PART 2

BIOLOGICAL CONSTRAINTS TO THINNING PRACTICE IN AUSTRALIA AND NEW ZEALAND

BIOLOGICAL CONSTRAINTS TO THINNING PRACTICE

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ABSTRACT

Biological factors, both inherent to the individual tree and due to tree-site interactions, impose constraints on thinning practice. The very fast early growth rate of **Pinus radiata** D. Don makes early thinning desirable to avoid problems of competition, disease and insect susceptibility and instability to wind. Correct silvicultural techniques have been devised to meet many of these problems and tree breeding offers solutions to others. However, there are still many natural risk factors which cannot be avoided, only minimised through careful planning.

INTRODUCTION

The biology of a species will have considerable bearing on the thinning techniques adopted for that species (Day, 1966). Other biological factors operating in the forest will also impose constraints on thinning practice in plantations in a number of ways. Some are of little consequence but others cause major modifications in thinning schedules. It is possible to classify all of these constraints into three groups.

(i) Inherent factors of the species, including growth pattern, tolerance, stem form and rooting habit.

(ii) The problems of susceptibility to disease and insect attack.

(iii) Site factors, including such diverse aspects as climate (including wind), soil water regime, soil physical and chemical factors. Here it is the resulting genotype-environment interaction which constitutes the biological constraint.

Although a *Pinus radiata* plantation is a species monoculture and thus a relatively simple biological system, in terms of these three groups of factors it is still extraordinarily complex. We have learnt a great deal about this system during the last fifty years and now know fairly well the biological limits within which commercial forestry can operate. But we still have major unsolved problems such as that of site quality deterioration during the first rotation and of damage during periods of unusually strong winds, so well illustrated here in the Australian Commonwealth Territory (A.C.T.) last year.

By focusing attention on those biological constraints about which relatively little is known it is hoped to emphasise where management should apply most caution in devising and imposing thinning schedules. Once the delicate fabric of the biological

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system is impaired the system may start to tear apart, no matter how well the yield calculations have been done or how well the economic worth of the thinnings has been assessed.

DISCUSSION OF CONSTRAINING FACTORS

Growth Habit of the Species

Pinus radiata is without doubt one of the best tree species in the world for use in plantations. Under suitable conditions, it has an extremely fast growth rate, is not particularly subject to constraints of thermoperiod or photoperiod, and produces a useful wood for both pulp and sawn timber. However, it is a fairly intolerant species, it possesses a high degree of inherent stem defect, is prone to snow breakage and is not particularly wind firm.

Plantations of *P. radiata* have mostly been planted at spacings ranging from 2.1 × 2.1 m to 3.0 × 3.0 m. At these spacings canopy closure occurs at around six to eight years depending on the site, and mutual competition between the trees is severe by ten to fourteen years (Forrest and Ovington, 1970). In an intolerant species such as *P. radiata* this has two undesirable effects from the point of view of harvesting.

(i) The coefficient of variation of mean diameter becomes quite high;

and (ii) The mean diameter of the largest trees, those destined to be the final crop, is restricted.

These aspects have been clearly recognised in Australian thinning practice, particularly in the S.E. of South Australia where a mosaic of site qualities within the plantations produces very variable early growth rates. Initiation of thinning regimes and the thinning interval are adjusted to suit the site quality. Major problems arise where there is a lack of markets for all or part of the crop at a time when thinning should commence. Competition within the stand increases, mortality can commence, and insects, disease, wind and snow increasingly threaten the stability of the plantation as a biological system. Management is then faced with problems of harvesting within a very unstable forest stand.

One possible solution to this problem caused by lack of a thinnings market and the need for early thinning is the adoption of much wider spacings, or rectangular spacings (Sutton, 1968). Here we encounter the problem of inherent poor stem form in *P. radiata.* A high proportion of stems possess defects such as sweep, kinks, large branches, ramicorm branches and multiple stems. High initial stockings are required to furnish sufficient numbers of good stems for retention after thinning. Initial espacements of more than 2.7 × 2.7 m appear not to provide sufficient numbers of good quality stems from which to select a final crop.

Tree breeding may provide us with better stock and so allow the adoption of wider initial espacements. It appears that stem form is a phenotypic character which is closely allied to the genotype, i.e., well formed trees on average produce well formed trees in their progeny. Emphasis on good stem form in the current tree breeding programme for *P. radiata* should result in improved trees in crops established from seed orchard seed. Queensland experience with *P. elliottii,* where marked gains in stem form have been achieved (Nikles, 1970) should be repeated with *P. radiata.*

Rooting habit is inextricably bound up with problems of wind stability of *P. radiata.*

Root growth and root configuration are without question modified by soil physical and nutritional factors. We will consider these later in this paper. What is apparent is that very little information has been published about root habit in this important species.

Current trends towards better site preparation prior to planting and improvement of the nutritional status of the soils should improve root growth. The significance of these changes to the rooting habit of the species in relation to wind stability remains to be seen. Much improved growth of the stems may even shorten the period before problems of wind stability are encountered. A great deal more research is needed into this difficult problem of root growth habit. Unlike stem form there are likely to be few rapid benefits from tree breeding. Management must learn how to recognise those situations where restricted root growth will either limit stem growth rates or lead to wind instability in the stand.

Susceptibility to Disease and Insect Attack

One of the contributions to this session deals specifically with this topic and so it need not be developed very fully here. We have an outstanding example in *Pinus radiata* cultivation of a biological constraint on thinning practice imposed by an insect predator, the sirex wood wasp (*Sirex noctilio* F.; Rawlings and Wilson, 1949). Evidence suggests that stands which have been thinned to schedule and maintained in a healthy state will have a low level of susceptibility to sirex attack. By contrast, dense unthinned stands can be highly susceptible given suitable weather conditions and can provide conditions conducive to a buildup in insect numbers, thus compounding the problem.

Fungal diseases have, in the main, not been a problem in *P. radiata* plantations where thinning programmes are concerned. In other species diseases, such as *Fomes annosus,* can place severe limitations on both the severity and frequency of thinning treatments, which can be applied. The spread of fungal diseases can often be facilitated through logging damage to stems and roots and in European practice where disease is often a problem, considerable effort is made to avoid damage during thinning. We have probably inherited this European attitude with the result that damage to residual trees has always been minimised as far as possible, often much more so than in the native eucalypt forest in Australia. It would be in our long term interests to maintain this attitude.

Site Factors

The interactions between climate and soil on the one hand and the tree crop on the other result in major constraints being imposed on thinning practices. Growth rate of the crop is the more obvious aspect of this interaction, controlling as noted earlier the rate of canopy closure and the onset of competition, and dictating in turn the initiation, frequency and intensity of thinning.

There are, however, other site factors of importance, many of particular importance in *P. radiata* plantations in Australia where the climate is severe and subject to extremes of heat, cold and drought.

Summer Drought and Dead Topping

Many parts of Australia are subject to severe summer drought resulting in leader death in young pine plantations (Johnston, 1964). Stems may die entirely or merely suffer distortion as side branches subsequently take over the role of leading shoot.

Either way there is a serious loss of first thinning production. There is no real solution to this problem other than to delineate areas likely to be subject to very severe drought and to exclude these from the planting programme. Site preparation techniques such as deep ripping may alleviate the problem on marginal sites, as may the adoption of much reduced stocking densities as discussed by Butcher and Havel (this journal).

Stability of the Stand

(a) *Wind* In recent years wind has assumed some importance as a site factor to be considered in silvicultural and management planning. Severe wind damage has been experienced in New Zealand (Wendelken, 1966), and quite recently in the Australian Capital Territory. Thinning schedules in South Australia (Lewis, 1963) have been devised partly to maintain a stand stable to winds.

As the plantations in both Australia and New Zealand increase in age, and consequently in height, further occurrences of wind damage can be expected. There are as yet few guidelines on which to base thinning schedules to suit conditions where wind is a problem. Based on European experience stable stands should be promoted by adopting reasonably frequent and not too intensive thinning schedules. Some of the more drastic thinning schedules designed recently to maximise economic gain (*see for example* Fenton and Sutton, 1968; Forrest, 1973) may, if followed, in some areas lead to wind damage following heavy, infrequent thinning.

(b) *Snow* At higher elevations where regular winter snowfalls occur *P. radiata* is particularly susceptible to snow breakage at around ten to fifteen years of age and especially immediately following first thinning. This appears to be very much in agreement with some European experience (*see* the conclusions of Schotte as reported by Persson, 1969). Damage will vary with the amount and type of snow and whether it is accompanied by wind. While regular thinning may help to reduce snow damage there appear to be few silvicultural solutions to this problem other than limiting plantings to below critical elevations. Present tree breeding practice is to favour multinodal trees with fine branches and this may be beneficial in the longer term in cutting down snow damage.

Storm Damage and **Diplodia** *Attack*

In areas of central and northern New South Wales and southern Queensland summer storms accompanied by hail are known to cause damage to the leading shoots of *P. radiata* often followed by infection by *Diplodia pinea* (Desm.) Kickx (Young, 1936; Gilmour, 1966). As in dead topping due to summer drought, *D. pinea* attack can result either in death of the tree or severe stem disorders resulting in much reduced thinning yield. Once again there appears to be no silvicultural technique available to avoid this particular biological/climatic problem other than to avoid planting sites subject to summer weather patterns which favour *D. pinea* attack.

Nutritional Disorders

A number of nutritional disorders in *P. radiata* plantations have resulted either in severe stem damage or establishment losses, both of which disrupt first thinning yields. Zinc deficiency in South Australia is an excellent example of a nutritional disorder which leads to severe stem damage (Kessell and Stoate, 1936; Raupach, 1967) while what appears to be a boron deficiency in some areas of New South Wales and New

Zealand can result in establishment losses as well as stem damage (Will, 1971; Windsor, 1971).

Research into the nutrition of pine plantations over the past few years has resulted in a number of successful fertiliser regimes being developed for particular sites (Gentle, 1971; Waring, 1973). The result has been that crops of pine can be grown with a degree of certainty as to thinning yield and final fellings. Nevertheless, there are still many unsolved problems in pine nutrition and new problems can arise as other major deficiencies are corrected. A major problem still is that of maintaining site productivity through successive rotations. Other less spectacular, but no less damaging, problems have arisen from time to time as new areas are planted, e.g. copper deficiency in parts of South Australia and New Zealand (Ruiter, 1969; Will, 1972).

CONCLUSIONS

The cultivation of *P. radiata* as a plantation tree has been mostly a spectacular success. However, this success has not been without some problems associated either directly with the biology of the species or indirectly through tree-site interactions. Restrictions on thinning yield and practice have been due to:

(i) Reduced stocking numbers due to establishment losses resulting in fewer trees available for thinning.
(ii) Damage caused to individual stems resulting in reduced thinning yields.
(iii) Loss of part or all of an age class on which allocations to industry depended.
(iv) The circumscribing of economically desirable thinning practice due to instability in the stands.

Management must realise that these restrictions can operate and can manifest themselves in these several ways. It is necessary that management recognise the conditions which can lead to these constraints and either eliminate them, for example by using seed orchard seed or adopting a particular fertiliser schedule, or avoid them as for example by clearfalling before wind damage is too high a risk.

Many of the biologically associated problems imposing constraints on thinning practice can either be eliminated or avoided by careful planning. The current trends towards very complete and intensive site preparation for plantation establishment, including ploughing and fertilisation is probably the best form of avoidance strategy available to the forester. However, the once in a century storm, the unprecedented drought year, the outbreak of a new disease cannot be avoided, but foresight and careful planning may help to minimise the risk.

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