THINNING BY POISONING IN STATE FORESTS
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SYNOPSIS

Thinning by poisoning has progressed over some 12,000 acres of exotic State forest since the practice was started in 1952 with the object of overtaking general arrears of treatment more quickly than has been possible by conventional methods. The practice has proved to have peculiar advantages in economy, in speed, in maintaining good access and stability, and in preserving the forest environment intact. These advantages appear to outweigh such risks to the health of the forest and safety of forest workers as are known to be incurred by the use of poisons.

Introduction

Thinning by poisoning unwanted trees will perhaps prove to be only a passing phase in the evolution of forest management in New Zealand. Whatever its duration and extent as a practice it is notable as a symptom of the ills and stresses that have brought it into being, and as a sign of the growing awareness that drastic steps are needed to cope with thinning on a vast scale in exotic forests. The development of poisoning techniques in State forests is also worth examining because it shows some aspects that may have wider application than routine thinning to waste.

Thinning Regimes

The situation that has to be faced in New Zealand today is that most stands planted prior to 1938 received only very light thinnings, and hence most stands over 22 years old (and many as old as 45 years) have not had any effective early thinning according to present standards. These recent but generally accepted thinning regimes for the more important exotic pines, applied regardless of thinning technique, may be summarised as follows:

Radiata pine (except stands receiving very early thinnings for pulp wood) 8 to 10 years (height 40 to 45 ft) thin to 250 stems per acre; 19 to 22 years (height 90 ft) thin to 100 stems. No further thinning unless rotation exceeds 40 years.

Corsican pine. 15 to 20 years (height 30 to 40 ft) thin to 450 stems per acre; 25 to 30 years (height 55 ft) thin to 250 stems. Subsequent thinnings at 10- to 15-year intervals in an 80- to 120-year rotation.
Other pines. Thinning regimes for slash, patula, loblolly, ponderosa, lodgepole, and strobus pines fall between those given for radiata and Corsican pines.

History

Large-scale thinning by poisoning was started in Karioi Forest in 1952, and during the next two years methods were largely developed here and at the Forest Research Institute. In 1955 and 1956 poisons were also used for thinning in Auckland and Canterbury Conservancies on a large scale. Since 1957 thinning by poisoning has become more general still, and has been adopted in almost all forests that are faced with serious arrears of tending.

This sequence is shown below:

1. 1952 and 1953, 400 acres treated Karioi Forest.
2. 1954 and 1955, 1600 acres treated Karioi Forest and Woodhill Forest, mainly.
4. 1958 and 1959, 5800 acres treated as in (3), but with additional areas in Rotorua and Southland Conservancies.

Of the total of 12,300 acres thinned by poisoning over 10,000 acres are contained in five forests, Karioi (4,400), Golden Downs (3,400), and Woodhill, Tairua, and Eyrewell (1,200 acres each). This has permitted the treatment of areas exceeding 500 acres of one species in stands of a uniform character, namely, in radiata pine at Woodhill, Golden Downs and Eyrewell, in ponderosa pine at Karioi, and in Corsican pine at Golden Downs. The 10–18-year-old radiata pine stands treated at Woodhill (Auckland Conservancy) and Golden Downs (Nelson Conservancy) are well stocked, having some 700 live stems per acre, and of good form, but with an average stem diameter of only 7 in. at breast height their thinnings have been too small to find a local market. The radiata pine stands at Eyrewell (Canterbury Conservancy) are older, 21 and 22 years of age, and carry only 250 live stems per acre, averaging 12 in. in diameter. Poisoning was adopted here because any other means of thinning was likely to incur great risk of wind throw, a major hazard for radiata pine on the Canterbury Plains. The ponderosa pine stands at Karioi (Wellington Conservancy) are 23 to 28 years old, carrying about 600 living stems per acre of 9 in. average diameter. Stem form is poor and the forest is remote from suitable markets. The Corsican pine stands in Golden Downs Forest are similar in age and stocking to the ponderosa pine at Karioi, but as the trees are slightly smaller and the terrain steeper, the obstacles to utilisation thinning are greater. Inevitably the remaining 2,000 acres treated in the same period in other parts of New Zealand are composed of relatively small stands of varying
age, species, and location. All this affords a wealth of useful experience in the use of poisoning as a silvicultural measure.

**Advantages**

The reason for adopting thinning by poisoning in forests is a simple one. As a means of first thinning poisoning is the most economical that can be employed with the exception of those cases where an intermediate yield can be taken off at a profit. Until this fact became apparent the traditional attitude that a thinning operation must involve felling and extraction had, because of the lack of markets for small logs, served to delay first thinnings far too long. The disastrous effect of this lack of treatment upon the quality of maturing stands is now well known, and this awareness has stimulated the search for a rapid economical means of overtaking the generally serious arrears of thinning.

Labour costs, on a man-hour basis, in first thinning a stand that is old enough to yield marketable produce are as follows:

- Thinning with extraction: 40 to 100 man hours per acre according to productivity of the stand.
- Thinning to waste with axe and saw: 20 to 30 man hours per acre according to conditions.
- Thinning to waste by poisoning: 6 to 16 man hours per acre according to conditions.

The economy which comes with a high output is the greatest merit of thinning to waste by poisoning. Progress of thinning to waste by axe and saw is inevitably slowed up by the debris which the work creates, particularly on broken ground and in trees much over 25 ft high.

When management has accepted the need for thinning by poisoning for the sake of rapidly overtaking arrears of treatment, it is normally found that several important advantages are obtainable through the practice. These are low costs, preservation of access over the forest floor, preservation of stability in thinned stands, and the reduction of physiological injuries such as desiccation and sun scald.

**Economy.** The low cost of thinning by poisoning is due to the simple nature of the equipment needed and to the fact that labour is easily trained in its use. These factors make it relatively easy to estimate the cost of future thinning by poisoning operations, and therefore they are sounder operations to budget for than are extraction thinnings. Thus it may be considered preferable to accept an outlay of £5 per acre on thinning by poisoning rather than to embark on an expensive commercial operation that may afford very little revenue and involve very heavy losses.

Looking ahead in the commercial field, there should be great caution in marketing the first thinnings of many exotic species as
relatively few can be converted to an attractive sawn product, largely because of the presence of knots, pith, low-density wood, and similar defects. The sale of such produce could do much to prejudice sawmillers against new species that will afford good timber only from more mature stands. In most young stands timely thinning to waste would ensure the availability of a substantially better product when the average log has grown to a more attractive size. The extraction of posts and pulp wood on easy country affords the only cases where utilisation thinnings are more economical than thinning by poisoning. Most instances of profitable sales of sawlogs from first thinnings are misleading because the actual thinning is normally one delayed long after the due time, and has been done when the second thinning is due. In such cases the apparent profit takes no account of the degrade in main-crop stems resulting from the unduly prolonged crowding of the stand which preceded the thinning.

Access. Preservation of easy access within a thinned stand is an outstanding advantage of thinning by poisoning. This is of immediate benefit in supervision, safety, fire prevention, and in daily getting men on and off the work as it progresses. In most New Zealand stands thinnings are infrequent and heavy by overseas standards, and the accumulation of slash caused by axe-and-saw thinning is tremendous, frequently making it almost impossible to cross a thinned stand. In stands thinned by poisoning dead trees disintegrate very slowly, and serious obstruction within six years of poisoning is exceptional.

Also following from the ease of access thus maintained in poisoned stands is the freedom allowed to the management to increase the intensity of the thinning soon after if this is desired. Normally it is physically impossible to do this in a stand thinned by other means.

Stability. Preservation of stability is of great importance in New Zealand because of the windiness of the country. Thinning by poisoning offers the best means of releasing selected crowns from competition without subjecting the released trees to suddenly increased exposure to wind. There are many stands now over 20 years of age that cannot be safely thinned by other means for this reason. The lack of wind damage in those parts of Eyrewell Forest which have been thinned by poisoning is really significant when seen against the history of wind damage in forests of the Canterbury Plains.

Climatic damage. The reduction of the ill effects to which conventional thinning exposes a stand are most evident when thinning by poisoning is employed. As the foliage of poisoned trees dies there is a gradual increase in the light and air currents around the living trees. This gradual removal of the crowns of competing trees reduces the physiological injuries that the surviving trees may sustain from additional exposure to strong sunshine and drying
Use of the knapsack pump for applying sodium arsenite in thinning by poisoning.

winds. Though this effect cannot be measured in any readily comprehensible terms, it is probable that it is a major factor in determining such phenomena as the resistance of immature radiata stands to attack by *Sirex noctilio*.

At the risk of digressing a little from the subject of thinning by poisoning, it might be noted that the benefits of a favourable microclimate are perhaps most apparent only when the forest environment has been impaired. It is this that probably explains why the response to some heavy thinnings is not proportional to the additional growing space provided. The losses of water through increased transpiration in main-crop trees that would follow a heavy intermediate felling must certainly be much reduced by the sheltering action of dead trees. In regard to the desiccation of forest, it is also noteworthy that the hottest burn in the 1936 Balmoral Forest fire was in the area of Corsican pine in which the ground was covered by slash after a recent thinning.

*Weed growth.* The retention of the partial forest canopy that is afforded by standing dead trees also preserves some of the shade cast by an unbroken canopy. This shade is generally of great value in keeping tall weeds in check.

*Disadvantages*

The foregoing paragraphs made brief mention of the amount of thinning by poisoning done, the reason for doing it, and some
of the advantages of the practice. Before describing methods employed some mention must be made of the disadvantages associated with thinning by poisoning. These are a sudden increase in susceptibility to disease, a risk of poisoning final-crop trees by translocation of poison through root grafts, some risk of arsenical poisoning among workers, and some danger from standing dead stems to men later working in a treated stand.

**Forest hygiene.** An aspect of thinning by poisoning which causes most concern among pathologists is the slow killing or weakening of a numerically large proportion of the stems in a poisoned stand. It is known that the wood wasp *Sirex noctilio* is attracted to dry living trees, and it has been stated (Rawlings and Zondag, 1959) that when the water content of a tree is lower than normal, as may be the case during the flight season of the insect, poisoning administers an additional check which predisposes the tree to heavy attack by *Sirex noctilio*. This sequence of cause and effect occurred on a serious scale among slash pine and maritime pine at Waitangi Forest in 1959, and has threatened to reach serious proportions elsewhere. However, the same authority has stated that “axe or saw thinning during the flight season results in an increase in *Sirex* population and mortality or damage to standing trees during the following two years”. Therefore the degree to which thinning by poisoning in particular aggravates the risk of disease is hard to define, and hence so much harder to condemn. Further, many foresters have come to look upon insects such as *Sirex noctilio* as just one among many of the adverse locality factors inseparable from pine forests in New Zealand, forests in which many calculated risks must be taken in management. Management must generally compromise between the risks attendant upon thinning by a method that may stimulate the activity of noxious insects and the consequences of falling far behind the programme of thinning.

**Unintentional poisoning.** The risk of poisoning trees other than those to which poison is intentionally applied has not proved to be serious. This damage is attributed entirely to natural grafting between roots of adjacent trees. Among pines there have been no cases of damage sufficient to outweigh the advantages of thinning by poisoning. The most serious case recorded was in four acres of slash pine in Waipoua Forest, where, in 1957, 17% of the main-crop trees were killed by ammonium sulphamate. Among other coniferous stands no more than 24% of the main-crop trees have been damaged in this way, and such damage is so uncommon that no pattern can be detected in its incidence. That this type of damage would occur among hardwoods such as poplars is very probable; and there is an instance of many standing trees being affected by ammonium sulphamate that was applied to cut stumps of hybrid
Use of the Anderson gouge for applying sodium arsenite in thinning by poisoning.

black poplars (*Populus serotina*) at Beaumont Forest to prevent regrowth of coppice shoots.

**Safety.** The accident risk in thinning by poisoning is mainly associated with the handling of arsenic compounds. In actual fact the majority of injuries occurring in thinning by poisoning are axe wounds incurred while trimming and notching stems preparatory to the application of this poison. However, the amount of axe work needed in this operation is much less than that needed in felling trees, and saws are not required. Therefore the danger from edged tools is not increased in poisoning.
The risk of arsenical poisoning is a manifest disadvantage in those operations where arsenic compounds are used. But through taking proper safety precautions these routine operations have been carried out over more than 5,000 acres with only one serious mishap. There remains, however, an element of risk in arsenical poisons that does not arise in handling other tree poisons or using other methods. The worst of these is the danger of undetected contamination, usually through absorbing small amounts of arsenic over a long period. These risks are best reduced by putting the arsenic compounds in specially selected containers and equipment. Recognition of this fact has led to the development of gouges that apply poison direct to the tree.

**Dead trees.** The danger created by standing dead trees can be an obstacle to work. The 30-year-old radiata pine stands in parts of Kaingaroa forest contain a high proportion of dead stems as a result of the 1949 epidemic attack of *Sirex noctilio*, and this has brought about the use of a specially strengthened tractor to crush these stems before felling gangs start work on the live stems. Such instances point to a possible additional expense arising from thinning by poisoning. But it is unlikely that standing dead trees less than 50 ft high would present a real danger, and thinning to waste would normally be confined to stands of a lesser height.

This discussion of the merits and weaknesses of thinning by poisoning cannot be closed without a survey of the methods used. In State forests three methods have been used—the application of arsenical solutions from knapsack pumps, the application of these solutions from gouges, and the application of ammonium sulphamate crystals.

The application of solutions of sodium arsenite or arsenic pentoxide to exposed cambium and sapwood surfaces from pumps was early found to be a most reliable means of killing trees with equipment that can easily be supplied to a forest. The working party needed is usually two men with axes to chop out slabs of bark at five-inch intervals around the stems and one man wearing protective clothing to spray on the poison from a knapsack pump. This method is slightly more expensive in man hours than others, but has the merit of low stores costs and rapid killing. At 1960 wage levels these cost elements, on an acreage basis, average: labour, £3; stores, £1 (only 5s. for poison at the rate of ½ gallon of the concentrate per acre and 15s. for equipment, etc.).

Although carrying the knapsack pump involves some hardship on rough ground, this method has been used with great success on flat country at Eyrewell Forest (1,200 acres treated), and over 3,000 acres of difficult country have been treated at Golden Downs with only one accident involving the use of the pump.

The application of arsenical solutions in gouges is a
recent development. In New Zealand a gouge must fulfil a wide variety of demands. It must be light enough to carry up steep hills, strong enough to penetrate rough bark, and have the capacity to treat up to 200 small trees before being refilled. Within the Forest Service a gouge designed by A. N. Anderson has been under trial for two years and promises to fulfil these conditions, providing a safe, cheap means of poisoning. A very large saving in labour costs derives from there being no need to trim branches or notch the bark of trees being poisoned with a gouge. Labour costs of £2 5s. per acre were sustained over several weeks in 1959 at Gwavas Forest when the Anderson gouge was used.

The use of a gouge to poison trees eliminates the risk of the injuries associated with the use of axes in dense untended stands; and, because the gouge is stuck into the tree near ground level, the poison is released well away from vulnerable parts of the worker's body.

The corrosive action of the solutions known to be suitable for tree poisoning imposes special problems in the design of gouges, as does the demand for lightness and safety. For instance, the action of the valve in the Anderson gouge, which can release a predetermined quantity of poison on impact, was impaired by corrosion. Most of such difficulties have now been overcome; and, though as yet little more than 200 acres have been treated with gouges, this technique is felt to have an important future.

Ammonium sulphamate has been used in about half of all thinning by poisoning carried out in State forests. As a killer it has proved less effective than arsenical poisons and is also about five times as expensive because of the higher initial cost and the greater quantities needed to obtain the equivalent effect. However, the ease of handling this compound is in many stations felt to outweigh all its weaknesses when compared with poisons harmful to humans.

Ammonium sulphamate is a crystalline powder that is usually applied to trees by spoonfuls into notches cut in the bark four inches apart around the stem. Its consistency, as a deliquescent powder, and its inadequate strength in solution prevent its application in pumps or gouges. Therefore the cost of axe work in cutting notches cannot be avoided. However, this is significantly cheaper than felling trees. In State forests the present costs of treating about 250 stems per acre ranging between four and twelve inches in breast-height diameter are (for the labour and stores costs only) about £3 each for wages and materials, that is for 7 to 10 man hours and 20 to 28lb. of ammonium sulphamate.

The rate at which ammonium sulphamate has killed trees, especially radiata pine, has caused some anxiety, as already remarked. But in 1959 and 1960 heavier doses have been used, and it appears that the dangers associated with slow and incomplete killing of

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trees have been much reduced. This has involved greater expenditure, and hence much of the poisoning now done with ammonium sulphamate may later be performed with sodium arsenite in gouges.

Conclusion

In conclusion it may be said that thinning by poisoning has now, by virtue of some peculiar advantages, become a recognised practice in New Zealand forests. Until either market conditions are so changed as to financially justify the extraction of small logs from first thinnings or current trials of intensive pruning and thinning of stands at the sapling stage are perfected and extended, thinning by poisoning is likely to increase in scope and efficiency. It is hard to foresee all the effects of tree poisons upon safety of workers and forest hygiene. But there is reason to believe that the benefits conferred are at least as great as the risks incurred. Indirectly also the improvement of poisoning techniques should be of great value to other forest operations, and they are already being applied to the conversion of inferior stands to other species and in the release of both natural and artificial regeneration in indigenous forests.

REFERENCES