FRIM Report : 94010 ODC 524.61 : 174.7

Mulanje cedar

(*Widdringtonia cupressoides* Endlicher)

inventory

Source : Johnston (1897)

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Mulanje Cedar Inventory

(Widdringtonia cupressoides Endl.)

Summary

An inventory of Mulanje cedar on Mulanje mountain was conducted and the results analysed. Approximate volumes of the crop and the health of the trees were of primary importance during the data collection.

The health of the crop was found to be as follows : Class 1, (0-10% needle browning), - 13%, Class 2, (11-25% of needle browning) - 23%, Class 3, (26-60% of needle browning), - 21% and Class 4, (61-100% of needle browning , dead and dying), - 43%, (30% of the total crop is dead). The figures are expressed as a % of the total tree volume.

Volume tables for the cedar were made. The total volume of the crop is approximately 110,000m^3 of which approximately 32,000m^3 is dead.

Recommendations for the survival of Mulanje cedar are proposed.

By

M.J.Lawrence, A.Oshino and C.Chinguwo

October 1994

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The authors would like to thank all the Forestry Dept. and FRIM staff who gave their aid during the inventory and report writing. A special thanks to the following for their aid :

Mr. Stewart (ODA Team Leader of FRIM Support Project)
Mr. Mumba (DFO - Mulanje)
Mr. Zangazanga (ADFO - Mulanje)
Mr. Ndodo (Forester - Fort Lister)
The Forestry hut caretakers
The Forestry guards who guided the team on the mountain.
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2.0 Materials and Methods

Using the 1:30,000 map, "Distribution of Mulanje cedar on Mulanje Mountain" (Dept. of Surveys 1977), the areas occupied by the cedar was split into 3 areas; 'North', 'East' and 'West'. This was to ease the actual field work. It was decided that it would take approximately six weeks of field work in order to assess the cedar. Each area was therefore assessed for two weeks.

This allowed the team to come off the mountain to rest, enter data into the computer and to re-equip themselves for the next two-week assessment.

(Note : Mchese mountain was not included in the inventory).

2.1 Probability Proportional to Size, (PPS), sampling

Within each of the three areas blocks of cedar had been measured, named and mapped by Sakai(1989). PPS sampling was used in order to locate the sample plots. Each *hectare* of forest was assigned a number as shown in the example below :

Table 1 : Example of hectare numbering for PPS

Block No.	Hectares	Hectare Nos.	Random Plot No.
1	50	1 - 50	11, 45, 36
2	25	51 - 75	55
3	13	76 - 88	77, 84
4	11	89 - 99	
5	85	100 - 184	100, 105, 177, 145, 150

Using the random number generator on a calculator numbers between 1 and, in this example, 184 were randomly chosen in order to choose the forest blocks. As can be seen from the results above the larger blocks are chosen more frequently than smaller blocks. This is obviously due to their larger size in the overall sample. Random selection of the blocks was done with replacement.

For example; Block 1 has 50 out of 184 chances of being chosen, (approx. 27% of the total area), and thus has a greater chance of being chosen than Block 4 which has only 11 out of 184, (approx. 6% of total area), chances of being chosen.

The advantage of this method is that whilst every *individual* hectare has an equal chance of being chosen, the larger *blocks* have a greater chance of being chosen than the smaller blocks. This in turn reduces the amount of walking from one block to another.

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The advantage of this method is that whilst every *individual* hectare has an equal chance of being chosen, the larger *blocks* have a greater chance of being chosen than the smaller blocks. This in turn reduces the amount of walking from one block to another.

Once the blocks had been chosen the location of the plots within each block was determined with the aid of a grid laid over the block on the map and co-ordinates randomly chosen.

More plots were selected than it was possible to assess in the time available. This was done in case any of the plots were inaccessible and reduced the bias that would have resulted from locating new plots whilst in the field.

2.2 Plot design

Each plot was designed dumbbell shaped as shown in figure 1 below. Sub-plot B would be 100 meters away from sub-plot A. The reasons for this are two fold ; 1) the area of each plot is increased and thus a greater area is assessed, 2) the variance is reduced.

o←————————100m————————→o

Centre of Sub-plot A   Centre of Sub-plot B

Figure 1.

The actual size of each sub-plot is dictated by the size of the cedar in the area as a Spiegel relascope was used to perform basal area sweeps. The larger the surrounding trees the greater the area of the plot. Basal area sweeps were used as it was decided that few trees would be found in the more traditional 0.04ha plots and also because it would be very difficult to lay out plots in most of the forest areas due to the difficult terrain.

Stems per hectare could then be calculated from the diameter at breast height of the trees in relation to the number found in the plot and the basal area factor used.

Variance is reduced by adding the numbers of trees of the same diameter found in the two sub-plots together and then dividing by 2 to get a plot average. The reduction in variance is shown in the example below.

Let us take two fictitious plots, 110 and 120, as our example.

Plot 110A has 6 trees of diameter 10cm.
Plot 110B has 0 trees of diameter 10cm.
Plot 120A has 11 trees of diameter 10cm.
Plot 120B has 3 trees of diameter 10cm.

If the results of the sub-plots were taken separately then there would be a range from 0 to 11 trees of diameter class 10cm. If, however, the sub-plots for each plot were added together and divided by 2 then the result would look like this :

Plot 11 has (6+0)/2 = 3 trees of diameter 10cm
Plot 12 has (11+3)/2 = 7 trees of diameter 10cm.

The range of values is now 3 to 7 trees, thus the variance of the results has been lowered.

2.3 Parameters assessed.

Tree - Height, diameter at breast height, (DBH), damage classification (see Appendix 1 for damage classification sheet), basal area and diameters up the stem with a Spiegel relascope for volume calculation. The relascope was used even though it is less accurate than measuring diameters up the stem with a tape as it allows for volume measurements of standing trees without having to fell them.

Site - Accessibility, (easy to very difficult), degree of slope, vegetation, (general type and % groundcover), altitude, exposure and regeneration of the cedar.

2.4 Forest areas assessed

Table 2 : Forest areas assessed on each of the six plateaux

Plateau	Forest Areas
Chambe	Malembe, Phalamata, Likhubula
Lichenya	Limbe, Tayamoyo
Thuchila	Chisepo, Mzimba, Mvunje, Thuchila, Co-op, Zagaru, Likhulezi
Chinzama	Minunu
Sombani	Phalombe, Namasile, Nathaka, Matambale, Moriya, Naikotho
Madzeka	Madzeka, Nayawani

As can be seen from the list above not all forest areas were sampled. This is either due to those areas not being selected or to the fact that the plot was inaccessible.

3.0 Results

3.1 Volume of the Resource

From the results of the first 2-week inventory conducted on Chambe and Lichenya Plateaux it was decided that a Standard Error of the Mean of 15% of the volume would be adequate with the resources available. Using the formula from Philip (1994) -

$$n=\frac{s^2}{D^2\overline{x}^2}=\frac{C^2}{D^2}$$

where -

- n = number of plots
- s^2 = variance of sample
- $D = s_{\bar{x}}/\bar{x}$ (where - $s_{\bar{x}}$ = standard error, $\bar{x}$ = sample mean)
- C = coefficient of variation ($s/\bar{x}$)
- s = sample standard deviation

Using this equation it was found that 66 plots were needed to attain this degree of accuracy. 67 plots were in fact laid in the time available.

The total volume of timber on Mulanje mountain was calculated as -

$110{,}000m^3 \pm 14{,}000m^3$ at 80% confidence limits

NB : Total volume and confidence limits given to 2 significant figures (Snedecor 1961).

where the confidence limits, (CL), are defined as

$$CL=\bar{x}\pm(1.28)\times s_{\bar{x}}$$

where -

- $\bar{x}$ = sample mean
- $s_{\bar{x}}$ = standard error
- 1.28 = constant from the Students t Distribution for ∞ degrees of freedom and P = 20

3.2 Volume equation.

Shown below is the general volume equation for both variants of cedar calculated from the volume data taken with the Spiegel relascope.

$$\textbf{Ln volume} = -10.0371 + 0.979291(\text{Ln } D^2H)$$

$R^2 = 98.23\%$ Std. Error = 0.1787

Where :

Ln vol = Natural log of volume
Ln D^2H = Natural log of D^2H
D = Diameter at Breast Height (cm)
H = Height (m)
R^2 = Measure of fit
Standard Error = standard deviation of the estimate (Freese 1990).

3.3 Testing for Variation in Stocking and Volume Production Between the Plateaux

The volume and stocking per hectare on each of the six plateaux was tested for significant differences using an analysis of variance.

No significant differences were found at the 95% Confidence Limits using Least Significant Differences.

3.4 Volume tables

Using the above equation and the limits of the tree heights and diameters measured, a volume table was constructed. However, due to the unwieldy size of the resulting table, it has been placed in Appendix 6 at the end of this report.

3.5 Bole length

The Atypical cedar had a mean clear bole of 62% of the total tree height. The Typical had a mean clear bole of 47% of the total tree height. This was what was expected due to the differing phenotypes of the two variations as mentioned in section 1.2. This has a direct bearing on the value of tree being utilised. The greater bole length and the smaller branching habit of the Atypical variant gives a greater amount of readily utilisable timber than a Typical variant of equal volume.

3.6 Proportions of Stems and Volumes of each variant

The proportions of both types of cedar are as follows :

Table 3: Summary of volume and stem data for Typical and Atypical cedar.

	Typical cedar	Atypical cedar	Unclassified cedar	Total
No. stems	29,000	110,000	30,000	170,000
% of total no. of stems	16%	65%	18%	N/A
Volume (m^3)	39,000	62,000	7,100	110,000
% of total volume	36%	58%	6%	N/A
Average tree volume (m^3)	1.35	0.55	0.24	0.62

NB : Unclassified is all those trees not classified as either Typical or Atypical. Average volume figures given to 2 decimal places. All others given to 2 significant figures.

From the above table it can be inferred that there are fewer small diameter trees to large diameter trees of Typical cedar than for Atypical cedar, (mean single tree volume of 1.35m^3 as opposed to the Atypical cedars 0.55m^3). Possibly this is due to the younger Typical cedar being more susceptible to the various causes of cedars decline than young Atypical cedar. A more likely cause is the tendency to fell large Atypical cedars in preference to Typical cedar due to its greater clear bole length and smaller branches.

3.7 Diameter distribution.

Figure 2 shows the diameter distribution of Mulanje cedar on the mountain. The distribution of the cedar follows the classic reversed J-shaped curve of a natural forest with most of the stems at the smaller diameter ranges, except, in this case, for the smallest diameter class. This gives a clear indication of how little recent regeneration is surviving. 10 cm diameter classes were used for greater graph clarity. Note that the graph shows the number of stems as the % of the total number of stems.

Diameter distribution of Mulanje cedar
on Mulanje mountain

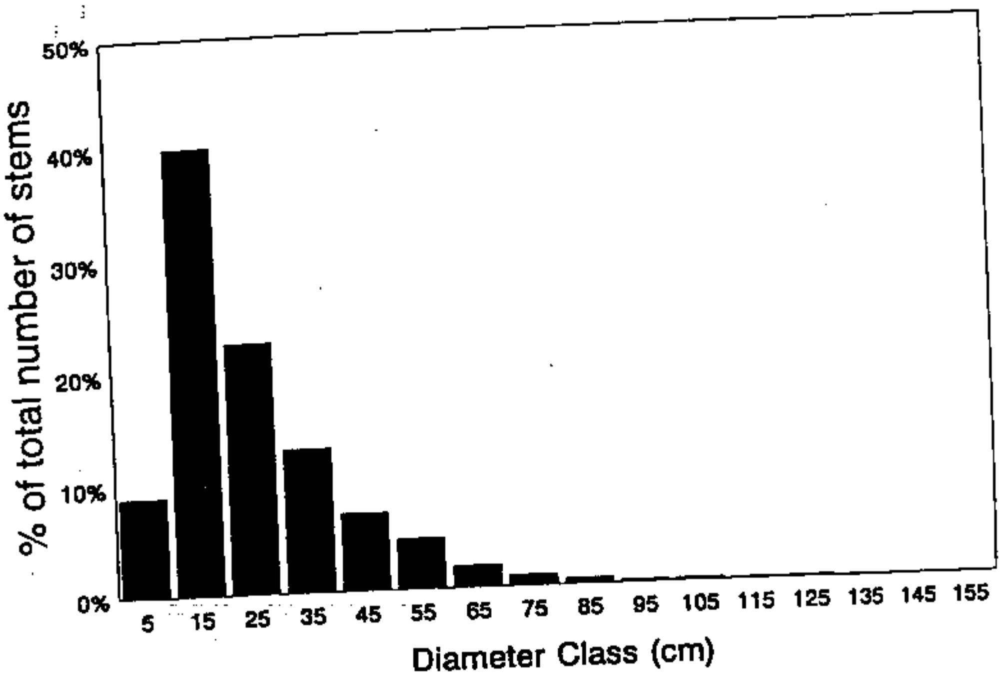

Figure 2

This curve is affected by the exploitation of the cedar. If no exploitation had occurred then there would be more cedar at the higher diameter ranges.

3.8 Volume Distribution in Each Damage Class

Volume distribution amongst representative damage classes are :

Category	Approximate volume (m^3)
1	14,000
2	25,000
3	22,000
4	46,000
(Dead)	*(32,000)*

NB : Figures are to 2 significant figures. This gives a total of 107,000m^3 which is then rounded off to 2 significant figures to 110,000m^3.

3.9 Tree damage

Figure 3 illustrates the damage trend of the cedar over the mountain.

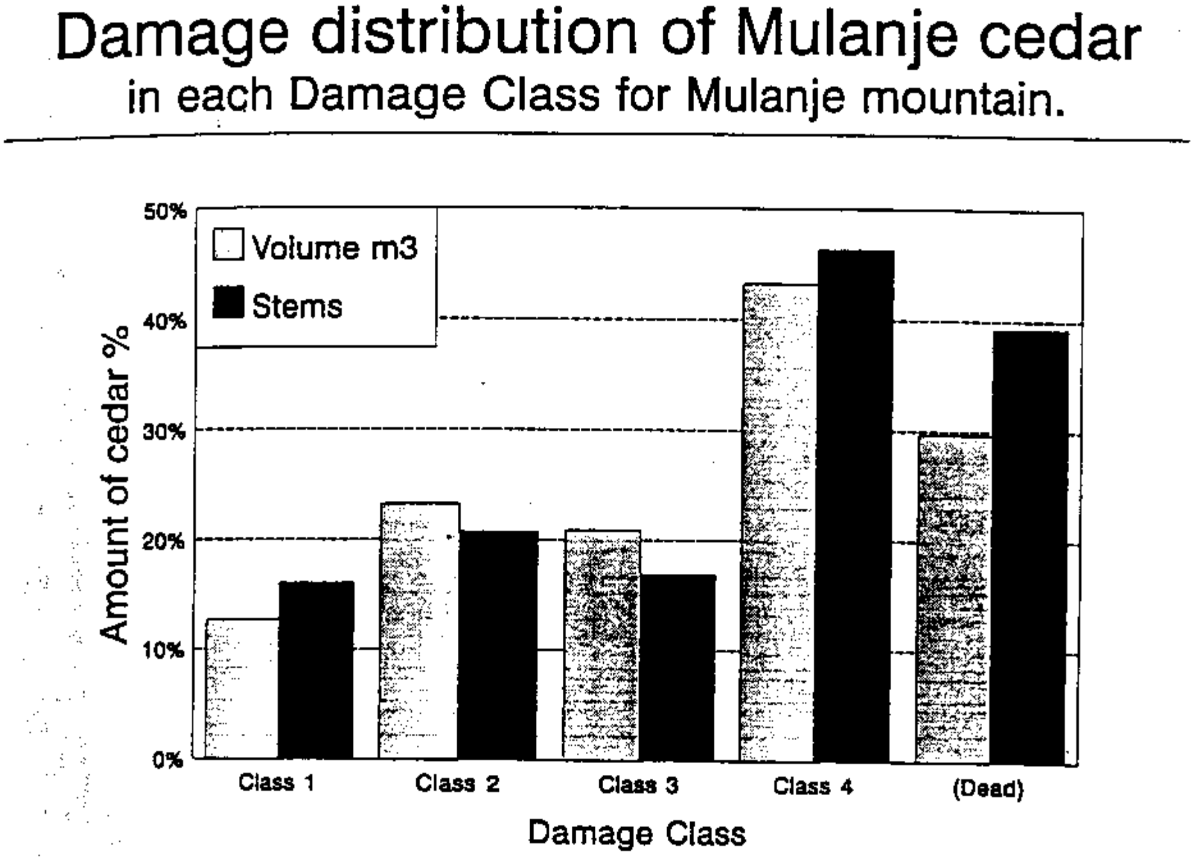

Figure 3

The amount of cedar in each Damage Class is presented as a % of the total of the parameters shown in the legend, ie. Class 3 accounts for approximately 21% of the total volume of the crop and approximately 17% of all the stems.

On the far right of the graph is the data for dead cedar. This has been extracted to give an indication of the amount of dead cedar. The Class 4 bars include the amount of dead cedar as dead cedar falls within this Class.

The Damage Classes are defined as :

Class 1 - 0-10% of needles brown
Class 2 - 11-25 % of needles brown
Class 3 - 26-60% of needles brown
Class 4 - 61-100% of needles brown and dead trees.

Figure 3 shows the overall poor health of the cedar on Mulanje. Over 40% of the crop is in Class 4.

Tables 4 and 5 show the Damage Classes of the cedar in each of the six plateaux and for the mountain as a whole expressed as both the % of the total number of stems and as a % of the total tree volume. The figures are rounded off to the nearest whole number for ease of reading.

Table 4 : Summary of the number of stems, (as a % of the total number of stems), in each Damage Class of Mulanje cedar on Mulanje mountain , (rounded to nearest whole number).

Area	Damage Class				
	1	2	3	4	(Dead)
Mulanje mountain	16%	21%	17%	46%	(39%)
Chambe	25%	22%	23%	30%	(30%)
Lichenya	36%	21%	21%	22%	(20%)
Thuchila	3%	18%	17%	62%	(52%)
Chinzama	23%	18%	13%	45%	(8%)
Sombani	3%	9%	20%	68%	(57%)
Madzeka	40%	47%	2%	11%	(11%)

NB : Both tables 4 and 5 include trees that were not classified as either Typical or Atypical but were still classified with respect to Damage Class. A full explanation of the Damage Classes can be found in Appendix 1.

Table 5 : Summary of the tree volume, (as a % of the total tree volume), in each Damage Class of Mulanje cedar on Mulanje mountain , (rounded to nearest whole number).

Area	Damage Class				
	1	2	3	4	(Dead)
Mulanje mountain	13%	23%	21%	43%	(30%)
Chambe	7%	30%	29%	34%	(32%)
Lichenya	23%	29%	32%	16%	(14%)
Thuchila	4%	16%	23%	57%	(38%)
Chinzama	33%	22%	15%	30%	(6%)
Sombani	8%	20%	21%	51%	(35%)
Madzeka	35%	37%	10%	18%	(13%)

Figures 4 to 7 show the % of each Diameter class in each of the four Damage Classes for both cedar variants. The % figures are calculated as the % of the total number of stems in **that** diameter class for **that** particular variant only. Thus the two variants can be compared directly.

Figure 4 shows the healthiest cedar, (0-10% of needle browning). The Typical cedar displays a slight downward trend as the tree diameters increase indicating that younger, smaller trees are slightly healthier overall. The Atypical variant shows a stronger correlation between increasing diameter and increasing % of healthy stems. The larger the diameter of Atypical trees the greater the proportion of stems within Class 1 except in the very smallest diameter class. This is possibly due to a tendency to fell the larger Atypical trees which are unhealthy due to its high value as timber.

Figure 5 shows the same kind of trends as figure 4 but of a more erratic nature. The curves tend to oscillate more widely.

Figure 6 illustrates a roughly equal distribution of stem proportions across the diameter range except for the higher diameters classes of Atypical cedar.

Figure 7, (overleaf), is approximately the opposite of figure 4 with the greater proportion of stems at the higher range of diameters for Typical cedar and a declining proportion of stems from the smaller to larger diameters for Atypical cedar in Class 4, the unhealthiest Class.

The 4 figures show that for Typical cedar it is the smaller diameter trees that are marginally more healthy than their larger brothers. Atypical cedar displays the opposite and the trend is much stronger. The larger trees are far more healthy in general than the smaller trees.

Distribution of Atypical and Typical cedar
in Damage Class 1

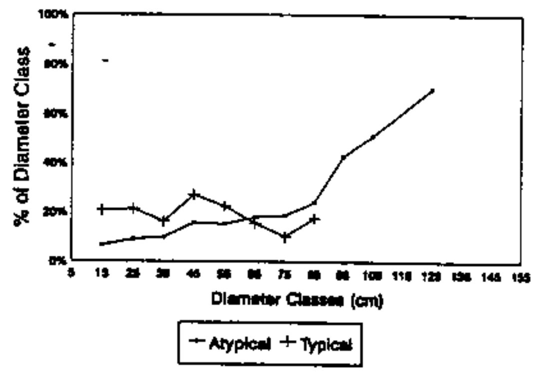

Figure 4

Distribution of Atypical and Typical cedar
in Damage Class 2

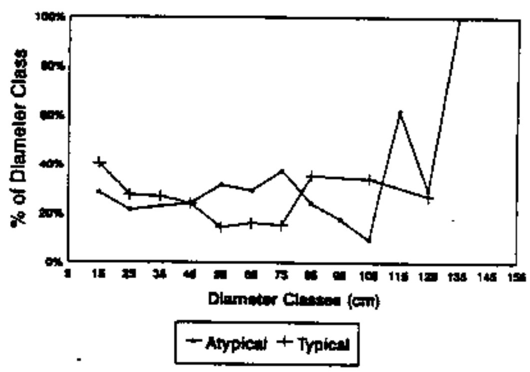

Figure 5

Distribution of Atypical and Typical cedar
in Damage Class 3

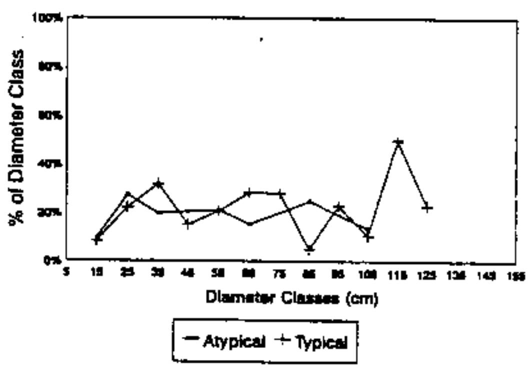

Figure 6

A possible reason for this relates to the way aphid damage spreads through the crown of the tree. Needle browning caused by aphids starts at the bottom of the crown near to the stem and then spreads upwards and outwards, (Chilima 1994). In the smaller diameter classes where the tree crown is small, any needle browning is quite obvious. The Atypical cedar has a thinner crown than the Typical cedar. Thus any damage in Atypical seedlings looks proportionately more than an equal amount of damage in Typical seedlings due to the differing size of the crowns. Also the smaller Atypical crown makes it easier to see any needle browning. This could tend to push Atypical seedlings into a higher Damage Class than a Typical tree with an equal amount of damage.

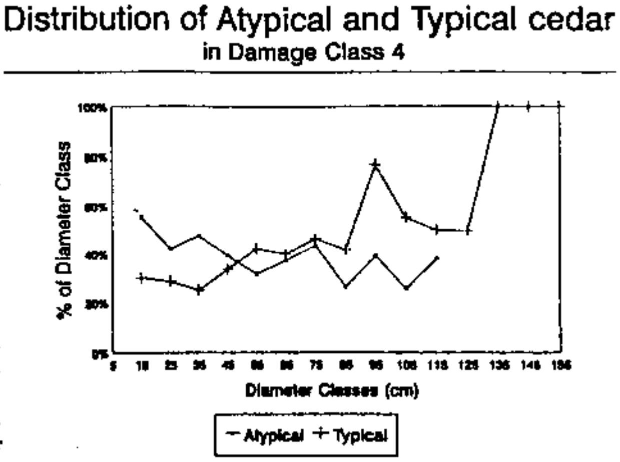

Figure 7

3.10 Access

Access to most of the cedar forests is difficult, almost impossible in some areas. This is probably one of the reasons that has helped the cedar to survive over-exploitation. Any felling of cedar must take into account the difficulty of the terrain.

Much of the cedar is on slopes which can be up to 45 degrees steep. Vegetation in most cases tends to consist of dense, tall groundcover with a variety of natural regeneration of trees. Unfortunately there is little regeneration of cedar, possibly partly due to the lack of management of the groundcover, hence the cedar seedlings are shaded out or smothered.

Appendix 5 contains brief summaries of the notes taken detailing site characteristics.

3.11 Deliberate damage to trees.

In some areas ring barking of trees and/or the burning of the base of trees was noticed. Whilst not seen in large numbers, it is an alarming situation when taken with the fact that there are already so many dead and dying trees which could be utilised. In Namasile forest area 2 trees of diameters in excess of 1 meter and heights of 30+ meters were found both of which had been deliberately killed by burning of the base of the trees.

3.12 Regeneration.

Regeneration of the cedar is extremely low. Of the seedlings seen over 40% were in Damage Categories 3 and 4, (note that these seedlings were not found within the plots). The frequent fires kill many seedlings. Aphids were also found on nearly all the seedlings inspected.

3.13 Zomba Plateau Mulanje cedar

The cedar located on Zomba Plateau is currently suffering due to the combined effects of the cedar aphid and drought. The exact effect of the aphid is difficult to gauge due to the effect of the drought. Constant monitoring is currently being carried out by the Entomology Section at FRIM.

4.0 Conclusions

Unless the major contributors to the destruction of the cedar are stopped then there is little hope for it's continued survival far into the next century. The aphid, fire, pine and human factors must be addressed urgently.

New plantings of cedar are an obvious answer to the threat to the survival of the cedar. They are, however, of little use if the *causes* of the decline of cedar are not tackled effectively and quickly. There is little point in expending time, money and manpower on a planting programme if the aphid or fires subsequently kill off the planted seedlings. The same can be said of expending scarce resources on promoting natural regeneration if the regeneration is to meet the same fate as the planted seedlings.

The amount of dead cedar causes something of a problem. Should the Forestry Dept. impose a ban on felling of the dead cedar or should licenses to fell and utilise the dead cedar be given out?

If a ban is imposed upon the utilisation of dead cedar then a lot of valuable timber goes to waste and local pitsawyers could lose employment causing resentment. Resentment which is often taken out on the forests themselves in the form of arson. However a ban could stop the deliberate destruction of the live trees and makes the cedar forests easier to police than if licensed felling were allowed. Any cedar coming off the mountain would have to be illegally felled if a complete ban was imposed.

If felling is allowed then this could cause more live trees to be deliberately killed weakening the cedar's chances of survival. It does give employment to the local people however which is very important especially in the current economic climate.

5.0 Recommendations

Below are a set of recommendations for the protection and regeneration of Mulanje cedar. It cannot be emphasised enough that *all* the recommendations be acted upon as soon as possible and as fully as possible. There is no point in getting rid of the aphids if the pine invasion and fires are allowed to continue unabated. This will lead to a wastage of valuable resources. This is the problem which has been encountered in the past with the pine eradication programme. A great deal of time, energy and money was put into the pine eradication programme but because it was not finished properly it has made little difference in the long term.

A decision must be made as whether to put enough resources into the protection of cedar as outlined in the recommendations and see the recommendations through to completion, or not to put the resources into cedar protection at all and use them elsewhere. A point to note whilst making this decision is that Mulanje cedar is Malawi's National Tree, it's growth potential is unique to Mulanje mountain and that Malawi is head of the SADC Region for forestry. For Malawi to lose Mulanje cedar will be a great blow to ecological biodiversity as well as Malawi's credibility as head of SADC forestry.

1. The aphid problem is currently being worked on by the Entomology Section at FRIM under the ODA funded Biological Control of Aphids Project. At present the parasitoid *Pauesia juniperorum* has been released on Zomba plateau and is being monitored for it's impact on the aphid population and how well it establishes itself, (Chilima 1994).

2. Fire control is of great importance. Fire breaks are maintained yearly in an effort to stop fires spreading into the forests. Unfortunately they do not stop the fires the local hunters light within the cedar forests in order to smoke out game. Although hunting is illegal there are fires most of the year round to facilitate hunting. Tighter controls are needed to stop the poachers. This would involve more manpower to safeguard the forests.

3. Control of pine invasion. The invasion of *Pinus patula* has been reported in the past by Sakai (1989). In his report he recommended the complete eradication of the pine from the mountain, especially Sombani plateau. During the inventory it was noted that the pine invasion continues, seemingly unabated. Sombani plateau is by far the worst affected area. In some parts of Matambale forest area are dense thickets of young pines of perhaps 50,000 - 60,000 stems per hectare. In other areas on the plateau are dense carpets of seedlings. The cedar has little chance of regenerating under such conditions. Serious thought and commitment must be made in order to clear the pine. The pine should be felled, seedlings uprooted and all pine cones burnt to destroy the seed.

4. Regeneration planting and encouragement of natural regeneration by management of the groundcover vegetation is necessary. However as noted earlier this will only be useful if the causes of the cedars decline are tackled.

5. It has been proposed that seed be collected from Mulanje and planted in areas yet to be affected by the aphid in order to preserve the genetic stock (Nsapato 1993). This should be carried out as soon as possible. If the sad event of the total eradication of cedar from the mountain were to occur then these proposed plantings could provide the seed source to replant Mulanje.

6. **Banning** the burning of cedar in the Forestry huts on Mulanje mountain should be instituted with **immediate effect**. Where there is pine near the huts this should be used for firewood instead. Sombani hut especially should adopt the burning of pine as there is a vast amount of pine that has been killed in a forest fire that is now going to waste.

7. All aspects of protection and exploitation should be assimilated into a management plan designed to ensure the sustainable utilisation of the resource.

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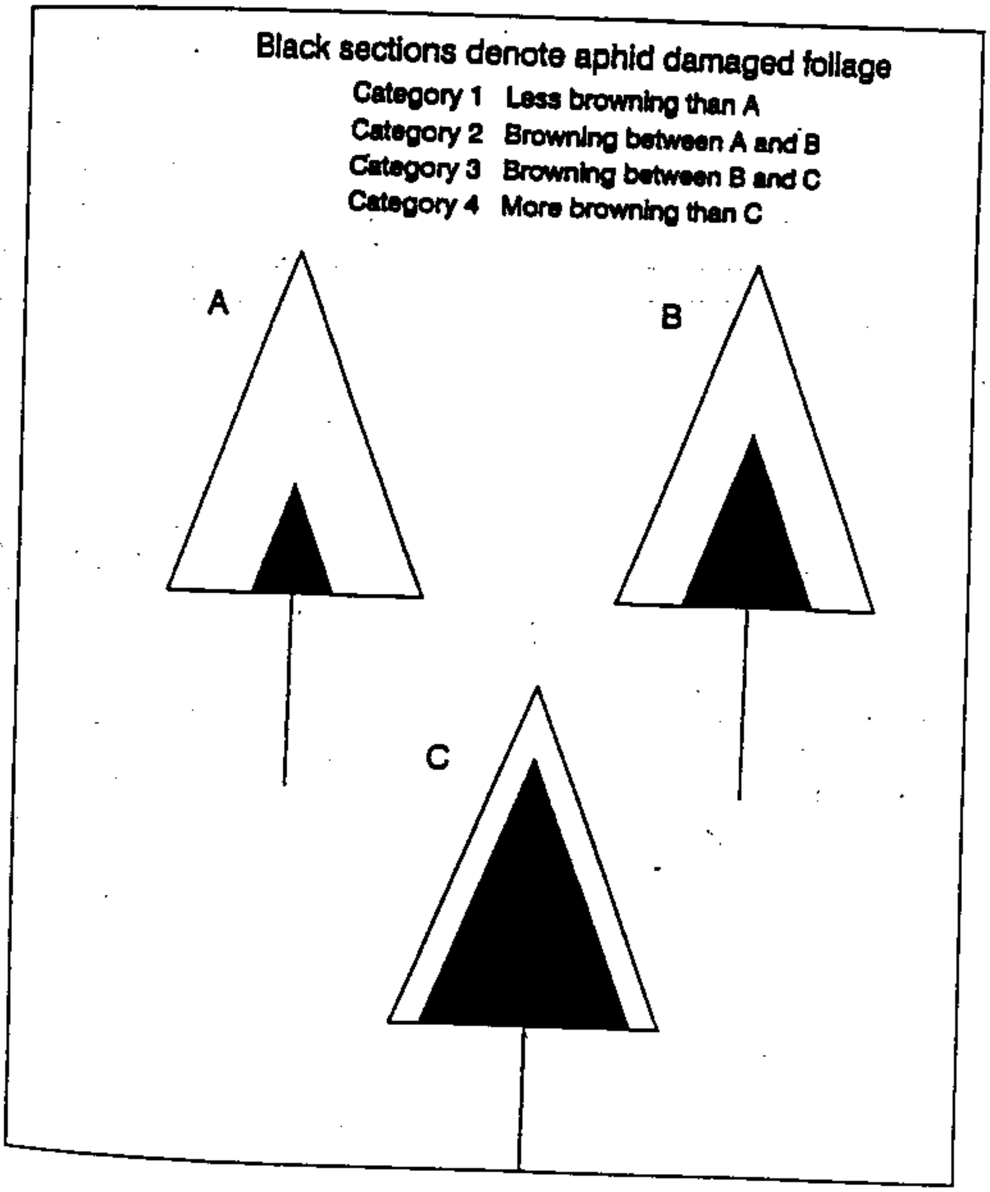
Appendix 1

The Damage Assessment sheet opposite, (Day et al, 1993), was used to assess the cedar for damage and to assign each tree a Damage Class.

Class 1 : 0-10% Needle Browning
Class 2 : 11-25%Needle Browning
Class 3 : 26-60% Needle Browning
Class 4 : 61-100% Needle Browning



Appendix 2

Figure 9 opposite shows the distribution of all the cedar with respect to the six plateaux and as a % of the total numbers of stems on each plateaux, in each of the Damage Classes.

It can be seen that Thuchila and Sombani have the greatest proportion of Class 4 stems. The general health of both plateaux is very poor.

The healthiest plateau is Madzeka with the greatest number of stems combined in Classes 1 and 2.

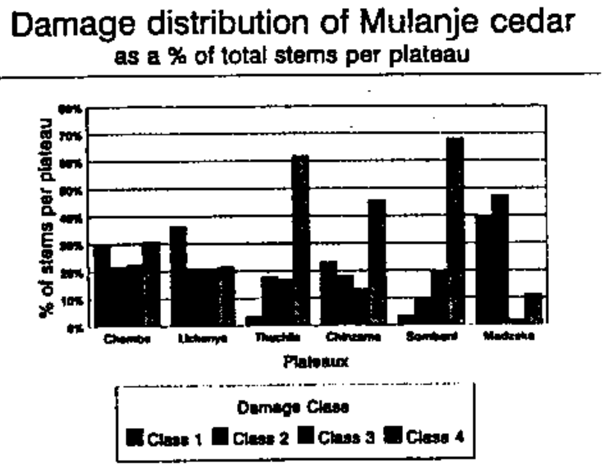


Figure 9

Figure 10 illustrates the damage trend with regard to the proportion of volume each Damage Class accounts for.

Note that Damage Class 4 on Chinzama plateau is smaller than in figure 9. This can be accounted for by the fact that mainly small trees with little volume suffered from damage the most. Thus a high percentage of Chinzama's stems account for a small proportion of it's volume. The same is true for Damage Class 1 on Chambe plateau and the opposite is true for Damage Class 2 on Madzeka plateau.

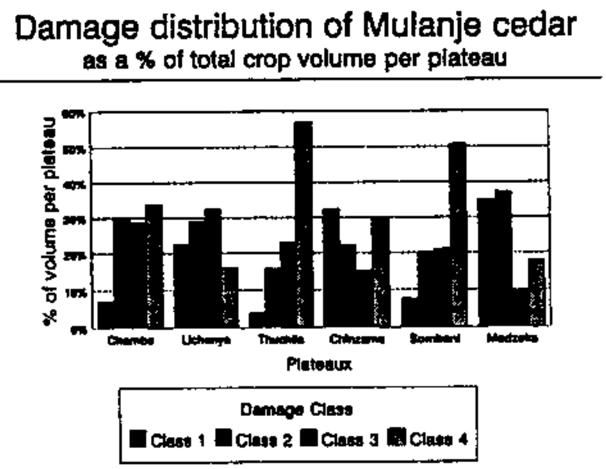


Figure 10

Figures 11 to 14 show some of the differences that were found between the two forms of cedar. For figures 11 and 12 the y-axis is the % of total number of stems on each plateau and not a % of the overall number of stems for Mulanje mountain. Note that total crop volume refers to the total crop volume of that particular variant within each plateau area for figures 13 and 14. Health at Chambe is similar for both variants in regard to volume with the Typical form being only slightly less healthy. With respect to stem numbers however the Atypical cedar is much healthier. Thus it can be concluded that the smaller stems of Atypical cedar make up much of Class 1 and the larger stems are pushed to the other Classes. Conversely the Typical form is more healthy on Lichenya plateau than the Atypical form.

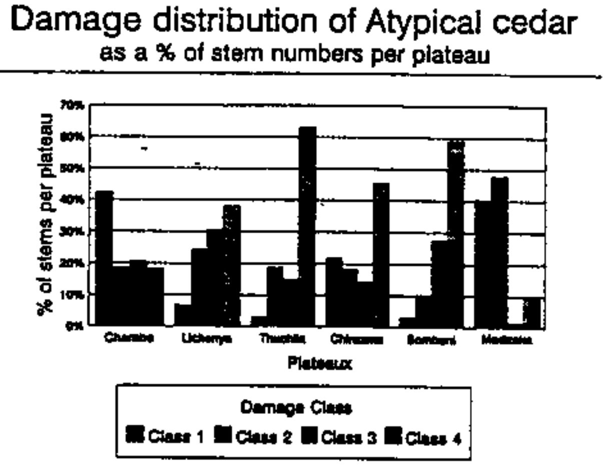


Figure 11

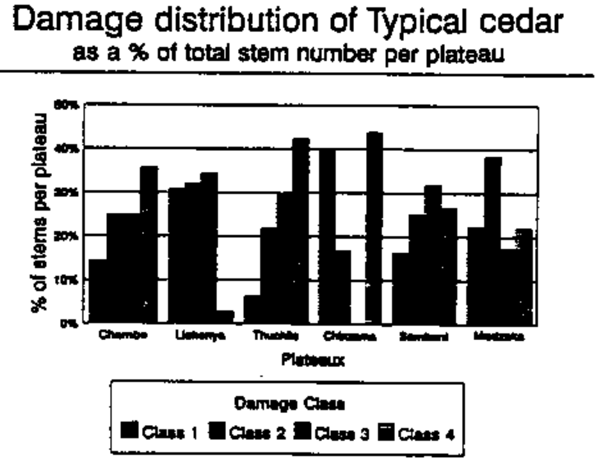


Figure 12

Both variants of cedar on Thuchila plateau are very unhealthy with most of the volume of cedar and number of stem dominating Class 4. This is unfortunate as Thuchila has the highest mean volume per hectare as noted in Section 3.3.

It is interesting to note that on Chinzama plateau no Typical cedar was found in Class 3. This does not mean that there are no cedar in this Class at Chinzama, only that they were not found during the inventory and thus it can be assumed that there are very few stems in this Class. The Typical variant has a greater % of stems than the Atypical cedar, and most, (approx. 55%), of its volume in Class 1. Typical cedar also shows a high percentage of stems in Class 4 with a correspondingly low proportion of volume in this Class. From this it can be inferred that the larger trees are healthier compared to smaller trees for this variant at Chinzama.

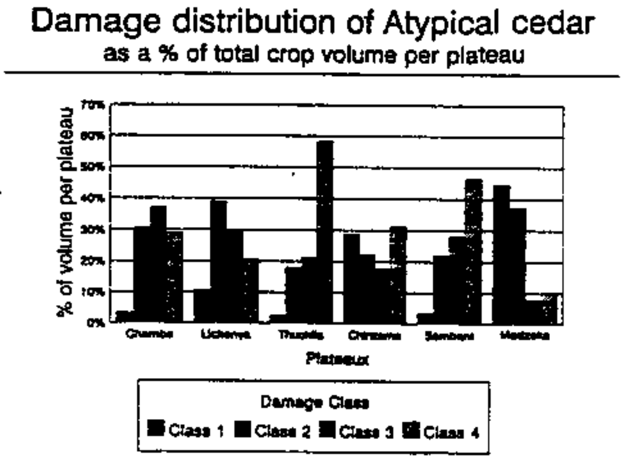


Figure 13

Sombani plateau displays a lot of unhealthy cedar of both variants. Many of the cedar of the Typical variant in Class 4 are the larger stems. The high % of volume, (approx. 45%), compared to a comparatively low proportion of stems, (approx.25%), illustrates this. This is the opposite of what was found at Chinzama. This possibly due to the fact that many of the plots at Sombani were on more difficult terrain and this may protect the trees from man who is less likely to either hunt game or pitsaw trees there when other cedar areas are more accessible.

Atypical cedar is healthier at Madzeka, most of the cedar belonging to either Class 1 or Class 2.

Damage distribution of Typical cedar
as a % of total crop volume per plateau

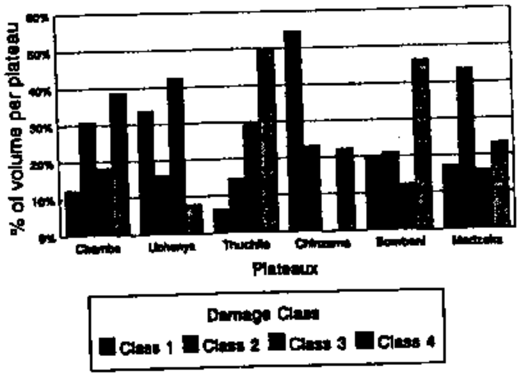


Figure 14

Appendix 3

Figures 15 and 16 show the diameter distributions of both variants on Mulanje mountain. Figure 15 shows the data as the proportion of each variant in each 10 cm diameter class as a % of the **total** number of stems on Mulanje mountain, Atypical and Typical combined. Figure 16 illustrates the data as the proportion of each variant in each diameter class as a % of the total number of stems of that variant on Mulanje mountain.

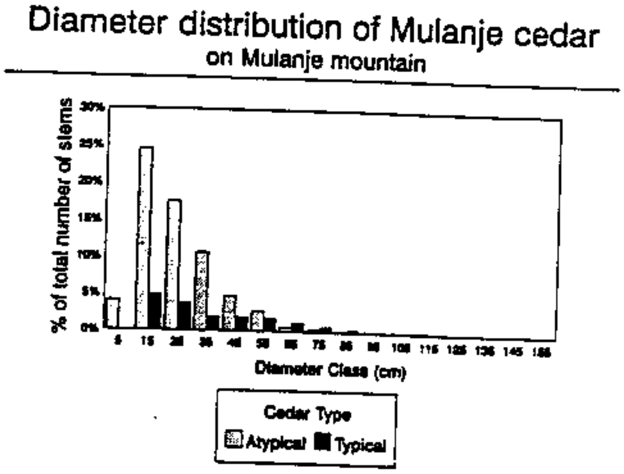


Figure 15

Both graphs illustrate the fact that there were no Typical cedar found at the smallest diameter class. A possible cause of this is the difficulty associated with identifying to which variant a seedling belongs.

Figure 15 clearly illustrates the numerical dominance of the Atypical variant.

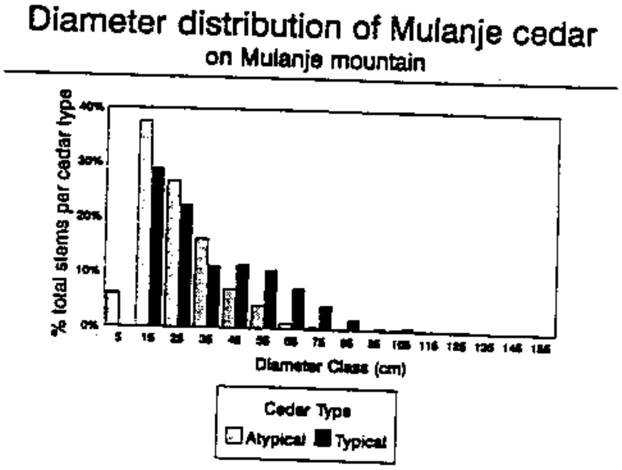


Figure 16

Figure 16 illustrates the fact that if there were an equal numbers of stems of each variant, (illustrated by using proportions of the total numbers of each variant separately), then the Atypical cedar dominates the lower diameter classes whilst the larger diameter classes are dominated by the Typical variant. Possible reasons are that the Atypical saplings are more resistant to damage or are not preferred by the aphids out of the two variants. Another possible reason could be that when trees are felled, the Atypical variant is preferred as it has a greater clear bole to tree height ratio and smaller knots, (lighter branching habit), than the Typical variant. However, this is just mere conjecture and if the answer is desired more study is required.

Appendix 4

General damage table for Typical and Atypical cedar on Mulanje mountain.

Table 6 : Distribution of proportion, (%), of stems in each diameter class and each Damage Class for both Typical and Atypical cedar.

Dia class (cm)	Damage Class									
	Class 1		Class 2		Class 3		Class 4		(Dead)	
	Atyp	Typ	Atyp	Typ	Atyp	Typ	Atyp	Typ	Atyp	Typ
5	100									
15	6.6	20.8	28.5	40.5	9.6	8.4	55.4	30.2	50.8	
25	9.1	21.4	21.5	27.5	27.3	22.2	42.1	28.8	22.2	4.8
35	9.9	16.2	22.9	26.9	19.7	31.8	47.5	25.1	37.3	12.6
45	15.8	27.2	24.2	24.1	20.6	15.1	39.4	33.7	21.0	13.3
55	15.3	22.5	31.6	14.6	21.3	20.7	31.7	42.2	16.6	28.3
65	18.1	15.6	29.3	16.2	15.3	28.4	37.3	39.9	16.9	19.5
75	18.9	10.2	37.6	15.4		28.1	43.6	46.2	34.9	38.1
85	24.3	17.7	24.2	35.5	25.1	5.0	26.4	41.7	13.1	20.9
95	42.9		17.8			23.2	39.3	76.8	21.5	50.5
105	51.3		9.4	34.2	13.6	10.6	25.7	55.2		35.8
115			61.9			49.9	38.1	50.1	24.4	
125	70.5		29.5	27.1		23.1		49.7		
135			100					100		100
145								100		100
155								100		100

NB : The proportion of stems is for each variant is the proportion of the total number of stems for that variant only.

Appendix 5

Summary of site characteristics.

Below is a general and concise site description for the six plateaux.

Chambe : Rocky outcrops, deep humus layer, lush, dense undergrowth, grazing apparent, sheltered- medium exposure, altitude 1820 - 1900m, access medium - difficult, slope 7.5 - 20o.

Lichenya : Lush, dense undergrowth, access easy - very difficult, sheltered - exposed, slope 9 - 45°, altitude 1790 - 1960m, a little cedar regeneration, very damp area.

Thuchila : Fire damage, slope 6 - 40° , sheltered - exposed, dense undergrowth, altitude 1775 - 2010m, access easy - difficult, 20 cedar seedlings.

Chinzama : Slope 35 - 44° , exposed, altitude 1890 - 1940m, access difficult, thick humus cover, dense undergrowth.

Sombani : Access easy - extremely difficult, altitude 1660 - 2265m, slope 9 - 46° , sheltered - exposed, huge rock outcrops, 17 cedar seedlings, pine invasion.

Madzeka : Access easy - difficult, slope 0 - 36° , altitude 1780 - 2000m, dense undergrowth, sheltered, lot of cedar regeneration (one plot only in Madzeka I forest area), fire damage, heavy humus layer.

Appendix 6

Overleaf is the volume table for cedar. Due to its large and unwieldy size it has been placed in the appendices.

Table 7 : Mulanje Cedar Volume Table

Height (m)

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
0.0192	0.0230	0.0267	0.0306	0.0342	0.0379	0.0416	0.0453	0.0490	0.0527	0.0564	0.0601	0.0638	0.0674	0.0711	0.0748	0.0784	0.0821	0.0857	0.0894	0.0930			
0.0232	0.0277	0.0322	0.0367	0.0412	0.0457	0.0502	0.0546	0.0591	0.0635	0.0680	0.0724	0.0768	0.0813	0.0857	0.0901	0.0945	0.0989	0.1033	0.1077	0.1121			
0.0273	0.0329	0.0382	0.0436	0.0489	0.0542	0.0596	0.0646	0.0701	0.0753	0.0806	0.0859	0.0911	0.0964	0.1016	0.1069	0.1121	0.1173	0.1225	0.1277	0.1329	0.1381		
0.0322	0.0384	0.0447	0.0509	0.0572	0.0634	0.0698	0.0758	0.0820	0.0881	0.0943	0.1004	0.1066	0.1127	0.1188	0.1250	0.1311	0.1372	0.1433	0.1494	0.1555	0.1618		
0.0372	0.0444	0.0517	0.0588	0.0661	0.0733	0.0808	0.0876	0.0948	0.1019	0.1090	0.1161	0.1232	0.1303	0.1374	0.1446	0.1516	0.1586	0.1657	0.1727	0.1798	0.1869		
0.0420	0.0508	0.0592	0.0674	0.0757	0.0839	0.0921	0.1003	0.1086	0.1166	0.1248	0.1329	0.1411	0.1492	0.1573	0.1654	0.1736	0.1816	0.1896	0.1977	0.2058	0.2138	0.2219	
0.0483	0.0577	0.0671	0.0765	0.0859	0.0952	0.1046	0.1138	0.1231	0.1323	0.1416	0.1508	0.1601	0.1693	0.1785	0.1877	0.1969	0.2060	0.2152	0.2244	0.2335	0.2427	0.2518	
0.0544	0.0650	0.0756	0.0862	0.0967	0.1072	0.1177	0.1281	0.1386	0.1490	0.1594	0.1698	0.1802	0.1906	0.2010	0.2113	0.2217	0.2320	0.2423	0.2526	0.2629	0.2732	0.2836	0.2806
0.0606	0.0727	0.0845	0.0964	0.1081	0.1199	0.1316	0.1433	0.1550	0.1667	0.1783	0.1900	0.2016	0.2132	0.2248	0.2364	0.2479	0.2595	0.2710	0.2826	0.2941	0.3056	0.3171	0.3204
0.0676	0.0808	0.0940	0.1071	0.1202	0.1333	0.1463	0.1593	0.1723	0.1853	0.1983	0.2112	0.2241	0.2370	0.2499	0.2629	0.2756	0.2885	0.3013	0.3141	0.3269	0.3397	0.3525	0.3653
0.0746	0.0894	0.1039	0.1184	0.1329	0.1474	0.1618	0.1762	0.1906	0.2048	0.2192	0.2335	0.2478	0.2621	0.2763	0.2906	0.3046	0.3190	0.3332	0.3473	0.3615	0.3757	0.3898	0.4036
0.0822	0.0983	0.1143	0.1303	0.1463	0.1621	0.1780	0.1938	0.2098	0.2254	0.2412	0.2569	0.2726	0.2883	0.3040	0.3197	0.3353	0.3508	0.3666	0.3822	0.3977	0.4133	0.4288	0.4444
0.0901	0.1077	0.1253	0.1427	0.1602	0.1776	0.1950	0.2123	0.2298	0.2468	0.2642	0.2814	0.2986	0.3158	0.3330	0.3502	0.3673	0.3844	0.4015	0.4186	0.4357	0.4527	0.4696	0.4868
0.0983	0.1175	0.1368	0.1557	0.1748	0.1938	0.2127	0.2316	0.2506	0.2694	0.2882	0.3070	0.3258	0.3446	0.3633	0.3820	0.4007	0.4194	0.4381	0.4567	0.4753	0.4938	0.5125	0.5311
0.1066	0.1277	0.1485	0.1693	0.1900	0.2106	0.2312	0.2518	0.2723	0.2926	0.3133	0.3337	0.3541	0.3746	0.3949	0.4152	0.4355	0.4559	0.4761	0.4964	0.5166	0.5369	0.5571	0.5773
0.1157	0.1383	0.1608	0.1834	0.2059	0.2281	0.2505	0.2727	0.2950	0.3172	0.3394	0.3616	0.3836	0.4057	0.4278	0.4499	0.4718	0.4938	0.5158	0.5377	0.5596	0.5816	0.6036	0.6253
	0.1494	0.1737	0.1980	0.2223	0.2464	0.2706	0.2946	0.3186	0.3425	0.3665	0.3904	0.4142	0.4381	0.4619	0.4857	0.5095	0.5332	0.5569	0.5806	0.6043	0.6280	0.6518	0.6753
	0.1608	0.1871	0.2133	0.2393	0.2653	0.2912	0.3171	0.3430	0.3688	0.3946	0.4203	0.4460	0.4717	0.4973	0.5230	0.5486	0.5741	0.5997	0.6252	0.6507	0.6762	0.7018	0.7271
	0.1727	0.2009	0.2290	0.2569	0.2848	0.3127	0.3406	0.3683	0.3960	0.4237	0.4513	0.4789	0.5066	0.5341	0.5616	0.5891	0.6165	0.6439	0.6713	0.6987	0.7261	0.7534	0.7807
	0.1850	0.2152	0.2453	0.2752	0.3051	0.3350	0.3648	0.3945	0.4242	0.4536	0.4835	0.5130	0.5426	0.5721	0.6015	0.6310	0.6604	0.6898	0.7191	0.7484	0.7777	0.8070	0.8363
	0.1977	0.2299	0.2621	0.2941	0.3261	0.3580	0.3899	0.4216	0.4533	0.4850	0.5166	0.5482	0.5799	0.6113	0.6428	0.6743	0.7057	0.7371	0.7685	0.7998	0.8311	0.8624	0.8937
		0.2452	0.2794	0.3136	0.3477	0.3817	0.4157	0.4496	0.4834	0.5172	0.5509	0.5846	0.6183	0.6519	0.6855	0.7190	0.7525	0.7860	0.8195	0.8529	0.8863	0.9196	0.9530
		0.2609	0.2974	0.3337	0.3700	0.4062	0.4423	0.4784	0.5144	0.5503	0.5863	0.6221	0.6579	0.6937	0.7294	0.7651	0.8008	0.8364	0.8720	0.9076	0.9431	0.9786	1.0141
		0.2771	0.3158	0.3545	0.3930	0.4314	0.4698	0.5081	0.5463	0.5845	0.6227	0.6608	0.6988	0.7368	0.7748	0.8127	0.8506	0.8884	0.9262	0.9640	1.0017	1.0394	1.0771
		0.2938	0.3348	0.3758	0.4166	0.4574	0.4981	0.5387	0.5792	0.6197	0.6602	0.7006	0.7408	0.7812	0.8214	0.8618	0.9018	0.9419	0.9820	1.0220	1.0620	1.1020	1.1420
		0.3110	0.3544	0.3977	0.4410	0.4841	0.5272	0.5702	0.6131	0.6558	0.6987	0.7415	0.7842	0.8268	0.8694	0.9118	0.9544	0.9969	1.0393	1.0817	1.1241	1.1664	1.2087
			0.3745	0.4203	0.4660	0.5116	0.5571	0.6026	0.6479	0.6931	0.7384	0.7836	0.8286	0.8737	0.9187	0.9637	1.0086	1.0536	1.0983	1.1431	1.1878	1.2326	1.2773
			0.3952	0.4435	0.4917	0.5399	0.5879	0.6357	0.6836	0.7314	0.7791	0.8267	0.8743	0.9219	0.9694	1.0168	1.0642	1.1115	1.1589	1.2061	1.2533	1.3006	1.3477
			0.4164	0.4673	0.5180	0.5687	0.6195	0.6698	0.7202	0.7706	0.8208	0.8711	0.9212	0.9713	1.0213	1.0713	1.1212	1.1711	1.2210	1.2708	1.3206	1.3703	1.4198
			0.4381	0.4916	0.5451	0.5984	0.6516	0.7046	0.7579	0.8108	0.8637	0.9166	0.9693	1.0220	1.0746	1.1272	1.1798	1.2323	1.2847	1.3371	1.3896	1.4418	1.4940
			0.4604	0.5166	0.5728	0.6288	0.6846	0.7406	0.7963	0.8520	0.9076	0.9631	1.0186	1.0739	1.1293	1.1845	1.2397	1.2948	1.3500	1.4051	1.4601	1.5151	1.5700
				0.5422	0.6012	0.6600	0.7187	0.7773	0.8356	0.8942	0.9526	1.0108	1.0693	1.1272	1.1852	1.2432	1.3012	1.3581	1.4168	1.4747	1.5324	1.5801	1.6479
				0.5684	0.6302	0.6919	0.7534	0.8148	0.8762	0.9374	0.9986	1.0597	1.1207	1.1816	1.2425	1.3033	1.3641	1.4247	1.4854	1.5460	1.6095	1.6670	1.7274
				0.5952	0.6600	0.7246	0.7890	0.8533	0.9176	0.9816	1.0457	1.1097	1.1736	1.2374	1.3011	1.3648	1.4284	1.4913	1.5564	1.6188	1.6823	1.7456	1.8088
				0.6227	0.6904	0.7579	0.8253	0.8926	0.9598	1.0268	1.0938	1.1606	1.2276	1.2943	1.3610	1.4276	1.4942	1.5607	1.6271	1.6933	1.7587	1.8260	1.8922
				0.6507	0.7214	0.7920	0.8624	0.9328	1.0030	1.0730	1.1431	1.2130	1.2828	1.3526	1.4223	1.4919	1.5614	1.6308	1.7003	1.7694	1.8368	1.9082	1.9774
					0.7531	0.8269	0.9004	0.9739	1.0471	1.1200	1.1934	1.2664	1.3393	1.4121	1.4844	1.5575	1.6301	1.7026	1.7751	1.8470	1.9166	1.9921	2.0643
					0.7855	0.8624	0.9391	1.0157	1.0921	1.1680	1.2447	1.3208	1.3969	1.4728	1.5487	1.6246	1.7002	1.7758	1.8515	1.9264	2.0024	2.0776	2.1531
					0.8186	0.8987	0.9786	1.0584	1.1381	1.2177	1.2971	1.3764	1.4557	1.5348	1.6138	1.6930	1.7718	1.8508	1.9294	2.0081	2.0847	2.1653	2.2436
					0.8524	0.9357	1.0190	1.1021	1.1850	1.2676	1.3506	1.4332	1.5157	1.5981	1.6804	1.7627	1.8448	1.9271	2.0090	2.0909	2.1727	2.2546	2.3362
					0.8868	0.9735	1.0601	1.1465	1.2329	1.3180	1.4051	1.4910	1.5769	1.6626	1.7482	1.8339	1.9193	2.0047	2.0900	2.1752	2.2604	2.3458	2.4305
						1.0130	1.1020	1.1919	1.2814	1.3712	1.4609	1.5500	1.6392	1.7283	1.8174	1.9063	1.9952	2.0839	2.1728	2.2613	2.3498	2.4383	2.5267
						1.0512	1.1447	1.2381	1.3309	1.4243	1.5174	1.6102	1.7028	1.7953	1.8879	1.9802	2.0725	2.1647	2.2569	2.3491	2.4409	2.5328	2.6244
						1.0912	1.1883	1.2851	1.3814	1.4788	1.5751	1.6713	1.7675	1.8636	1.9596	2.0556	2.1513	2.2470	2.3428	2.4382	2.5337	2.6291	2.7244
						1.1319	1.2326	1.3330	1.4328	1.5334	1.6337	1.7336	1.8334	1.9331	2.0327	2.1321	2.2315	2.3306	2.4301	2.5291	2.6281	2.7271	2.8260
						1.1733	1.2777	1.3818	1.4850	1.5897	1.6934	1.7970	1.9005	2.0038	2.1070	2.2102	2.3132	2.4161	2.5190	2.6217	2.7243	2.8269	2.9294
							1.3236	1.4315	1.5382	1.6469	1.7543	1.8616	1.9687	2.0756	2.1827	2.2895	2.3963	2.5029	2.6097	2.7158	2.8222	2.9284	3.0348
							1.3703	1.4820	1.5923	1.7049	1.8161	1.9272	2.0382	2.1489	2.2597	2.3703	2.4808	2.5912	2.7014	2.8116	2.9217	3.0317	3.1418
							1.4177	1.5333	1.6473	1.7640	1.8791	1.9940	2.1088	2.2233	2.3380	2.4524	2.5668	2.6810	2.7951	2.9091	3.0230	3.1366	3.2505
							1.4660	1.5856	1.7033	1.8241	1.9431	2.0619	2.1806	2.2989	2.4176	2.5358	2.6541	2.7722	2.8902	3.0081	3.1259	3.2436	3.3612
							1.5151	1.6386	1.7601	1.8851	2.0081	2.1309	2.2536	2.3758	2.4985	2.6208	2.7430	2.8650	2.9869	3.1088	3.2305	3.3521	3.4737
								1.6926	1.8179	1.9471	2.0743	2.2010	2.3277	2.4540	2.5807	2.7070	2.8332	2.9593	3.0852	3.2111	3.3368	3.4624	3.5880
								1.7473	1.8765	2.0101	2.1413	2.2723	2.4031	2.5333	2.6643	2.7946	2.9248	3.0550	3.1851	3.3150	3.4448	3.5746	3.7041
								1.8029	1.9360	2.0741	2.2094	2.3446	2.4796	2.6144	2.7491	2.8836	3.0180	3.1523	3.2864	3.4205	3.5544	3.6883	3.8220
								1.8594	1.9965	2.1389	2.2787	2.4180	2.5572	2.6963	2.8352	2.9739	3.1126	3.2510	3.3894	3.5276	3.6658	3.8036	3.9417
								1.9167	2.0610	2.2050	2.3489	2.4926	2.6361	2.7794	2.9226	3.0656	3.2085	3.3513	3.4939	3.6364	3.7789	3.9217	4.0632
									2.1236	2.2720	2.4203	2.5682	2.7161	2.8636	3.0113	3.1587	3.3060	3.4530	3.6000	3.7468	3.8936	4.0401	4.1866
									2.1870	2.3400	2.4926	2.6450	2.7973	2.9494	3.1013	3.2531	3.4047	3.5562	3.7076	3.8588	4.0098	4.1605	4.3117
									2.2514	2.4086	2.5660	2.7229	2.8796	3.0362	3.1926	3.3488	3.5050	3.6609	3.8167	3.9724	4.1279	4.2833	4.4388
									2.3167	2.4788	2.6404	2.8019	2.9632	3.1243	3.2852	3.4460	3.6066	3.7671	3.9274	4.0876	4.2477	4.4070	4.5674
									2.3829	2.5488	2.7158	2.8819	3.0479	3.2136	3.3791	3.5445	3.7097	3.8748	4.0397	4.2044	4.3691	4.5326	4.6978
										2.6213	2.7923	2.9631	3.1337	3.3041	3.4743	3.6444	3.8142	3.9839	4.1535	4.3229	4.4922	4.6613	4.8303
										2.6941	2.8698	3.0454	3.2208	3.3959	3.5708	3.7456	3.9202	4.0946	4.2687	4.4429	4.6169	4.7907	4.9644
										2.7679	2.9484	3.1288	3.3090	3.4889	3.6686	3.8481	4.0275	4.2067	4.3857	4.5646	4.7433	4.9219	5.1004
										2.8426	3.0281	3.2133	3.3983	3.5831	3.7677	3.9521	4.1363	4.3203	4.5042	4.6879	4.8714	5.0548	5.2381
										2.9184	3.1088	3.2989	3.4889	3.6786	3.8680	4.0573	4.2465	4.4354	4.6242	4.8128	5.0012	5.1895	5.3777
											3.1905	3.3856	3.5806	3.7752	3.9697	4.1640	4.3581	4.5520	4.7457	4.9392	5.1326	5.3259	5.5190
											3.2732	3.4734	3.6734	3.8731	4.0726	4.2720	4.4711	4.6701	4.8688	5.0673	5.2658	5.4640	5.6621
											3.3570	3.5623	3.7674	3.9723	4.1768	4.3813	4.5856	4.7896	4.9934	5.1970	5.4005	5.6039	5.8070
											3.4418	3.6523	3.8626	4.0726	4.2824	4.4920	4.7014	4.9106	5.1196	5.3283	5.5370	5.7454	5.9537
											3.5278	3.7434	3.9589	4.1742	4.3892	4.6040	4.8186	5.0330	5.2472	5.4612	5.6751	5.8887	6.1022
												3.8356	4.0564	4.2770	4.4973	4.7174	4.9373	5.1570	5.3765	5.5957	5.8146	6.0338	6.2526
												3.9289	4.1551	4.3810	4.6067	4.8322	5.0574	5.2824	5.5072	5.7318	5.9565	6.1805	6.4046
												4.0233	4.2549	4.4863	4.7174	4.9483	5.1788	5.4093	5.6396	5.8695	6.0994	6.3290	6.5585
												4.1188	4.3559	4.5928	4.8293	5.0657	5.3018	5.5377	5.7734	6.0088	6.2441	6.4792	6.7141
												4.2154	4.4581	4.7005	4.9426	5.1845	5.4261	5.6676	5.9088	6.1498	6.3906	6.6312	6.8714
													4.5614	4.8095	5.0571	5.3046	5.5519	5.7988	6.0457	6.2923	6.5386	6.7844	7.0306
													4.6658	4.9196	5.1729	5.4261	5.6790	5.9317	6.1841	6.4364	6.6884	6.9402	7.1916
													4.7714	5.0309	5.2900	5.5489	5.8076	6.0660	6.3241	6.5821	6.8398	7.0973	7.3546
													4.8782	5.1436	5.4084	5.6731	5.9375	6.2017	6.4655	6.7293	6.9928	7.2561	7.5192
													4.9881	5.2573	5.5281	5.7986	6.0688	6.3389	6.6087	6.8782	7.1476	7.4167	7.6856
														5.3723	5.6490	5.9254	6.2017	6.4776	6.7533	7.0287	7.3039	7.5790	7.8537
														5.4885	5.7712	6.0537	6.3358	6.6177	6.8994	7.1808	7.4620	7.7429	8.0236
														5.6060	5.8947	6.1832	6.4714	6.7594	7.0470	7.3346	7.6218	7.9086	8.1953
														5.7246	6.0195	6.3141	6.6084	6.9025	7.1962	7.4897	7.7830	8.0760	8.3688
														5.8448	6.1456	6.4464	6.7468	7.0470	7.3469	7.6466	7.9460	8.2451	8.5441
															6.2729	6.5799	6.8866	7.1930	7.4992	7.8050	8.1108	8.4160	8.7211
															6.4016	6.7148	7.0278	7.3406	7.6529	7.9650	8.2770	8.5886	8.9000
															6.5314	6.8511	7.1704	7.4895	7.8082	8.1267	8.4449	8.7625	9.0806
															6.6626	6.9887	7.3144	7.6398	7.9650	8.2898	8.6145	8.9388	9.2629
															6.7981	7.1276	7.4598	7.7917	8.1234	8.4547	8.7857	9.1165	9.4470
																7.2679	7.6066	7.9451	8.2832	8.6211	8.9586	9.2959	9.6330
																7.4095	7.7548	8.0998	8.4446	8.7891	9.1332	9.4770	9.8206
																7.5524	7.9045	8.2561	8.6075	8.9587	9.3094	9.6599	10.0101
																7.6967	8.0555	8.4138	8.7720	9.1297	9.4872	9.8444	10.2013
																7.8425	8.2079	8.5731	8.9379	9.3025	9.6667	10.0307	10.3943
																	8.3617	8.7337	9.1054	9.4768	9.8478	10.2186	10.5891
																	8.5169	8.8958	9.2744	9.6527	10.0306	10.4083	10.7858
																	8.6735	9.0594	9.4449	9.8301	10.2151	10.5997	10.9840
																	8.8315	9.2244	9.6170	10.0092	10.4011	10.7927	11.1840
																	8.9908	9.3909	9.7905	10.1899	10.5888	10.9875	11.3858
																		9.5584	9.9658	10.3721	10.7782	11.1840	11.5896
																		9.7282	10.1422	10.5559	10.9692	11.3822	11.7948
																		9.8980	10.3203	10.7413	11.1618	11.5821	12.0020
																		10.0713	10.5000	10.9292	11.3561	11.7837	12.2108
																		10.2481	10.6811	11.1188	11.5521	11.9870	12.4215
																			10.8638	11.3088	11.7488	12.1920	12.6340
																			11.0480	11.4988	11.9468	12.3867	12.8482
																			11.2337	11.6819	12.1487	12.6071	13.0642
																			11.4209	11.8667	12.3521	12.8172	13.2819
																			11.6086	12.0631	12.5563	13.0290	13.5014
																				12.2611	12.7620	13.2425	13.7228
																				12.4607	12.9694	13.4577	13.9458
																				12.6619	13.1784	13.6748	14.1704
																				12.8648	13.3891	13.8932	14.3969
																				13.0589	13.6014	14.1135	14.6252
																					13.8153	14.3355	14.8552
																					14.0309	14.5592	15.0870
																					14.2481	14.7845	15.3206
																					14.4649	15.0118	15.5558
																					14.6874	15.2404	15.7929