting (±25)
- -v. heavy cutting(±100)
- b -Building site
- (with dot) -sites where cutting has effectively reduced infestation and spreading.
- (with triangle) -cutting has had NO effect

MAP 16 HIGH PERCENTAGE OF SEEDLINGS AND YOUNG PLANTS IN ALIEN POPULATIONS AT VARIOUS SITES and AREAS WITH POPULATIONS OF THE SAME AGE (1976)



KEY

- -*P. pinaster* populations which have uniform age groups
- -*Hakea* spp. uniform age groups

KEY

- |                                       |                                       |
|---------------------------------------|---------------------------------------|
| <b>p</b> -high percentage of          | <b>a</b> -high % of <u>Acacia</u> spp |
| <b>p</b> <u>P. pinaster</u> seedlings | <b>a</b> -mod. % " "                  |
| <b>h</b> -high % of <u>Hakea</u> spp. | <b>100</b> -infestation index         |

The effect of fire on Pinus pinaster.

No seedlings or young plants were found in the burnt area.

The infested area has not been burnt during the 16 years, and was lightly infested (1 tree per 400m<sup>2</sup>)

The young plants appear to be susceptible to fire.



1976

Site near a plantaton at Silvermine.



1959/60



1976

PLATES 21 & 22

Woody fruits of Hakea sp. opening after fire to release the seeds.

Dense stand of Hakea seedlings at 92/72 after 3 adult plants being cut.



1976



Lightly infested areas cleared of Pinus pinaster.



1959/60



1976

Heavily infested areas cleared of Pinus pinaster.



1959/60



1976

PLATE 17

Site 90/88

Pine seedling regeneraton after cutting.



1976

PLATE 18

Site 91/88

Clearing of dense stands of Pinus pinaster.

1976

Heavily infested areas of Pinus pinaster recently cleared.



1959/60



1976

Cleared areas of Pinus pinaster.



1959/60

1976

Showing cleared areas and recent plantations of Pine at Silvermine. Pinus spp, Hakea spp and Acacia spp are found in the Silverrivier valley.



1959/60



1976

Showing areas cleared of Pinus pinaster.



1959/60



1976

The effect of *Pinus pinaster* cutting near Woodhead Reservoir.



1959/60



1976

Areas at Red Gods that have been cleared of light infestations of cluster pine

1960



1976



## ACKNOWLEDGEMENTS

The author would like to express thanks both to Dr E. J. Moll and Dr A. V. Hall, for their invaluable and assistance.

Without the foresight of Dr Hall 16 years ago, the results of this survey could not have been found.

I would also like to thank Mr B. M. McKenzie, Mr B.M. Quail, the City Council and the Forestry Department for their help.

I would also like to thank Mrs G Bisagno for typing this project.

REFERENCES

- ADAMSON, R.S. 1931 The Plant Communities of Table Mountain  
I. Preliminary Account. J. Ecbl. 15 :  
278 - 309.
- CAMPBELL, B.C. 1974 A Vegetation Survey of Some of the Forest  
Patches on Table Mountain. Unpubl. Bot.  
Hon. Project. U. C. T.
- CAMPBELL, B.C. & E. J. MOLL - 1975 The Forest Communities of Table Mountain,  
South Africa. In Moll & Campbell, 1976  
Appendix.
- COWLING, R. The Ecological Status of the Understory  
Communities of Pine Forests of Table  
Mountain. In Moll & Campbell. 1976  
Appendix.
- GLYPHIS, J. A Phytosociological Survey of the Back  
Table of Table Mountain. In Moll &  
Campbell 1976. Appendix.
- HALL, A.V. 1961 Distribution Studies of Introduced Trees  
and Shrubs in the Cape Peninsula.  
J.S. Afr. Bot. 28 (2) : 101 - 110.
- LUCKOFF, C.A. 1951 Table Mountain. A.A. Balkema. Cape Town.
- MacKENZIE, B. A Phytosociological Study of Orange Kloof,  
Table Mountain. In Moll and Campbell 1976.  
Appendix.
- MOLL, E.J. and CAMPBELL, B.C. 1976 A Conservation and Management Report of  
Table Mountain. Dept, of Bot. U. C. T.
- McLACHLAN, D.M. 1974 The Fire Ecology of Table Mountain.  
Project.
- POYNTON, R.J. 1973 In Our Green Heritage. ed. Elmmelman, Wicht  
and Ackerman.
- TAYLOR, H.C. 1969 Pest plants and Nature Conservation in the  
Winter Rainfall Region. J. Bot. Soc. S. Afr.  
55 : 32 - 38.
- TAYLOR, H.C. 1975 Weeds in the South Western Cape Vegetation.  
S. Afr. Forestry J. 93 : 32 - 36.
- TAYLOR, H.C. (In press) Ecology and Phytogeography of  
Southern Africa. ed. M.J.A. Werger, Junk.  
The Hague, Holland.

- WERGER, M.J.A. 1974 Concepts and Techniques Applied in the Zürich - Montpellier Method of Vegetation Survey. *Bothalia* 11. 3 : 309 - 323.
- WICHT, C.L. 1945 Preservation of the Vegetation of the South Western Cape. Special publ. R. Soc. S. Afr.
- ZAHN, U.A. and E. J. NEETHLING 1929 The Cluster Pine (*Pinus Pinaster*) at The Cape. S. Afr. J. Sci. 26 : 195 - 210.
- REPORT ON TABLE MOUNTAIN BY THE MOUNTAIN CLUB OF S.A. 1974
- VELD AND FLORA. 1976. Vol. 62. No. 3 2-4.