ines for the aged Regrowth and Two-Tiered Karri Forests

by F.J. Bradshaw

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Silvicultural Guidelines for the Treatment of Even-aged Regrowth and Two-Tiered Karri Forests

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INTRODUCTION

The broad silvicultural policy for the karri forest in areas where continuous wood production is an objective is based upon even-aged management. Where mature stands are to be cut they are clear felled to produce even-aged regrowth stands. The regrowth forest which results will be thinned (perhaps several times) before a final felling at no less than 100 years of age.

There are some stands however which because of their two-tiered structural composition are not suited for immediate clear felling. To do so would result in the waste of potential yield. An intermediate thinning treatment can be applied which will allow this potential yield to be utilized at the time of a later clear felling.

There are other two-tiered stands however where an intermediate treatment is of little or no value.

The object of this paper is to provide operational foresters with guidelines for the appropriate silvicultural treatment of even-aged regrowth and two-tiered stands, and to indicate the rationale on which these guidelines are based.

The structure of these stands should be seen as a continuum, rather than discrete stands for which a precise prescription can be written. The principles outlined should give operational foresters the flexibility required for practical application while still meeting the objectives of silviculture and management.

The Karri forest may be considered to consist of three broad silvicultural types. These are:

- Single Storied Mature Stands
- Even-Aged Regrowth Stands
- Two-Tiered Stands

Structural Types

(a) Single Storied Mature Stands

These are virgin stands where the forest canopy is recognizably a single layer of mature and overmature trees. They generally have a canopy cover of 70 - 80% (the maximum for the species) predominantly within this single layer. In mixed stands of karri and marri, the marri forms a lower layer than the karri but in the context of this paper is considered to be part of the single upper-storey. Although a few smaller or younger stems do occur they are not significant in the context of silvicultural treatment (Fig. 1). When stands such as this are to be logged, they will be clear felled (with or without seed trees) and regenerated to an even-aged stand.

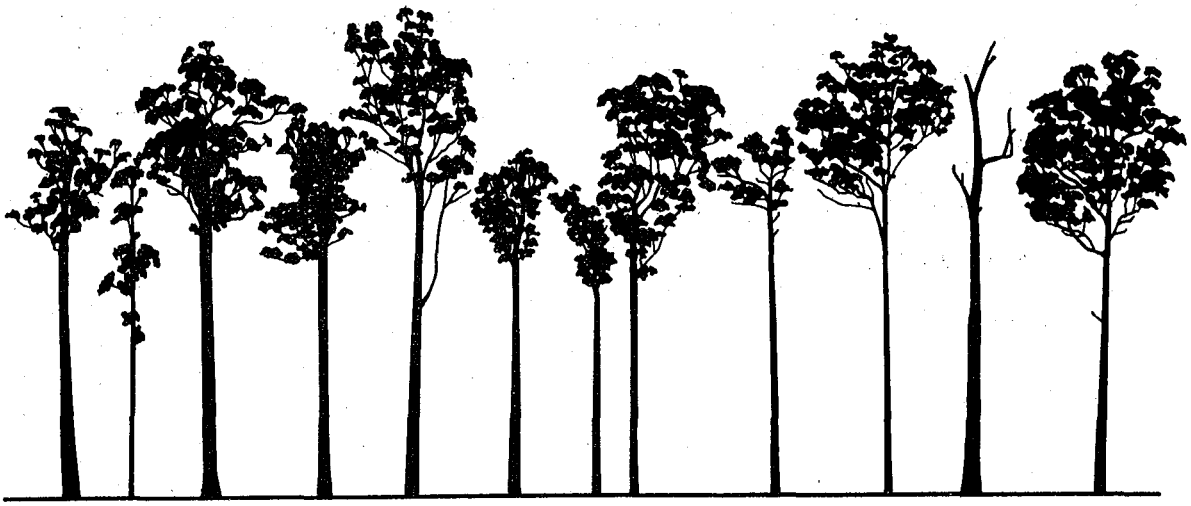


FIGURE 1: A diagrammatic representation of a single-storey mature karri forest.

(b) Even-Aged Regrowth Stands

These stands consist of a predominantly single storey of immature trees of the same age. These stands have resulted from the complete, or near complete, removal of the original mature forest by either logging, clearing for agriculture, or by wildfires. For practical purposes stands containing up to 15% crown cover of an overstorey canopy have been included within this group (Fig. 2). While most of this type has been mapped there are some virgin even-aged stands of immature trees in excess of 80 years old which have not been identified by conventional aerial photography, but which can be recognized as they are located in the field.

The silvicultural objective for these stands is to be one or more thinnings followed by clearfelling when the trees begin to decline in growth rate. This will not be before 100 years of age.

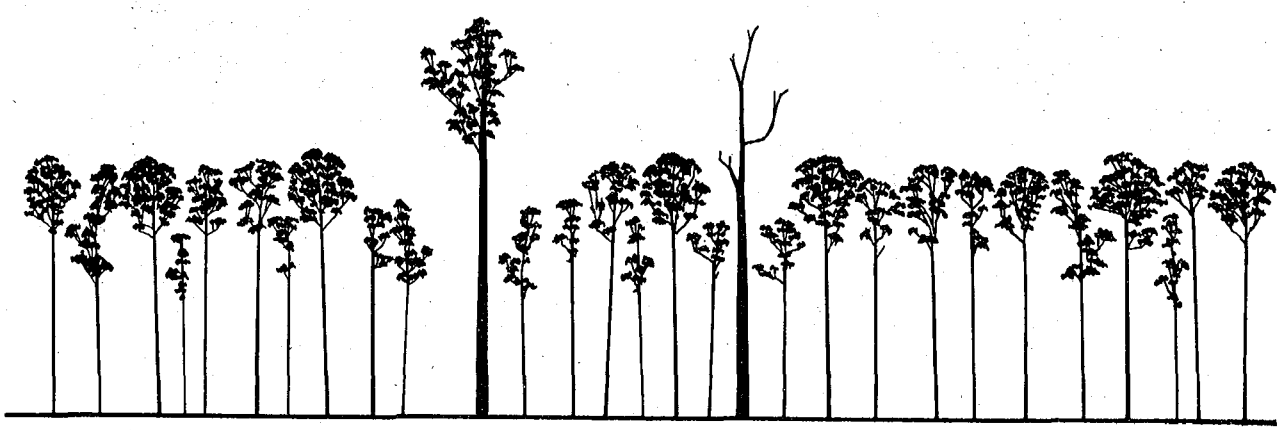


FIGURE 2: Even aged regrowth forest about 50 years old. Stands containing up to 15% crown cover of veteran trees are included in this category for management purposes.

(c) Two-Tiered Stands

These stands consist of two distinct layers which are distinctly different in age or maturity (Fig. 3). These result from selective logging or the less complete removel of the original overstorey by agricultural clearing or wild fire. These stands are extremely variable in composition. The overstorey may be vigorous or decadent and may vary in crown cover from 15 - 50%. Gaps containing the regrowth lower storey may be distinct or ill-defined and may vary in diameter from 40 m to 140 m (stem to stem).

The long-term silvicultural objective is to convert these stands to even-aged by clearfelling. However the immediate clear felling of some of these stands would result in the potential loss of production from regrowth trees which have not reached sawlog size, but if left to grow would provide an additional yield of sawlog.

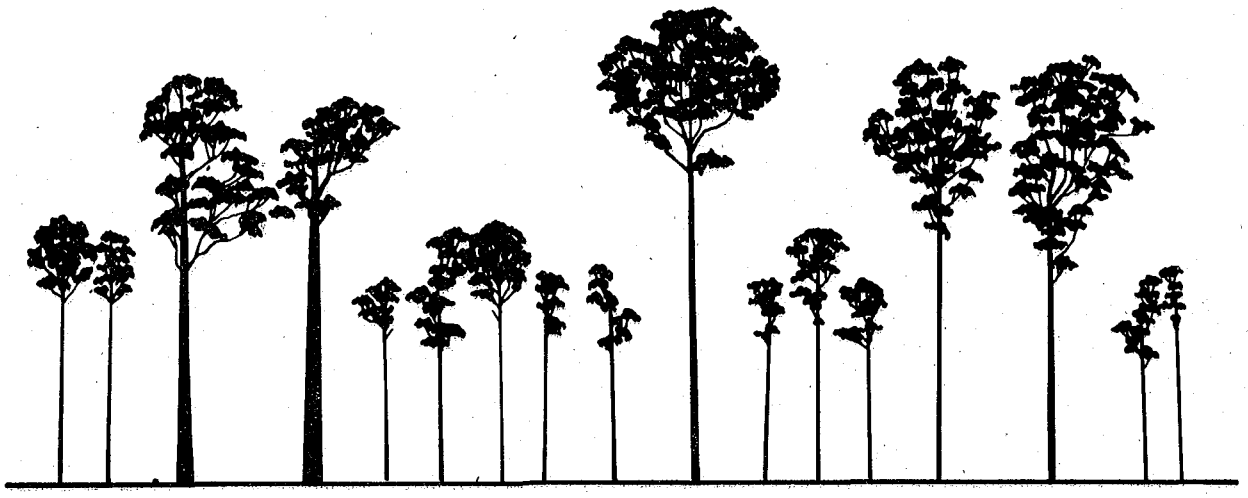


FIGURE 3: An example of the structure of a two-tiered forest. A wide range of overstorey crown cover percentage and gap size are included in this category resulting in a variety of silvicultural requirements.

Background Considerations

(a) Why Even-Aged?

The karri forest will regenerate following the creation of gaps in the original canopy by death due to old age, injury, or severe fire, or by felling. Provided that seed is available and mineral soil is exposed regeneration will occur in relatively small gaps or very large openings. (eg: clear felling). Examples of regeneration developing in a wide range of "gap" sizes may be seen in the virgin forest.

When a forest is to be used for production purposes factors, such as: growth rate, suppression of younger trees by older trees, and the damage to regrowth by the falling of larger trees, while of no consequence in a natural forest, become important factors to consider.

In the context of long term production, silvicultural systems must be formulated which are not only successful in the short term but are capable of producing long term and repeatable production from a healthy forest. A practice which leads to a dead end does not qualify as a silvicultural system. In this sense the creation of regeneration which is not able to develop satisfactorily or will be damaged by the felling of other trees before it can be efficiently utilized does not provide the basis for a satisfactory silvicultural system.

This is the case with selective logging if the gaps created are too small for the species concerned. If the gap is too small, although it will initially regenerate, a part or all of this space will later be taken up by the established surrounding trees. The regeneration may be killed, become suppressed or seriously retarted by this competition.

Selective logging also implies the ultimate removal of all the original trees. If these trees cannot be removed without damaging the adjacent regrowth already established then there is no point in having established it, and the practice is not silviculturally sound. The original gap size which is necessary to allow subsequent felling without damage to regrowth is a function of tree height and crown size. With karri tree heights of 75 - 85 m and a crown diameter of 25 m the gap size required is very large: much larger than that required to allow satisfactory development of regeneration. Adding to this the weight of the logs which require very large machinery to move, and the use of fire for the creation of ashbed, the necessity for clear felling (in effect, very large gaps) is evident. This is also the reason why clear felling and even-aged management is the preferred system for all the very tall forests of the world, in particular during the conversion from virgin to managed forests. (Fig. 4).

A problem arises with stands which are already unevenaged, such as the two-tiered forests under discussion. Their continued management as unevenaged forest is impractical. However with substantial portions of the stand occupied by regrowth 20 - 40 years of age which is too small to be efficiently utilized, immediate clearfelling and conversion to even aged stands will result in a loss of potential yield.

The objective is therefore to determine which of the variety of stands involved are suitable for treatment to bring this regrowth up to a utilizable size before conversion and which stands are not - within a 30 to 40 year period.

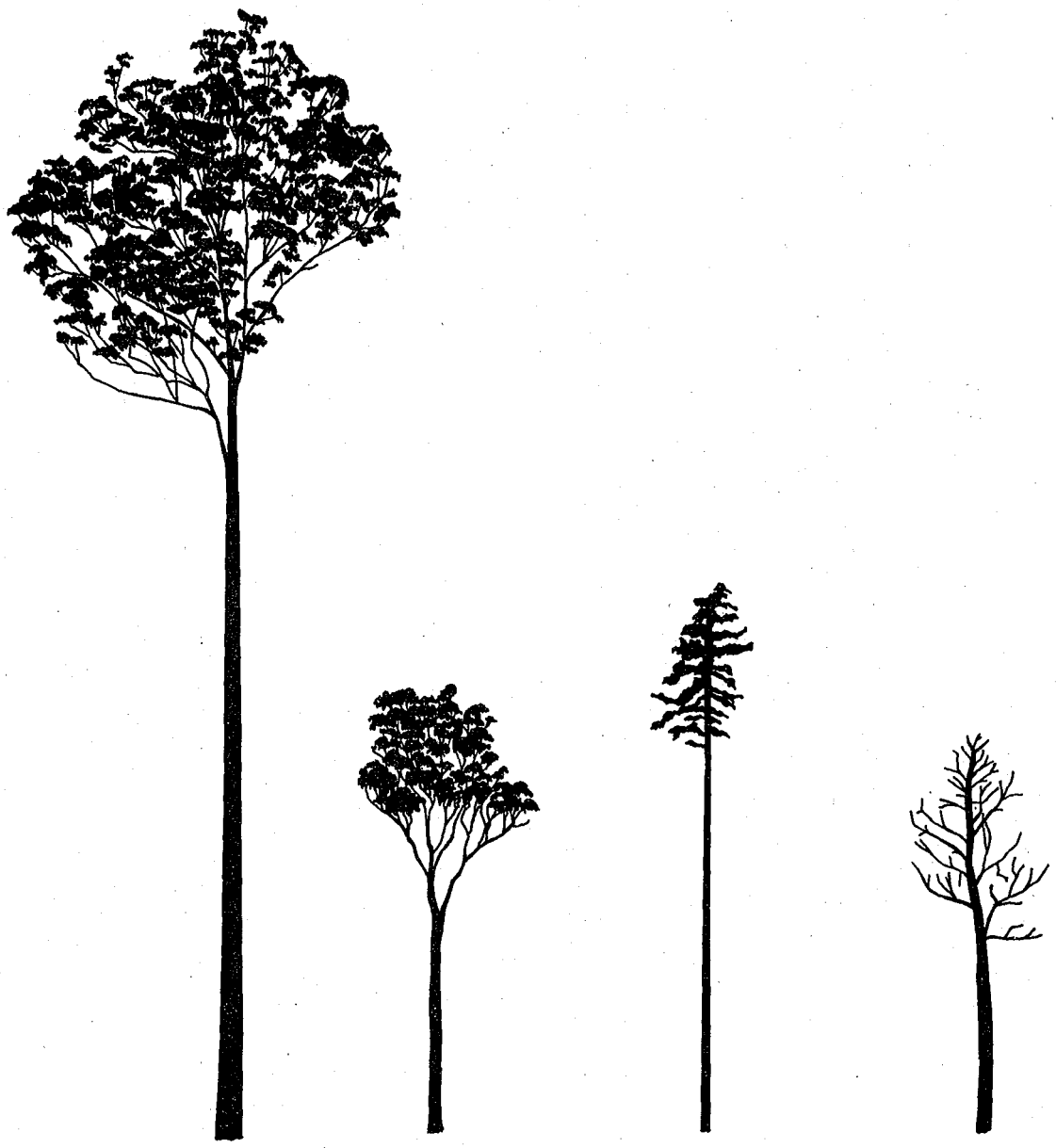


FIGURE 4: Tree height and crown shape are important considerations in the formulation of a silvicultural system. The relative sizes of these species dramatically illustrate the different gap sizes which are required to enable them to be felled without damage to regrowth.

(b) Effect of Overstorey Competition

Rotheram (1983) has shown that a mature karri tree standing above 50 year old regrowth will have a suppressing effect on the regrowth to a distance of twice the crown radii of the veteran and that for every 1% crown cover there is a 2% loss in regrowth volume. At about 20 - 25% crown cover of veterans (at even spacing), the influence of the veterans overlaps so that above this crown cover it can be expected that no regrowth will develop beyond this age without the suppressing influence of the overstorey trees. However since the overstorey is not usually of even distribution it is necessary to estimate the minimum gap size above which some regrowth will develop without the influence of the surrounding veteran trees.

The influence of one tree on another may be considered to be the combination of two "zones of influence" about the individual tree, extending well beyond the individual tree crowns (Opie, 1968).

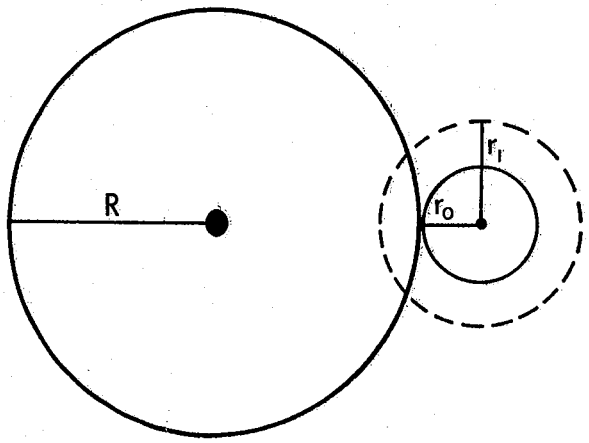


FIGURE 5: The zone of influence around a tree is usually considered to be proportional to its basal area. The zone increases as the tree increases in diameter. The larger the desired final size of the regrowth, the larger the gap required for its development.

Regrowth stems at a distance greater than $R + r_o$ from the larger tree will not be influenced by it. However as the regrowth stem increases in diameter its own zone of influence increases and r_o increases to r_1. Gap size which will allow one regrowth stem to develop without the influence of the larger tree is therefore 2 (R + r), r depending on the desired size of the regrowth stem.

Assuming a crown diameter of the veteran trees to be about 25 m and the space required for the regrowth to increase as it grows to a minimum sawlog size of 55 - 60 cm dbhob, then the minimum gap size to allow one regrowth stem to develop without the suppressing effect of the veterans is estimated to be in the order of 55 - 60 m (stem to stem).

This is not a precise figure since it will depend on the size and vigour of the veteran trees - however it will serve as a guideline.

(c) Commercial Thinning Objectives

Thinning objectives may be varied to achieve different management objectives. In a general sense thinning has the capacity to increase yield by salvaging mortality. Thinning also makes it possible to reduce the time taken to reach a minimum size required for utilization. However thinning which is too heavy may also result in a loss of either total volume or sawlog volume.

Long term sawlog yield projections (Bradshaw and Lush, 1981) indicate a diminished supply until the regrowth produced from about 1970 reach a size suitable for sawmilling. Maximising the volume of sawlogs available during this period is therefore a major objective.

Present practice permits the commercial thinning of regrowth stands when they reach 30 m in codominant height. Thinning of smaller stands than this are not considered in this paper.

The objective for thinning the existing stands which range in codominant height from 30 - 45 m where the crop trees have not reached a size suitable for milling is:

- to increase the rate of diameter growth on the crop trees so that they will reach sawlog size sooner while ensuring that potential sawlog volume is not diminished.

- to salvage trees which will be lost through mortality, providing a useful intermediate yield.

Within the framework of the long term yield projections maximizing potential sawlog yield from these stands is more important then increasing growth rate of individual stems.

Thinning is based upon the removal of all dominated and subdominant trees and some of the codominants. Intensity will therefore vary and the basal area to be retained varies with age and site, reflected by codominant height (Table 1). Notwithstanding the above, crop trees should not be reduced below 100 stems per hectare at this stage. This number will provide a full stocking of crop trees prior to the next thinning all of which will yield sawlogs (mean dbh 60 cm). Stocking below this number will result in a reduction of potential sawlog yield.

Older even-age stands, all originating before 1925 as a result of early agricultural clearing or by natural means, also occur throughout the forest. The trees in these stands have already reached sawlog size but because they are still immature and are capable of further growth it is inappropriate to clear fell them and regenerate at this stage. They should be thinned, or clear felling should at least be deferred.

If thinned then the objective is to salvage future mortality but without loss of future volume increment per hectare. The thinning is therefore more conservative since any loss of increment will be a loss of sawlog increment. Volume increment in these stands is more important than increased size of individual stems. The thinning is therefore based on the removal of dominated and subdominant trees only - this will equate to a retained basal area of about 25 m^2/ha.

Stand Definition and Silvicultural Treatment

(a) Even-Aged Stands

Stands in this category are characterized by a predominantly single storey of trees of the same age which have not reached maturity. Stands containing up to 15% overstorey of older trees are included in this category.

(i) CODOMINANT HEIGHT LESS THAN 30 m

These stands are not at present considered for routine commercial thinning, because of the practical problems associated with logging and utilizing thinnings of this size.

Although a thinning of this size and smaller regrowth is likely to be feasible in the future, specific prescriptions have yet to be developed.

(ii) CODOMINANT HEIGHT 30 - 45 m

Most of the stands which have been mapped in the age group 30 - 60 years (4700 ha) fall into this group. At this stage of development all or at least the smaller crop trees will be sub-sawlog size. (Fig. 6). These stands should be thinned according to the following criteria:

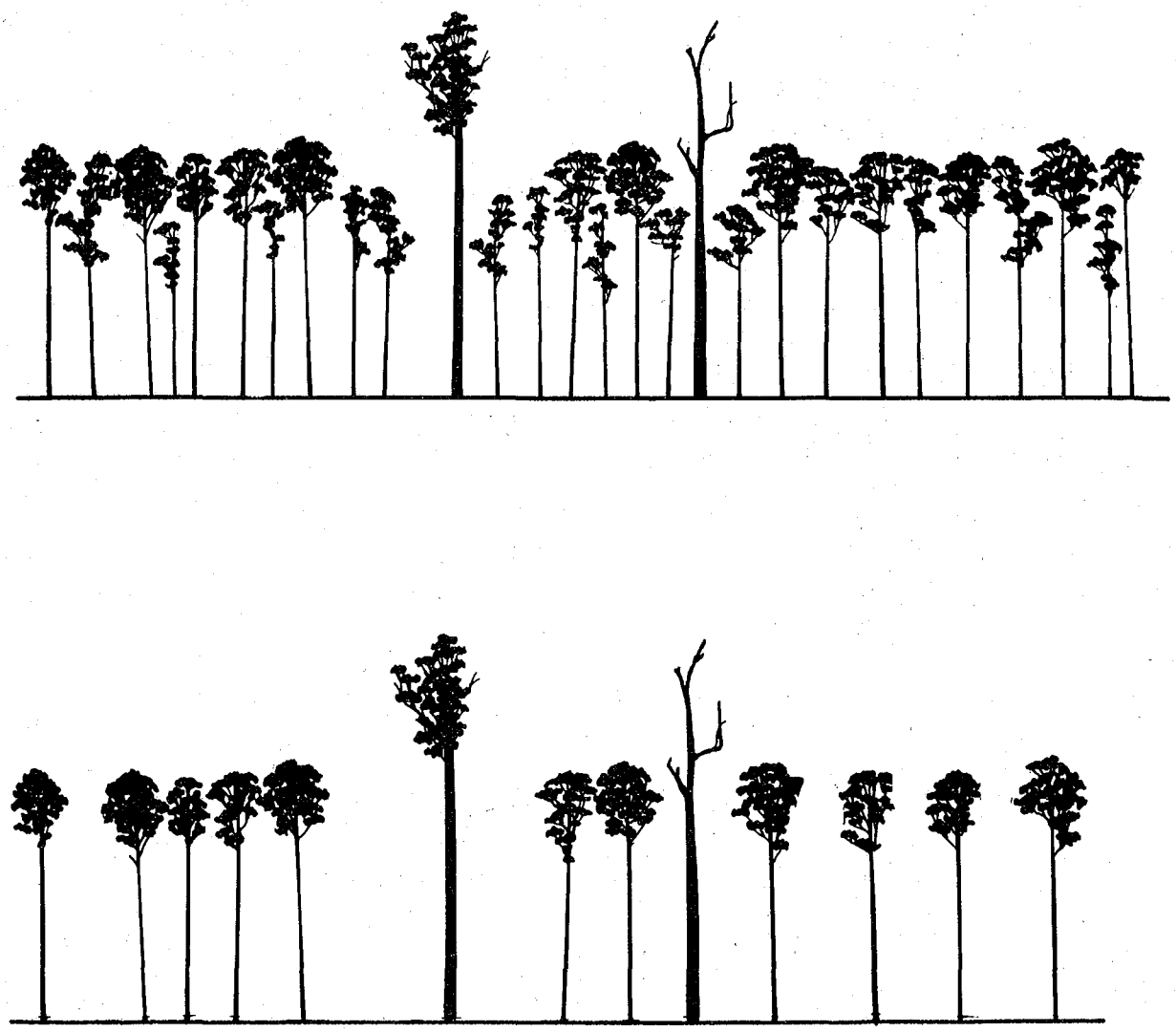


FIGURE 6: 40 m even aged regrowth before and after thinning. The veteran cull tree has been retained because it cannot be removed without excessive damage to crop trees.

Basal Area of regrowth stems to be retained varies according to codominant height (see Table 1) with the proviso that they are not thinned to less than 90 stems/ha.

TABLE 1

THINNING INTENSITY

Codominant Height (m)	BAOB Retained (m^2/ha)
Less than 29 m	Delay thinning
29 - 31	8
32 - 34	10
35 - 37	12
38 - 41	14
42 - 45	16
46 - 48	18

Trees Retained, in order of priority should be: in the dominant and co-dominant class; have a healthy crown; have good form without excessive branching; be selected with due regard to spacing. Closer spacing will be required near natural gaps; minor existing butt damage in vigorous, well growing trees may be tolerated.

Veteran Trees may be removed after thinning of the regrowth provided it can be done without damage to crop trees. Smaller, vigorous, "veterans" which will continue to produce sawlog volume may be left as growing stock if it is the only stem effectively occupying the site.

Natural Gaps will result in an overall reduction in the average basal area of regrowth stems retained. Additional stems in well stocked areas should not be left to make up this deficiency except at the very edge of the gap. For the purpose of checking thinning intensity, basal area sweeps or plots should be confined to areas where stocking is not influenced by natural gaps using appropriate adjustments for "half plots" if necessary. Veteran basal area should not be included.

(iii) CODOMINANT HEIGHT OVER 45 m

These stands have not previously been considered for thinning. Relatively few such areas have been identified and mapped using conventional aerial photography because of the difficulty in separating the appearance of the crown from those of mature trees. However they can be readily identified in the field and stands up to about 100 years of age should be considered in this category. Thinning in this class should be conservative. All dominant and codominant trees should be retained except for those whose boles are damaged to the extent that further growth will not improve their sawlog potential. As a guide, basal areas retained would be of the order of 25 m^2/ha.

(b) Two-Tiered Stands

A wide variety of two-tiered stands exist. These stands have been considered for conversion to even-aged stands without further treatment. The only consideration has been that if the regrowth is too small, clearfelling would be delayed until such time as it would at least yield chipwood volume and thereby prevent its wastage. The potential does exist in some of these stands to provide a yield of sawlogs not previously considered before later conversion to even-aged stands.

The object of this section is to provide guidelines for the most appropriate treatment of the stands encountered.

These stands may be grouped as follows:

OVERSTOREY DENSITY	OVERSTOREY CONDITION	GAP SIZE OR OVERSTOREY DISTRIBUTION
15 - 50%	- Vigorous	- Large Gaps - Small Gaps
	- Mature or Decadent	- Large Gaps - Small Gaps - Irregular Gaps

(i) OVERSTOREY VIGOROUS, LARGE GAPS

Figure 7A shows a diagrammatic representation of these stands. They are in effect a combination of the two even-aged stands described on page 9 with the occasional veteran providing a third canopy level.

The vigorous upper storey has resulted from wildfires while the lower storey of regrowth has usually resulted from selective logging in the past.

Appropriate treatment for these stands is a thinning (Figure 7B) to the two intensities described on page 9. Further thinnings should take place until the immature overstorey begins to decline in growth rate at which time it may be clearfelled and converted to an even aged regrowth stand.

This treatment will provide an additional sawlog resource from the younger regrowth and a marginal increase in the yield from the older immature stands. The latter results from a delay in clearfelling while the stand is still growing well rather than from the thinning.

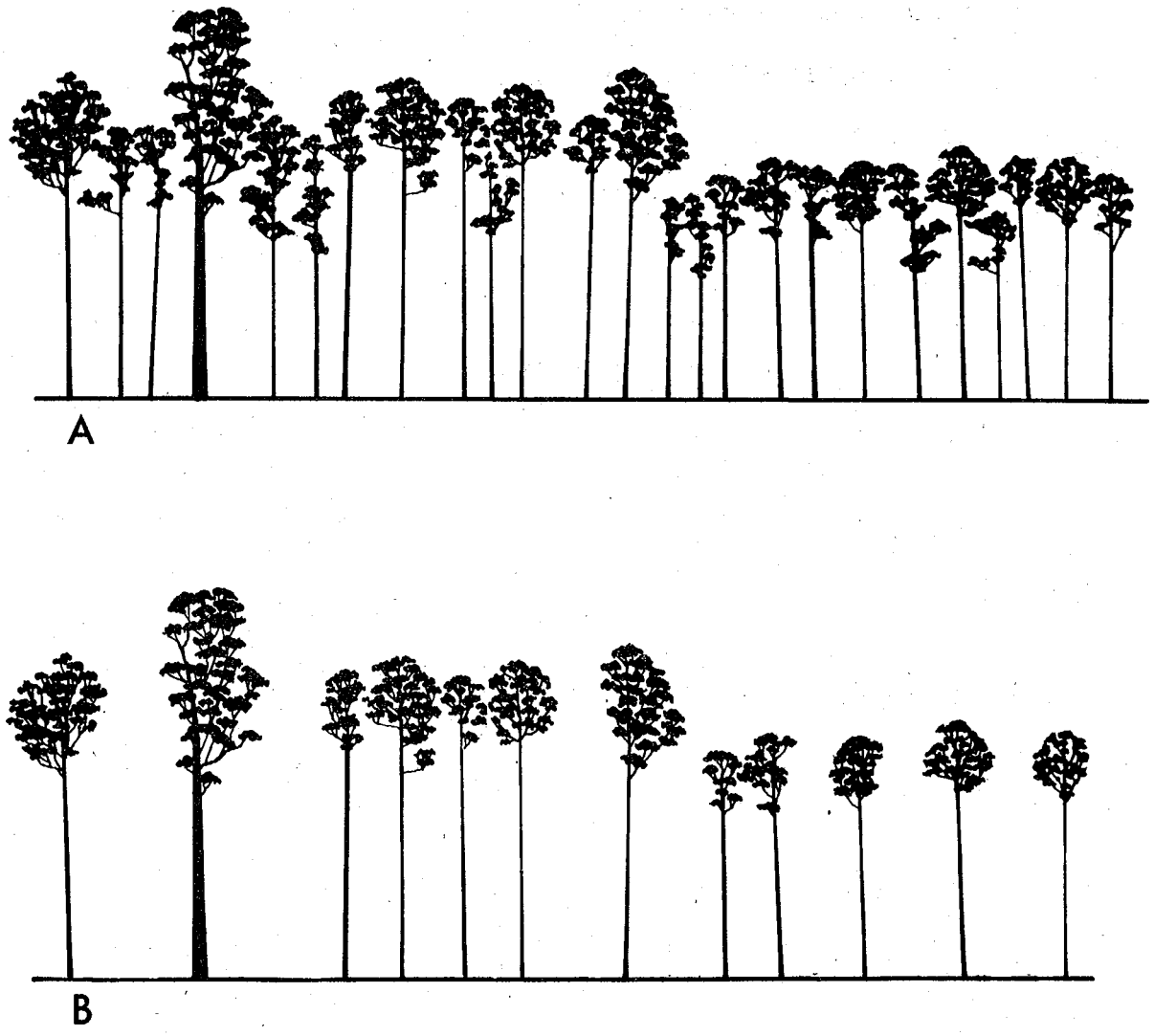


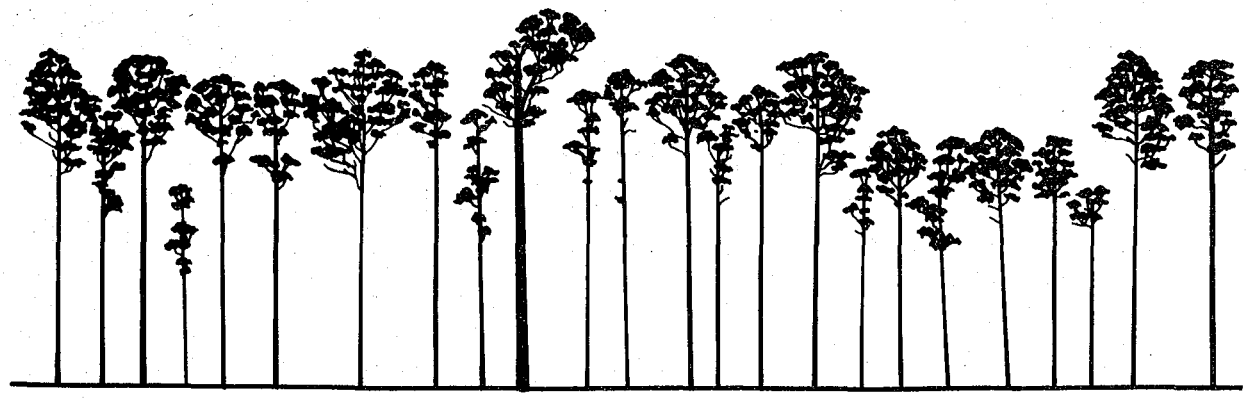
FIGURE 7A: Two tiered forest with a vigorous overstorey of 60 m immature trees and an understorey of 40 m regrowth in a large gap.

B: After thinning of both size classes. The thinning of the older trees is more conservative.

(ii) OVERSTOREY VIGOROUS, SMALL GAPS

These stands (Figure 8A) are similar to the stand just described, except that the gaps occupied by the younger component are smaller. When these stands are thinned (Figure 8B), many of the younger stems which are subdominant to the immature trees, are removed in the process of releasing the larger trees from competition. Therefore while this thinning is the most appropriate treatment it will result in only a minimal additional resource from the younger regrowth and the stand begins to approach an even aged stand by the process of the actual thinning.

Subsequent treatment may involve further thinnings until the upper storey trees begin to decline in growth.



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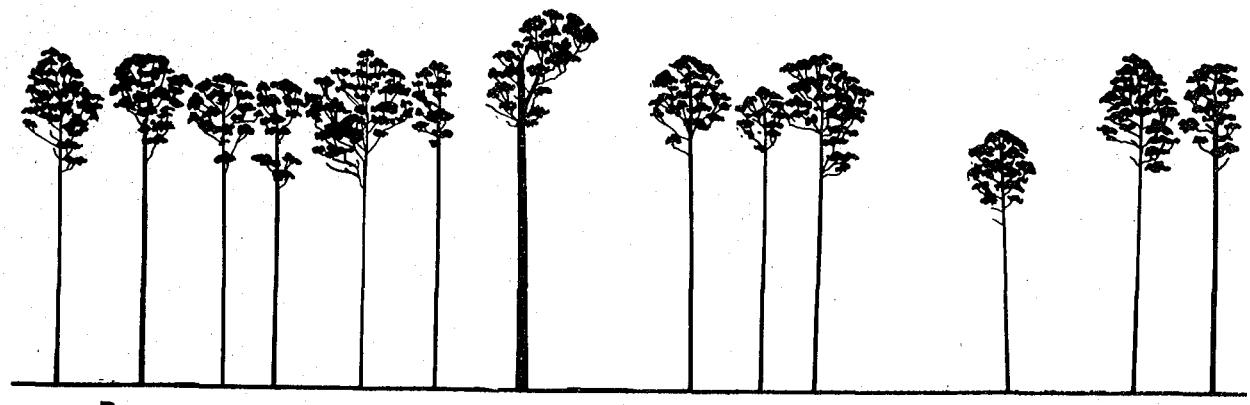


B

FIGURE 8A: Two-tiered forest with a vigorous overstorey of 60 m immature trees and an understorey of 40 m regrowth in small gaps.

FIGURE 8B: After thinning a high proportion of the understorey regrowth are removed. The additional future yield from the 40 m stands will be minimal.

(iii) OVERSTOREY MATURE OR OVERMATURE, LARGE GAPS

Figure 9A illustrates a stand of this type. In this situation there is no advantage to be gained by attempting to thin the upper storey. However when the gap is as large as that illustrated (140 m), a thinning of the lower storey (Fig. 9B) will provide for a significant number of regrowth stems to grow through to sawlog size, without being inhibited by the surrounding trees.

The regrowth component of such stands should therefore be thinned, together with the removal of any dominated stems among the upper storey. Subsequent treatment would be clearfelling when the regrowth stems are of sawlog size. This will provide an additional yield of sawlogs not previously considered.

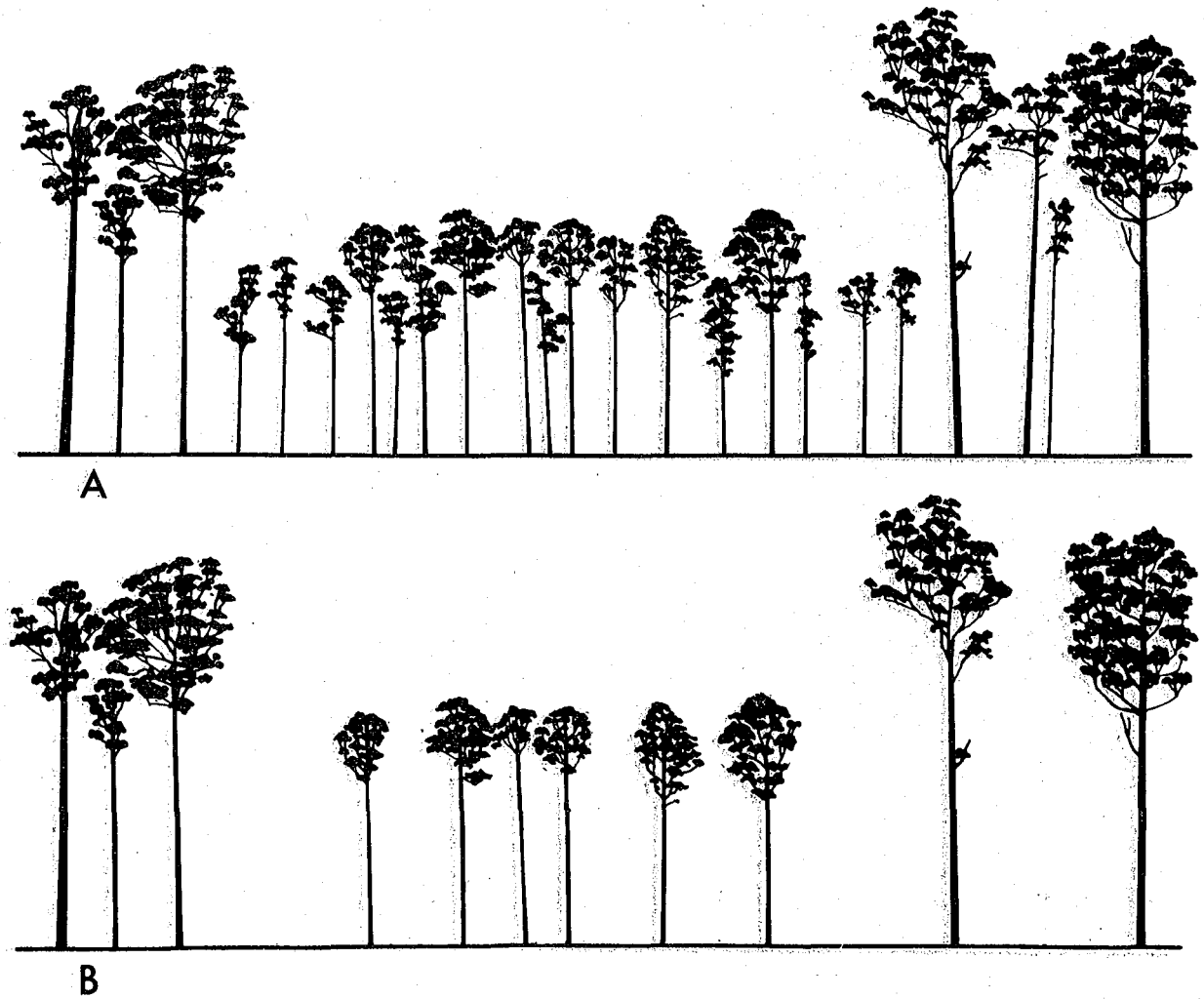


FIGURE 9A: Two tiered forest with an overstorey of mature trees and a lower storey of regrowth in large gaps.

FIGURE 9B: After thinning of the lower storey a significant number of crop trees remain with sufficient space to grow into sawlogs.

4.2.4 OVERSTOREY MATURE OR OVERMATURE, SMALL OR IRREGULAR GAPS

Figure 10A and 11A illustrate stands of this type. If the regrowth storey is thinned (Figures 10B, 11B) there are very few stems which will have sufficient space to develop into sawlogs without the suppressing influence of the larger trees. (It is estimated that a gap of 55 - 60 m will allow only one stem to develop to a sawlog free of overstorey competition.)

Where gap sizes are less than about 60 m, thinning is therefore not considered appropriate and the stand should be clearfelled when it is appropriate for other reasons.

Where gap sizes exceed 60 m, it becomes a value judgement as to how many regrowth crop trees per gap warrant a thinning operation as opposed to clear felling. An 80 m gap (stem to stem) may serve as a useful guideline for the present time.

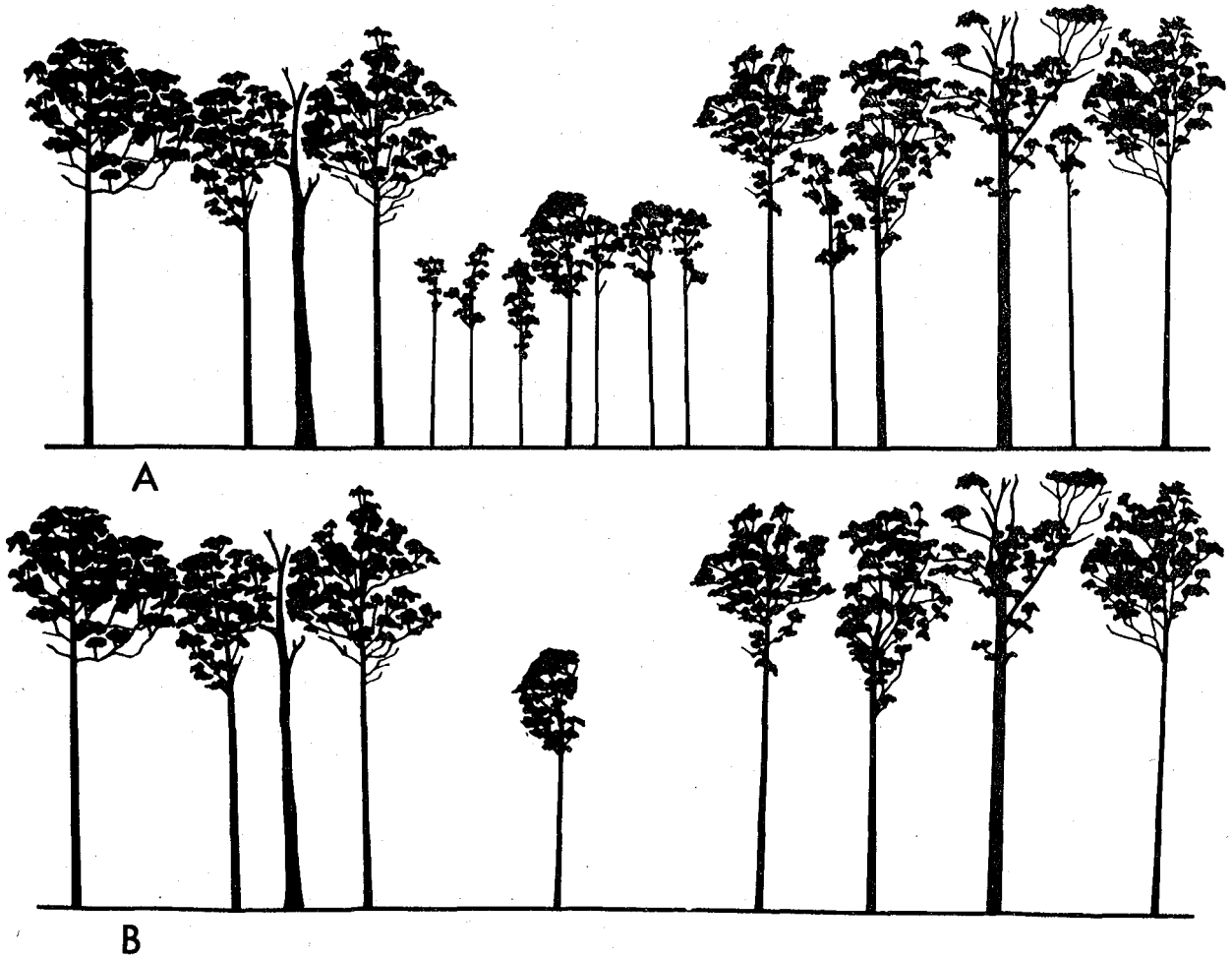
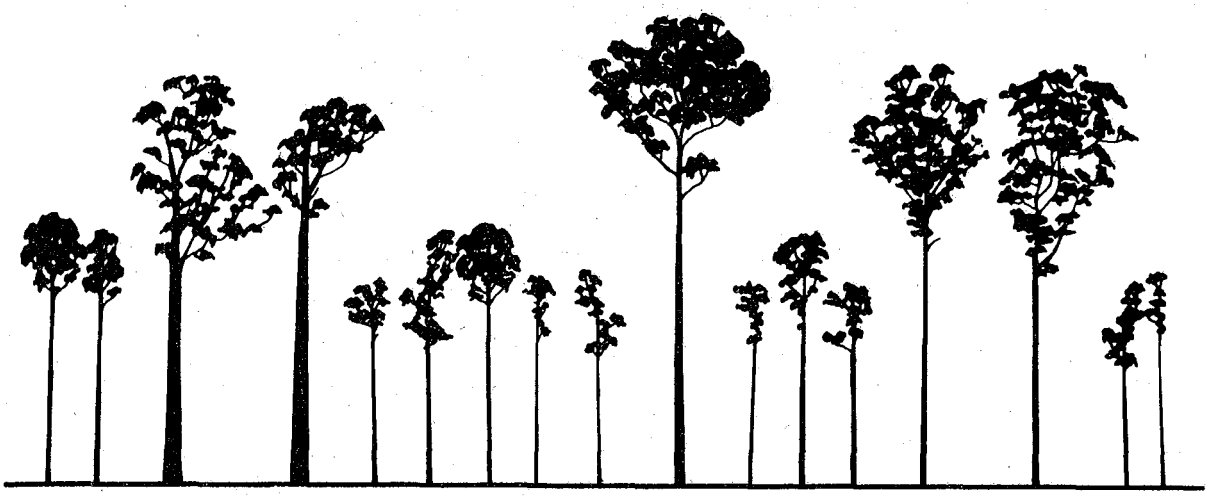


FIGURE 10A: Two-tiered forest with an overstorey of mature trees and regrowth in small gaps.

FIGURE 10B: Thinning leaves very few stems with the space necessary to grow into sawlogs. Stands with gaps of this size and smaller should be clearfelled.



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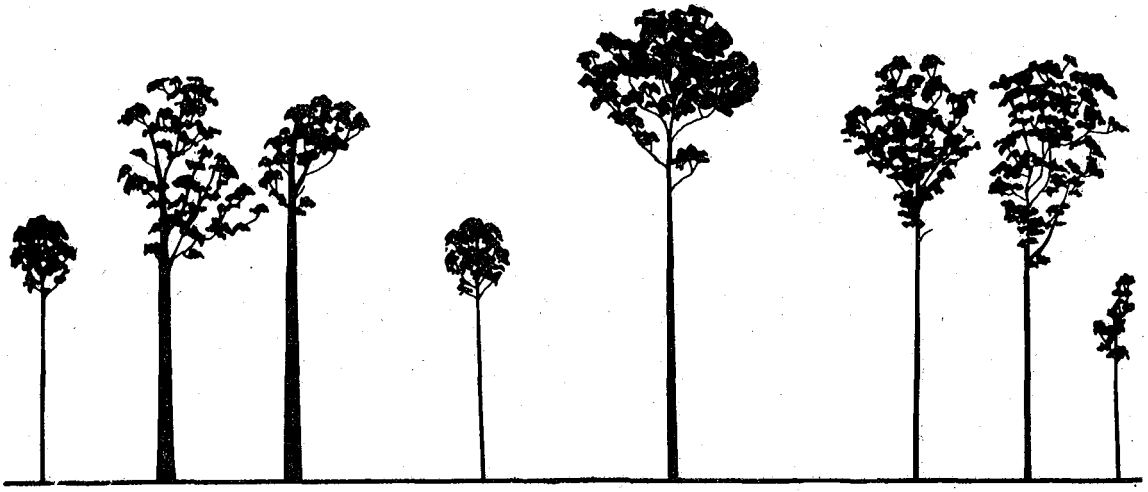

B

FIGURE 11A: Irregular gap sizes in a two-tiered forest. This is common in the group selection cutting of the 1950's and 1960's.

FIGURE 11B: If thinned, very few stems would remain to grow into sawlogs. Clear felling is more appropriate.

(v) REGROWTH LESS THAN 30 M, OR DAMAGED

The above discussion has concerned two-tiered stands where the regrowth has reached 30 m codominant height and is basically undamaged.

Where the regrowth has not reached this height, the delay in waiting for it to do so followed by the time to reach sawlog size may delay access to the overstorey resource longer than can be justified by the relatively small amount of ingrowth - and may indeed be offset by decay in older trees. Where the gaps are large it is recommended that the regrowth be thinned to 100 stems per hectare as soon as it is economically feasible to do so. Although this will sacrifice some log length they will reach sawlog size sooner.

Where the gaps are small (less than 60 m diameter), almost all of the regrowth stems will be subject to competition from the surrounding large trees before they reach sawlog size. Thinning is therefore not justified and these stands can be clearfelled at any time after the regrowth reaches a size suitable for utilization as chipwood.

Where regrowth has been damaged, thinning could be justified if undamaged crop trees exist at the rate of 75 spha or more, at least in the larger gaps.

Practical Application

Within the karri forest available for wood production there are approximately 4,700 ha of even-aged regrowth in the 30 - 45 m codominant height class available for thinning now.

These areas have been mapped and include all areas greater than two hectares. Of the even aged regrowth larger than 45 m codominant height, only 116 ha have been specifically mapped. There is an unknown area which will only be located as coupes are inspected prior to logging. They are not expected to be significant in an overall sense but nevertheless require appropriate treatment as the opportunity arises.

There are 27,000 ha of karri forest which have been selectively cut and will therefore be two-tiered to some degree. In addition to this area there is an unknown area of virgin two-tiered forest resulting from wildfire and agricultural clearing. The mapping of those areas of two-tiered forest which are considered thinnable is underway at present.

Leaving aside the even-aged stands which can be thinned to a regular programme even when maps are available for two-tiered stands, operational foresters will be faced with a complex situation. In the field, the structural types illustrated in Figures 6 to 11 will be found to form a mosaic of all these types grading from one to another. Although the appropriate silvicultural treatment can be identified, the different treatments of one stand relative to another involves other important management considerations. One approach to the problem is to:

- define broad areas where gap sizes frequently exceed 60 m in diameter (stem to stem) or where the upper storey is immature, by a combination of aerial photography and field inspection.

- Divide these areas into those containing regrowth above and below 30 m codominant height.

- All other areas are available for clearfelling when it is appropriate to do so (small wood removal may be necessary prior to clear felling).

- Within the broad areas which have been defined as potentially thinnable, carry out a thinning throughout the area but without removing any large material. After this operation is completed the mosaic which results will be more readily interpretable. A decision to clear fell portions of this area can then be made on the basis of the manageable boundaries and protection strategies. There is no commitment to immediate clear felling since no large trees will have been removed and the area is still in a condition of full stocking. Where gaps are too small for further regrowth development a subsequent operation may remove all regrowth stems even if the area is not to be clear felled immediately.

For the second category of large gap areas, where the regrowth is too small to be commercially thinned, no operation should take place at this stage. When the regrowth is large enough, thin to 100 spha as described earlier.

Other approaches or refinements to the application of these prescriptions will undoubtedly evolve as further improvements are made to the identification of these areas.

REFERENCES

BRADSHAW F.J. & LUSH A.R. (1981). "Conservation of the Karri Forest", Forests Department of Western Australia.

OPIE J. (1968). "Predictability of Individual Tree Growth Using Various Definitions of Competing Basal Area" Forest Science, 14, 3.

ROTHERAM I. (1983). "Suppression of Growth of Surrounding Regeneration by Veteran Trees of Karri (E. diversicolor)". Australian Forestry, 46, 1.