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A Report on Mulanje Cedar(*Widdringtonia nodiflora*) Resources on Mulanje Mountain.

Summary: A brief ecology of the Mulanje cedar (*Widdringtonia nodiflora*) stands on Mulanje is described. The effect of management of the cedar on regeneration and stand structure is outlined. The results of a pilot survey of cedar stands on Thucila and Lichenya plateaux are presented. The moister forest on Lichenya were poorer in cedar and had a more luxuriant evergreen understorey layer. It was concluded that the climate of Lichenya is marginal for cedar while the drier conditions on Thuchila are much more favourable for cedar regeneration and stand development. The practical implications of the results and methods which might be used to increase the stock of young cedar are discussed.

Cross References 81032

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Ecology of the Cedar Forests on Mulanje Mountain

The Mulanje cedar(*Widdringtonia nodiflora*) forests on Mulanje Mountain are mostly confined to hollows, valleys and areas around the base of steep cliffs, at altitudes between 1525m and 2133m. The intervening plateau and watershed areas support tussocky grassland or secondary scrub. Although the distribution of grassland and forest appears to have remained virtually unchanged since the first descriptions of the vegetation were written 90 years ago (9,10,17,18,20) most authorities consider the fragmented forest patches to be relics of a formerly more extensive forest (9,13,18,19). The only direct evidence for this hypothesis is buried tree-stumps found, under the grasslands on Thuchila in 1894 (13,18,19) and the occasional tree fern which still survives at some distance from the present forest edge.

The primeval wildwood would never have consisted of continuous unbroken forest over the whole of the plateaux, however, as natural events such as lighthing fires, windthrow and landslides would have occurred periodically clearing large and small areas. These would gradually regenerate until, if the succession was uninterupted, dense nature forest was restored. Thus the landscape of the plateaux must have consisted of a patchwork of open, regenerating, middle-aged and mature forest stands.

Mulanje cedar does not regenerate under a closed canopy and it is assumed that conditions inthe ground layer of middle-aged or mature stands are unsuitable for germination and seedling establishment(14,16). Mulanje cedar seedlings and saplings are sometimes present on the edge of the forest in open shrub communities, usually in association with pioneer species such as *Philippia benguelensis* and *Hypericum revolutum*(7,9,13). This suggests that in the natural forest Mulanje cedar would have been among the first species to recolonize bared areas after fire or windthrow but whereas most of the other pioneers are relatively short-lived and would have been gradually supressed by shade-tolerant evergreen forest species, Mulanje cedar would have persisted in the canopy or emergent layer. Thus fires at intervals of 100-200+ years were essential for the rejuvenation and ultimate survival of the cedar stands.

After people began to settle in the areas around Mulanje Mountain the frequency of fires on the plateaux is thought to have increased (9,13,19). Eye-witness accounts from the end of the nineteenth century describe how fires spread from villages on the outer slopes by jumping from one tuft of grass to another, up the sides of the massif to the plateau level(10). As these man-made fires supplemented natural lightning fires the period between disruptions will have decreased and the natural succession would have been truncated at the early Mulanje cedar/pioneer shrub stage. Although young cedar stands can regenerate after fire by coppice regrowth (8,12,21), in South Africa it has been found that 3 fires in succession are sufficient to destroy Mulanje cedar coppice (21). Thus as the frequency of fires increased forest, must have been gradually eliminated from the plateaux until the present situation was reached in which forest was restricted to areas where the terrain afforded some protection from fire although even these valleys must have experienced the occasional rejuvenating fire for the cedar to have survived..

The absence of forest cover and in particular mature broadleaved stands must have resulted in widespread soil degradation and bauxite hard-pan development over the plateau areas. This change, plus the continual attrition oftheforest patches by grassfires must have accentuated the boundary between forest and grassland, reducing the transition zone to a narrow belt of open srub.

The Effect of Management on the Cedar Forests

When Alexander Whyre visited the cedar forests on Lichenya in 1891 he considered they were in imminent danger of extinction from the devastating effects of the annual grassfires(10). Shortly afterwards Cpt. Manning arrived at a similar conclusion concerning the stands on Thuchila(17). There was abundant evidence that grassfires were destroying trees on the edges of the stands and "in exceptionally dry seasons....these fires even penetrated some of the damp forests" which occupied the more sheltered ravines. It is also significant that, on Thuchila at least, there were "large numbers of young trees growing in all the woods" (18). These have now reached middle-age and make up the dominant age-class on the northern plateaux of Mulanje.

From 1901 efforts were made to protect the forest patches especially the young cedar stands, by early burning the grasslands, (1). Initially the response to fire protection appears to have been good and early reports indicate that at first there was abundant natural regeneration(2,3). But by 1913 much of the sapling regeneration was suffering from competition with "inferior species" and attempts were made to free the cedar by cutting shrubs and climbers in the better stocked stands (4,5). All subsequent reports indicate that further natural regeneration was limited to areas of local disturbance, usually fire or felling which can result in a certain amount of scanfication of the humus layer(15). Since 1949 the grasslands on Mulanje have been pretected from fire by a system of external fire-breaks(13). This has resulted in a thickening of the grass layer and in some areas, colonization of the grassland by pioneer trees and shrubs, which appear to be the first stage in a succession to evergreen forest. Where there is adequate seedfall (ie within 10-50m of a middle-aged or mature stand) Mulanje cedar is often a constituent of the scrub development. Over large areas, however 30 years of fire protection has not resulted in any significant recolonization by woody species. The reason for this has not been adequately investigated but it could be that the soils are too degraded or that the occasional accidental burn is sufficient to prevent seedling establishment.

The Forestry Department began cutting cedars on Mulanje from 1901 although prior to this there was some localized cutting by the Missions and the Public Works Department(12). A history of the subsequent exploitation up to 1960 is given in Chapman(12). Since then cutting has been undertaken by private sawyers under licence from the Forestry Department. Today there are no substantial blocks of cedar on the main massif which have not been cut-over in the past. It is important to note, however, that felling of Mulanje cedar has been largely (although not exclusively) restricted to dead or over-mature trees. This policy has been practicable as Mulanje cedar timber remains utilisable for a number of years after the tree has died.

Since 1902, sporadic planting has occurred on Thuchila, Sombani, Chambe and Lichenya plateaux. Unfortunately accurate records of the early plantings hace not been preserved and it is difficult to distinguish some of the first plantations on Thuchila from the abundant natural regeneration which is reputed to have occurred during the initial period following fire protection. Younger plantations on Lichenya are generally recognisable as such by the regular arrangement of the stems. There was no evidence that artificial thinning or any other silvicultural operation had been carried out in any of the planted stands visited during a recent survey and the development of a broadleaved understorey has given them "natural" appearance.

In addition to Mulanje Cedar, various exotic trees have been planted on Mulanje from time to time. There are scattered _Eucalyptus spp._ on Thuchila and Lichenya and blocks of _Cupressus lusitanica_ on Sombani, Chambe and Lichenya. _Pinus patula_ was first planted on Mulanje in 1946 in Sombani and Chambe basins, as a nurse crop for the frost-tender Mulanje cedar. The original intention was to underplant with cedar when the _P.patula_ was able to provide sufficient shelter. This aim was never realised, however, and the extensive plantations on Chambe are now managed exclusively for the production of softwood timber while the plantations on Sombani, having reached maturity, are soon to be clear felled.

The present stands of cedar on Mulanje can be divided into the following broad age classes:

(1) Mature or over-mature stands(120-200+years). These have been cut-over in the past and appear to be reverting to pure evergreen broadleaved forest.

(2) Middle-aged stands(70-120 years) consisting of trees which were either present as saplings when fire control was introduced at the end of the last century or regenerated during the brief period of favourable conditions which followed protection.

(3) Pole stands (30-70 years). These are mostly planted although natural pole stands occur in the Likulezi and Ruo valleys.

(1) and (2) are the dominant classes on Mulanje.

Pilot Survey - August/October 1982

The aim of the survey was to determine the structure and size-class distribution of Mulanje cedar stands on Lichenya and Thuchila plateaux. This was done by means of an inventory of all stems greater than 10cm d.b.h. in 18 temporary sample plots(TSP).

The boundaries of the evergreen forest patches on Lichenya and Thuchila were traced from aerial photographs on to the 1:30,000 Department of Surveys map of Mulanje. These were then divided into compartments of about 30-50ha using natural features such as stream and breaks of slope. The initial siting of TSP within each compartment was carried out using a 3mm x 3mm grid overlay and selecting coordinates at random. This random location proved to be a useful objective starting point but the actual siting of plots often had to be altered considerably in the field to avoid inaccessible slopes, exotic plantings and other undesirable features not apparent from the map or aerial photos. Thus the method of locating plots is best described as semi-objective.

During two weeks spent on Mulanje it was possible to sample 8 TSP on Lichenya and 10 TSP on Thuchila. Each TSP was 0.1ha(31.6m x 31.6m). The boundaries were marked by slashing a swath about 1m wide through the undergrowth. Within each TSP the diameter of every tree, including dead trees and stumps, over 10cm d.b.h. was measured and the bark blazed to avoid recounting. The diameter of stumps was measured just below the cut surface. Three types of tree were recognised: (a) live cedar (b) dead cedar and (c) broadleaved trees (including Podocarpus). For each TSP a record was made of (1) height of the cedar canopy (11) height of the understorey, (iii) height of the ground layer (iv) slope (v) aspect and (vi) altitude.

Pilot Survey Results

Summaries of data for the 18 TSP are given in Appendices 1 and 2. In order to make clearer comparisons between the stands on Lichenya and Thuchila TSP were grouped into broad age classes according to the mean diameter of live cedars in each plot. The size-class distribution for Mulanje cedar in most TSP tended to approximate towards the normal distribution, suggesting the stands were more or less even aged. Therefore the grouping into age classes, representing progressive stages in a natural succesion, was considered valid. The age classes were (a) regeneration stand(mean dbh <15cm), (b) pole stand (mean dbh 15cm–30cm), (c) middle-aged stand(mean dbh 30cm–50cm) and mature stand(> 50cm d.b.h.).

A summary of the data by stand age-class is given in Table 1 and the diameter-class distribution for each age class in Figs 1–4. The stocking of cedars on both plateaux was greatest in the pole stands and then began to decline with increasing age(Table 1). In the middle-aged and mature stands on Lichenya there was no recruitment of young cedars into the smaller age classes(Fig.2) while on Thuchila recruitment after the pole stage was minimal and confined to the occasional sapling on the edge of the stand(Fig.4).

The stocking of broadleaved trees remained more or less constant from the pole stage to maturity(Table 1). Recruitment of young broadleaved trees appears to take place in all stands although there was a decline in trees in the 10–15cm size-class as the lichenya stands reached maturity(Figs 1 & 3).

The stocking and basal area(BA) of cedars was greater on Thuchila than on Lichenya for all age-classes. In the mature stands the BA of cedar

TABLE 1: SUMMARY OF PLOT DATA BY STAND AGE CLASS

STAND AGE CLASS	REGENERATION (< 15cm)		POLE (15cm–30cm)		MIDDLE-AGED (30cm–50cm)		MATURE (> 50cm)	
	LICH	THUCH	LICH	THUCH	LICH	THUCH	LICH	THUCH
NUMBER OF PLOTS	4	1	3	2	2	5	2	2
(1) LIVE CEDAR								
STEMS /HA	310	480	513	845	155	216	37	205
MEAN DBH	11.1	9.2	22.8	25.3	42.6	42.4	72.7	59.8
MEAN BASAL AREA	3.00	3.17	20.36	42.69	22.13	30.30	15.55	53.59
(2) DEAD CEDAR								
STEMS/HA	-	20	133	265	20	136	35	105
MEAN DBH	-	60.0	25.6	40.7	60.1	64.7	70.8	63.4
BASAL AREA	-	56.55	5.82	33.09	5.43	33.79	13.78	32.43
(3) NON-CEDAR								
STEMS/HA	N/A	108	657	470	945	466	720	350
MEAN DBH	N/A	8.15	14.9	14.1	17.7	16.2	23.3	16.8
BASAL AREA	N/A	1.41	11.63	7.38	23.27	9.75	30.47	6.92

on Thuchila was over 3 times the BA on Lichenya(Table 1).

The stocking and BA of broadleaved trees was greater on Lichenya than on Thuchila for all age-classes. This difference increased with age and at the mature stage the BA of broadleaves on Lichenya was over 4 times the BA on Thuchila(Table 1).

The density of dead cedar trees and stumps was greater on Thuchila than Lichenya for all age classes but in the mature stands the ratio of dead: living cedar was higher on Lichenya (95%) than Thuchila(51%).

Discussion and Implication of the Results

The results show that the forests on Thuchila had a much higher proportion of cedar than stands of a similar age on Lichenya. At the same time the development and vigour of the evergreen understorey was greater on Lichenya than Thuchila. The reason for this difference is almost certainly climatic.

Lichenya has an average rainfall of 3580mm/year compared with only 2000mm/year on Thuchila. In the past the wetter climate on Lichenya must have reduced the frequency, intensity and spread of sporadic fires, which were necessary for the rejuvenation of the cedar stands. Also the moister conditions have favoured more luxuriant growth of evergreen broadleaved species which compete with the cedar, accentuating the decline in cedar numbers which occurs as the stand ages and completely eliminating further recruitment. Additional evidence indicating that conditions on Lichenya are marginal for cedar is the complete absence of cedar in the forest patches in the Southern portion of the plateau.

Natural regeneration in the cut-over stands on Lichenya is hindered by the deep humus layer and only intense burns during dry conditions are likely to be effective in creating conditions suitable for germination and early seedling establishment. Obviously burning under such conditions is unacceptable because of the danger of the fire getting out of control. The alternative method of restocking cut-over stands by replanting should be effective providing selective thinning of the broadleaved trees and creeper cutting are carried out to free the young trees from competition.

The climate on Thuchila is much more favourable for the development of cedar stands and regeneration should easier to obtain. Seedfall should be adequate along the forest edge and in clearings within the forest, and preparing suitable seedbeds by mannual scarificationor light early burning may be sufficient to insure natural regeneration.

Research Priorities

The pilot survey has enabled a comparison to be made of the development of cedar stands on Thuchila and Lichenya. If further TSP were assessed their size-class distributions would, in most cases, approximate towards one of the distributions given in Figures 1-4. In this way stands could be classified according to their structure and management prescriptions could be developed for each type. A classification of all the major stands on Mulanje would probably take between three and six months.

The most important priority is to develop techniques for regenerating the cedar stands since the natural rejuvenating agent - fire - has been largely controlled. In stands of the Lichenya type the most efficient method will probably prove to be planting with moderately intensive tending. On the drier northern plateaux, however, some combination of selective cutting, scarification, early burning or direct seeding may be more cost-effective. A simple experiment to test some of these options has been established recently on Thuchila(Appendix 3). Similar trials, not necessarily replicated but including as many different stands and positions as possible, would yield much useful information at relatively small cost. If these were carried out in conjunction with the classification of cedar stands outlined above it could lead to reliable prescriptions being developed for each type of stand.

Fig.1 Size-class Distribution of Broadleaved Trees in the Cedar Stands on Lichenya Plateau

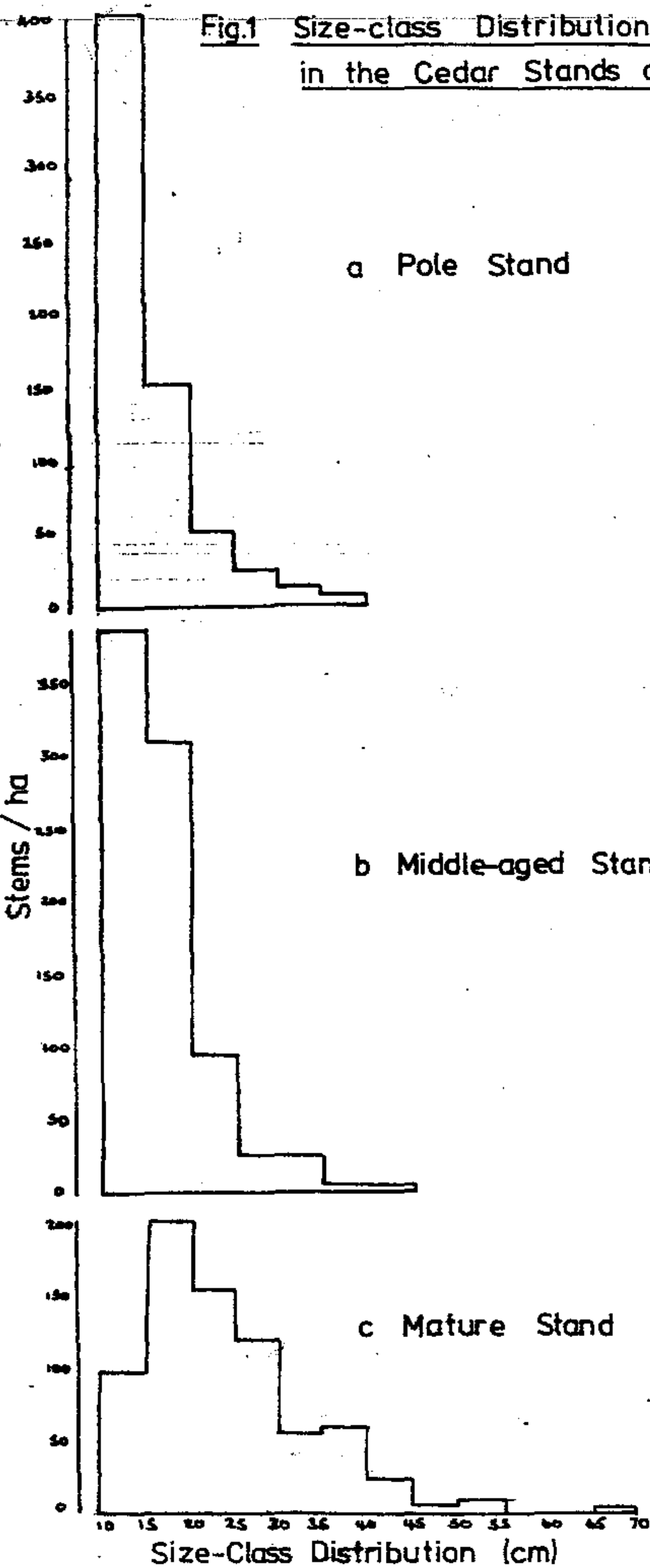


Fig. 2. Size-class Distribution for the Cedar Stands on Lichenya Plateau

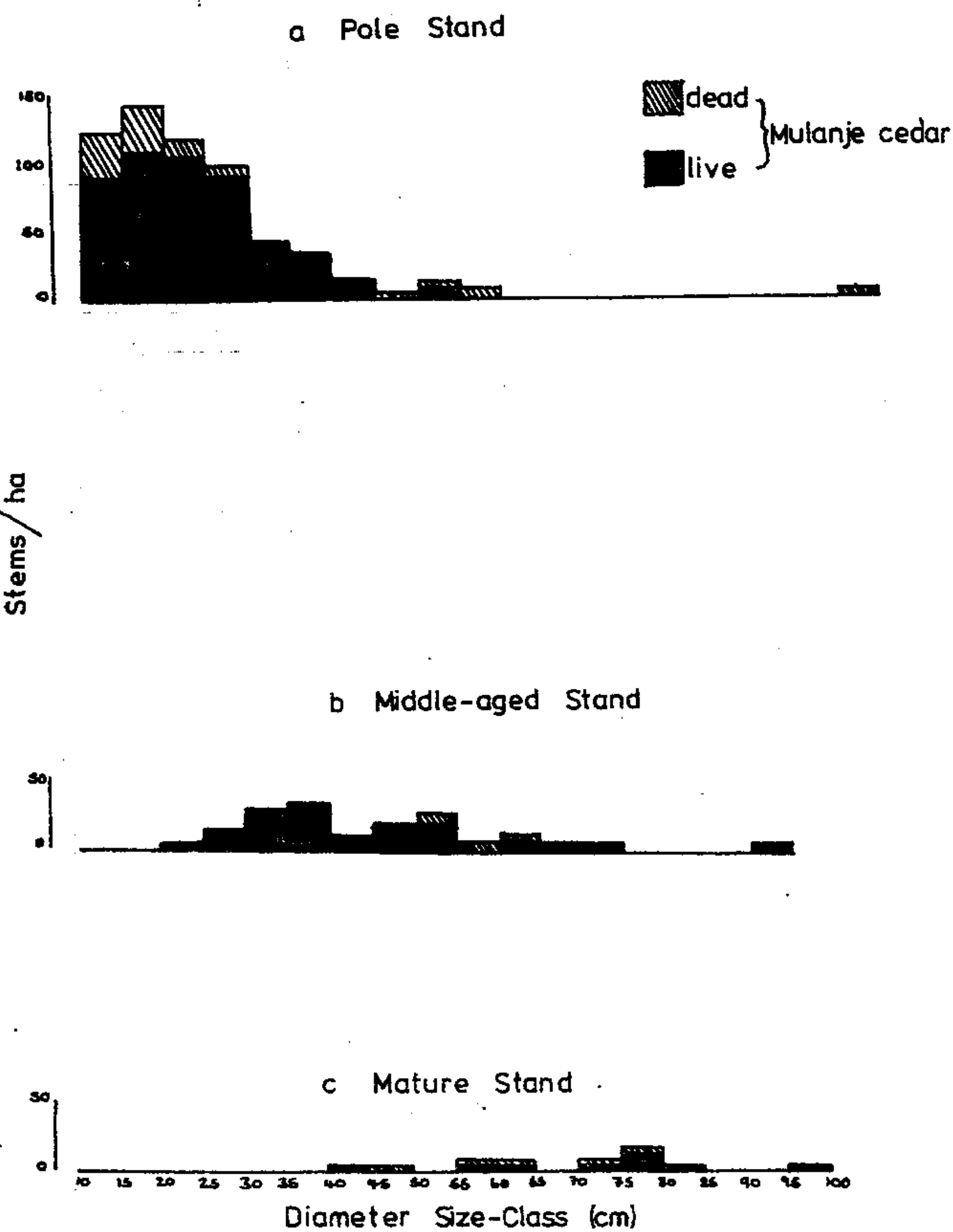


Fig.3. Size-class Distribution of Broadleaved Trees in the Cedar Stands on Thuchila Plateau

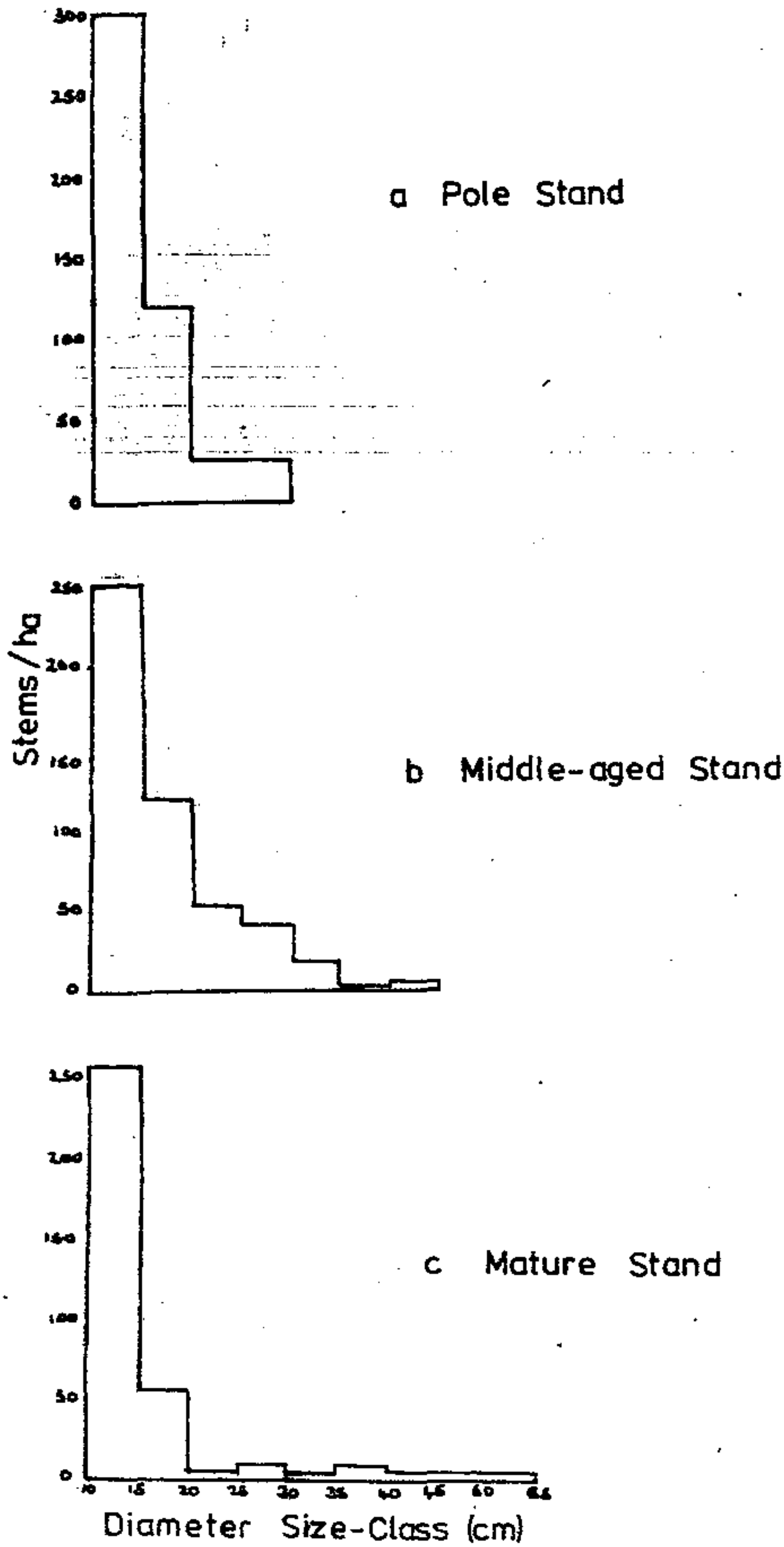
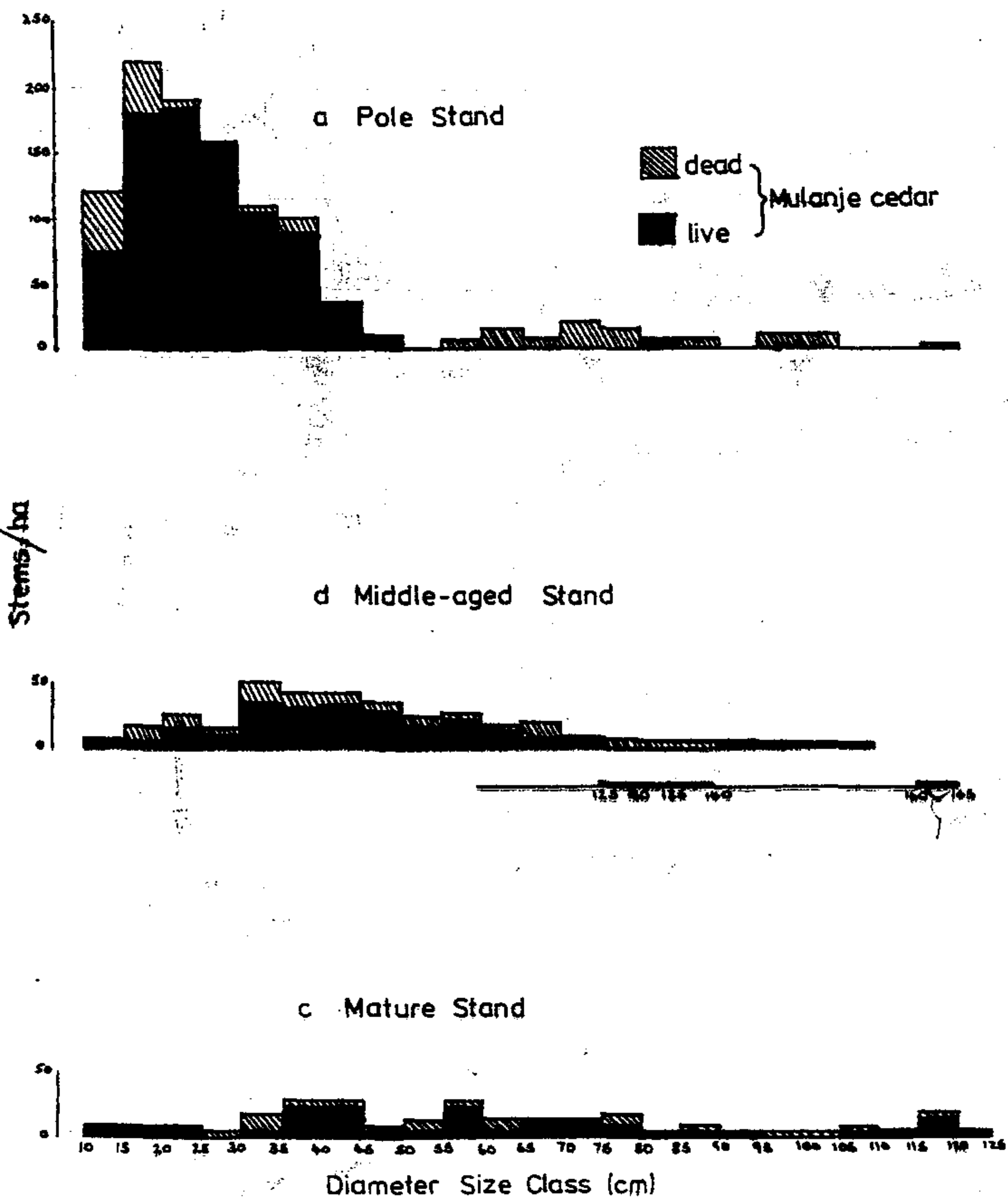


Fig. 4. Size-class Distribution for the Cedar Stands on Thuchila Plateau



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APPENDIX I

LICHENYA CEDAR SURVY - SUMMARY OF RESULTS

PLOT NUMBER	004C	016	004B	017	014B	013	002	018
SLOPE	15–25°	10–15°	8–12°	10–15°	20–25°	5–12°	5–35°	22–25°
CANOPY (m)	10	10–15	15–23	20–25	22–28	22–28	25–30	25–30
UNDERSTOREY(m)	4	5–8	10–15	10–20	5–20	6–15	6–18	10–20
GROUND LAYER(m)	1	1–2	1–2	1–2	1–2	1–2	1–2	1–2
1. CEDAR(LIVE)								
S.P.H.	310	660	410	470	160	150	30	45
MEAN D.B.H.(cm)	3.0	13.4	19.3	28.3	20.5	23.7	11.5	19.6
BASAL Area(m^2/ha)	0.9	8.3	7.9	10.2	5.1	5.3	1.6	2.6
2. CEDAR(DEAD)								
S.P.H.	–	170	170	60	10	30	70	–
Mean D.B.H.(cm)	–	1.9	7.7	7.8	3.1	7.7	27.6	–
Basal Area(m^2/ha)	–	1.6	3.2	1.9	0.5	1.3	3.9	–
3. NON-CEDAR								
S.P.H.	–	110	770	1090	880	1010	650	790
Mean D.B.H.(cm)	–	1.9	13.2	19.8	25.2	21.3	30.6	30.3
Basal Area(m^2/ha)	–	1.3	8.9	13.0	13.2	13.0	12.5	13.7

UNDERSTOREY(m)	5-10	7-10	7-15	8-12	5-15	8-12	12-15	10-12	12-18	10-19
GROUND LAYER(m)	1-2	1-3	1-2.5	2-3	2-3	2-3	2-3	15-2	2-3	2-3
(1) LIVE CEDAR										
S.P.H.	480	770	920	260	230	200	120	270	290	120
Mean D.B.H.(cm)	9.2	25.0	25.6	35.9	43.0	43.7	44.3	45.1	54.2	65.4
Basal Area(m^2/ha)	3.17	37.95	47.43	26.29	33.40	30.07	18.52	42.22	66.84	40.33
(2) DEAD CEDAR										
S.P.H.	20	210	320	110	270	90	20	190	90	120
Mean DBH(cm)	60.0	47.2	34.2	50.6	58.6	49.0	116.5	48.9	72.6	54.2
Basal Area(m^2/ha)	56.55	36.7	29.48	22.15	72.82	16.97	21.32	35.67	37.21	27.65
(3) NON-CEDAR										
S.P.H.	108	490	450	650	670	370	260	380	490	210
Mean DBH(cm)	8.15	12.9	15.3	14.7	18.3	14.2	17.7	16.2	14.0	19.6
Basal Area	1.41	6.44	8.31	10.97	17.56	5.88	6.53	7.79	7.52	6.32

APPENDIX 3

An Experiment to Determine the Effect of Burning and Scarification on the Regeneration of Mulanje Cedar

Site The experiment was carried out on the southern edge of the cedar stand approximately 500m N.N.E. of Thuchila Hut.

Method The experiment was laid out according to a randomized block design with 3 treatments replicated 3 times, making a total of 9 plots (3m x 3m-square). The treatments were:

(a) Scarification - all above ground vegetation was removed and the surface of the humus layer screefed to a depth of about 10cm.

(b) Shelter & Scarification - all above ground vegetation was removed except for a few scattered "pioneer" shrubs (*Hypericum revolutum*, *Philippia*, etc). The top 10cm of the humus layer was screefed as in (a).

(c) Burning - dry heather and braken was piled on to the plot to a depth of about 1m and burnt.

Each of the above treatments were consolidated by lightly trampling the ground. Then 1gm of *Widdringtonia nodiflora* cedar (ex Zomba Plateau) was sown broadcast on each plot.

Assessment The Forester (Cedar) and Forester Officer (SARFO) have been asked to visit the plots when they are at Thuchila and report germination of seedlings to FRIM. All seedlings should be marked with a stick to distinguish fresh germinants from older seedlings.