Thinning Control

by T J D Rollinson

Forestry Commission
Field Book 2

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London: Her Majesty's Stationery Office

First published 1971 (*as Booklet 32*)
Third edition 1985 (*as Booklet 54*)
Reprinted 1988 (*as Field Book 2*)

ISBN 0 11 710256 3

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Acknowledgements

Thanks are due to many people who have helped with ideas and suggestions for improvements to the text and layout of this Field Book.

Thanks are also due to past and present members of the Mensuration Branch of the Forestry Commission whose work has been used as the basis for some of the sections in this Field Book, and in particular to P N Edwards who wrote an earlier draft, J M Christie who was responsible for most of the tables, and R T Bradley and G J Hamilton who were authors of previous versions of this publication (Forestry Commission Booklets 17 and 32). This Field Book reprints the information contained in Forestry Commission Booklet 54 (1985).

Introduction

This Field Book is printed on waterproof paper and is designed for forest use. It provides a simple guide to the control of volume to be removed when marking a thinning. There are three sections. The first section describes the Yield Class system and the assessment of yield class in a stand. The second section covers thinning practice, that is, the type, intensity and cycle of thinning, how to calculate the thinning yield, the timing of thinning, and how the thinning is controlled. The final section describes the field procedures for estimation of top height, basal area and volume marked, and how to calculate mean diameter. A checklist of the office and field procedures to be followed when marking a thinning is printed on page 56 inside the back cover.

Thinning is the removal of a proportion of the trees in a crop, and it is usually practised in order to provide more growing space for the remaining trees, to increase the total yield of usable timber over the life of the stand, and to provide an intermediate yield of timber.

If a crop is to be thinned, there are choices to be made on the age of first thinning, the type of thinning, the intensity of thinning, the thinning cycle, the thinning yield, and the age at which thinning should cease. These choices will depend on such factors as the objectives of the owner, the markets available at the time and likely to be available in the future, the quality of the stand, its liability to wind damage and the cost of harvesting the timber.

The main objectives of thinning control are usually to combine maximum profitability in the long run with the maintenance of a regular supply of material from thinnings. Failure to control the volume removed as thinnings can result in over cutting which leads to a loss in volume production, or under cutting which depresses profitability. Such failure to control the thinning may also produce an erratic flow of timber to the consumer.

The precision of control will depend upon the expertise and resources available, as well as the nature of the crop being thinned. Normally it should be possible to control yields to within 15 per cent of the target thinning yield, but achieving this degree of control may be unduly expensive in mixtures or crops that are very variable in other ways.

This Field Book provides no more than a guide to thinning yields. Efficient thinning practice depends upon intelligent application of the guide under a wide range of conditions. For example, it may pay to thin an understocked stand because of contractual commitments, despite the loss of increment which is likely to result.

The Yield Class System

The concept of yield class

Before a manager can decide on an appropriate thinning regime for the various crops comprising his forest, he requires information about the current and future rates of growth of the crops. The growth of trees may be measured in terms of increases in height, diameter, volume or weight. Of these, volume is the most meaningful for purposes of management.

In an even-aged stand the cumulative volume production, including dead trees and thinnings, divided by the age of the stand is referred to as the mean annual increment (MAI). After planting, MAI increases during the early years of vigorous growth, reaches a maximum, and then declines with increasing age. The point at which the MAI curve reaches a maximum is the maximum average rate of volume increment which a particular stand can achieve, and this indicates the yield class. For example, a stand with a maximum MAI of 14 cubic metres per hectare has a yield class of 14.

In order to assess yield class it is possible to avoid the measurement or prediction of cumulative volume production because there is a good relationship between top height and cumulative volume production of a stand. The relationship allows yield class to be read directly from top height/age curves (see pages 38–54).

Yield class obtained through top height and age of the stand alone is termed General Yield Class (GYC). Yield class obtained from some measure or prediction of the actual mean annual volume increment of the stand is termed Local Yield Class (LYC). Where LYC is known, it should be used in preference to GYC for thinning control.

Assessment of general yield class

a. Estimate the top height of the stand (see page 22).
b. Determine the age of the stand. This is defined as the number of growing seasons since planting.
c. Use the top height/age curves on pages 38–54 to determine the general yield class of the stand. For example, if the top height of a stand of Sitka spruce is 19 m at an age of 40 years, then using the top height/age curve on page 41, the GYC is found to be 14.

The yield class determined at some earlier date can be used at subsequent thinnings provided that the pattern of height growth follows the trend of the curves. Usually re-assessment of yield class need only be carried out at about 10 year intervals.

The yield class for species other than those for which curves are provided can be estimated by using the curves suggested in the following Table:

For these species:		Use curves for:
Maritime pine	*Pinus pinaster*	LP
Weymouth pine	*Pinus strobus*	SP*
Monterey pine	*Pinus radiata*	CP
Bishop pine	*Pinus muricata*	CP
Serbian spruce	*Picea omorika*	NS*
Silver fir	*Abies alba*	NF
Coast redwood	*Sequoia sempervirens*	GF*
Wellingtonia	*Sequoiadendron giganteum*	GF*
Alders	*Alnus* spp.	SAB
Norway maple	*Acer platanoides*	SAB
Hornbeam	*Carpinus betulus*	Be
Sweet chestnut	*Castanea sativa*	Be
Red oak	*Quercus rubra*	Be

* The Yield Class is likely to be one greater than that derived using the General Yield Class curves.

Where there is more than one species in the stand, the GYC of each species should be assessed separately. It may be necessary to increase the number of sample plots to estimate top height so that the minimum number of top height trees is measured in each species. The average yield class of the stand can be obtained by averaging the component yield classes according to the proportion of the canopy each occupies. For example, if one species occupies 40 per cent of the canopy and has a GYC of 10, whilst a second species of GYC 14 occupies 60 per cent of the canopy, the average GYC is:

$$\frac{(10 \times 40 + 14 \times 60)}{100} = 12.4 \text{ (which rounds to 12)}$$

Uneven-aged stands are treated in a similar way in that the yield class of each category is assessed separately, and the average yield class again obtained, weighted according to the proportion of the canopy occupied by each category.

When, for any reason, the rate of height growth has changed appreciably in the life of the stand, for example because it has been in check, or because it has been fertilised, an adjusted age should be used instead of the actual age. This procedure is discussed in Forestry Commission Booklet 48 *Yield Models for Forest Management,* page 11.

Further information on height measurement is given in Forestry Commission Booklet 39 *Forest Mensuration Handbook,* Part V, Chapter 4, pp.143–146.

Further information on yield class assessment is given in Forestry Commission Booklet 48 *Yield Models for Forest Management,* pp.4–15.

Thinning Practice

Thinning type

Thinnings may be either *selective* or *systematic*.

Selective thinning is one in which trees are removed or retained on their individual merits.

In *low* thinning, trees are removed predominantly from the lower canopy, that is, the suppressed and sub-dominant trees. Low thinning tends to result in relatively dense stands of evenly distributed trees. In *crown* thinning trees are removed predominantly from the upper canopy, that is, some dominants and co-dominants, with the aim of giving selected dominants freedom to grow rapidly. Some trees may also be removed from the lower canopy. Crown thinnings are often used at the first and second thinnings, especially for shade tolerant trees, in order to increase the size of tree being removed, and to encourage the growth of the remaining trees where very large trees are much more valuable. However, a true crown thinning cannot be maintained throughout a rotation, because too few competing trees remain to give a reasonable thinning yield. Over a rotation, the distinction between low and crown thinnings tends to become academic. For example, even if a low thinning is used, some thinning in the upper canopy is usually inevitable in order to release the better dominants, which will form the ultimate main crop of the stand. A stand could be thinned by removing the dominant trees, but this would result in a considerable reduction in total volume production over the rotation.

The commonest type of selective thinning is known as *intermediate* thinning. It involves removal of most of the suppressed and sub-dominant trees, and also opening up the canopy by breaking up groups of competing dominant and co-dominant trees, so as to encourage the development of the better trees and to leave an open and fairly uniform stand.

Systematic thinning is a thinning in which trees are removed according to a predetermined system which does not permit consideration of the merits of individual trees.

Systematic thinnings are usually one of the varieties of line thinning such as row thinning, strip thinning, chevron thinning, or some combination of these, and are commonly used for the first, and sometimes the second, thinning. Systematic thinning is usually cheaper and easier to manage than selective thinning, but the operation may leave parts of the crop unthinned and may result in losses of volume production and reduced stand stability. Systematic thinning should only be considered where the saving in cost is greater than the likely loss of future revenue.

Further information on line thinning is available in Forestry Commission Leaflet 77 *Line Thinning*.

Thinning intensity

The *thinning intensity* is the rate at which volume is removed, e.g. 10 m^3/ha/year. It should not be confused with the thinning yield which is the actual volume removed in any one thinning.

Over a wide range of thinning intensities the cumulative volume production of usable timber is unaffected. At low intensities, stands will be overstocked, unless the initial plant spacing is very wide, and the cumulative production of usable timber is reduced because some trees die before they are harvested. At high intensities, stands do not fully utilise the growing space created by the thinnings, so that cumulative production is reduced. The maximum thinning intensity which can be maintained without causing a loss of cumulative volume production is known as the marginal thinning intensity. For most species this critical intensity assessed from the time the stand has reached the threshold basal area (see page 16) up to the time of maximum mean annual volume increment is about 70 per cent of the maximum mean annual volume increment per year (i.e. removing 70 per cent of the yield class each year). Thus, the marginal thinning intensity of a stand of yield class 20 is 14 m^3/ha/year (70 per cent of 20).

The threshold basal area is given in Table 2 on pages 16–17, while the age of maximum mean annual increment is shown on the yield class curves on pages 38–54.

The choice of thinning intensity depends on the location of the stand, the markets available, and the objectives of the owner. Higher intensities will be reflected in greater increases in mean diameter of the maincrop trees. In addition, the greater thinning yields resulting from higher intensities provide greater revenues. Taken together, these features tend to make higher thinning intensities more profitable, although the reduced volume of the final crop has to be taken into account. The marginal thinning intensity is often chosen as it produces the highest possible thinning yields without reducing the total volume production over the rotation, but there are circumstances when it will not be the best choice. If thinnings are difficult to sell, thinning may not be undertaken, or a lower thinning intensity adopted. If large sized trees are required as soon as possible, a higher thinning intensity may be adopted even though total volume production will be reduced.

Thinning cycle

The *thinning cycle* is the interval in years between successive thinnings.

For the purpose of determining the thinning yield (defined below), the cycle is the number of years before the next thinning, not the number of years since the last thinning which has little relevance to future growth. The cycle has an influence on profitability as the value per cubic metre of any single thinning depends in part on the scale of the operation. Long cycles involve heavier single thinnings which are usually more profitable, but may increase the risk of windblow owing to a dramatic opening up of the canopy and in extreme cases they may result in some loss of volume production. The choice of thinning cycle will usually depend on local management considerations and on the yield class of the crop. The usual length of thinning cycle is from 4 to 6 years in young or fast growing crops, and about 10 years for older or slower growing crops.

Thinning yield

The *thinning yield* is the actual volume removed in any one thinning. If a fully stocked stand is thinned at the marginal thinning intensity, the thinning yield will be 70 per cent of the maximum mean annual increment (i.e. 70 per cent of the yield class) multiplied by the cycle. For example, the thinning yield for a stand of yield class 14 being thinned at the marginal thinning intensity on a 5 year cycle is:

$$70\% \times 14 \times 5 = 49 \text{ m}^3/\text{ha}$$

If the marginal thinning intensity has been chosen, the normal thinning yield can be read from Table 1 according to the yield class and thinning cycle.

Table 1 Table of thinning yields

Yield class	Volume per net hectare (cubic metres overbark to 7 cm top diameter) — Thinning cycles (Number of years before **next** thinning, **not** since the last)						
	3	4	5	6	8	10	12
4					22.4	28	33.6
6			21	25.2	33.6	42	50.4
8		22.4	28	33.6	44.8	56	67.2
10	21.0	28.0	35	42.0	56.0	70	84.0
12	25.2	33.6	42	50.4	67.2	84	
14	29.4	39.2	49	58.8	78.4		
16	33.6	44.8	56	67.2	89.6		
18	37.8	50.4	63	75.6			
20	42.0	56.0	70	84.0			
22	46.2	61.6	77				
24	50.4	67.2	84				
26	54.6	72.8					
28	58.8	78.4					
30	63.0	84.0					

These thinning yields can be taken from the time that the threshold basal area is reached up until the time of maximum mean annual increment, which is indicated on the top height/age curves.

If the marginal thinning intensity has not been chosen, the actual thinning intensity can be used to calculate the thinning yield. For example, the yield from a stand of yield class 14, being thinned at an intensity of 80 per cent of the marginal thinning intensity on a 5 year cycle is:

$$80\% \times 70\% \times 14 \times 5 = 39.2 \text{ m}^3/\text{ha.}$$

In all cases, the thinning yield should not be so heavy that it opens up the stand to the risk of windblow, or to invasion by other woody species, and thinning should not take all the dominant and good quality trees so that none are left to form a reasonable crop after thinning.

Understocked stands

The normal thinning yields are intended for use with fully stocked stands, so some reduction in yield will be necessary for stands which are understocked, perhaps caused by over-thinning in the past. However, it will usually be more practical to leave such stands until they have reached full stocking again (see 'Timing of Thinning' on page 16). If it is decided to thin an understocked stand, recovery of full stocking will be delayed much less if the thinning yield is reduced by at least one year's cut. For example, it may be best to take a 3 year cut even if it is proposed to thin again in 4 years time.

Overstocked stands

In stands which are overstocked, perhaps because of a lack of thinning in the past, or a delay in the time of first thinning, the thinning yield can be increased to reduce the stocking level. For example, a 6 year cut may be taken even if it is proposed to thin again in 5 years time. If the stand is still overstocked at the next thinning, the procedure may be repeated so as to achieve a controlled reduction in stocking. Where there is a choice, short rather than long cycles should be used when thinning overstocked stands. This is particularly relevant where there is a risk of windblow.

Mixtures

The thinning yield from mixtures should be determined in the same way as for pure stands, except that a weighted mean yield class should be used, weighting each species according to the percentage of the canopy of the stand that it is expected to occupy after the thinning. For example, if the stand after thinning is expected to be 75 per cent Sitka spruce, yield class 16, and 25 per cent Lodgepole pine, yield class 8, then the thinning yield at the marginal thinning intensity on a 5 year cycle is:

$$(75\% \times 16 + 25\% \times 8) \times 70\% \times 5 = 49 \text{ m}^3/\text{ha}$$

Uneven aged stands

In two storeyed single species stands, the thinning yield should be calculated in the normal way using the weighted mean yield class of both the components. However, in all aged stands the whole of the maximum mean annual increment can be removed each year. For example, if the yield class is 12, then on a 5 year cycle each 'thinning' yield would be $12 \times 5 = 60$ m^3/ha. The yield will consist of trees of all ages and all sizes, and the largest trees will be of rotation age.

Diseased stands
In diseased stands, the thinning yield may have to be reduced or thinning may be suspended altogether. The correct treatment will depend on the nature and extent of the disease.

Stands with patchy growth or partial check
When parts of a stand are ready for thinning, but others are not, thinning will usually only be started when the thinnable parts are large enough for economic working. Usually, the full thinning yield will be taken from fully stocked parts of the stand, while the other areas may be left unthinned. For example, if a stand is only 65 per cent fully stocked, then only 65 per cent of the thinning yield will be available.

Line thinning
With selective thinnings, the thinning intensity is usually controlled by fixing the thinning cycle and adjusting the thinning yield. In line thinnings, however, it is not always practicable to make precise adjustments to the thinning yield. For example, the harvesting method may reduce the options for varying the thinning yield, if maximum efficiency of harvesting is to be achieved. In line thinnings therefore it is usually more convenient to control the thinning intensity by adjusting the thinning cycle.

If there are overriding management reasons why the thinning cycle cannot be adjusted, then the scope for modifying the thinning yield, given a fixed cycle, is most restricted in the case of row thinnings. For example, if it is desired to thin by removing single rows, then the options are: removal of every fourth row (25 per cent), every third row (33 per cent) or every second row (50 per cent). With chevron patterns of thinning the possibilities of adjusting the thinning yield are greater. Examples of two common situations are given below. They show the various steps required to derive an appropriate thinning pattern for a fixed cycle. A worked example is included in brackets after each step.

1. ROW THINNING

a. Determine the yield class of the stand (16).
b. Choose the thinning type (row thinning).
c. Choose the thinning intensity (marginal thinning intensity).
d. Choose the thinning cycle (6 years).
e. Work out the thinning yield (70% × 16 × 6 = 67.2 m^3/ha).
f. Estimate the volume per hectare before thinning (150 m^3/ha).

g. Express the thinning yield as a percentage of the estimated volume per hectare before thinning ($\frac{67.2 \times 100}{150} = 44.8\%$).
h. Choose a row removal pattern appropriate to this thinning percentage. (In this example, the nearest equivalent for a single row removal pattern would be to remove every second row (50 per cent)).
i. If the percentage resulting from the chosen row removal pattern is greater or less than the required percentage, the thinning cycle should be altered, or the thinning yield at the next thinning should be reduced or increased, or the removal pattern reconsidered. (In this example, the removal of every second row would cause some loss of increment and it would be necessary to extend the thinning cycle by about 2 years. Alternative approaches would be to take a smaller cut after the planned cycle of 6 years, or to remove every third row on a 5 year cycle).

2. CHEVRON THINNING

a. As for row thinning.
b. Choose the thinning type (chevron thinning).
c–g. As for row thinning.
h. Choose the spacing between main racks, and the number of rows to be removed (every 20th row removed) to create main racks.
i. Deduct the volume percentage removed by creating the main racks (1 in 20 = 5%) from the target percentage (44.8 − 5 = 39.8%). Note that if the main racks are not parallel to the rows, the percentage removed is in effect the mean rack width expressed as a percentage of the distance between racks.
j. The remaining volume must be removed from the side racks. As the remaining fully stocked portion of the stand is less than the total area (in this example 95 per cent), then the proportion of the remaining growing stock to be removed is:
($\frac{39.8 \times 100}{95} = 41.9\%$).
k. The thinning yield is controlled through varying the side rack width, the angle of the side rack to the main racks, or the distance between the side racks, so that the required percentage of the fully stocked area is removed. Given two of these factors, the third can be found as follows:

$$d = r \times \frac{f}{p} \qquad r = d \times \frac{p}{f} \qquad f = d \times \frac{p}{r}$$

where p is the proportion of the fully stocked area required to be removed from the side racks (see step j above),
d is the distance between side racks,
r is the mean rack width, and
f is a factor which varies according to the angle of the side rack with the main rack:

Angle	30°	35°	40°	45°	50°	55°
Factor (f)	200	174	156	141	130	122

Example: If the mean rack width is 2 m, and the angle between main and side racks is 40°, then the distance between side racks is:

$$2 \times \frac{156}{41.9} = 7.45\text{m}$$

A line thinned stand may take longer to reach the basal area required before a further thinning is justified than would be the case with a selective thinning.

Net and gross areas

The thinning yields in this booklet refer to fully stocked areas. The gross area which includes roads, rides, or other non-productive land should be reduced to a net area which excludes such land, before the volume per hectare is calculated for the purposes of thinning control. The training and supervision of markers is easier if estimates of the volume marked per *net* hectare are made. For example, extraction racks should not be included in the area being marked, as the thinning yield should be controlled in the productive area *between* the racks. When the racks themselves are marked it will usually be easiest to control the volume marked in the normal way between the racks, and to estimate the total volume removed by adding on the extra volume removed from the racks.

Timing of thinning

A stand will not normally be thinned unless it is fully stocked. This may be judged by visual inspection, or, more objectively, by using the following procedure:

1. For conifers
   a. Estimate the top height of the stand (see page 22).
   b. Estimate the basal area per hectare (see page 23).
   c. Compare the basal area with the threshold basal area given in Table 2.
2. For broadleaves
   a. Estimate the top height of the stand (see page 22).
   b. Determine the yield class of the stand (see page 6).
   c. Estimate the basal area per hectare (see page 23).
   d. Compare the basal area with the threshold basal area given in Table 2.

Table 2 Threshold basal areas for fully stocked stands
(Basal areas in square metres per hectare)

Species		Top height	
		10	12
Scots pine		26	26
Corsican pine		34	34
Lodgepole pine		33	31
Sitka spruce		33	34
Norway spruce		33	33
European larch		23	22
Japanese and Hybrid larch		22	22
Douglas fir		28	28
Western hemlock		32	34
Red cedar		—	49
Grand fir		—	39
Noble fir		—	45
	Yield class		
Oak	4	24	24
	6	—	26
	8	—	27
Beech and Sweet chestnut	4	—	22
	6	—	24
	8	—	—
	10	—	—
Sycamore, ash, birch and alder	4	—	17
	6	—	17
	8	—	17
	10	—	18
	12	—	19

If the basal area is equal to, or greater than, the value in the table, the stand is fully stocked and therefore ready for thinning. If the basal area is less than the value in the table, the stand is not fully stocked. If however, it is still intended to thin the stand, then the thinning yield should be reduced to compensate, or the thinning cycle should be extended to allow the stand time to recover.

If the thinning yield is more than 60 m³/ha, the threshold basal area in Table 2 should be increased before comparing it with the actual basal area. If the thinning yield is between 60 and 80 m³/ha, increase the Table value by 10 per cent. If it is over 80 m³/ha, increase the Table value by 20 per cent.

Time of first thinning

The time of first thinning will vary depending on the species, yield class and initial spacing of the stand, the thinning

(metres)								
14	16	18	20	22	24	26	28	30
27	30	32	35	38	40	43	46	—
33	33	33	34	35	36	37	39	—
31	30	30	31	31	32	33	34	—
34	35	35	36	37	38	39	40	42
34	35	36	38	40	42	44	46	49
22	22	23	24	25	27	28	30	—
23	23	24	24	25	27	28	29	—
28	29	30	31	32	34	35	37	40
35	36	36	36	37	38	38	39	40
50	51	53	55	57	60	63	66	70
39	39	39	39	39	40	41	43	45
46	46	47	48	49	51	52	54	—
23	23	24	24	—	—	—	—	—
25	24	24	25	25	25	25	—	—
25	24	24	24	25	26	26	26	—
23	25	27	30	—	—	—	—	—
25	25	27	29	31	33	36	—	—
27	27	27	28	29	31	33	35	37
28	28	27	27	28	29	31	33	35
17	18	21	—	—	—	—	—	—
18	19	22	25	—	—	—	—	—
18	20	22	25	28	—	—	—	—
19	20	23	26	30	33	—	—	—
20	21	24	27	31	35	—	—	—

Table 3 Standard thinning ages

Species	Spacing (m)	Yield class				
		30	28	26	24	22
Scots pine	1.4					
	2.0					
	2.4					
Corsican pine	1.4					
	2.0					
	2.4					
Lodgepole pine	1.5					
	2.0					
	2.4					
Sitka spruce	1.7				18	18
	2.0				18	19
	2.4				19	20
Norway spruce	1.5					20
	2.0					21
	2.4					23
European larch	1.7					
Japanese larch Hybrid larch	1.7					
	2.0					
	2.4					
Douglas fir	1.7				16	17
	2.0				16	17
	2.4				17	18
Western hemlock	1.5				19	20
Western red cedar/ Lawson cypress	1.5				21	22
Grand fir	1.8	19	20	20	21	21
Noble fir	1.5					22
Oak	1.2					
Beech	1.2					
Sycamore/ Ash/Birch	1.5					

20	18	16	14	12	10	8	6	4
			21	23	25	29	33	40
			22	24	27	31	35	45
			24	26	29	34	39	49
18	19	20	21	23	25	28	33	
19	20	21	22	24	27	30	36	
20	22	23	25	27	30	34	41	
			19	21	23	26	31	40
			20	22	25	28	34	44
			21	24	27	31	38	48
19	20	21	22	24	26	29	33	
20	21	22	23	25	27	30	35	
21	22	24	25	28	30	34	40	
21	22	23	24	26	28	31	35	
22	23	25	26	29	31	35	41	
24	25	27	28	31	34	39	46	
				18	20	22	26	32
			14	15	17	19	22	26
			15	16	18	20	23	27
			16	17	19	21	25	30
17	18	19	21	23	25	28		
18	19	20	22	24	27	30		
19	20	22	24	27	30	34		
21	22	24	26	28				
23	24	26	28	30				
22	23	24	25					
23	25	27	29	31				
						24	28	35
					26	29	32	37
				14	15	17	20	24

intensity, the yield of the first thinning, and harvesting and marketing considerations.

The earliest age at which thinning can take place without losing cumulative volume production is known as the standard thinning age. This is not necessarily the recommended first thinning age and there may be good reasons for starting thinning at other ages.

The standard thinning age is later in more widely spaced stands and also for a heavy first thinning, as otherwise the stocking will be reduced to a level which would cause a loss of cumulative volume production. There are many circumstances where the most profitable treatment will be to begin thinning later than the standard thinning age, notably where the standing value of the trees in such a thinning is low. Where the first thinning is delayed, then it will need to be heavier so that the stand returns to the correct growing stock level. It may not be possible to do this in one operation if the thinning has been considerably delayed, as this could lead to loss of volume production or stand instability. Subsequent thinnings will also need to be heavier than normal to compensate. Delaying the first thinning is unlikely to cause any reduction in cumulative production of usable timber unless the thinning is delayed so long that trees start dying, but it will affect the mean diameter of the trees.

The standard thinning age for a wide range of species, yield classes and initial planting spacings is given in Table 3 on pages 18–19.

Control of thinning

Thinning can be controlled in terms of the number of trees, the basal area, or the volume. Control by the number of trees is not recommended as the result of the thinning is very dependent on the thinning type. If the smallest trees are removed, the stand will be left much denser than if the same number of larger trees are removed.

Thinning should therefore be controlled by basal area or volume, and this can either be by the amount *removed,* or the amount *remaining*. Control by the amount removed is preferable for four reasons:

a. It is easier to do.
b. It tends to produce a constant and predictable yield of timber which is useful for planning purposes.
c. It discourages drastic reduction of the level of the growing stock which can lead to windblow or other damage caused by a sudden opening up of the canopy.
d. It considerably reduces the effect of inaccurate yield class assessment, which can occur if the local yield class has not been measured.

Therefore, it is strongly recommended that control of thinning should be by the basal area or the volume *removed*. It is essential that the stocking of all stands should be checked before thinning to see that it is adequate (see 'Timing of Thinning' on pages 16–17).

This booklet assumes that the thinning will be controlled by the *volume* removed. This is easier than using basal area as, for a given intensity, the volume removed is constant up to the age of maximum mean annual increment, whereas the basal area removed declines as the stand gets older.

A checklist of office and field procedures to be followed when marking a thinning is printed on page 56 inside the back cover.

Field Procedures

Measuring top height

The top height of a stand is defined as the average of the total heights of a number of 'top height trees' in the stand, where a 'top height tree' is the tree of largest dbh (diameter at breast height, 1.3 m) in a 0.01 ha sample plot. This is not necessarily the tallest tree.

To obtain a reliable estimate of top height for the stand, a series of sample plots should be randomly located throughout the stand, and the height of the tree of largest dbh in each plot (radius 5.6m) is measured. The number of top height trees to be measured will depend on the area of the stand and its uniformity. Table 4 gives the minimum number of trees required to give an adequate estimate of top height.

Table 4 Number of top height trees

Area of stand (ha)	Uniform crop	Variable crop
0.5–2	6	8
2–10	8	12
Over 10	10	16

Measuring basal area

To check whether a stand has reached the threshold basal area it is necessary to take sample measurements using a relascope or sample plots as described below:

1. Using a relascope
   a. Choose a number of sample points throughout the area being assessed. These should be chosen preferably systematically or with a point sampling grid on a map, using as a rough guide the numbers given in Table 5. (See note about selection of plots in mixtures on page 12). Each point should be at least the minimum distance from the edge of the area given in Table 6 below.

Table 5 Number of relascope sweeps

Area (ha)	Uniform crop	Variable crop
0.5–2	12	16
2–10	16	24
Over 10	20	32

Table 6 Minimum distances (in metres) of sample points from edge of stand

Maximum likely dbh of trees (cm)	Relascope factor	
	2	0.5
20	7	14
30	11	21
40	14	28
50	18	35
60	21	42
70	25	49
80	28	56

   b. At each point, do a 360° sweep with the relascope, and record the number of trees counted. Note that accurate use of a relascope requires practice.
   c. If the point is on sloping ground, multiply the count by the secant of the angle of slope, from Table 7.
   d. Work out the average count, and multiply this by the relascope factor. The result is the estimated basal area per hectare of the stand.

Table 7 Slopes

Angle of slope (degrees)	Correction factor (secant)
5	1.004
7½	1.009
10	1.015
12½	1.024
15	1.035
17½	1.049
20	1.064
22½	1.082
25	1.10
30	1.15
35	1.22
40	1.31
45	1.41
50	1.56
55	1.74
60	2.00

Note: In stands with a regular pattern of variation, e.g. line mixtures, the sample points should not be chosen at random, but chosen so that they give equal weighting to each component. For example, in 3 row hardwood: 3 row conifer mixtures, all sample points should be midway between a row of conifers and a row of broadleaves. In more complex line mixtures, it is advisable to place equal numbers of sample points between each pair of rows.

2. Using sample plots
   a. Lay out the plots throughout the stand. Table 8 gives a guide to the number needed. Choose a plot size which includes 7-20 measurable trees.

Table 8 Number of sample plots

Area of stand (ha)	Uniform crop	Variable crop
0.5–2	6	8
2–10	8	12
Over 10	10	16

Table 9 Circular and square plot sizes

Shape	Length in metres for plot size (ha)							
	0.005	0.01	0.02	0.05	0.10	0.20	0.50	1.00
Circular (radius)	4.0	5.6	8.0	12.6	17.8	25.2	39.9	56.4
Square (sides)	7.1	10.0	14.1	22.4	31.6	44.7	70.7	100.0

Table 10 Rectangular plot sizes in plantations where rows are clearly visible

Average spacing between rows (m)	3 rows wide		4 rows wide	6 rows wide	9 rows wide
	Distance in metres along the row for plot size (ha)				
	0.005	0.01	0.02	0.05	0.10
1.5	11.1	22.2	33.3	55.6	74.1
1.6	10.4	20.8	31.2	52.1	69.4
1.7	9.8	19.6	29.4	49.0	65.4
1.8	9.3	18.5	27.8	46.3	61.7
1.9	8.8	17.5	26.3	43.9	58.5
2.0	8.3	16.7	25.0	41.7	55.6
2.1	7.9	15.9	23.8	39.7	52.9
2.2	7.6	15.2	22.7	37.9	50.5
2.3	7.2	14.5	21.7	36.2	48.3
2.4	6.9	13.9	20.8	34.7	46.3
2.5	6.7	13.3	20.0	33.3	44.4
2.6	6.4	12.8	19.2	32.1	42.7
2.7	6.2	12.3	18.5	30.9	41.2
2.8	6.0	11.9	17.9	29.8	39.7
2.9	5.7	11.5	17.2	28.7	38.3

Note:
Doubling the number of rows doubles the plot area, and similarly halving the distance halves the plot area.

b. Use rectangular plots where the planting rows are still clearly visible, and circular plots in all other stands. Tables 9 and 10 give the dimensions of a range of plots. Plots should be laid out with care. The centre point of each circular plot must be chosen at *random*. The location of rectangular plots must also be chosen at random, but two of the sides of each plot must be parallel to the rows, and both must be midway between two adjacent rows. The boundary of each plot must be at least 5m from the edge of the stand. The dimensions of the plots should be measured horizontally. For plot sides on sloping ground, multiply the dimension given in Table 9 or 10 by the secant of the angle of slope from Table 7. Use this corrected dimension for measuring directly up or down the slope.

c. Measure the dbh of all the trees in the plot, and record the number of trees in each dbh class.

d. Using Table 11 (page 31) find the basal area appropriate to each dbh class, and multiply by the number of trees in each dbh class to give the total basal area in each class.

c. Add all these basal areas together and divide by the sum of the plot areas, to give the estimated basal area per hectare of the stand.

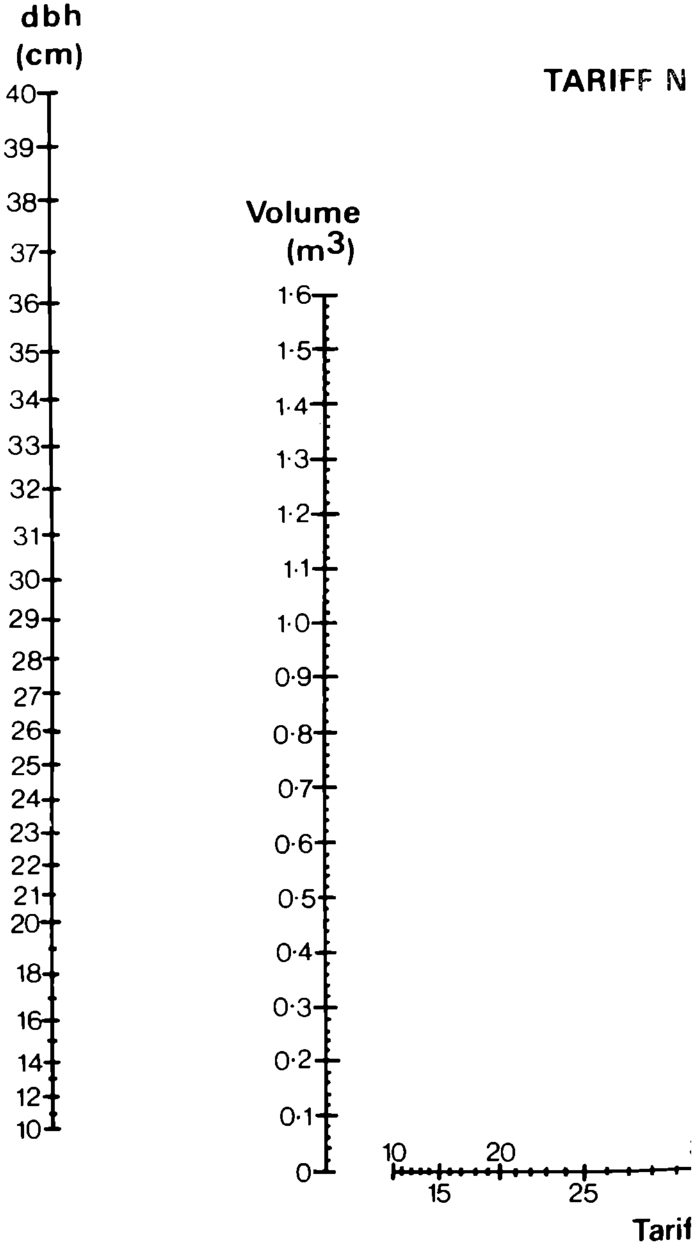
Measuring the volume marked

Having chosen the thinning yield, the marker proceeds to mark the stand, and from time to time checks the yield of thinning marked, modifying the marking as necessary. The check is essentially very simple.

To estimate the volume per hectare which is being marked it is necessary to take sample measurements. This is achieved either by using a relascope to estimate basal area which is converted to volume using an estimated form height, or by measuring the basal area of thinnings which fall within sample plots of known area, and converting to volume using an estimated tariff number. These two procedures are described below:

1. Using a relascope
   a. Estimate the top height of the stand (see page 22).
   b. Estimate the form height of the stand using the top height/form height tables on pages 32–34.
   c. Select four random points in the marked area.
   d. At each point, do a 360° sweep with the relascope, and record the number of *marked* trees counted. Only trees with a dbh of at least 7cm should be counted. If the point is on sloping ground, multiply the count by the secant of the angle of slope, from Table 7 on page 24.
   e. Work out the average count, and multiply this by the relascope factor. The result is the average basal area marked per hectare.
   f. Multiply by the form height to give the estimated volume marked per hectare.
2. Using sample plots
   a. Estimate the top height of the stand (see page 24).
   b. Estimate the tariff number of the stand using the top height/tariff number tables on pages 35–36. Add 1 if a crown or systematic thinning has been marked.
   c. Select two random plots of the same size which contain between 7–20 *marked* trees (see page 26, paragraph b). Measure the dbh of all the marked trees of 7cm or more in the plots, and calculate the mean dbh (see page 31).
   d. Estimate the mean volume from the mean dbh and tariff number which have already been calculated, by using the chart in the centre of this booklet.
   e. Work out the average number of marked trees in these two plots, and divide by the plot area to give the estimated number of marked trees per hectare.

Continued on page 30


dbh
(cm)
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
18
16
14
12
10
Volume
(m3)
1·6
1·5
1·4
1·3
1·2
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
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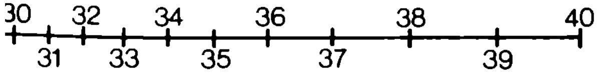
TARIFF N
10
20
15
25
Tarif

UMBER CHART



f Number

f. Multiply the mean volume by the number of marked trees per hectare to give the estimated volume marked per hectare.

If the stand is being line thinned, it may be simpler to estimate the volume per hectare of the stand *before* thinning, and to calculate the volume removed as a percentage of that volume. The volume per hectare should be estimated using either of the above procedures, but measuring all trees in the plots instead of only the marked trees. For example, if one row in four is being removed, and the volume before thinning is 128 m^3/ha, the thinning yield will be

$$\frac{128}{4} = 32\ m^3/ha.$$

The ultimate objective is for the marker to be able to mark the correct thinning yield without needing to use the above procedures, except when a new crop type is encountered. Even so, it is recommended that occasional checks should be made to confirm the accuracy of marking. If checks show that the thinning yield has not been marked correctly, it is usually simpler to correct the over- or under-stocking at the next thinning than to mark the stand again.

Calculating mean diameter

For most mensurational purposes, the mean diameter of a stand is that of the tree of mean basal area: this is also called the quadratic mean dbh. The mean diameter can be calculated as follows:

1. Using the basal area table below.
   a. Convert each dbh into a basal area using Table 11.
   b. Add all the basal areas together.
   c. Divide by the number of trees, to give the mean basal area.
   d. Convert this to the mean dbh using Table 11.
2. Using a calculator which has a square root key.
   a. Square each dbh.
   b. Add all the squared values together.
   c. Divide by the number of trees, to give the mean squared dbh.
   d. Calculate its square root, which is the mean dbh.

Table 11 Basal areas

dbh or diameter (cm)	Basal area or cross-sectional area (sq m)	dbh or diameter (cm)	Basal area or cross-sectional area (sq m)
7	0.0038	34	0.091
8	0.0050	35	0.096
9	0.0064	36	0.102
10	0.0079	37	0.108
11	0.0095	38	0.113
12	0.0113	39	0.119
13	0.0133	40	0.126
14	0.0154	41	0.132
15	0.018	42	0.139
16	0.020	43	0.145
17	0.023	44	0.152
18	0.025	45	0.159
19	0.028	46	0.166
20	0.031	47	0.173
21	0.035	48	0.181
22	0.038	49	0.189
23	0.042	50	0.196
24	0.045	51	0.204
25	0.049	52	0.212
26	0.053	53	0.221
27	0.057	54	0.229
28	0.062	55	0.238
29	0.066	56	0.246
30	0.071	57	0.255
31	0.075	58	0.264
32	0.080	59	0.273
33	0.086	60	0.283

Table 12 Thinning form height

Top height (m)	Species						
	SP	CP	LP	SS	NS	EL	JL/HL
8.0	2.26	2.52	2.72	2.83	2.52	1.70	2.35
8.5	2.50	2.77	2.94	3.04	2.74	1.97	2.63
9.0	2.75	3.03	3.17	3.26	2.97	2.25	2.91
9.5	2.99	3.28	3.40	3.48	3.19	2.52	3.19
10.0	3.23	3.53	3.63	3.69	3.42	2.79	3.47
10.5	3.47	3.78	3.85	3.91	3.64	3.07	3.75
11.0	3.71	4.03	4.08	4.13	3.87	3.34	4.03
11.5	3.95	4.28	4.31	4.34	4.09	3.61	4.31
12.0	4.19	4.54	4.53	4.56	4.32	3.89	4.59
12.5	4.43	4.79	4.76	4.78	4.54	4.16	4.87
13.0	4.67	5.04	4.99	5.00	4.77	4.43	5.15
13.5	4.91	5.29	5.21	5.21	5.00	4.70	5.43
14.0	5.15	5.54	5.44	5.43	5.22	4.98	5.71
14.5	5.40	5.80	5.67	5.65	5.45	5.25	5.99
15.0	5.64	6.05	5.89	5.86	5.67	5.52	6.27
15.5	5.88	6.30	6.12	6.08	5.90	5.80	6.55
16.0	6.12	6.55	6.35	6.30	6.12	6.07	6.83
16.5	6.36	6.80	6.57	6.52	6.35	6.34	7.11
17.0	6.60	7.05	6.80	6.73	6.57	6.62	7.39
17.5	6.84	7.31	7.03	6.95	6.80	6.89	7.67
18.0	7.08	7.56	7.26	7.17	7.02	7.16	7.95
18.5	7.32	7.81	7.48	7.38	7.25	7.44	8.23
19.0	7.56	8.06	7.71	7.60	7.48	7.71	8.52
19.5	7.80	8.31	7.94	7.82	7.70	7.98	8.80
20.0	8.05	8.57	8.16	8.03	7.93	8.26	9.08
20.5	8.29	8.82	8.39	8.25	8.15	8.53	9.36
21.0	8.53	9.07	8.62	8.47	8.38	8.80	9.64
21.5	8.77	9.32	8.84	8.69	8.60	9.08	9.92
22.0	9.01	9.57	9.07	8.90	8.83	9.35	10.20
22.5	9.25	9.83	9.30	9.12	9.05	9.62	10.48
23.0	9.49	10.08	9.52	9.34	9.28	9.89	10.76
23.5	9.73	10.33	9.75	9.55	9.50	10.17	11.04
24.0	9.97	10.58	9.98	9.77	9.73	10.44	11.32
24.5	10.21	10.83	10.20	9.99	9.96	10.71	11.60
25.0	10.45	11.08	10.43	10.21	10.18	10.99	11.88

Table 12 Thinning form height *(continued)*

Top Height (m)	Species						
	DF	WH	RC	LC	GF	NF	OMS
8.0	2.22	2.90	2.35	1.47	2.21	3.16	2.78
8.5	2.43	3.13	2.56	1.90	2.46	3.37	3.07
9.0	2.64	3.36	2.77	2.34	2.70	3.58	3.36
9.5	2.85	3.59	2.97	2.76	2.95	3.79	3.65
10.0	3.06	3.82	3.18	3.18	3.20	4.00	3.94
10.5	3.28	4.06	3.39	3.60	3.44	4.21	4.23
11.0	3.49	4.29	3.59	4.01	3.69	4.42	4.52
11.5	3.70	4.52	3.80	4.41	3.94	4.63	4.81
12.0	3.91	4.75	4.01	4.81	4.18	4.84	5.10
12.5	4.12	4.99	4.21	5.20	4.43	5.04	5.39
13.0	4.33	5.22	4.42	5.59	4.67	5.25	5.68
13.5	4.54	5.45	4.63	5.97	4.92	5.46	5.97
14.0	4.75	5.68	4.83	6.34	5.17	5.67	6.26
14.5	4.96	5.91	5.04	6.71	5.41	5.88	6.55
15.0	5.18	6.15	5.25	7.08	5.66	6.09	6.84
15.5	5.39	6.38	5.45	7.43	5.91	6.30	7.13
16.0	5.60	6.61	5.66	7.79	6.15	6.51	7.42
16.5	5.81	6.84	5.87	8.13	6.40	6.72	7.71
17.0	6.02	7.07	6.07	8.47	6.65	6.93	8.00
17.5	6.23	7.31	6.28	8.81	6.89	7.14	8.29
18.0	6.44	7.54	6.49	9.14	7.14	7.35	8.58
18.5	6.65	7.77	6.69	9.46	7.38	7.55	8.87
19.0	6.86	8.00	6.90	9.78	7.63	7.76	9.16
19.5	7.07	8.24	7.11	10.09	7.88	7.97	9.45
20.0	7.29	8.47	7.31	10.40	8.12	8.18	9.74
20.5	7.50	8.70	7.52	10.70	8.37	8.39	10.03
21.0	7.71	8.93	7.73	10.99	8.62	8.60	10.32
21.5	7.92	9.16	7.93	11.28	8.86	8.81	10.61
22.0	8.13	9.40	8.14	11.56	9.11	9.02	10.90
22.5	8.34	9.63	8.35	11.84	9.36	9.23	11.19
23.0	8.55	9.86	8.55	12.11	9.60	9.44	11.48
23.5	8.76	10.09	8.76	12.38	9.85	9.65	11.77
24.0	8.97	10.33	8.97	12.64	10.10	9.85	12.06
24.5	9.19	10.56	9.17	12.89	10.34	10.06	12.35
25.0	9.40	10.79	9.38	13.14	10.59	10.27	12.64

Continued overleaf

Table 12 Thinning form height *(continued)*

Top height (m)	Species			
	Oak	Beech	SAB	
8.0	1.00	1.04	0.50	SAB–use for
8.5	1.28	1.36	0.85	sycamore, ash
9.0	1.56	1.72	1.24	birch and alder
9.5	1.85	2.05	1.63	
10.0	2.13	2.40	2.00	Beech–use
10.5	2.41	2.70	2.38	also for
11.0	2.70	3.00	2.76	Sweet
11.5	3.00	3.26	3.13	chestnut
12.0	3.28	3.52	3.50	
12.5	3.55	3.78	3.83	
13.0	3.84	4.04	4.16	
13.5	4.12	4.30	4.48	
14.0	4.41	4.56	4.80	
14.5	4.70	4.82	5.10	
15.0	4.98	5.08	5.40	
15.5	5.26	5.31	5.69	
16.0	5.53	5.54	5.98	
16.5	5.86	5.82	6.26	
17.0	6.19	6.02	6.50	
17.5	6.50	6.26	6.75	
18.0	6.82	6.50	7.00	
18.5	7.13	6.75	7.24	
19.0	7.44	7.00	7.48	
19.5	7.76	7.21	7.69	
20.0	8.07	7.42	7.90	
20.5	8.37	7.65	8.12	
21.0	8.67	7.88	8.34	
21.5	8.94	8.09	8.53	
22.0	9.21	8.30	8.72	
22.5	9.47	8.52	8.94	
23.0	9.73	8.74	9.17	
23.5	9.96	8.95	9.33	
24.0	10.19	9.16	9.49	
24.5	10.42	9.37	9.64	
25.0	10.65	9.58	9.79	

Table 13 Tariff numbers

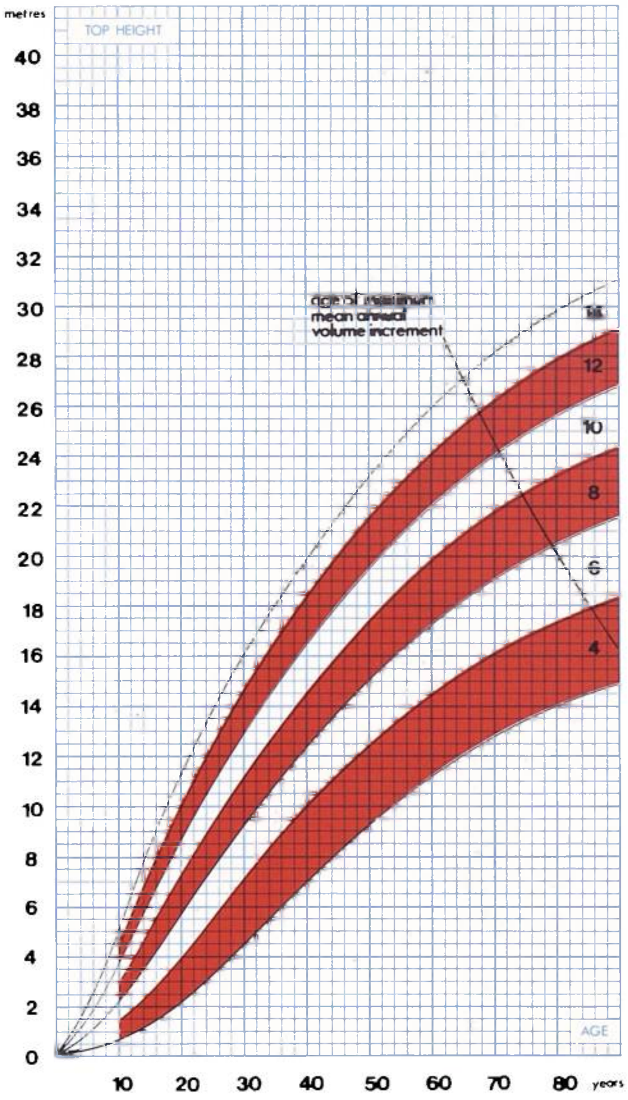
Top height (m)	Species							
	SP	CP	LP	SS	NS	EL	JL/HL	
8.0	16	15	14	15	15	13	15	Add 1 to the tariff number for crown or systematic thinning.
8.5	16	15	15	15	16	14	15	
9.0	17	16	15	16	17	14	16	
9.5	17	17	16	17	17	15	17	
10.0	18	17	17	17	18	16	17	
10.5	18	18	18	18	18	17	18	
11.0	19	19	18	18	19	17	19	
11.5	19	19	19	19	19	18	19	
12.0	20	20	20	20	20	19	20	
12.5	20	21	20	20	21	19	21	
13.0	21	22	21	21	21	20	21	
13.5	21	22	22	22	22	21	22	
14.0	22	23	23	22	22	21	23	
14.5	23	24	23	23	23	22	23	
15.0	23	24	24	23	23	23	24	
15.5	24	25	25	24	24	24	25	
16.0	24	26	25	25	25	24	25	
16.5	25	26	26	25	25	25	26	
17.0	25	27	27	26	26	26	27	
17.5	26	28	27	26	26	26	28	
18.0	26	29	28	27	27	27	28	
18.5	27	29	29	28	28	28	29	
19.0	27	30	30	28	28	28	30	
19.5	28	31	30	29	29	29	30	
20.0	28	31	31	29	29	30	31	
20.5	29	32	32	30	30	30	32	
21.0	29	33	32	31	30	31	32	
21.5	30	33	33	31	31	32	33	
22.0	30	34	34	32	32	33	34	
22.5	31	35	35	32	32	33	34	
23.0	31	36	35	33	33	34	35	
23.5	32	36	36	34	33	35	36	
24.0	32	37	37	34	34	35	36	
24.5	33	38	37	35	34	36	37	
25.0	33	38	38	35	35	37	38	

Table 13 Tariff numbers *(continued)*

Top height	Species							
(m)	DF	WH	RC	GF	NF	OAK	BIRCH	
8.0	14	16	13	13	13	15	13	OAK
8.5	15	16	13	14	14	16	13	Use also
9.0	15	17	14	15	15	16	14	for beech,
9.5	16	18	14	15	15	17	14	ash, elm, alder and
10.0	16	18	15	16	16	17	15	Sweet
10.5	17	19	15	17	17	18	15	chestnut
11.0	17	19	16	17	17	18	16	
11.5	18	20	16	18	18	19	16	
12.0	19	21	17	19	19	19	16	BIRCH
12.5	19	21	17	19	20	20	17	Use also
13.0	20	22	18	20	20	20	17	for
13.5	20	23	18	21	21	21	18	sycamore and poplar
14.0	21	23	19	22	22	21	18	
14.5	21	24	20	22	22	22	19	
15.0	22	24	20	23	23	22	19	
15.5	23	25	21	24	24	23	20	
16.0	23	26	21	24	24	23	20	
16.5	24	26	22	25	25	24	21	
17.0	24	27	22	26	26	24	21	
17.5	25	27	23	26	26	24	21	
18.0	25	28	23	27	27	25	22	
18.5	26	29	24	28	28	25	22	
19.0	27	29	24	28	28	26	23	
19.5	27	30	25	29	29	26	23	
20.0	28	30	25	30	30	27	24	
20.5	28	31	26	30	30	27	24	
21.0	29	32	26	31	31	27	24	
21.5	29	32	27	32	32	28	25	
22.0	30	33	28	33	32	28	25	
22.5	30	34	28	33	33	29	26	
23.0	31	34	29	34	34	29	26	
23.5	32	35	29	35	34	29	26	
24.0	32	35	30	35	35	30	27	
24.5	33	36	30	36	36	30	27	
25.0	33	37	31	37	36	30	27	

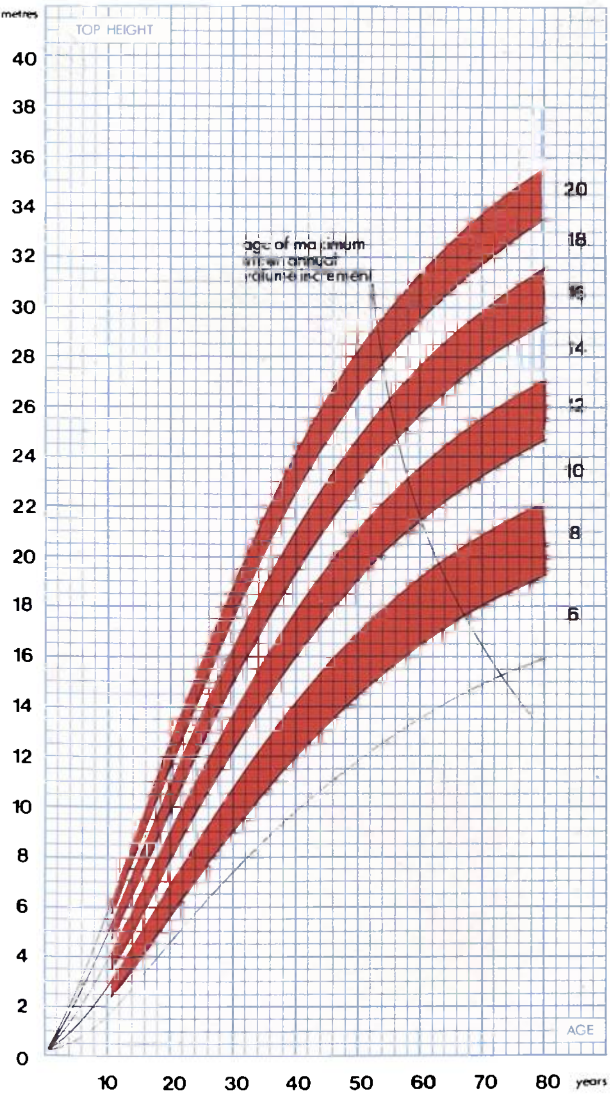
General Yield Class Curves

Scots Pine



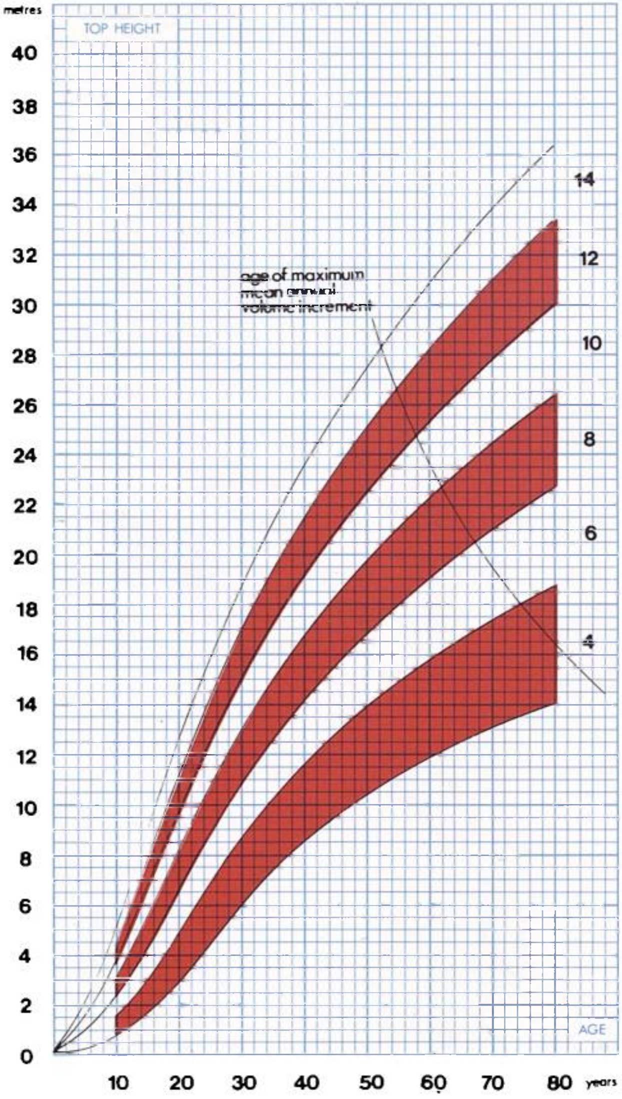
GENERAL YIELD CLASS CURVES

Corsican Pine



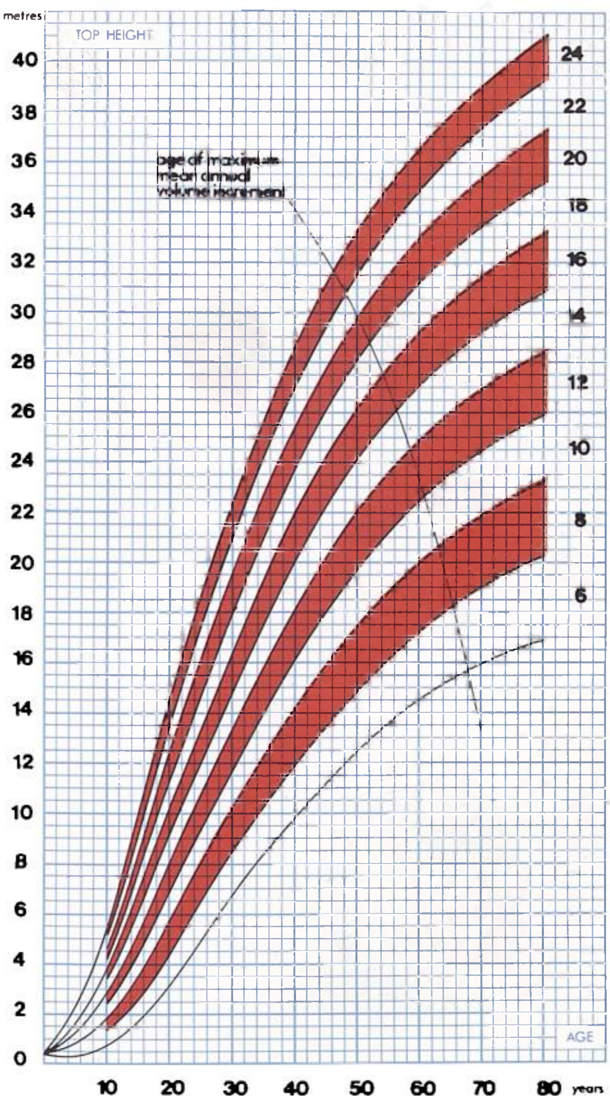
GENERAL YIELD CLASS CURVES

Lodgepole Pine



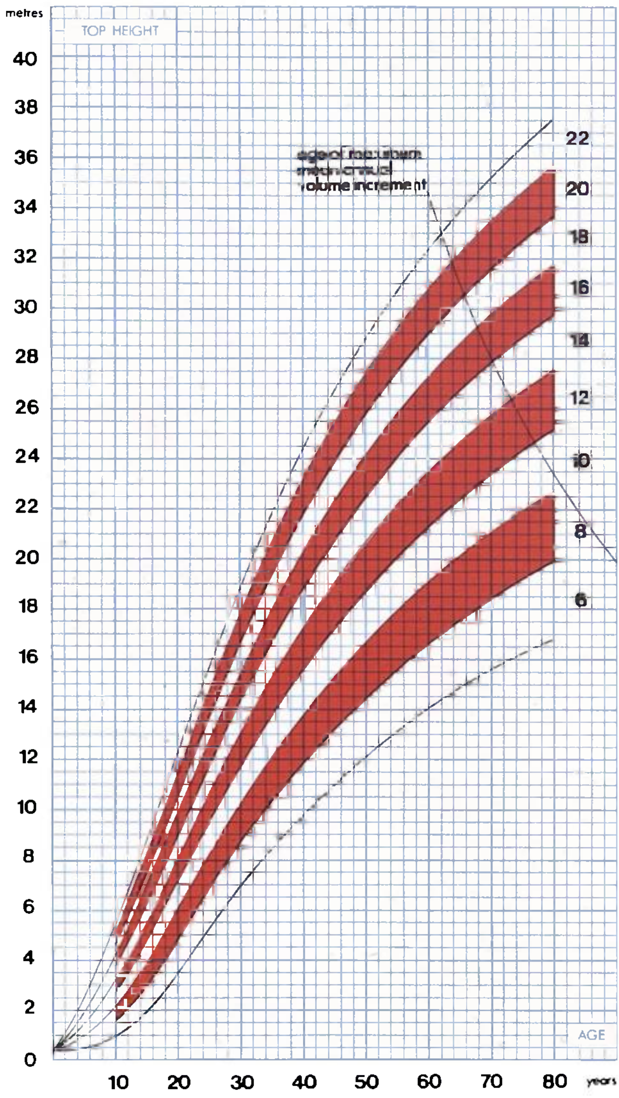
GENERAL YIELD CLASS CURVES

Sitka Spruce



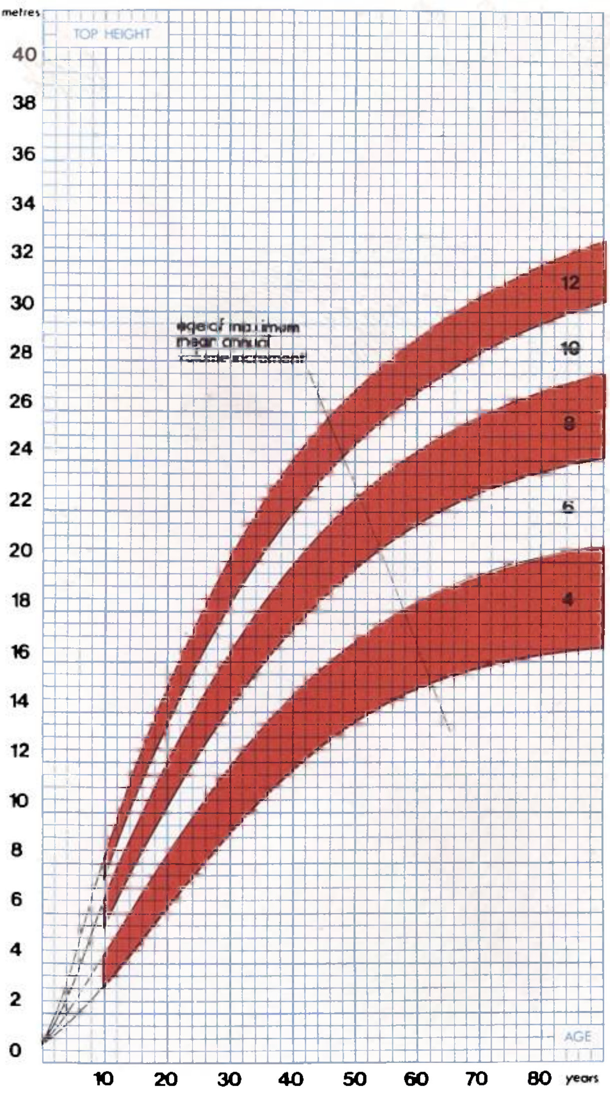
GENERAL YIELD CLASS CURVES

Norway Spruce



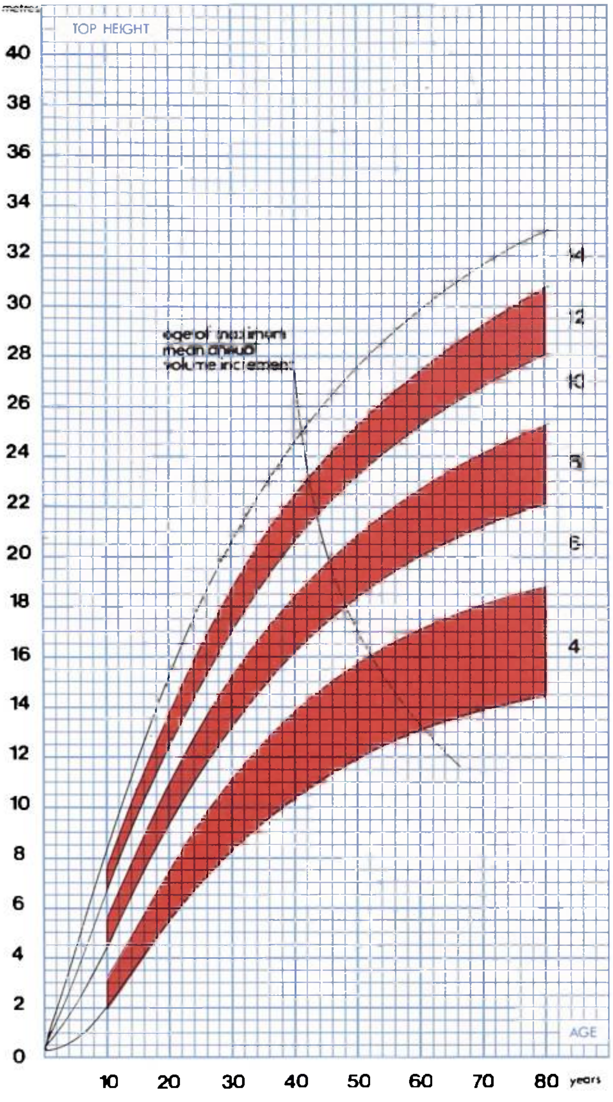
GENERAL YIELD CLASS CURVES

European Larch



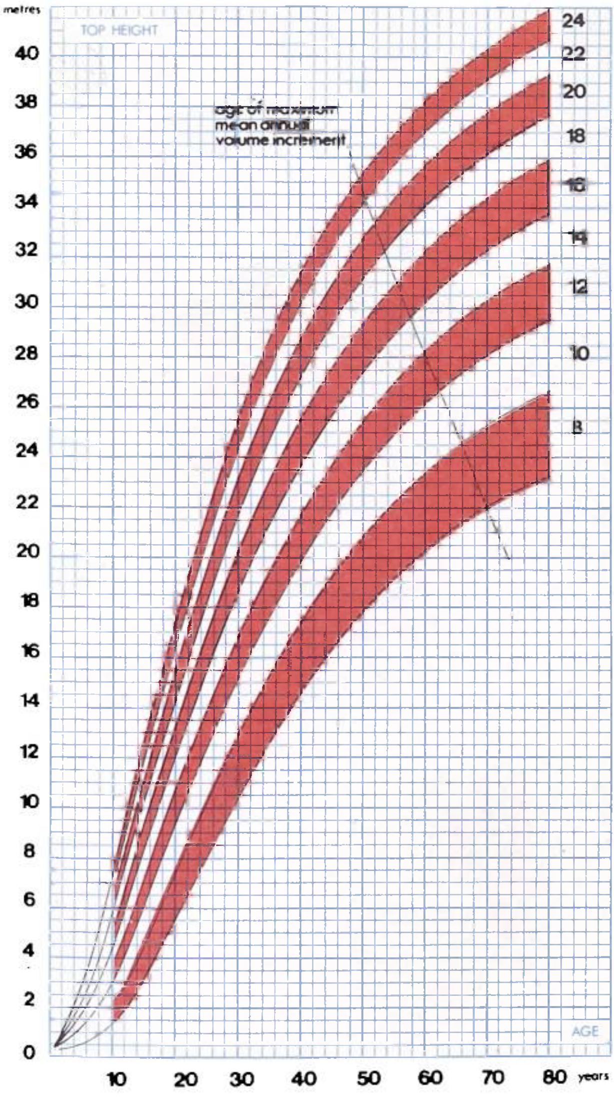
GENERAL YIELD CLASS CURVES

Japanese Larch & Hybrid Larch



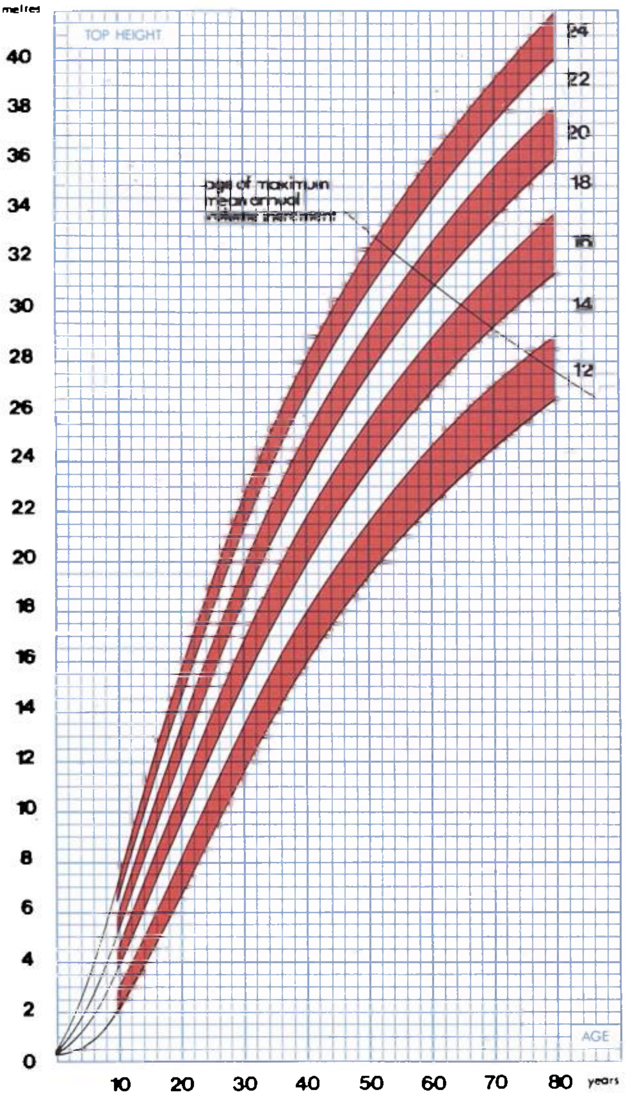
GENERAL YIELD CLASS CURVES

Douglas Fir



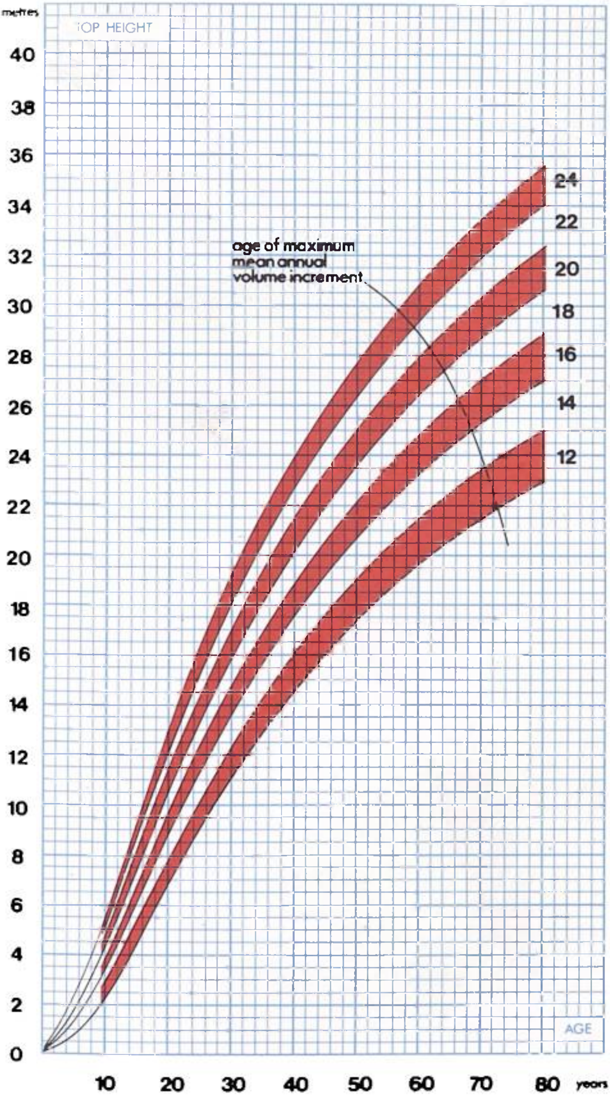
GENERAL YIELD CLASS CURVES

Western Hemlock



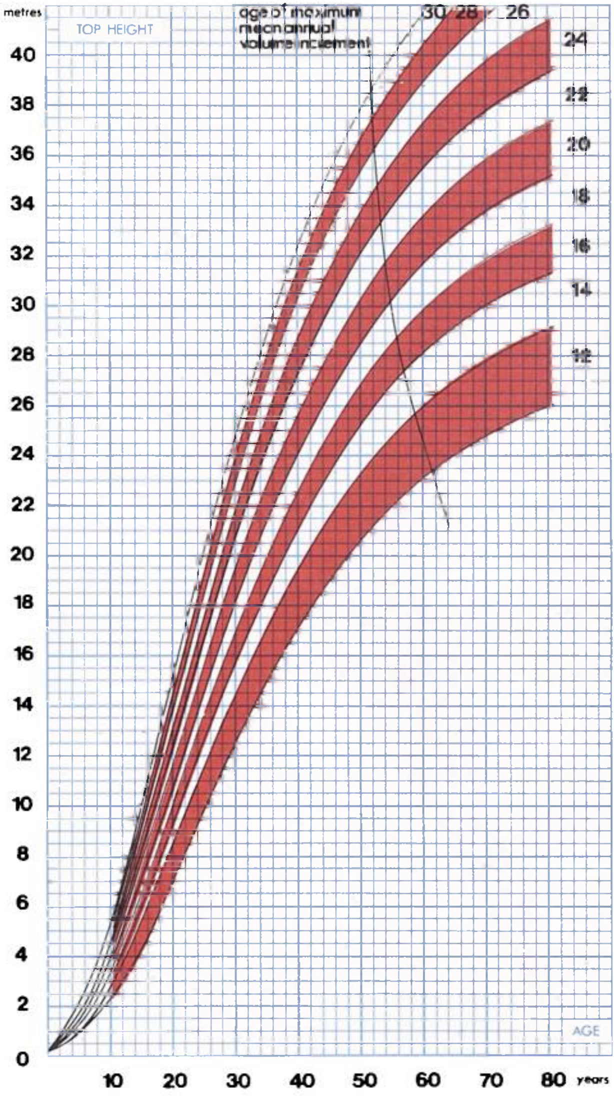
GENERAL YIELD CLASS CURVES

Western Red Cedar & Lawson Cypress



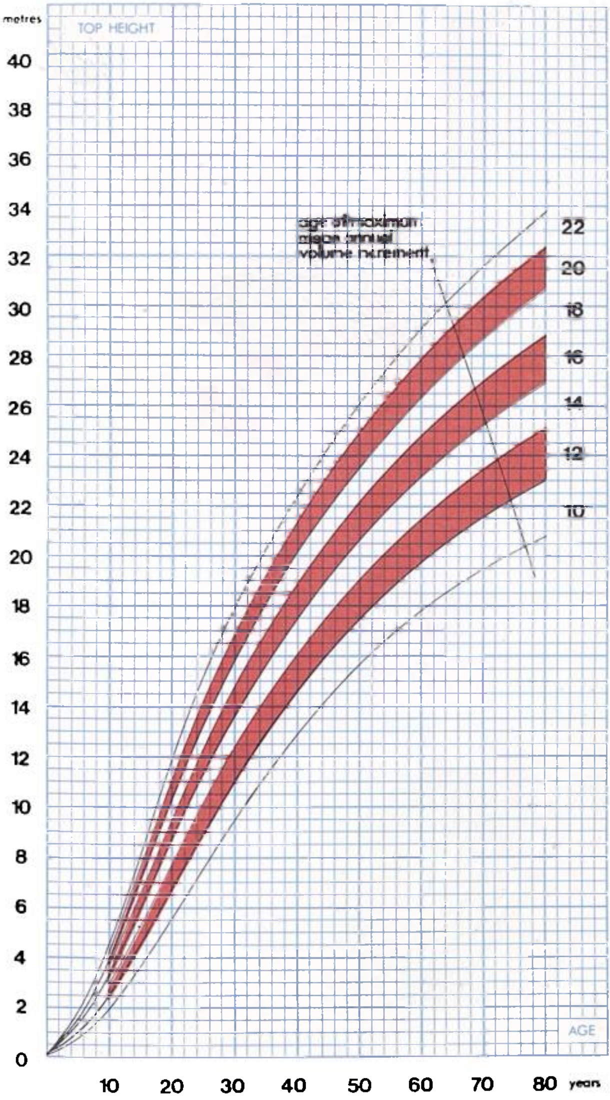
GENERAL YIELD CLASS CURVES

Grand Fir



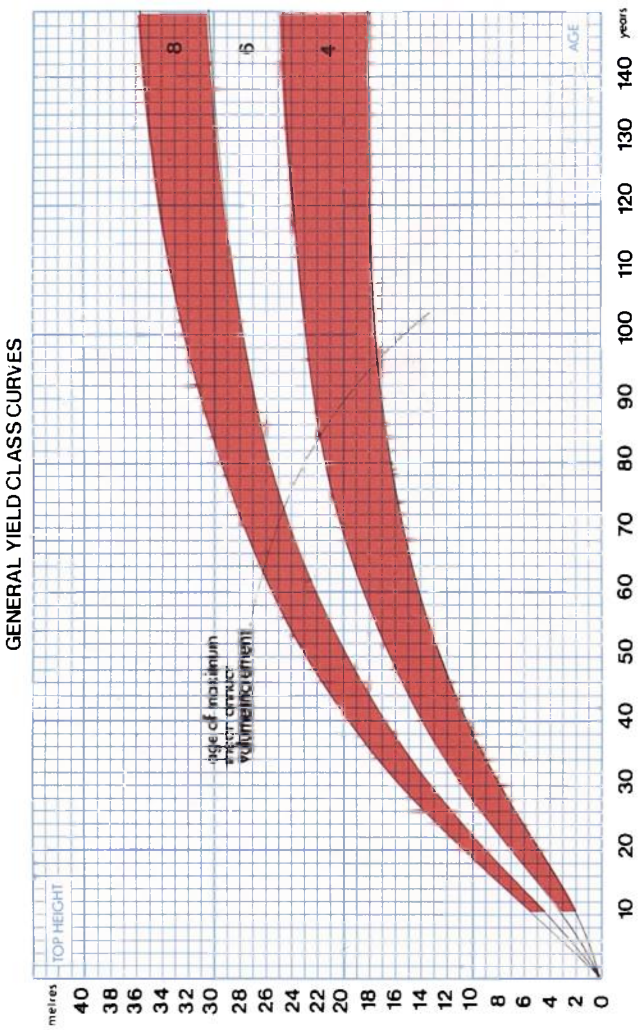
GENERAL YIELD CLASS CURVES

Noble Fir

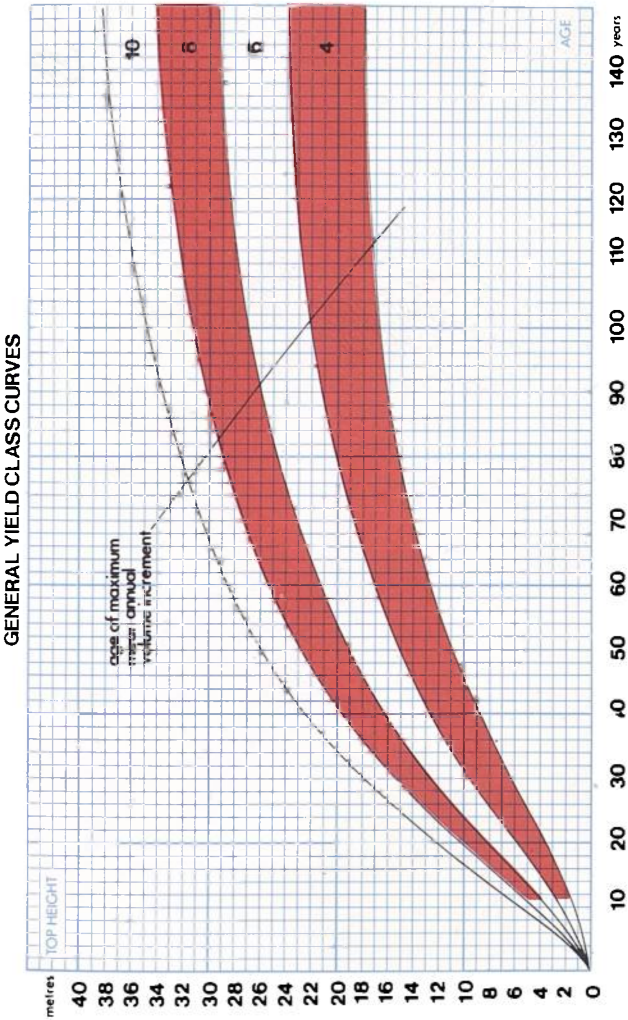


GENERAL YIELD CLASS CURVES

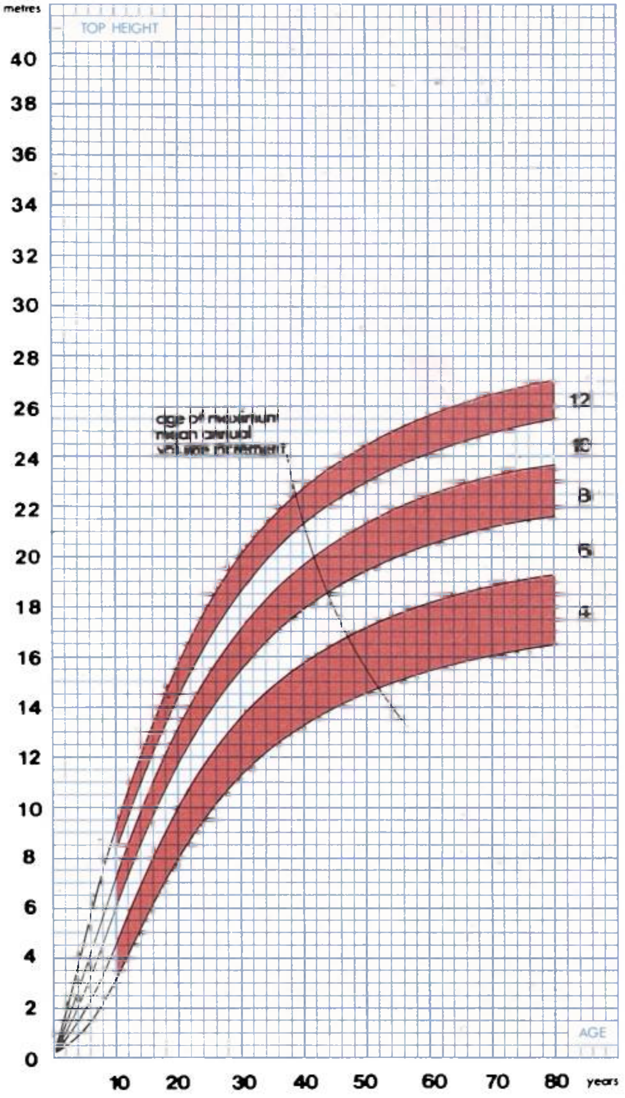
Oak


GENERAL YIELD CLASS CURVES
TOP HEIGHT
metres
AGE
years
8
6
4
age of maximum mean annual volume increment

Beech

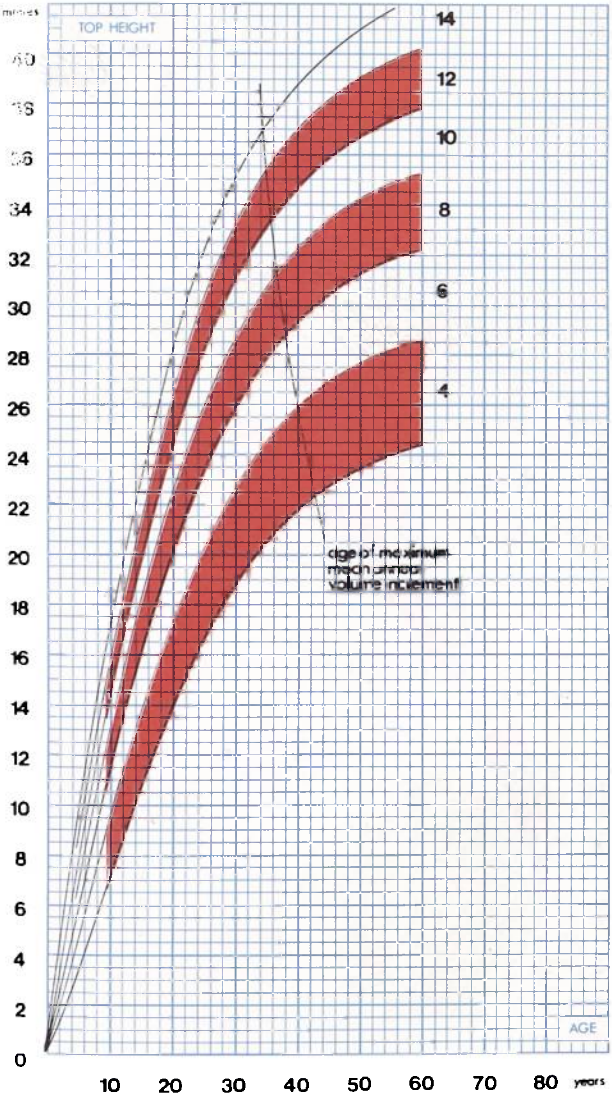

GENERAL YIELD CLASS CURVES
TOP HEIGHT
metres
40 38 36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
10 20 30 40 50 60 70 80 90 100 110 120 130 140 years
AGE
age of maximum mean annual volume increment
10
8
6
4

Sycamore, Ash and Birch



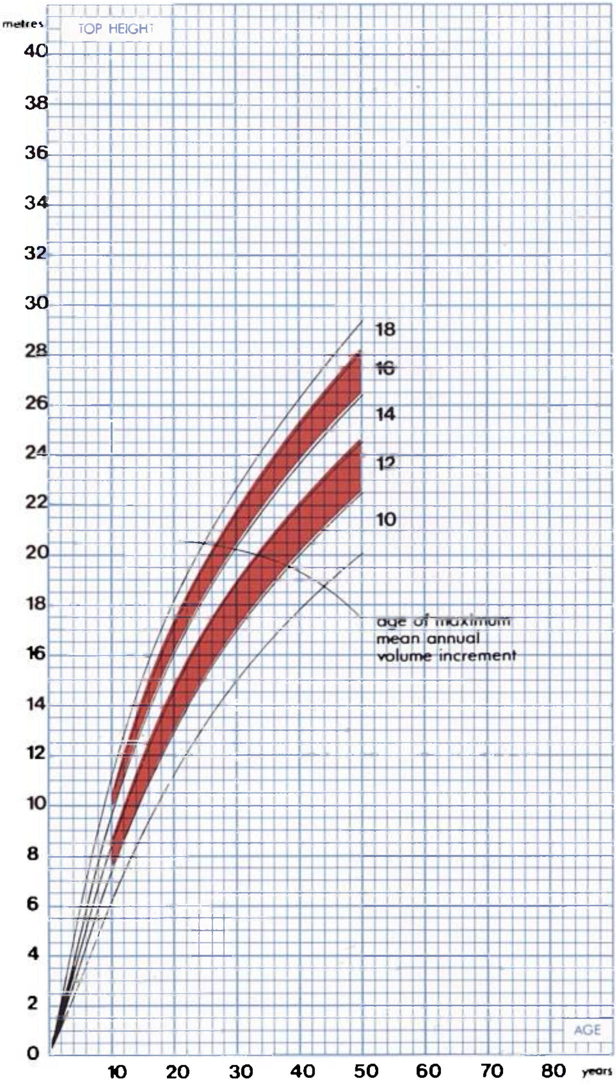
GENERAL YIELD CLASS CURVES

Poplar



GENERAL YIELD CLASS CURVES

Nothofagus



GENERAL YIELD CLASS CURVES

rther information is available from:

Forestry Commission Publications
Leaflet 77 Line Thinning (1980)
Bulletin 14 Forestry Practice (1985)
Booklet 39 Forest Mensuration Handbook (1985)
Booklet 47 Investment Appraisal in Forestry (1981)
Booklet 48 Yield Models for Forest Management (1981)
Booklet 49 Timber Measurement – A Field Guide (1983)
These can be obtained from the Forestry Commission Publications Section (address below), from HMSO or any good bookshop, excepting Booklet 48 which is available only from the Forestry Commission Publications Section.

2. Advice on any matter relating to timber measurement is available from the Mensuration Officer, Forestry Commission Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, GU10 4LH. Tel: Bentley (0420) 22255.

Enquiries relating to this publication should be addressed to the Publications Officer, Forestry Commission Research Station, Alice Holt Lodge, Wrecclesham, Farnham, Surrey, GU10 4LH

Checklist

1. Determine the Yield Class of the stand (see page 6).
2. Choose the thinning type (see page 8).
3. Choose the thinning intensity (see page 9).
4. Choose the thinning cycle (see page 10).
5. Work out the thinning yield (see page 11).
6. Check that the stand is ready for thinning (see page 16).
7. Start by marking a representative corner of the stand.
8. Measure the volume marked (see page 27).
9. Repeat this procedure several times and if the volume marked is found to be consistently greater or less than the specified thinning yield, adjust the size, or number, or both of the trees being marked accordingly.
10. Continue marking to this revised standard, making only occasional checks.

Printed in the United Kingdom for HMSO
Dd 289897 C35 12/87 28614

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