

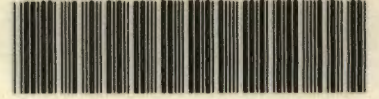
CHARACTERISTICS OF, AND DIFFERENCES
BETWEEN, FYNBOS VEGETATION AT FOUR,
TWELVE AND THIRTY FIVE YEARS
AFTER BEING BURNT.

IAN P. NEWTON
UNIVERSITY OF CAPE TOWN
1978

Being part of the work carried out to fulfil
the requirements of the degree of B.Sc (Hons.)
in Botany.

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EXAMINER'S REPORT - HONOURS PROJECT

CHARACTERISTICS OF, AND DIFFERENCES BETWEEN, FYNBOS
VEGETATION AT FOUR, TWELVE AND THIRTY-FIVE YEARS AFTER
BEING BURNT

I.P. NEWTON

This project is poorly presented and rather untidy. The student has not used enough of his own initiative in discussing the results. He has not always referenced correctly and his literature survey is incomplete.

There was however a large amount of work put into this project in terms of data collection, identification and statistical analysis. However, some tables and diagrams are unclear and could be simplified.

If the results had been better discussed, some of which are extremely interesting in view of current thought on fynbos succession it would be a valuable contribution to the ecology of the area.

B. McKenzie

BRUCE MCKENZIE.

The above assessment is accurate and I have nothing further to add except to confirm the mark of [redacted] Class III.

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NOTE : There is NO Figure 6. ?

ABSTRACT

Fynbos vegetation was sampled in 4, 12 and 35 year old stands (age since last burn) at Orange Kloof on the south-east slopes of the Table Mountain massif.

Species lists, percentage cover, leaf size, life forms and growth forms were recorded from 20 4 m.² plots thrown randomly in each stand. Comparisons were then made between the three age groups by means of tables, Venn diagrams and statistical tests.

Results indicated that life forms showed no significant differences between the three stands. The 4 and 35 year stands were similar with respect to leaf size distribution, while 12 and 35 year stands were similar with respect to average height. 12 and 35 year stands were also similar with respect to growth forms.

Maximum cover was recorded in the 12 year stand. The highest number of species was recorded from the 4 year stand, while decreased numbers were recorded from the 35 and 12 year stands respectively.

The results were correlated with previous dominance and succession theories.

INTRODUCTION

I. Fynbos, consisting mainly of Acock's veld types 69 and 70 (^{clocks} 1975) is believed to be an ancient flora, due to the lack of any one species or life form dominating the vegetation (Levyns 1952; Adamson, 1931). It is rich in species (about 6000) and is the World's smallest floral kingdom (Good, 1974). It is believed to have the highest rate of generic endemism in the world (Good, 1974).

Taylor (1973) expressed the hypothesis that Fynbos has a cyclic succession with fire being an important factor in the cycle, i.e. it is a fire adapted vegetation.

I.I History

There is evidence that man used fire in his cave dwellings 40 000 B.P., and that he utilized plants which have a pronounced response to fire e.g. certain Iridaceae, but it is not known if he purposely burnt the veld for these plants, or to encourage game (Deacon and Brooker; Deacon. in Bands 1977). Natural fires from lightning or rock falls, such as the one caused during the Ceres earthquake of 1969 (Taylor 1978), must have occurred many times in the past, and these fires would spread over great distances due to the lack of fire breaks, such as occurred during the great fire of 1869, which burnt from Swellendam to Humansdorp (Burnam, 1963).

Schweitzer and Scott (in Moll, McKenzie, and McLachlan ¹⁹⁷⁸ no date) suggested the Hottentots burnt Fynbos on a regular basis, to encourage game to the new shoots.

From the earliest days of the white inhabitants, firing the veld was declared undesirable, not from the point of view of the veld, but because of the danger to property. In 1687 a law was passed which stated that a person firing the veld would receive a severe scourging for the first offence and death by hanging for the second. This was re-enacted by the Dutch East India Company in 1740 and was still in force when the British took over in 1806. In 1859, the act was modified to a maximum of £ 100 or 6 months (Botha. in Bands 1977).

Until ^{date?} recently it was thought that the effect of fire on Fynbos was detrimental, and various acts were made by the Forestry department to forbid burning (Bands, 1977). However they found that the older the vegetation became, the more difficult it became to protect

against fire, due to litter accumulation (Taylor 1973).

Investigations were carried out, which indicated that in most Fynbos communities litter begins to accumulate in quantities large enough to be a fire hazard from about four years after being burnt. (Rf.) After 20 to 30 years, the shrubs appeared to die off, leaving only a few leaves alive at the tips of otherwise "dead" branches. Where forest and other trees are in the vicinity, these begin to take over from the Fynbos vegetation. The opening canopy due to the "senescing" of the shrubs lead to the resprouting of Geophytes, which are usually most abundant in the year following a fire (Taylor 1973).

I.2 Present management

Nowadays, Fynbos under the jurisdiction of the Forestry department, is divided into ^{blocks} areas of 5 - 15 km² which are burnt rotationally on 8 - 15 year cycles (Kruger 1977). This is also advantageous to certain animal species, which need Fynbos at a particular age for some part of their life cycle. An example of this is the Cape Sugarbird (Promerops cafer) which nests in winter because the nectar of certain Protea flowers are most nutritious at this time of year, and energy to feed the young appears to be more important than the cold weather. (The Protea bushes usually only flower during a fixed period after a fire e.g. 10 to 20 years, so these birds need vegetation ⁱⁿ of this age group to survive (Louw pers. comm.). It is needless to point out the problems of burning vegetation before it has had a chance to produce seed.

I.3 Fire adaptations

Vegetation which has been burnt every 10 - 40 years for the past several tens (hundreds ?) of thousands of years must have evolved strategies to overcome this problem. Kruger (1977a) lists 4 ^{strategies} ~~methods~~ by which the present day Fynbos deals with this problem:

1. Dormant buds.

These may be below ground in bulbs, corms or rhizomes, or above ground such as those in the stems of Protea arborea.

2. Fire resistance

Some species have thick bark and a crown shape that deflects the heat, allowing the plant to survive largely intact e.g. Protea nerifolia.

3. High seed production

This is the major means of survival among the Restioid and ericoid species. Numerous, usually short lived seeds are shed annually, some of

which survive the fire, or may arrive from an unburnt area and germinate.

4 Seed protection

In this group long lived seeds are produced which may remain viable for up to 15 years. The seed may have a hard pericarp and testa, or it may be retained on the parent plant, until the parent plant is burnt. An example is the genus Leucadendron, where 49 out of the 90 species retain their seed in a cone like fruit for up to 8 years. (Reference) Williams?

Similar strategies have been reported from other mediterranean type vegetations (Naveh 1977).

If this vegetation is well adapted to regular fires, one would expect many members of the mature community to be present ~~from very~~ shortly after a fire. This was one of the characters looked at in this survey. The fire resistant adaptations of the species were not investigated. The results of this section of the survey are included in the section on succession (^{part} 4).

1.4 Succession

1.4.A General

The classical concepts of succession (Cowles; Clements; Weaver and Clements; Odum. in Noble and Slatyer 1977) assume that, following a disturbance such as a fire, the community gradually assumes the ~~s~~ structure and composition of the surrounding undisturbed area, by an orderly and predictable series of replacements, from the pioneer species through to the climax species. Egler (1953 - 54) ^{stated that} ~~said~~ the initial species composition can determine the subsequent pattern of development. He proposed a system of relay floristics, which will be discussed in more detail in section 4 . Drury and Nisbet (in Noble and Slatyer 1977) said that early species "attempt" to delay the secondary succession rather than preparing the way for it. Connell and Slatyer (in Noble and Slatyer 1977) combined the latter two proposals, and said the invasion, of longer lived species depends on their chance establishment in gaps in the early species.

1.4.B Succession in Mediterranean vegetation

Hanes (in Noble and Slatyer 1977), found that the sequence of succession in burnt Chaparral was unusual. Shrubs of the mature community were present in the vegetation of the first year after a burn, and invasion by new species was very limited once the first year population was established. Other surveys (Noble and Slatyer 1977)

showed a similar phenomenon in Australia.

In Israel, Naveh (1977) found that fire caused a temporary domination of herbs, which rapidly reverted to a domination of the major woody species.

Kruger (1977a) noted that Fynbos went through a number of phases following a fire:

- 1. 0 - 4 years. The post fire stage. In this stage ^{graminoids} reach maximum biomass.
- 2. 4 - 5 years. The canopy cover reaches 80% of preburn level. The vegetation becomes flammable as dead leaves and shoots of hemicryptophytes accumulate.
- 3. 5 - 15 years. Transitional phase. All plants attain maturity in this phase.
- 4. 15 - 30 years. Mature phase. Tall shrubs reach maximum height and maximum flowering activity. The reseedling low shrubs e.g. Erica sp. begin to die. Litter accumulates and the lower strata is reduced in importance. There is no germination.
- 5. 30 + years. Senescent phase. Mortality among seed regenerating shrubs accelerates. Foliage on the survivors becomes reduced to tufts on the branch tips. The crowns open. There is some seed regeneration and forest precursors arrive. (not on all sites).

From the foregoing, it would appear that the Mediterranean type vegetation is closely linked with fire where ever it occurs. One would expect this, since dry summers are ideal times for fires, and unlike desert vegetation, the ample rains in winter allow quite dense vegetation stands to form.

Data collected was compared with the various succesion theories to determine the one it most closely resembled.

1.5 Dominance

As noted, there appears to be a lack of any one species dominating Fynbos (Levyns 1952 ; Adamson 193II). Adamson (1935) notes that at 4 years, Euryops abrotanifolius appears to dominate the vegetation, but ~~by~~ by sampling the vegetation, it was found that its ground cover was not as high as expected.

In 193II Adamson stated that life form dominance is usually shared by two or more groups which would change with age. Even if two life forms remained dominant, the dominant species would change with time. He did not say which were the dominant life forms present in Fynbos.

If one combines this view with Krugers' phases (1977a), one may be able to say that this is true at some stages. The first couple of years after a fire, one would expect geophytes and hemicryptophytes to be dominant, while in the senescent phase the dominance would be shared by phanerophytes, geophytes and hemicrypto - phytes. In the mature phase however, one would expect an almost exclusive phanerophyte community.

Data collected was used to test the lack of dominance hypotheses.

I.6 Senescence

Senescence, being a controversial ^{topic} essence in Fynbos, it is necessary to include a note on it.

Kruger (1977a) puts a senescent phase as the last stage of Fynbos before it is replaced by forest. Both Kruger and Taylor (1973) state that the shrubby vegetation dies back, leading to an open canopy and a lot of dead material. They both indicate there is some germination of seeds and re - sprouting of geophytes. Taylor (1973) says the forest species only take over when they are present in the vicinity, for which a minimum rainfall or a river would be necessary, as trees usually need a rainfall of greater than 1 000 mm in order to grow.

In some cases, such as the 35 year old stand at Orange Kloof, the Fynbos is vigorous, although it is being invaded by forest species. With further protection it should develop into a closed scrub forest community without any general senescence of the vegetation (McKenzie, Moll and Campbell 1977).

Attempts at recording the degree of senescence by means of the field form (appendix I) proved to be very subjective, due to the shrubs having a few healthy leaves at the tips of otherwise "dead" branches. There is a note on the findings of both the above and this project, with respect to senescence in section 4.1.

I.7 The "tree" element

By this it is usually meant the forest pioneers e.g. Virgilia oroboides (Campbell pers. comm.).

No Virgilia oroboides is not a normal fynbos element.

It has been suggested that forest is in fact the climax stage of Fynbos for the following reasons: (Moll, McKenzie and McLachlan ¹⁹⁷⁸ no data)

No this is not a normal fynbos element in this region

I. The vegetation is so diverse, it seems unusual that there is no tree element.

- 2. Non indigenous trees e.g. Acacia sp. and Pinus sp. invade the area and grow very easily.
- 3. There is evidence for the presence of Podocarpus forests on the Cape flats. (Schalke 1973).

Doubt has however been expressed about how widespread these forests were in the S.W. Cape. Van Zinderen Bakker (1974) pointed out that the actual level of Podocarpus pollen was very low, and that the trunks of Podocarpus found on the flats, could have been transported by ocean currents.

It is possible that the frequent fires keep the tree element restricted, as forest precursors are found in most Fynbos stands of 30 years or more, except in very dry areas (Moll, McKenzie and McLachlan no date). If the Podocarpus and other forests did grow on the flats, it is likely that this occurred during the pluvials experienced in Africa in the recent Pleistocene. Hypothermals occurred from 50 000 to 43 000 B.P., 30 000 to 12 000 B.P. and 5500 to 4700 B.P.. The first two were major cool periods, with drops of 4°C. and 9°C. respectively below the present day average. The second of these is known as the Mount Kenya hypothermal, and is thought to have coincided with a major pluvial (Coetzee and Van Zinderen Bakker 1970; Morton 1972; Hedberg 1969). The increased rainfall would have led to improved conditions for the establishment of forest, while that factor along with the colder weather would probably decrease the frequency of fires.

This is the wrong term - misread the paper on it

If Fynbos has a forest climax, it would be expected to become more mesophytic in form, with a resulting increase in average leaf size (McKenzie pers. comm.). One would also expect an increase in the average height of the vegetation. The growth form (Whittaker 1975) would also be expected to change from sclerophyll shrubs to broad-leaf evergreen trees.

Growth form and height data was collected and compared with the above hypotheses.

1.8 Summary of parameters investigated

- 1. Percentage cover of the vegetation.
- 2. Average height of the vegetation.
- 3. The leaf size distribution.
- 4. Life forms and Growth forms.
- 5. Species composition.

Data collected in 4, 12, and 35 year stands. Stands compared with each other, and with other workers theories mentioned in introduction.

THE AREA :: PHYSICAL

1. LOCATION

The 4 year stand was situated ~~to~~ the south - east of Constantia - Nek. The 12 year stand was situated to the north - west of Constantia - Nek. The 35 year stand was situated at the ~~west~~^{north} end of Orange Kloof. (Figure I.)

The area is situated at the southern end of the Table Mountain massif, approximately 18° 25' W. and 34° 05' S.. It is in the Table Mountain nature reserve, and is now under the control of the forestry division of the Cape Town municipality.

2. GEOLOGY

The geology above 350 meters is granite overlain by Table Mountain shale, which in turn is overlain by Table Mountain sandstone (McKenzie 1976).

3. CLIMATE

Climatic figures from the actual sites surveyed were not available but Table I. gives temperature and rainfall figures from the Kirstenbosch station which is close by. The winds are predominantly cyclonic north - west in winter and anticyclonic south - east in summer. Bergwinds often precede advancing frontal systems (Kruger 1977a). Low clouds often increase effective precipitation in summer. (Ref.).

Table II. Average monthly temperature and rainfall figures from Kirstenbosch station.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temp. °C.	19,7	20,1	19,1	17,2	14,9	13,4	12,6	12,6	13,7	15,2	17,1	18,7
Rf. mm.	39,4	35,3	40,6	114,8	169,4	190,4	190,4	173,5	112,6	78,7	42,7	39,3

Daily temperature range : 7,7° - 9,8°C.

Annual rainfall : 1227 mm.

Occasional mild frosts.

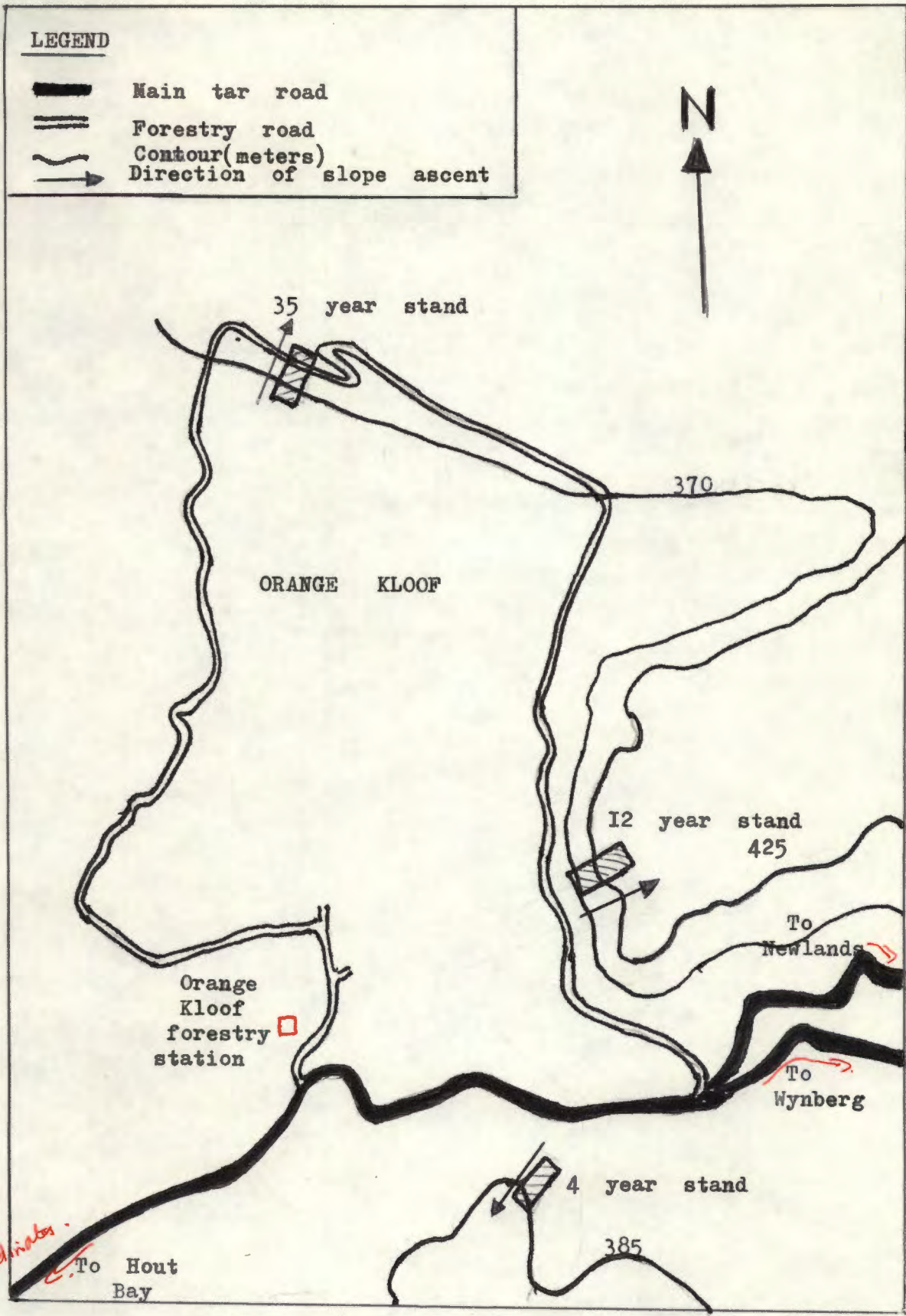


Figure I. The location of the three stands.

METHOD

For data capture, the field form (appendix 2) was used. ^{Twenty.} ~~of~~ 4 m.² random ^{quadrats} plots were thrown in each of 4, 12 and 35 year Fynbos stands. The 35 year stand was divided into two areas, a wet and a dry, with 10 random plots in each.

The information gathered consisted of species lists, percentage projected canopy cover, leaf size, average height, life form and growth form for each species. Rock cover, litter depth and soil depth were recorded for each plot, the last of which was measured by pushing a rod once randomly into each plot.

Leaf size classes were based on those of Raunkiaer (1934) ^{not referenced.} and were coded a - e and stem monocotyledons. The letters represent:
a:- leptophyll, leaf area up to 25 mm.²
b:- nanophyll, leaf area from 25 mm.² to (9 X 25)mm.²
c:- microphyll, leaf area from (9 X 25) to (9² X 25) mm.²
d:- mesophyll, leaf area from (9² X 25) to (9³ X 25) mm.²
e:- macrophyll, leaf area greater than (9³ X 25) mm.²

Life forms were based on those of Raunkiaer (1934), and those used were:

Phanerophyte: tree or shrub, perrenating bud 25 cm. or more above ground level.

Chaemophyte: shrub or subshrub; herb other than below, perrenating bud less than 25 cm. above ground level.

Hemicryptophyte: perrenating bud at ground level.]

Geophyte: perrenating bud below ground level.] Both lumped as Geophyte

Therophyte; annual

The reasons for lumping geophytes and hemicryptophytes in this survey were:

1. Together they form the herbaceous understory, and theoretically are the major growth forms the first couple of years after a fire.
2. Many of the hemicryptophytes spread horizontally from just below the ground surface, that one wonders if there is such a large difference between the two.
3. To perform the statistical tests, certain groups had to be lumped, and these two classes were one obvious choice.

Growth forms were based on those of Whittaker (1975), and those used were:

1. Sclerophyll shrub.
2. Broad leaved evergreen tree / shrub.
3. Deciduous "daisy" leaved shrubs. (Euryops, Senecio, and Osmotopsis).
4. Tufted or graminoid herbs.
5. Forbs.
6. Fern.
7. Needle leaved evergreen. (The only case was the alien Pinus sp.)

RESULTS AND DISCUSSION

2 General

The distances separating the three stands was not great (about 3 km. maximum), and the altitudes were similar, so one can assume similar macroclimates in all 3 stands. Due to drainage and soil patterns, each stand would have a different water content, which would lead to variations in the climax communities and the rate at which these would be reached. Figure 2 gives some idea of the variations in community structure which may be found in this area. **Table 2 gives the physical factors and litter depth found in each plot.**

The three tables: 3, 4, and 5, summarize the data collected in the 4, 12, and 35 year stands respectively. Figures 3, 4 and 5 give a general view of each of the stands.

The first two columns of tables 3, 4 and 5 need some explanation.

A, the first column. This is the average projected canopy cover (PCC) of each species as calculated from the number of plots in which it occurred i.e. if species x occurred in two plots in a stand at 5 % and 15 % PCC in each plot respectively, then $A = 5 + 15 \div 2 = 10 \%$.

B, the second column. This is the total average PCC of each species as calculated from the total number of plots in each stand, i.e. 20. For the case cited in A above, the total average cover would be $5 + 15 \div 20 = 1 \%$. This should give a better estimate of the PCC of that species over the whole stand.

2.1 The 35 year stand

As mentioned the 35 year stand was divided into two, a wet area (plots I - 10) and a dry area (plots II - 20). The difference between the two areas with respect to the two major life forms and the tree element is given in table 6.

It is evident that the wet area has more species, and also that all of the forest precursors ^{species} are found in this area. ~~Table 5 indicates that~~ the tall Brunias are also found in the wet area (fig. 7). Except for Protea cynaroides, all the Proteaceae are confined to the dry area. Two stem monocotyledons, Tetraria cuspidata and Thamnochortus dichotomous were confined to the dry area. Bobartia sp. was found only once in the dry area, while Watsonia was equally distributed between the two areas. Phanerophytes are dominant in the wet area,

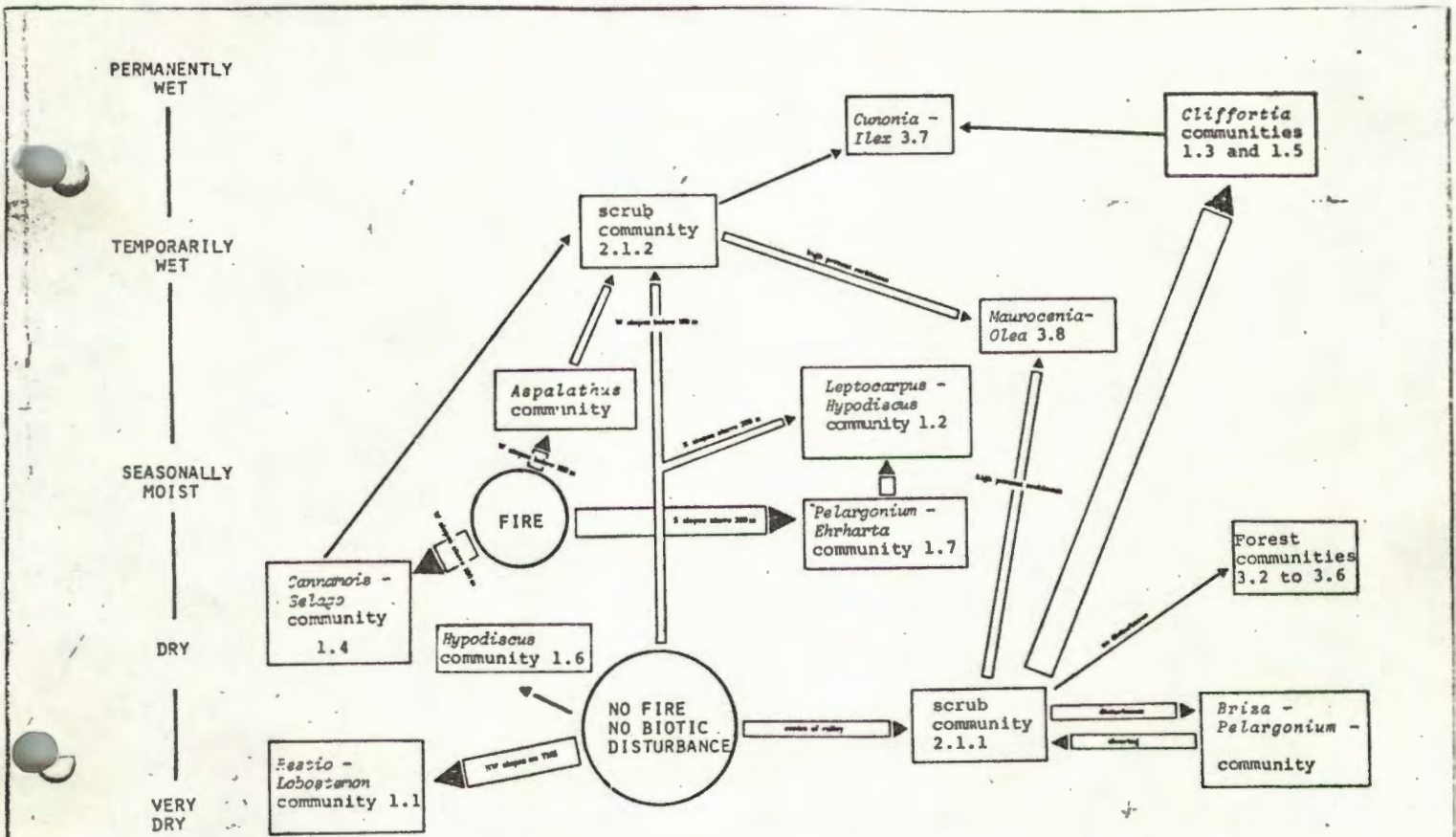


Fig 2. Diagrammatic representation of community dynamics in Orange Kloof. The relative width of arrows indicate the rate at which the change may occur.

(McKenzie, Moll and Campbell, 1977)

Table 2. Rock cover, litter depth and soil depth in each of the plots sampled, and the average figure for each stand.

Plot no.	Rock cover %	Litter depth cm	Soil depth cm	Plot no.	Rock cover %	Litter depth cm	Soil depth cm
<u>4 Year</u>							
I.1	20		5	2,14			18
1.2	10		3	2,15			10
I.3	40		5	2,16			16
1.4	15		25	2,17		5	17
1.5	30		10	2,18		5	18
1.6	25		9	2,19		5	5
1.7	15		6	2,20		30	15
I.8	10		8	<u>Avg.</u>	0,25	6,31	13,425
I.9	15		4				
I.10	5		15	<u>35 Year</u>			
I.11	25		10	3,1	30		13
I.12	20		9	3,2	20		21
I.13	15		9	3,3	15	2	12
I.14	5		11	3,4			15
I.15	30		15	3,5			21
I.16	20		5	3,6	35		20
I.17	8		7	3,7		25	25
I.18	25		8	3,8		2	14
I.19	20		14	3,9		30	22
I.20	10		20	3,10			10
<u>Avg.</u>	18,15		9,9	3,11	5		10
				3,12		15	10
<u>12 Year</u>				3,13	10	5	12
2.1			15	3,14		1	89
2,2	3	10	10	3,15	5	2	5
2,3		50	8,5	3,16	10	5	15
2,4		12	12	3,17	10		12
2,5		2	13	3,18			8
2,6			17	3,19			15
2,7		0,2	20	3,20	5		17
2,8			16	<u>Avg.</u>	7,25	4,35	18,33
2,9		0,5	10				
2,10			20	<u>SLOPE</u>			
2,11		1	5	Stand 1.	North - east facing		
2,12		5	10	Stand 2.	West facing		
2,13	2	0,5	13	Stand 3.	South facing		

Table 3. The four year stand; species list, percent cover (A), Total average cover (B), leaf size (C), average height cm.(D), life form (E), growth form (F) and the plot numbers in which each species occurred.

Symbols in column E represent: P = phanerophyte; C = chamaephyte; G = geophyte; T = therophyte.

Symbols in column F represent : D = deciduous leaf shrub; S = sclerophyll shrub; F = forb; Gr = graminoid or tufted herb; Fn = fern; N = needle leaf evergreen; Su = succulent; BE = Broad leaf evergreen tree/shrub.

Species	A	B	C	D	E	F	Plot numbers
<u>Euryops abrotanifolius</u>	16,45	16,45	b	53,8	P	D	ALL
<u>Aspalathus sp.</u>	7,4	5,2	a	21,6	C	S	I-8,10,12,15,17,19
<u>Haemanthus sp.</u>	I	0,15	e	5	G	F	1,13,17
<u>Penea mucronata</u>	1,7	0,25	a	25	P	S	I,10,16
<u>Oxalis sp.</u>	1,4	0,9	b	6,4	T	F	I,4,6-13,16,17,19
<u>Osteospermum sp.</u>	1,2	0,55	b	26,1	T	F	1,5,6,11,14,15,17,19,20
<u>Pinus seedling</u>	1	0,2	b	24,5	P	N	1,3,14,17
<u>Cliffortia atrata</u>	2	0,6	a	23,3	P	S	I,2,5-7
<u>Erepsia anceps</u>	2	0,7	b	18,1	C	Su	I,4,8,10,14,16,17,
<u>Erica conica</u>	1,8	0,35	a	38,8	P	S	1,3,6,14
<u>Pelargonium sp.</u>	1	0,25	b	19	C	F	1,2,4,12,13
<u>Metastasia sp.</u>	1	0,1	b	25	P	S	1,18
<u>Picinia bracteata</u>	2,3	1,4	b	33,8	G	Gr	I,7-9,11,13,15,17,19
<u>Tetraria cuspidata</u>	5,7	4,5	-	57,1	G	Gr	1,2,5-8,11-17,19
<u>Helichrysum odoratissimum</u>	1,5	0,3	a	15	C	S	1,13,16,18
<u>Anthospermum aethiopicum</u>	11,9	11,4	a	59,5	P	S	2-4,6-18,20
<u>Bobartia sp.</u>	3,7	2,2	d	56,7	G	Gr	2,4,9-17,19
<u>Lobelia pinifolia</u>	5,7	3,4	a	34,2	P	S	2,3,6,7,9-12,15,16,19,20
<u>Struthiola ciliata</u>	1,1	0,9	b	46,9	P	S	2-7,10-16,18,19
<u>Picinia anceps</u>	1,8	0,55	b	25	G	Gr	2-4,11,13,16,17
<u>Agapanthus sp.</u>	2,6	0,9	e	18,3	G	Gr	2,6,9,10,13,15
<u>Senecio rigidus</u>	I	0,35	c	36,6	P	S	3,7,9,11,12,17,18
<u>Restio filiformis</u>	1,3	0,2	-	53,3	G	Gr	3,5,9
<u>Tetraria paludosa</u>	15	0,75	-	80	G	Gr	4
<u>Alien grass</u>	3,4	1,2	c	28,6	G	Gr	4,7,9,13,14,16,18,19
<u>Muraltia sp.</u>	1,1	0,5	a	9	C	S	4,6,9,12,14,15,17-19
<u>Thesium strictum</u>	I	0,25	b	37	P	S	5,7,11,16,17
<u>Erica plukenetti</u>	I	0,05	a	30	P	S	5
<u>Wildenowia lucaena</u>	12,5	0,25	-	75	G	Gr	5,16
<u>Hypodiscus aristatus</u>	8	0,4	-	85	G	Gr	5
<u>Watsonia sp.</u>	1	0,15	e	46,7	G	Gr	5,15,18
<u>Eriospermum (lancefolia?)</u>	11	0,25	d	8	G	Gr	6,8,11,12,14
<u>Leucadendron strictum</u>	3	0,15	c	25	P	S	7
<u>Psoralea sp.</u>	I	0,05	a	20	C	S	7
<u>Restio triticens</u>	1,5	0,3	-	50	G	Gr	7,9,12,19
<u>Rhynchosia sp.</u>	I	0,25	c	11	C	S	8,11,12,15,19
<u>Brunia nodiflora</u>	10	0,5	a	60	P	S	9
<u>Elegia juncea</u>	10	0,5	-	70	G	Gr	9
<u>Diospyros glabra</u>	10	0,5	b	75	P	S	9
<u>Restio cuspidatus</u>	2	0,1	-	50	G	Gr	10
<u>Acacia longifolia</u>	1,5	0,08	c	43,3	P	S	11-13,18-20
<u>Schiza pectinata</u>	I	0,11	-	25	G	Fn	11,19
<u>Aspalathus hispidula</u>	I	0,05	-	30	P	S	11
<u>Pelargonium cuculatum</u>	1	0,1	c	32,5	P	BE	14,19
<u>Tetraria bromoides</u>	3	0,15	-	80	G	Gr	20
<u>Tetraria ustulata</u>	I	0,05	-	50	G	Gr	16
<u>Restio sieberi</u>	I	0,05	-	70	G	Gr	18

Table 4. The twelve year stand, Species list, percent cover (A), total average cover (B), leaf size (C), average height cm.(D), life form (E), growth form (F) and the plot numbers in which each species occurred.

Symbols in column E represent: P = phanerophyte; C= chamaephyte; G = geophyte; T = therophyte.

Symbols in column F represent: S = sclerophyll shrub; BE = broad leaf evergreen tree/shrub; Fn = fern; Gr = graminoid or tufted herb.

Species	A	B	C	D	E	F	Plot numbers
<u>Protea arborea</u>	I5	0,75	d	210	P	S	I
<u>Aspalathus sp.</u>	I3,3	II,95	a	91,1	P	S	I,2,4-13,15-20
<u>Brunia nodiflora</u>	I2,3	II,1	a	91,9	P	S	I-6,9-20
<u>Erica conica</u>	22,4	22,4	a	103	P	S	I-20ALL
<u>Struthiola ciliata</u>	1,25	0,25	a	108,3	P	S	I,11,12
<u>Rhus incana</u>	8,1	2,85	c	66,4	P	BE	I,2,6,13-15,17
<u>Fteridium aquilinum</u>	6,25	5	e	65,9	G	Fn	1,4,6,7,10-18,20
<u>Oxalis sp.</u>	I	0,25	b	17	T	F	I,3,5,8,14
<u>Ficinia bracteata</u>	6,75	1,35	b	61,25	G	Gr	I,4,13
<u>Leucadendron strictum</u>	13,65	13,65	c	111	P	S	ALL
<u>Anthospermum aethiopicum</u>	I,53	I	a	93,8	P	S	2-5,7,8,11-17
<u>Leptocarpus sp.</u>	3,3	0,5	-	128,3	G	Gr	2,10,12
<u>Cliffortia atrata</u>	5,25	I,05	a	80	P	S	2,4,6,11
<u>Salvia sp.</u>	5,4	I,35	b	48	P	S	2,6,8,13
<u>Erica nudiflora</u>	7,1	4,6	a	78,5	P	S	3-8,10,12,13,16-19
<u>Lobostemon sp.</u>	2	0,1	c	90	P	S	3
<u>Protea repens</u>	2,5	0,5	c	85	P	S	4-7
<u>Watsonia sp.</u>	I	0,1	e	125	G	Gr	6,7
<u>Bobartia sp.</u>	I	0,05	d	90	G	Gr	6
<u>Widdringtonia cupressoides</u>	6,5	0,65	c	140	P	S	7,19
<u>Phylica pubescens</u>	2,5	0,75	b	68,3	P	S	2,8,10,11,13,17
<u>Protea nerifolia</u>	4	1,6	c	94,4	P	S	8,10-12,15,17-19
Alien grass	I,5	0,15	b	15	G	Gr	8,14
<u>Mimetes hartogia</u>	I,5	0,15	c	95	P	BE	8,12
<u>Halleria elliptica</u>	20	I	c	150	P	BE	9
<u>Clutia sp.</u>	2	0,1	b	110	P	BE	9
<u>Olea capensis</u>	8	0,4	c	230	P	BE	11
<u>Pelargonium cucculatum</u>	I,5	0,15	c	72,5	P	BE	14,15
<u>Passerina sp.</u>	2	0,1	a	170	P	S	15
<u>Restio triticens</u>	10	0,5	-	50	G	Gr	17
<u>Chironia vecifera</u>	2	0,2	a	30	P	S	18,20
<u>Erica plukenetti</u>	I	0,05	a	95	P	S	19
<u>Myrsine africana</u>	2	0,1	a	70	P	S	19

Table 5. The thirty five year stand; species list, percent cover

(A), total average cover (B), leaf size (C), average height cm.
(D), life form (E), growth form (F) and the plot numbers in
which each species occurred.

Symbols in column E represent: P = phanerophyte; C = chamaephyte;
G = geophyte; T = therophyte.

Symbols in column F represent: Gr = graminoid or tufted herb;
Fn = fern; S = sclerophyll shrub; F = forb; D = deciduous leaf shrub;
N = needle leaf evergreen; Su = succulent; BE = broad leaf evergreen
tree/shrub.

Species	A	B	C	D	E	F	Plot numbers
<u>Watsonia sp.</u>	7,5	5,9	e	98,8	G	Gr	I-5,8,10,13-19
<u>Hypodiscus aristatus</u>	6	I	-	86,6	G	Gr	I,12,17
<u>Pteridium aquilinum</u>	12,8	5	e	63,1	G	Fn	I,3,4,6-8,10
<u>Cliffortia pedunculata</u>	18	3	b	63,3	P	S	I,5,6
<u>Anthospermum aethiopicum</u>	4,3	I,9	a	81,5	P	S	I-4,6-8,11,16,19
<u>Diosma hirsuta</u>	I	0,05	a	35	P	S	I
<u>Agapanthus sp.</u>	I	0,1	e	30	G	Gr	I,2
<u>Penea mucronata</u>	5,5	3,4	a	78,2	P	S	I,4,5,8-14,16
<u>Pelargonium sp.</u>	I	0,17	b	25	C	F	I,2,6
<u>Erica hispidula</u>	26,6	22,2	a	82,5	P	S	2-5,8-20
<u>Euryops abrotanifolius</u>	I	0,05	b	60	P	D	2
<u>Protea cynaroides</u>	8,6	I,4	d	83,3	P	S	2,3,7
<u>Restio triticens</u>	3,5	0,39	-	78,3	G	Gr	2,11
<u>Widdringtonia cupressoides</u>	19,5	4,3	c	235	P	S	2,5,7,13
<u>Ficinia anceps</u>	7,25	I,6	b	32,5	G	Gr	2,5,7,10,14,19
<u>Pinus seedling</u>	I	0,05	b	20	P	N	2
<u>Anthospermum ciliari</u>	2,3	I,05	a	47,1	P	S	2,10,13,15-18,20
<u>Crassula roschia</u>	I	0,05	c	85	P	Su	2
<u>Alciopi tabularis</u>	2,2	0,72	d	63,5	P	S	3,10,13-16,19
<u>Helichrysum cymosum</u>	5	0,27	b	50	P	S	3
<u>Tetraria autumnalis</u>	20	I	-	80	G	Gr	3
<u>Senecio sp.</u>	I	0,22	d	56,3	P	D	3,4,6,7
<u>Montinia caryophyllaceae</u>	3	0,17	b	80	P	S	4
<u>Stilbe vestita</u>	I,5	0,17	a	75	P	S	4,5
<u>Erica comica</u>	2	0,1	a	90	P	S	5
<u>Elegia juncea</u>	3	0,17	-	120	G	Gr	5
<u>Osmotopsis asteriscoides</u>	4,5	0,45	c	85	P	D	5,8
<u>Brunia nodiflora</u>	12,75	2,8	a	142,5	P	S	6,8-10
<u>Clutia sp.</u>	2,75	0,6	b	76,2	P	BE	6,7,9,11
<u>Bobartia sp.</u>	5,4	2,1	e	125	G	Gr	6,11,13-18,20
<u>Cassine peragua</u>	5	0,2	d	300	P	BE	6
<u>Maytenus oleiodes</u>	10	0,5	c	200	P	BE	6
<u>Rhus glabra</u>	7,5	0,83	c	90	P	BE	7,10
<u>Halleria elliptica</u>	8	0,44	c	55	P	BE	7
<u>Quonia capensis</u>	12	0,67	d	250	P	BE	9
<u>Thamnochortus nutans</u>	8	0,44	-	95	G	Gr	9
<u>Erica plukenetti</u>	2,4	0,67	a	48	P	S	11,15-19
<u>Cliffortia atrata</u>	2	0,1	a	45	P	S	11,20
<u>Tetraria cuspidata</u>	18	0,9	-	85	G	Gr	11
<u>Thamnochortus dichotomus</u>	8,25	I,8	-	60	G	Gr	11-13,15,19
<u>Leucadendron salignum</u>	9,8	2,72	c	89	P	S	13-20
<u>L. olifolium</u>	30	3	b	135	F	S	14,16
<u>Protea arborea</u>	22,5	2,15	d	100	P	S	16,20



Figure 3. General view of the 4 year stand. Firebreak to right.



Figure 4. General view of 12 year stand. Pine plantation behind.



Figure 5. General view of the 35 year stand. Dry area top right.



Figure 7. Tree - like Brunia nodiflora.

while in the dry area phanerophytes and geophytes are in approximately the same proportions.

Table 6. Relative numbers of phanerophytes, geophytes and the "tree" element found in the wet and dry areas of the 35 year stand.

	<u>WET</u>	<u>BOTH</u>	<u>DRY</u>
Phanerophytes	18	7	5
Geophytes	5	5	2
Total Species	24	12	7
Tree element	4	2	0

Table 7 gives a list of species common to two or three of the stands, along with their total average covers and average heights. Nine of the twelve species found in both the wet and dry areas of the thirty five year stand were also found in one or both of the other stands.

There are several vegetation characteristics which can be individually compared in the three stands.

2.2 Number of species per stand

The number of species present in each stand is given in table 8.

Table 8. The number of species present in each stand.

<u>Age of Stand (years)</u>	<u>Number of species</u>
4	47
12	33
35	43

The 12 year stand, being almost in Kruger's (1977a) mature phase, would be expected to have the most species. This apparent discrepancy will be commented upon further in the section entitled life forms (section 2.8).

Figure 8a graphically illustrates the species distribution among the 3 stands. This diagram indicates that almost half of any stand's species are also found in one or both of the other stands in this survey. The 12 year stand has more shared than peculiar species. This would be expected in a transitional phase.

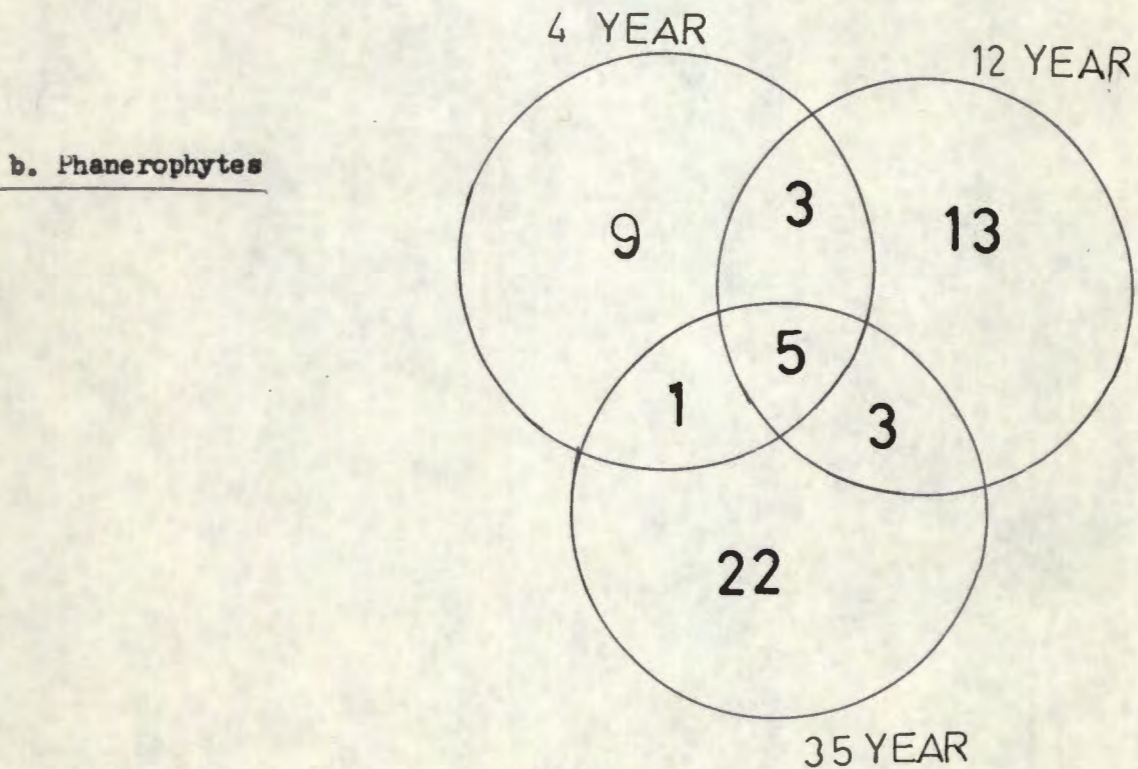
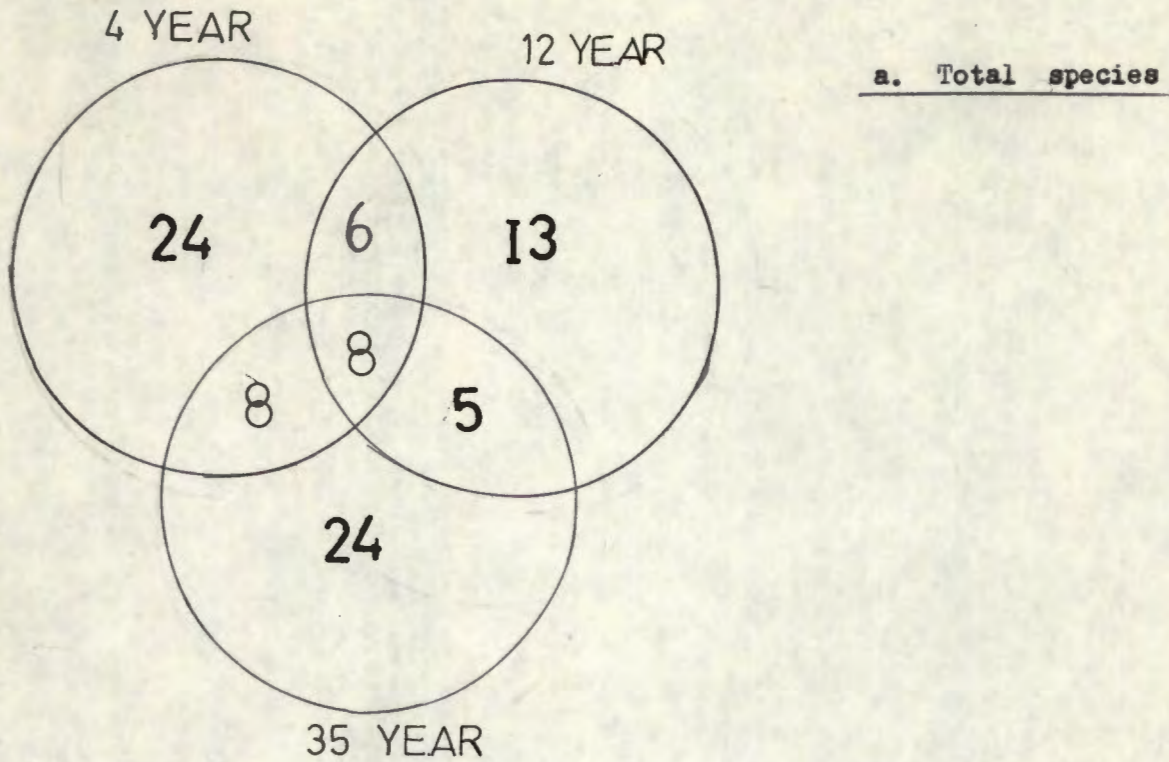
2.3 Number of species per plot

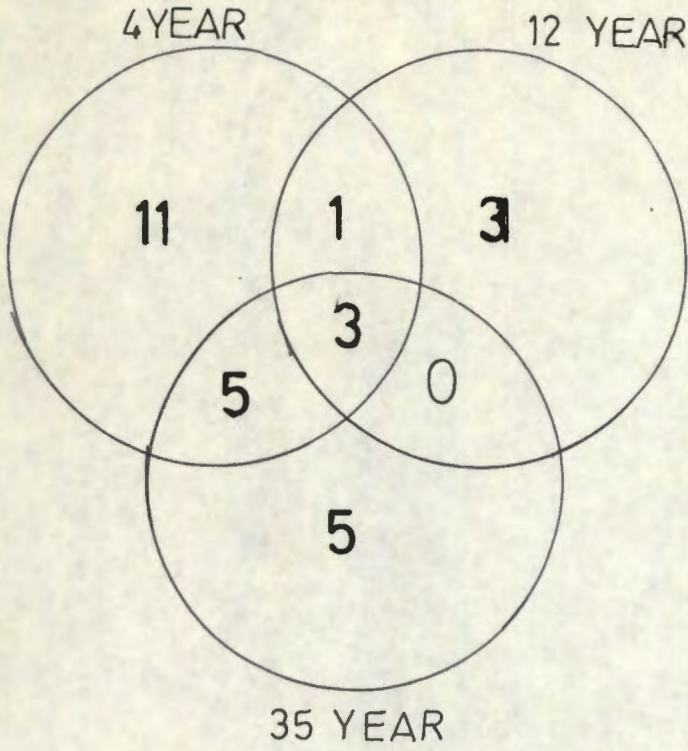
Table 9 shows a decrease in the number of species per

Table 7. Species common to two or more stands, with their average heights and total percentage cover figures.

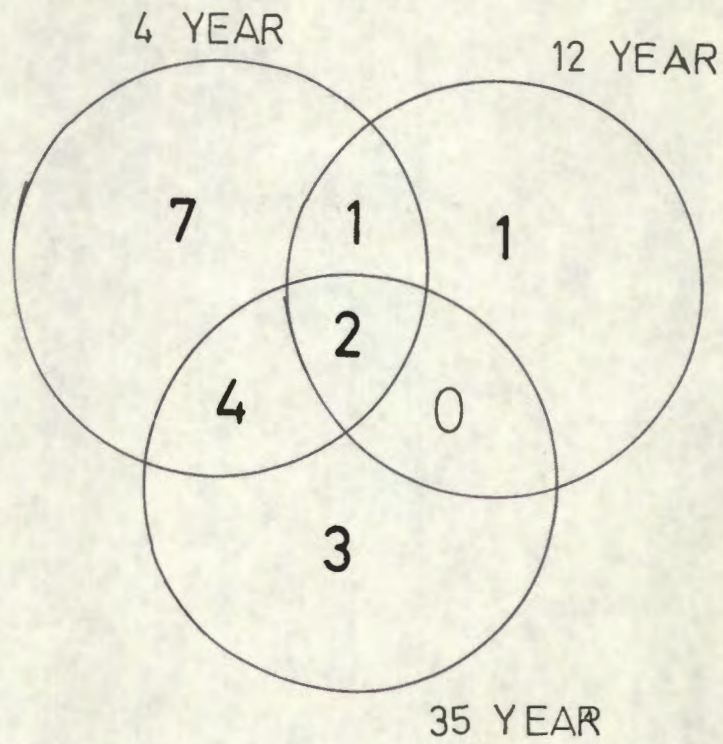
SPECIES	4 year		12 year		35 year	
	% cover	Av. ht. cm.	% cover	Av. ht. cm.	% cover	Av. ht. cm.
<u>Aspalathus sp.</u>	5,2	21,7	11,95	91,1		
<u>Ficinia bracteata</u>	1,4	33,8	1,35	61,25		
<u>Leucadendron strictum</u>	0,15	25	13,65	111		
<u>Oxalis sp.</u>	0,9	6,4	0,25	17		
<u>Pelargonium cucculatum</u>	0,1	32,5	0,15	72,5		
<u>Struthiola giliata</u>	0,9	46,9	0,25	108,3		
<u>Anthospermum aethiopicum</u>	11,4	59,5	1	93,8	1,9	81,5
<u>Bebartia sp.</u>	2,2	56,7	0,05	90	2,1	125
<u>Brunia nodiflora</u>	0,5	60	11,1	91,9	2,8	142,5
<u>Cliffortia atrata</u>	0,6	23,3	1,05	80	0,1	45
<u>Erica conica</u>	0,35	38,8	22,4	103	0,1	90
<u>E. plukenetti</u>	0,05	30	0,05	95	0,67	48
<u>Restio triticens</u>	0,3	50	0,5	50	0,39	78,3
<u>Watsonia sp.</u>	0,15	46,7	0,1	125	5,9	98,8
<u>Clusia sp.</u>			0,1	110	↑ 0,6	76,2
<u>Halleria elliptica</u>			1	150	0,44	55
<u>Protea arborea</u>			0,75	210	↑ 2,15	100
<u>Pteridium aquilinum</u>			5	65,9	5	63,1
<u>Widdringtonia cupressoides</u>			0,65	140	↑ 4,3	235
<u>Agapanthus sp.</u>	0,9	18,3			0,1	30
<u>Elegia juncea</u>	0,5	70			0,17	120
<u>Euryops abrotanifolius</u>	16,45	53,8			0,05	60
<u>Ficinia anceps</u>	0,55	25			1,6	32,5
<u>Hypodiscus aristatus</u>	0,4	85			1	86,6
<u>Pelargonium sp.</u>	0,35	19			0,17	25
<u>Penea mucronata</u>	0,25	15			3,4	78,2
<u>Tetraria cuspidata</u>	4,3	57,1			0,9	85

Figure 8a - n_1 , Venn diagrams showing the relation between the three stands with respect to species, phanerophytes, geophytes, stem monocots, the tree element and the different leaf sizes and growth forms.

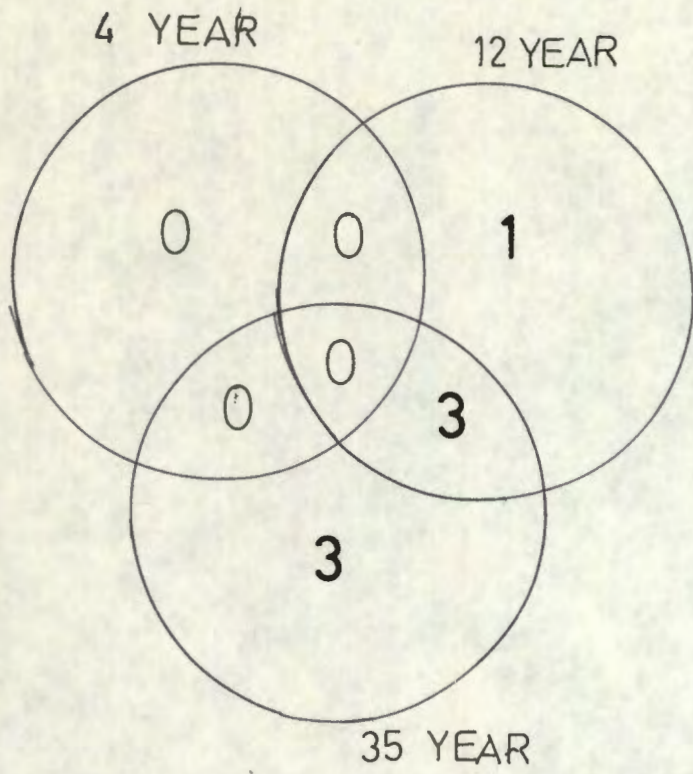




c. Geophytes

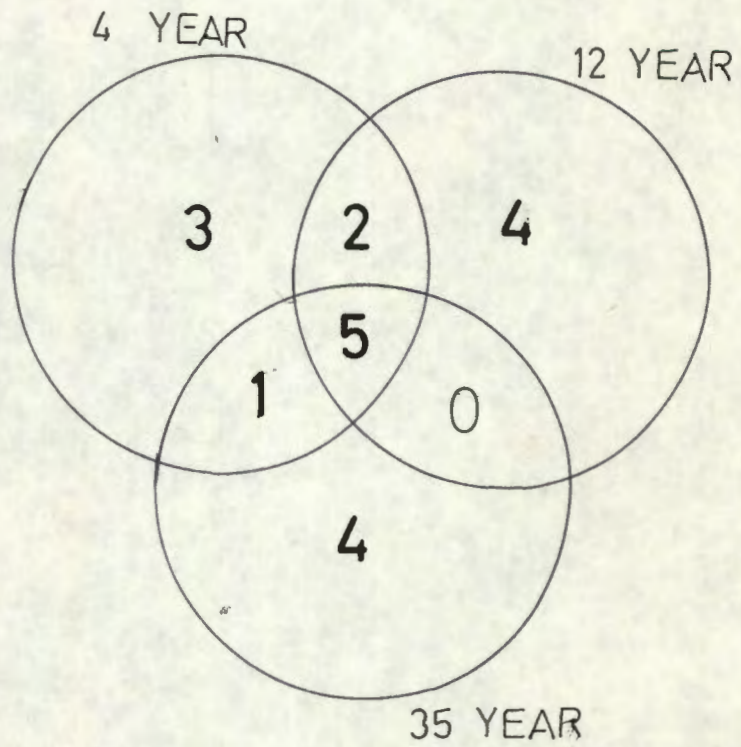


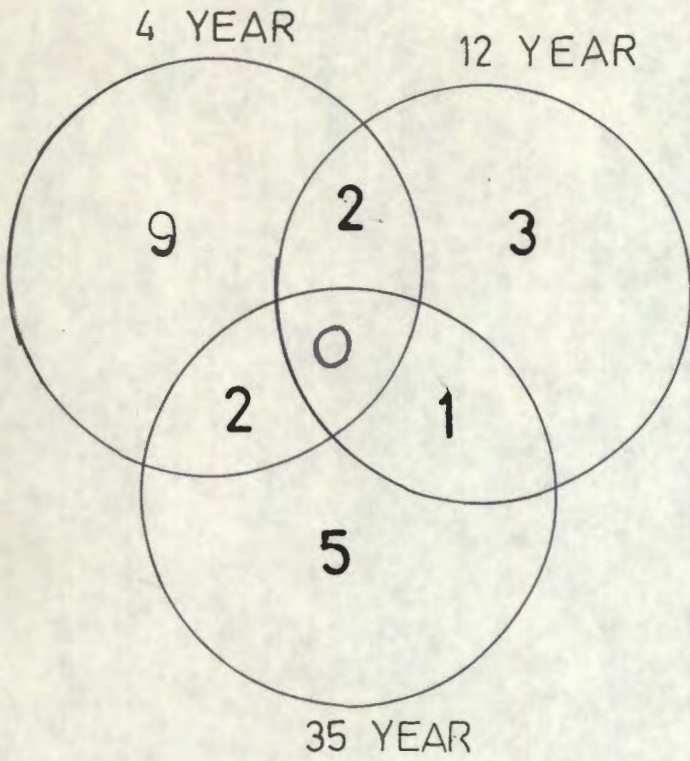
d. Stem monocots



e. Tree element

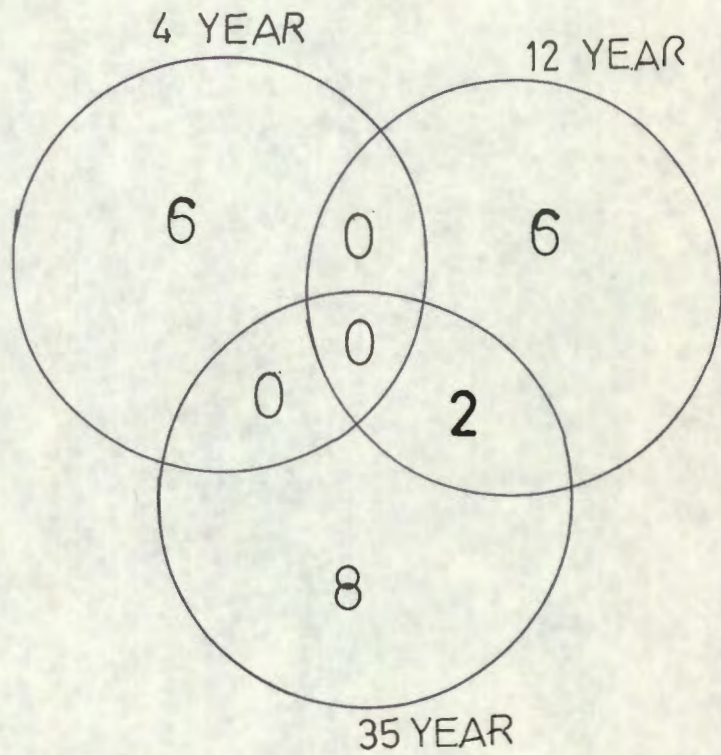
f. a size leaf
(leaf area up to 25 mm.²)

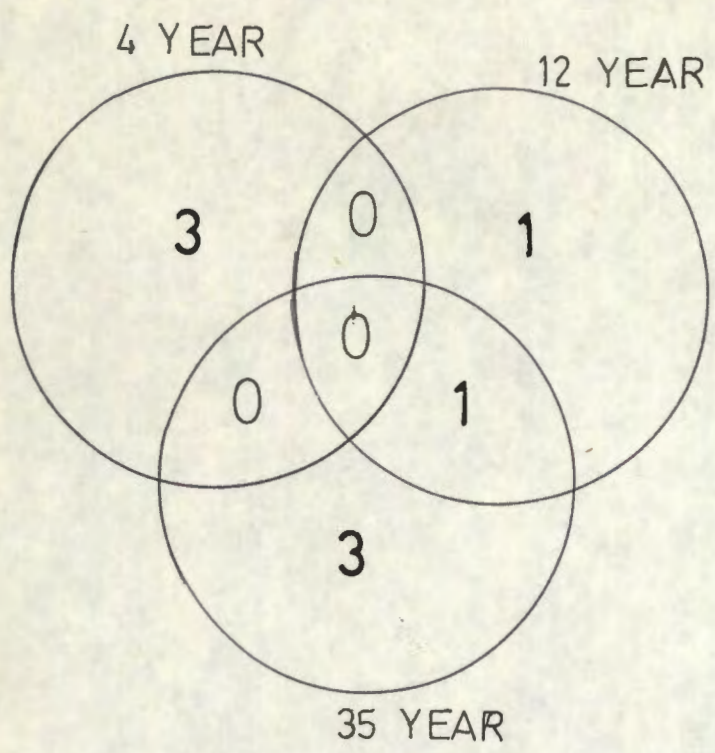




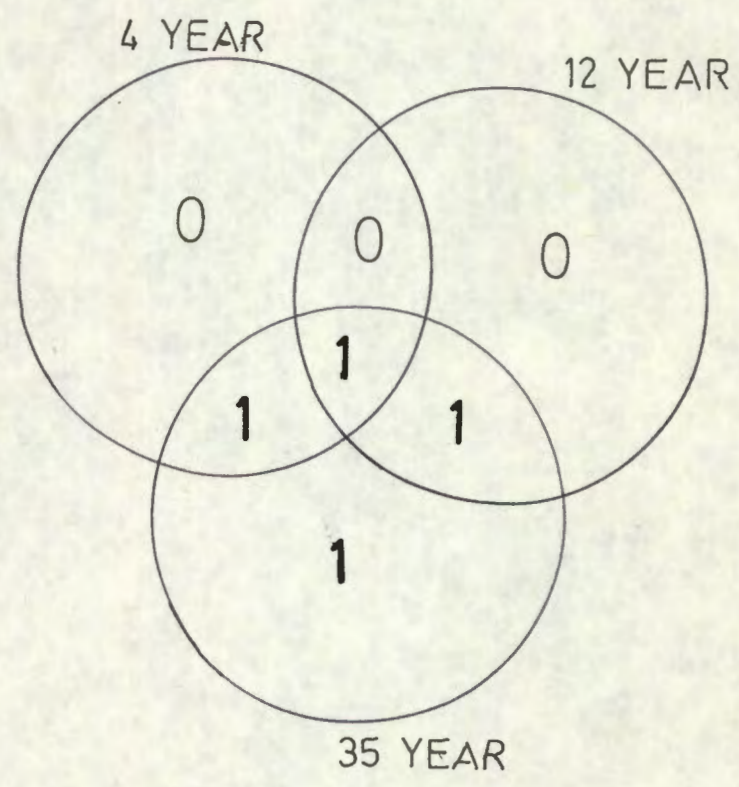
g. b size leaf
 (leaf area 25 mm.² to
 [9 x 25] mm.²)

h. c size leaf
 (leaf area 9 x 25
 to [9² x 25] mm.²)

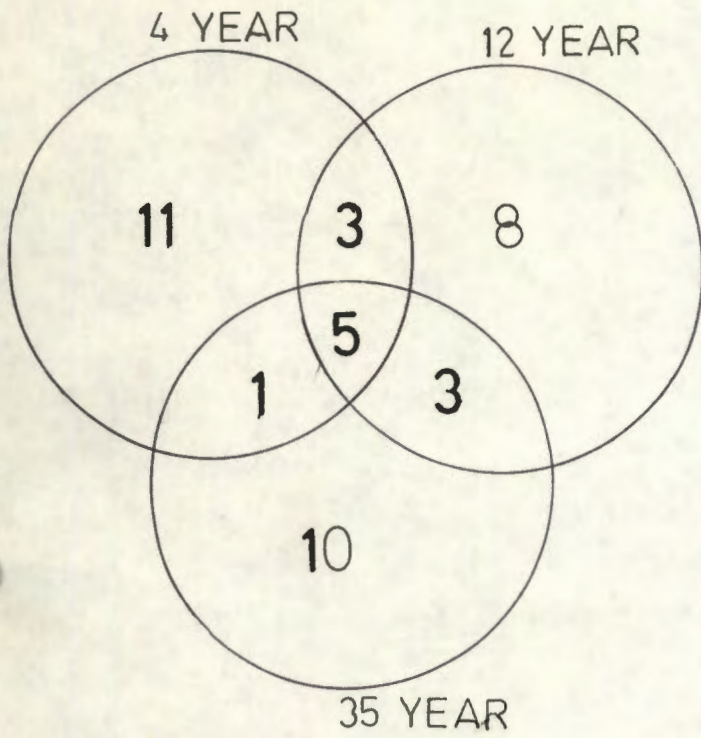




i. d size leaf
 (leaf area $[9^2 \times 25]$ mm.²
 to $[9^3 \times 25]$ mm.²)

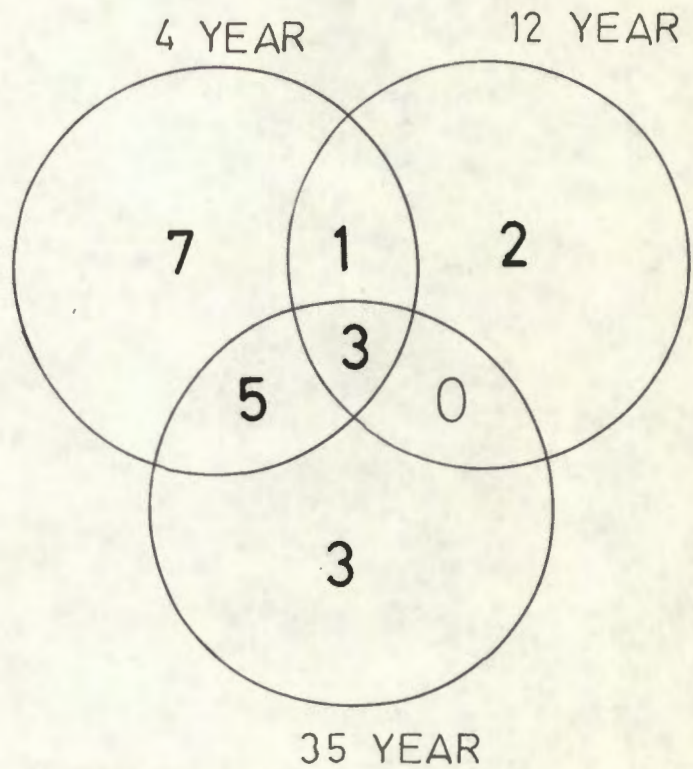


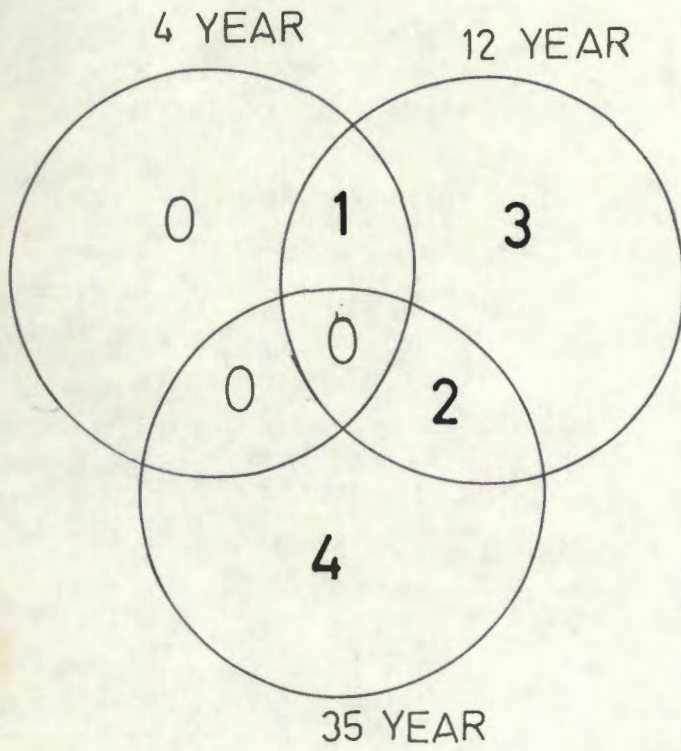
j. e size leaf
 (leaf area greater
 than $[9^3 \times 25]$ mm.²)



k. Sclerophyllous shrub

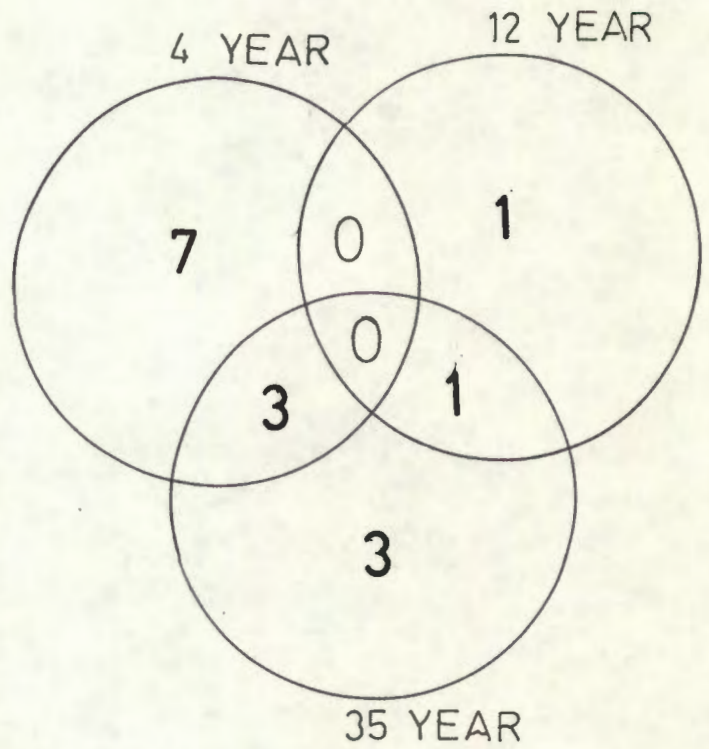
l. Graminoid or tufted herb





n. Broadleaf evergreen tree / shrub

n. Other



2m. x 2m. plot with increasing age.

Table 9. The average number of species \pm I standard deviation per plot in each of the three stands.

<u>Age of stand (years)</u>	<u>Number of species</u>
4	12,95 \pm 2,77
12	9,45 \pm 1,85
35	8,77 \pm 2,53

This average decrease in species numbers per plot, with increasing age would be expected, because as the plants get larger, fewer will fit into a given area. One should note the slightly larger difference between the 4 and 12 year stands than between the 12 and 35 year stands. This can be correlated with the decreased rate of growth around 12 years (see vegetation height, section 2.5). The low standard deviation figures, indicate a fairly even distribution of species throughout the stands.

2.4 Vegetation projected canopy cover.

Table 10. The average projected canopy cover \pm I s.d. of the vegetation in each stand

<u>Age of stand (years)</u>	<u>% PCC</u>
4	62 \pm 15,7
12	83,5 \pm 12,9
35	67,2 \pm 25,2

See also figure 9.

The 12 year stand can be seen to have the greatest cover, and also the smallest s.d.. Cover can probably be correlated with vigour. Allowing for variations in growth speed from area to area, this vegetation is probably just entering the mature phase described by Kruger (1977a). It would be at this stage (just before flowering) that the vegetative growth would reach its maximum.

Kruger (1977a) also says that cover in 4 - 5 year old fynbos, is about 80 % of that at preburn level (which would be in the mature phase with the Forestry departments' present burning regime). In this case it is 74,25 % of that in the 12 year stand.

The 35 year stand has a lower cover reading than the 12

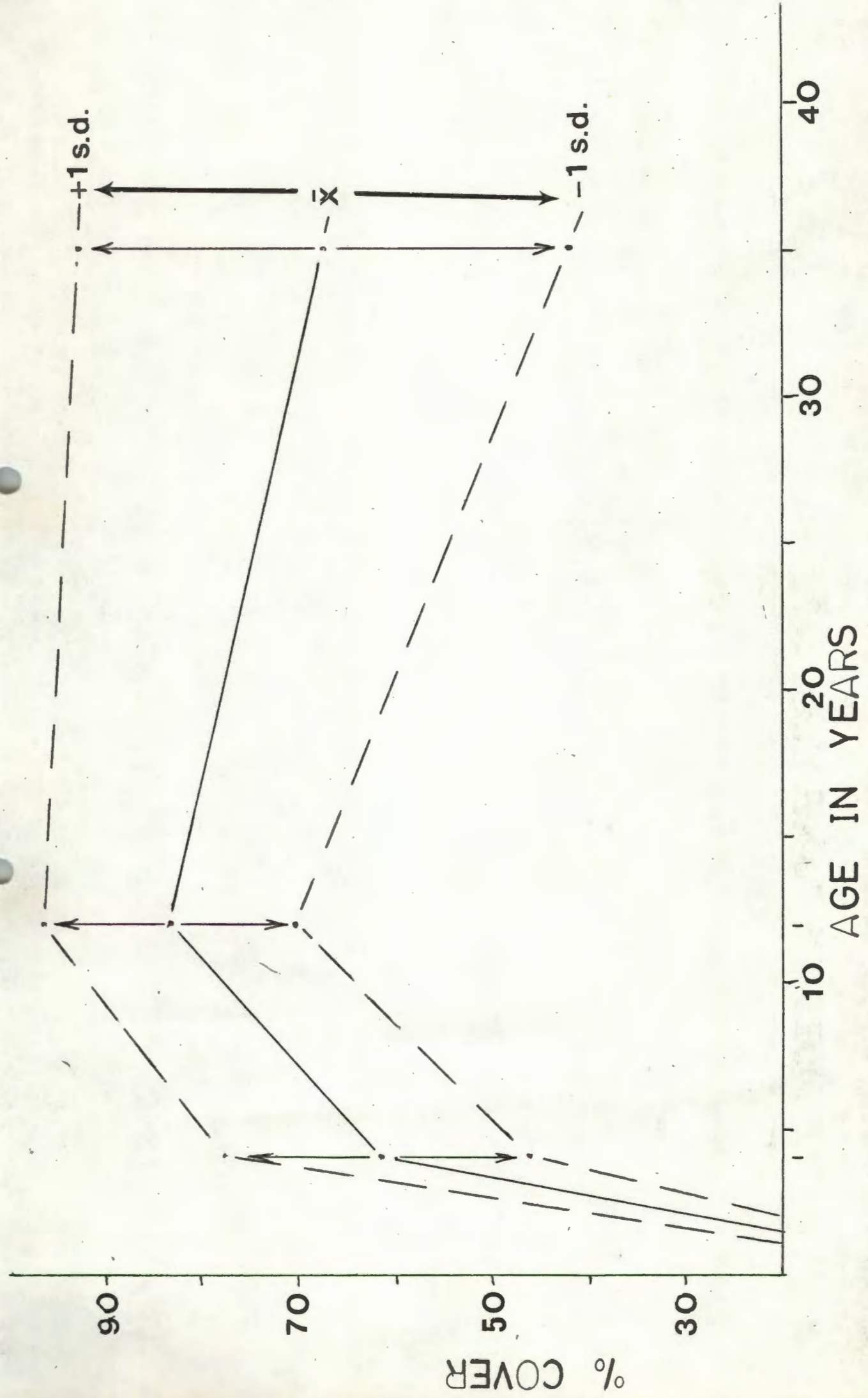


Figure 9. Range (± 1 s.d.) of vegetation PCC in each stand and the change with age.

year vegetation, which once again appears to fit in with Kruger's phases, in this case the senescent phase of decreasing cover. McKenzie, Moll and Campbell (1977) said there was no general senescence in this area, a statement with which the author agrees, as only Erica hispidula and Pteridium aquilinum showed signs of mass dying back. It would have been interesting to compare cover figures for this area at 12 - 15 years after a burn, to see how much the cover in this area had decreased. Unfortunately none were available. One should note that the range of covers encountered in this stand is greater than in either of the other two stands, and that the minimum cover encountered was lower than that of the minimum cover at 4 years, while the highest cover was almost as high as the maximum cover in the 12 year stand. Cover variations for the 4 and 12 year stands barely overlapped.

There was no pattern with respect to individual species' cover at different ages; table 7.

2.5 Vegetation height

Table II. The average height \pm 1 s.d. of the vegetation in each stand. (centimeters)

<u>Age of stand (years)</u>	<u>Average height cm.</u>
4	38,59 \pm 21,55
12	94,21 \pm 47,51
35	90,02 \pm 58,47

See also figure 10.

These figures indicate an initial rapid growth rate up to about 12 years which then appears to stop. Only one fynbos shrub increased its height after 12 years, Brunia nodiflora. This would align itself with Krugers' phases (1977a), as the vegetation would have little or no vertical growth once maturity is reached.

Figure II shows the change in height of a few species present in 2 or 3 of the stands. All show a rapid increase in height to 12 years, followed by extinction or a much reduced rate of growth. Several species (figure II; table 7) have a taller average height in the 12 year stand than in the 35 year stand. There may be a number of reasons for this:

- I. The conditions in the 35 year stand are not so good for growth.

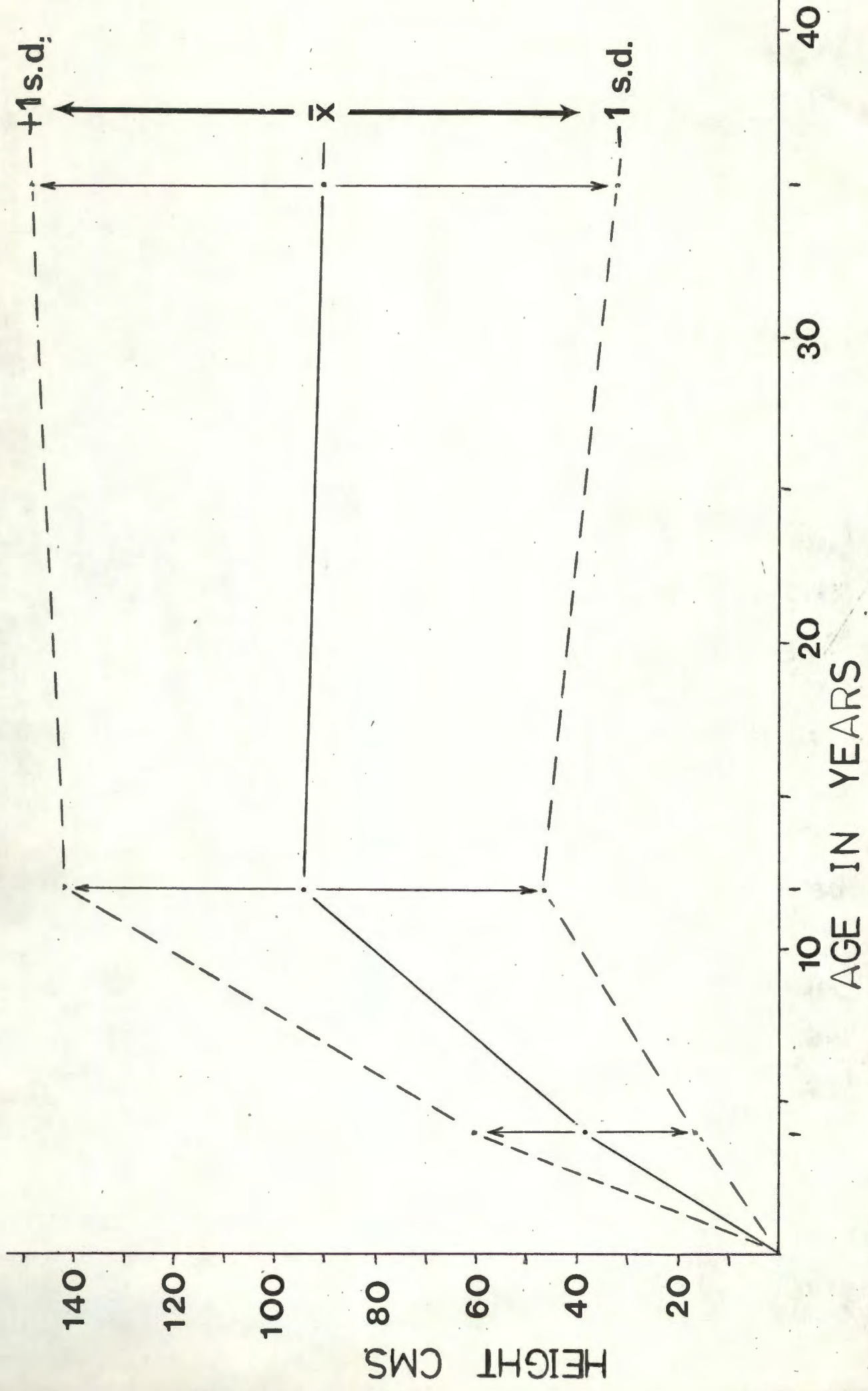


Figure 10: Change in average height (± 1 s.d.) of the vegetation with increasing age.

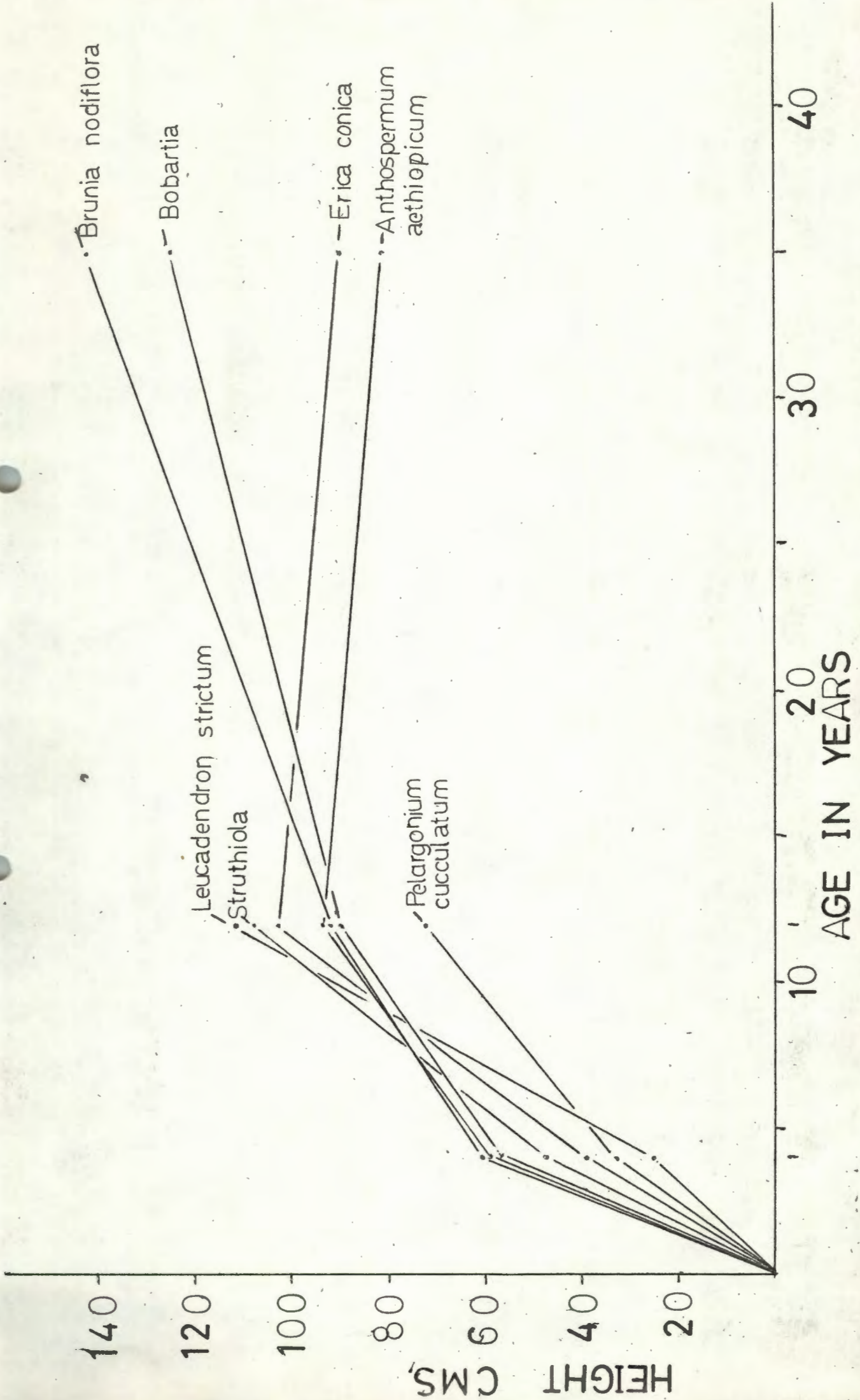


Figure II. Average heights of a few species found in more than one stand.

2. The plants are in their second generation since the last burn.

3. The plants may only grow to approximately the height reached by 12 years, and the lesser height at 35 years is due to environmental factors.

2.6 Leaf sizes

Table I2. The numbers and percentages of each leaf size found in the three stands.

Leaf size		a	b	c	d	e	stem
Age in years		lepto - phyll	nano - phyll	micro - phyll	meso - phyll	macro - phyll	monocots
4	no.	11	13	6	3	2	12
	%	22,9	27,0	12,5	6,2	4,1	25,0
12	no.	11	7	9	2	2	2
	%	35,4	19,3	25,8	6,4	6,4	6,4
35	no.	10	7	10	5	4	7
	%	22,7	18,1	22,7	9,0	6,7	18,1

The percentage figures for each stand look similar when viewed as a whole. The χ^2 test was carried out on these results revealing:

1. Comparing all 3 stands; $\chi^2 = 22,515$; $\chi^2(8;0,05) = 15,507$

Therefore there is a significant difference between the three stands.

2. Comparing the 4 and 12 year stands; $\chi^2 = 14,747$

$$\chi^2(4;0,05) = 9,48$$

Therefore there is a significant difference between the 4 and 12 year stands.

3. Comparing the 12 and 35 year stands; $\chi^2 = 22,99$

$$\chi^2(4;0,05) = 9,48$$

Therefore there is a significant difference between the 12 and 35 year stands.

4. Comparing the 4 and 35 year stands; $\chi^2 = 6,82$

$$\chi^2(4;0,05) = 9,48$$

Therefore there is no significant difference between the 4 and 35 year stands.

Note. Leaf sizes d and e were combined for the calculations. See also figure I2.

One can see that the 'a' leaf species remain fairly constant in all the stands. The 'b' leaf species have their greatest

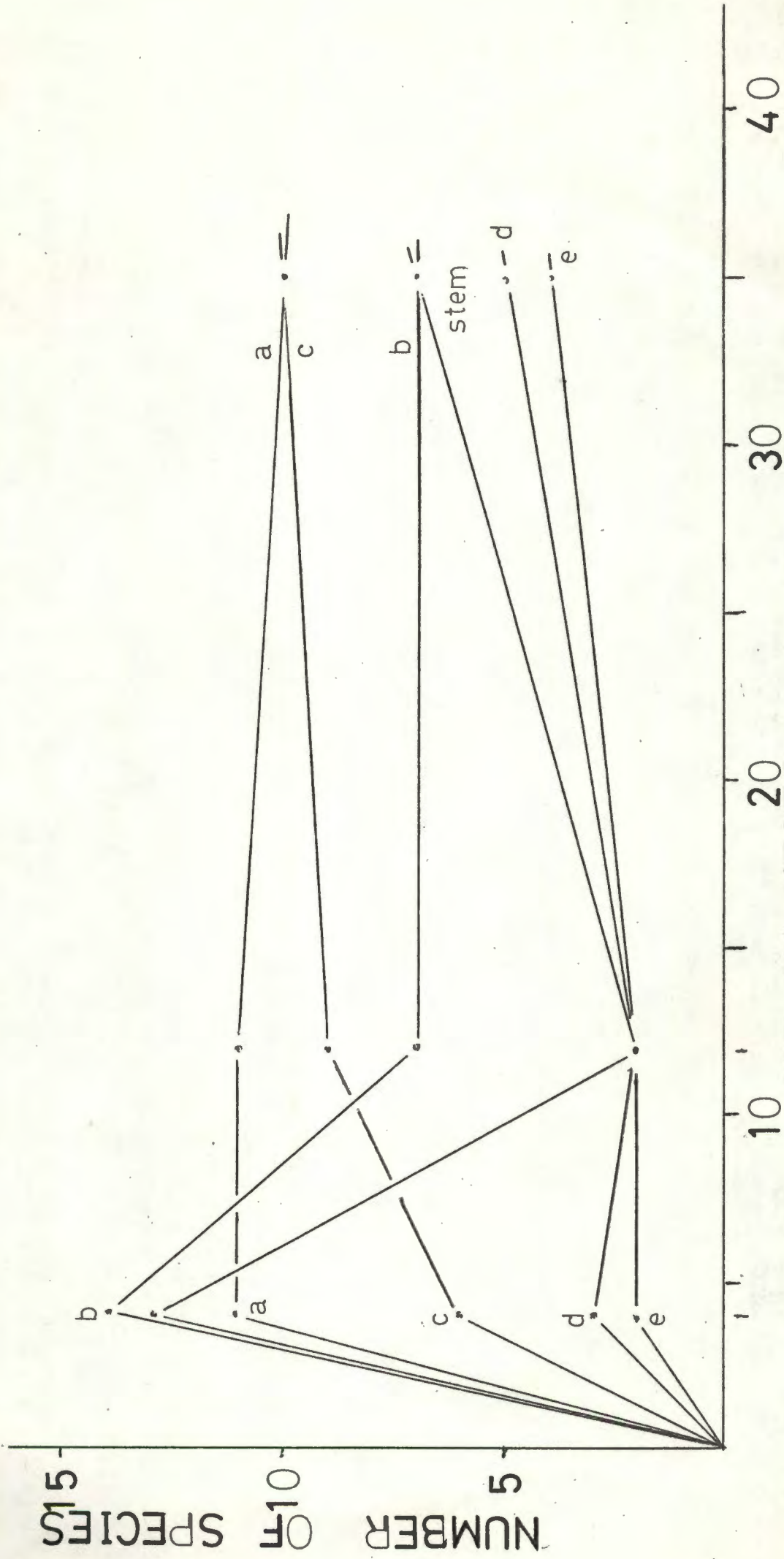


Figure 12. The variation in leaf size composition of the vegetation with increasing age.

a = leptophyll; b = nanophyll; c = microphyll; d = mesophyll; e = macrophyll.

number in the 4 year stand, where they are in a slight preponderance over the other leaf sizes. The number of 'c' leaf species increases gradually with age, until in the 35 year stand it shares leaf size dominance with 'a' species. Neither 'd' nor 'e' leaf species occur in very great numbers, but both have their highest proportions in the oldest stand. The stem monocotyledons have their greatest number in the 4 year stand, followed by the 35 year stand. Their numbers in the 12 year stand are very low, the same as the 'd' and 'e' leaf species.

Figures 8 d, f - j show the distribution of each leaf size species throughout the stands. One can see that the 'a' leaf species are the only ones with any large amount of sharing between all three stands. The 'b' leaf species have no species common to all three stands. The two species common to the 12 and 35 year stands in the 'c' leaf species are both tree elements, Widdringtonia ^{nodiflora} cupressoides and Halleria elliptica. The 'd' leaf species are mostly confined to their own stands, while all the 'e' leaf species encountered were also present in the 35 year stand. As one would expect, the stem monocots are found in the 4 and 35 year stands, with quite a high proportion shared.

Only two factors here can be correlated with the succession phases of Kruger (1977a). They are the stem monocotyledon (= geophytes) variations with age, and the slight increase in 'c' leaf species as the vegetation becomes more mesophytic i.e. more forest like.

2.7 Growth forms

Table 13. The number and percentage of each growth form found in the three stands.

Age in years \ Growth form	Sclerophyll shrub	Graminoid or tufted herb	Broadleaf ever-green shrub/tree	Other
4 no.	20	16	1	10
%	42,6	34	2,1	21,3
12 no.	19	6	6	2
%	57,6	18,2	18,2	6,1
35 no.	19	11	6	7
%	44,2	25,6	14	16,3

See also figure 13.

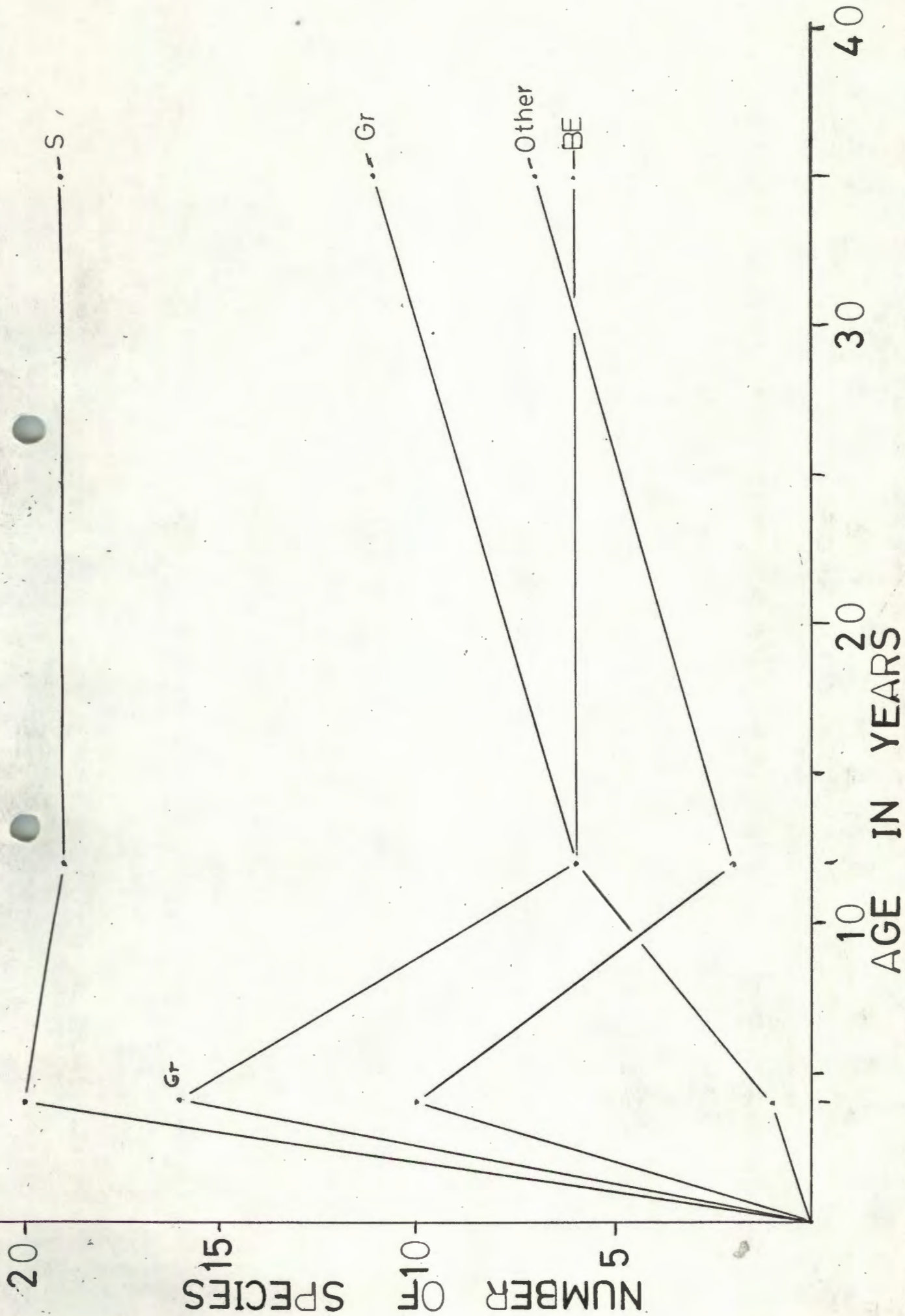


Figure 13. The variation of the growth form composition of the vegetation with increasing age.

S = sclerophyll shrub; Gr = graminoid or tufted herb; BE = broad leaf EVERGREEN TREE / SHRUB

The χ^2 test was carried out to compare the three stands.

The results showed:

1. Comparing all three stands; $\chi^2 = 21,446$; $\chi^2(6;0,05) = 12,59$
therefore there is a significant difference between the three stands.

2. Comparing the 4 and 12 year stands; $\chi^2 = 18,886$

$$\chi^2(3;0,05) = 7,814$$

Therefore there is a significant difference between the 4 and 12 year stands.

3. Comparing the 12 and 35 year stands; $\chi^2 = 3,56$

$$\chi^2(3;0,05) = 7,814$$

Therefore there is no significant difference between the 12 and 35 year stands.

4. Comparing the 4 and 35 year stands; $\chi^2 = 11,356$

$$\chi^2(3;0,05) = 7,814$$

Therefore there is a significant difference between the 4 and 35 year stands.

In this case the 12 and 35 year stands are not significantly different, partly because of the broad leaf evergreen (forest) element. Naturally not all the tree elements are broad leaf evergreens or vice - versa, but many are in this case.

From figure I3 one can see that sclerophyll shrubs are predominant at all stages, a fact that would be expected in fynbos, which is classified as sclerophyllous shrubland (Acocks 1975). The graminoid or tufted herbs are at their maximum at 4 years. There is a sharp decline at 12 years followed by a gradual increase. The broad leaf evergreen element increases to 12 years and then levels out. The presence of a wet area in the 12 year stand is possibly the reason for the relatively large number of broad leaf evergreen shrubs at this age. The 'other' growth forms follow the same curve as the graminoids, only in lesser numbers.

Figures 8 k - n show the distribution of each growth form species throughout the three stands. One can see that the sclerophylls are fairly evenly distributed among the stands, with a reasonable amount of sharing. A large proportion of graminoids are shared between the 4 and 35 year stands, and the same applies to a lesser extent to the 'other' growth forms.

Only one broad leaf evergreen was encountered in the 4 year stand, and that species was also present in the 12 year stand.

The graminoid element, and to a lesser extent the broad leaf evergreen element, can be correlated with Krugers' (1977a) fynbos phases.

One should note that there is a certain amount of personal opinion with respect to these growth forms, and it is sometimes difficult to decide where sclerophylly and non-sclerophylly meet.

2.8 Life forms

Adamson (1935) studied the regeneration of fynbos after a fire. He recorded life forms present in a stand on Table Mountain 7 months, 1 year, 2 years and 6 years after being burnt. Table I4 compares his 6 year figures with those recorded for the 4 year stand in this survey.

Table I4. The number and percentage of life forms recorded by Adamson (1935) in a 6 year stand on Table Mountain, compared with those recorded in the 4 year stand of this survey.

Age in years \ Life form	P	C	H	G	T	Total
6 (Adamson 1935)						
no.	40	26	15	15	3	99
%	40,4	26,3	15,15	15,15	3	
			30,3			
4 (this survey)						
no.	18	6	20		2	47
%	38,3	12,8	42,6		4,3	

P=Phanerophyte; C=Chamaephyte; H=Hemicryptophyte; G=Geophyte; T=Therophyte

The χ^2 test was carried out to see if there was any significant difference between the two stands. The results gave : $\chi^2 = 4,615$; $\chi^2_{(3;0,05)} = 7,814$. Therefore there is no significant difference between the two stands. This finding is useful, since if two different stands at a similar age have a similar life form composition, then it is more likely that the stand chosen is representative of 'typical' fynbos at that age.

Table 15. The number and percentage of each life form found in the three stands.

Individuals or species

Age in years	Life form	Stand			
		P	C	G	T
4	no.	18	6	20	2
	%	38,3	12,8	44,7	4,3
12	no.	24	1	7	1
	%	72,7	3	21,2	3
35	no.	30	1	12	-
	%	68,8	2,2	28,8	-

P=Phanerophyte; C=Chamaephyte; G=Geophyte; T=Therophyte

The χ^2 test was carried out to see if there was a significant difference between the 3 stands. The results showed:

I. Comparing all 3 stands; $\chi^2 = 4,638$; $\chi^2(2;0,05) = 5,99$

Therefore there is no significant difference between the 3 stands.

For this test Phanerophytes and chamaephytes were lumped, as were geophytes and therophytes. Since life forms are mainly based on the survival mechanism of the plant during unfavourable periods, and since chamaephytes and therophytes are such a small proportion of the total, this lumping (which was necessary for this test) is unlikely to affect the result significantly.

See also figure I4.

From the table above, one can see that phanerophytes and geophytes form the bulk of the species. Some of the chamaephytes in the 4 year stand were young shrubs which were phanerophytes by 12 years.e.g. Aspalathus sp.

Figure I4 shows graphically the variation in the numbers of the 2 major life forms as well as the total number of species and the tree element. Note that the species making up the tree element are also included in the phanerophyte curve. One can see from this graph that the geophytes are largely responsible for the variations in the total number of species, The phanerophyte numbers remain remarkably constant, their increase being brought about mainly by the influx of the tree element.

Figure 8b shows the distribution of the phanerophyte

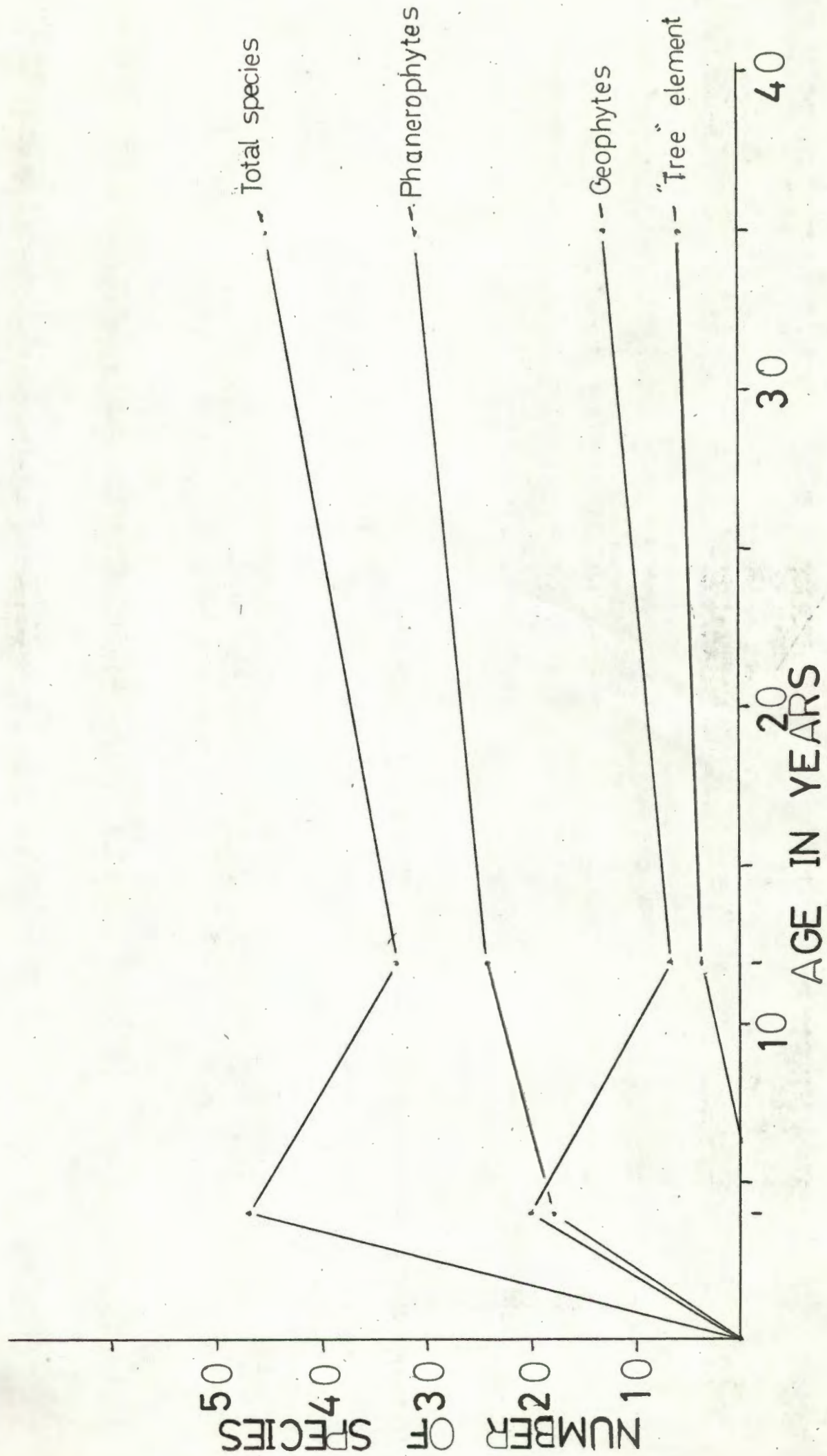


Figure 14. The variation in number with age of the total number of species, the tree element, Phanerophytes and geophytes.

species among the 3 stands. Half the species in the 4 year stand are also found in either of ^{the other} two stands, while less than ^{either of} a third of those in the 35 year stand are also found in the other two stands. With respect to the geophytes, about half the species in any one stand are also found in one or both of the other stands. More than two thirds of the geophytes recorded were found in the 4 year stand.

Except for the 4 year stand, one cannot really say the vegetation is dominated by 2 or more life forms. In the other two stands, phanerophytes considerably outnumber other life forms. In Adamsons' (1935) stand, the sharing of dominance by phanerophytes and hemicryptophytes / geophytes also leans towards phanerophyte dominance as the stand gets older. His claim that in fynbos life form dominance is shared by two or more forms should certainly not be based on the stands he sampled between 1927 and 1933.

With respect to Krugers' fynbos phases (1977a), the number of geophytes present in each stand fits in well; in preponderance shortly after a burn, then decreasing in number, and then finally increasing again as the shrub canopy opens at 30 to 40 years of age. Since shrubs mature from about 10 to 30 years, and the understory is reduced in importance, one would expect a majority of phanerophytes at this stage, which is what was found. Once in the senescent phase, forest precursors should arrive, further increasing the overall number of phanerophytes, which again was found to occur.

3 Dominance of individual species

3.1 The four year stand

In this stand Euryops abrotanifolius appears to be in complete dominance on first viewing the stand. As Adamson (1935) noted however, it does not cover as much of the soil area as expected, with numerous plants in between. Of the species present, only E. abrotanifolius, Anthospermum aethiopicum and Struthiola ciliata are present in 75 % or more of the plots sampled, and only E. abrotanifolius and Anthospermum aethiopicum have total average covers of 10 % or more. Geophytes are only slightly more abundant than phanerophytes, and together they share life form dominance.

3.2 The twelve year stand

In this stand there are fewer total species than the 4 year stand, but no one plant appears dominant on viewing the vegetation. Four species appear in 75 % or more of the plots sampled, and all four have greater than 10 % total average cover. The 4 species were Erica conica, which appeared in all 20 plots sampled with a total average cover of 22,4 %, Aspalathus sp., Brunia nodiflora and Leucadendron strictum. All four were present in the four year stand in low covers.

3.3 The thirty five year stand

In this stand only two species appear in more than 75 % of the plots sampled, and only Erica hispidula has a total average cover of greater than 10 %. Watsonia sp. was the other species, with a total average cover of 5,9 %.

interesting in view of pasture culture. Should be commented on

Although dominant in area, E. hispidula was hardly noticeable in the vegetation because :

- 1. The flowers were brown, and so blended in with the background.
- 2. Often the lower 3/4 of the plant was 'dead'.
- 3. They were relatively small plants compared with some of the other species present.

3.4 General

The results of this survey appear to agree with the view of Levyns (1952) and Adamson (1931) that the vegetation is not dominated by any one species.

4 Succession

To properly determine succession, (a) single area(s) should be monitored from the pre - burn stage through to the next pre - burn stage, 30 or more years later. This was not possible for obvious reasons. Allowing for species variations due to the mini - climate, soil and water patterns of each stand, one can formulate some concept of succession from the data collected in this survey.

By referring to table 7, one can see that, of the 84 species encountered in this survey, 28 (33,3 %) occurred in two or three of the stands, and of these only 5 did not occur in the 4 year stand. Three of these were forest species and one was a successful world wide Pteridiophyte. The fifth was Protea arborea, a species which survives burns by means of buds in the stem. (Kruger 1977a).

Of those species found in the 4 and 35 year stands, (9) 5 were geophytes, ~~one was a shrub~~, 1 a short lived shrub, 1 an alien and 2 were fynbos shrubs. Only one typical fynbos sclerophyll shrub was present - Penⁿea mucronata. The other fynbos species present in these two stands was a non - sclerophyll, Pelargonium sp.

Of the 14 species occurring in the 4 and 12 year stands, 6 do not occur in the 35 year stand as well. With the exception of Oxalis, they are all typical fynbos species. 7 of the 14 are sclerophyll shrubs.

It appears that many of the 'typical' fynbos species are established in the stand from an early stage in the post fire succession. This can be explained by the fire resistant adaptations referred to in the introduction (Kruger 1977a). The method by which the species in this survey survived the burn was not recorded, since one cannot be sure without a preburn survey and experimentation.

From the data collected, one cannot say that there is any true succession as stated by the classical concepts (Cowles; Clements; Clements and Weaver; Odum; in Noble and Slatyer 1977). There is rather, a temporary co - dominance of several species at various stages after a fire, depending on their rate of growth. First the quick growing geophytes and Euryops abrotan - ifolius, then a multiple shrub dominance, followed by a dying

back of the shrubs, coupled with a re-sprouting of the geophytes and invasion of forest species i.e. a complete lack of dominance of anything, and finally a slow take over by the forest trees. This type of succession is closest to that of Eglers' (1953 - 4) relay floristics, whose ideas can be shown by a simple diagram, figure 15. The idea has been modified by the author for the fynbos stands sampled, figure 16.

Like most of man's models of natural systems it is very generalised. A wet area near a forest would probably lead to forest species being found 7 or 8 years after a burn. A dry area on the other hand, remote from forest, would probably be in the ericoid / proteoid stage, with no forest precursors present 30 or more years after a fire. Such a phenomenon was noted at an old stand near Worcester, in the Cape, This area in the Little Karoo had Protea sp. in flower, with no sign of forest precursors, although it had been last burnt in 1910 according to the land owner.

The fynbos sampled appears to correlate very well with the growth phases of Kruger (1977a). Only two exceptions were noted :

- 1. Some forest species were present in the 12 year stand, but this was probably due to the presence of a drainage area in the stand.
- 2. There did not appear to be any large degree of senescence in the 35 year stand, but again, this was probably because of water patterns in the soil.

Growth forms and life forms, and their correlation with the succession and dominance theories have been discussed in their own sections (2.7 ; 2.8).

4.1 Senescence

As mentioned above, there appeared to be no general senescence in the old stand sampled. Two old stands sampled with the field form (appendix I) at Garcia pass and Knysna, had indications of senescence in the Proteas, i.e. a few leaves on the tips of otherwise 'dead' branches, but Berzelia sp. vigorous growth and was reaching heights of 2 m. and more. The Bruniaceae do not appear to be affected by age as much as most other fynbos shrubs.

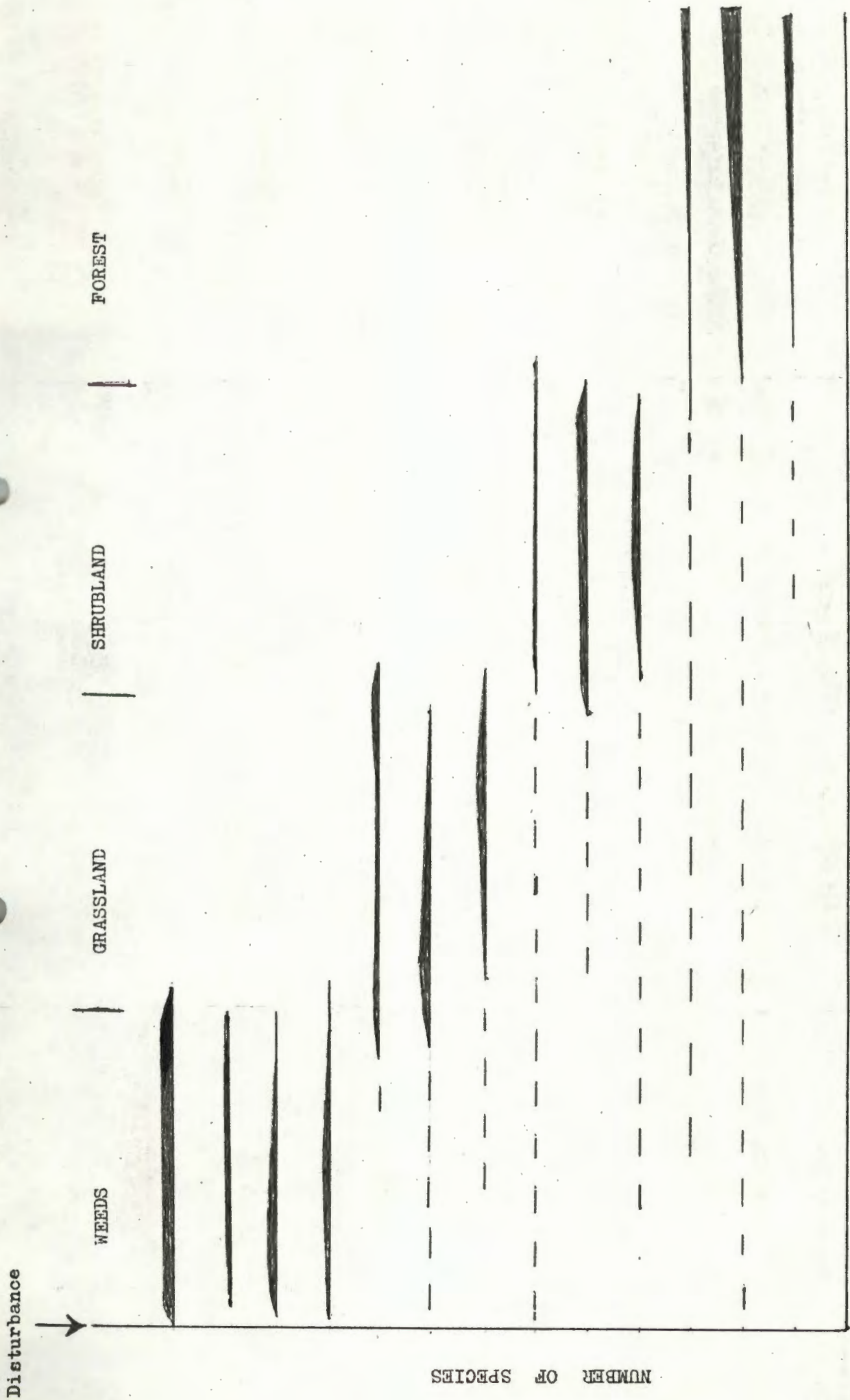
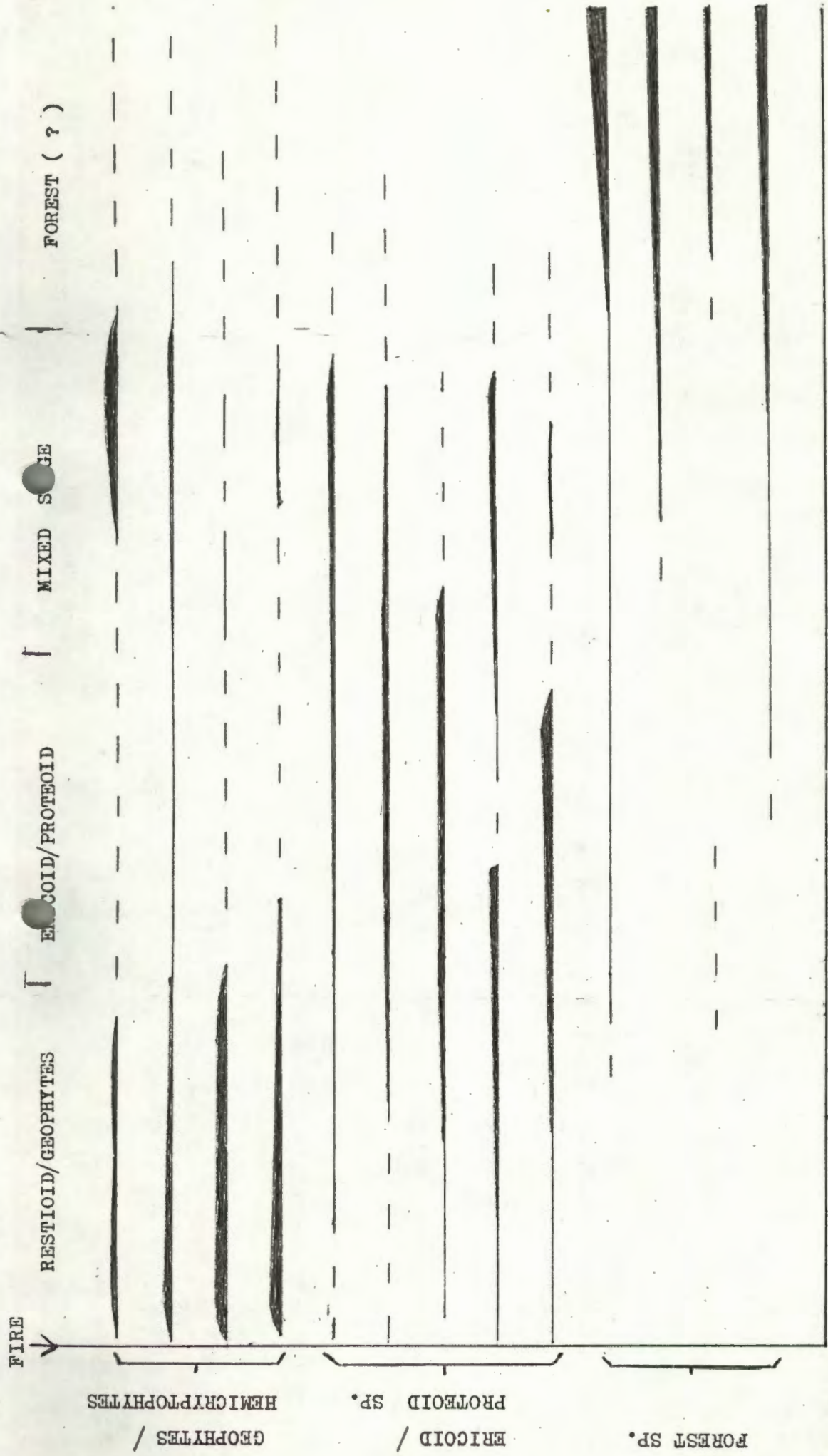


Figure 15. Eglers' idea of relay floristics. (1953 - 54).

Dotted line ; present in small numbers / seedlings etc. Thickness of solid lines proportional to relative abundance of that species.

AGE →



45

25

AGE IN YEARS (APPROXIMATE)

Figure 16. Eglers' (1953 - 54) idea of relay floristics modified for fynbos by the author.

Dotted line : present in dormant state, bulbs, seeds etc. Thickness of solid lines proportional to relative abundance of that species.

Mixed stage : Ericoid / Proteoid dying, canopy opening, resprouting of

At the stand near Worcester, mentioned above, there was no indication of any of the Proteas dying. Again it appears that the rate of aging and senescence are linked with water availability.

5 The tree element

This is one element that is not present in the early post burn stage, probably because forests are not fire adapted vegetation and therefore have no fire resistant structures. Establishment would depend on the arrival of a propagule in the post burn community from an established forest or woodland. Since many trees are slow growing, it is possible that they are unable to establish themselves in young vigorous growing fynbos, except in wet areas. See figure 8 e.

In one of the stands at Knysna, Protea mundii of 10 to 12 m. was growing, intermingled with typical forest species of a similar height or smaller. This was in an area of high rainfall and a subtropical climate. It may be possible that some fynbos shrubs have the potential of becoming trees under optimum conditions, and once again water is probably an important factor.

CONCLUSIONS

In the three stands sampled, 4, 12 and 35 years after burning:

1. There was little difference in life form composition.
2. The 4 and 35 year stands had a similar composition of leaf size classes.
3. The 12 and 35 year stands had a similar composition of growth forms.
4. Forest precursors were found in the 12 and 35 year stands.
5. Maximum height and PCC are reached at about 12 years.
6. The graminoid and bulbous herbs are responsible for the high species figures recorded from the 4 year stand.
7. There is no single species dominance.
8. Except for the 4 year stand, when phanerophytes and geophytes share life form dominance, phanerophytes alone are the dominant life form.
9. Most of the more common fynbos species are present in the early post burn succession.
10. Succession occurs with respect to flowering times,
11. Water availability appears to be an important factor in the aging of fynbos.
12. Vegetation differences between the stands correlated well with Krugers' fynbos phases, scheme of "succession". (1977a).

Burning of the vegetation should be adjusted to suit the area, especially with respect to water availability. Burning should also only be carried out four to five years after the slowest maturing fynbos species have begun to flower. In average fynbos this would be about 20 years after the last burn, as 15 years is about the maximum required for ^{some} fynbos species ^(eg?) to reach maturity. (McKenzie pers. comm.)

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APPENDIX I. Form used in the senescence investigation.

FYNBOS SENESCENCE

Location: ----- Altitude: -----
 Slope : ----- Geology : -----
 Rainfall: ----- Aspect : -----

PLANT TYPE	B.B. cover				Max ht	% dead branches			
	<0,5m	0,5-1m	1-2m	>2m		<0,5m	0,5-1m	1-2m	>2m
Restios									
Grasslike									
Other herbs									
Woody Ericoid									
Proteaceae									
Other woody									
Forest spp.									

Forest spp.

Dominant Protea spp:

Age, structure, Max. ht., and % dead branches of each Protea :

Age	Structure	Max. ht.	% dead

Litter depth on corners and midpoints of plot sides (m.)

Corner	Side
1	1
2	2
3	3
4	4

