ARTIFICIAL PRUNING OF EXOTIC CONIFERS.

By H. ROCHE and G. H. HOCKING.

Artificial pruning has been given prominence in forestry literature during recent years; more particularly in Great Britain, where the earlier planting of the Forestry Commission is reaching a stage where pruning must be considered. In New Zealand the extensive exotic plantations of the nineteen-twenties are also reaching a stage where pruning, to be effective, must not be delayed.

Objects of Pruning.

Increased value of clean timber produced by pruning over that from unpruned trees is obviously the premise upon which the justification of pruning rests, except in a few particular cases to be mentioned later. To the forester the important question is whether clean exotic timber will command an enhanced price which will be reflected in stumpage obtainable for pruned trees, or, as Craib (1) claims for South Africa, will a sufficient proportion of clean timber be obtainable from unpruned stands to meet the demands of the market? Donald (2), and Hawley and Clapp (4) quote definite prices for clean and knotty timber in England and eastern United States respectively, but in New Zealand the market for exotic timber has not yet evolved sufficiently for qualitative differences within a species to be reflected in price. Indeed, our market for exotics is dominated by material from farm shelterbelts; and forest grown, let alone pruned, timber has as yet played only a minor part. Milling operations are scattered and mainly in the hands of small operators who are quite incapable of providing the market with graded produce.

However, a continuation of the steady increase in consumption of exotic timber, with extension of its use for building purposes, should result in a demand for an increasing quantity of clear material for interior finish. Grading and price differentiation are natural concomitants of this trend.

Pruning of stands in early years to correct malformation appears advisable in many cases. The commonest defects at this stage are double leaders and "rosette" tops caused by wind breaking the soft new growth in the spring. At Erua, Central North Island, 27 per cent. of a stand of five-year-old Pinus murrayana and 8 per cent. of P. ponderosa of the same age had such injuries which were corrected with secateurs for about 2/9 per acre.

The stimulation of growth in the upper crown by the judicious removal of lower green branches is a secondary object which may warrant consideration in certain cases. Pines planted on less favourable sites often show premature "stag-heading" or at least a weak attenuated leader. This is particularly so when adverse conditions such as drought follow years favourable to growth. A reduction of
the crown should then restore the balance between leaf and root activity, promoting normal crown development. Several silviculturists refer to pruning for this purpose. Admittedly the stimulation might be only temporary and could not overcome the disadvantage of bad site, but it is interesting to note that green pruning has been suggested in Queensland (7) as a method of improving the sparse crowns associated with needle-fusion.

In parts of the South Island, green pruning of *Pinus radiata* has been undertaken with the main object of minimising snow breakage.

**Character of New Zealand Exotic Plantations.**

Nowhere in New Zealand, nor probably elsewhere, do planted or second-growth conifers, with the exception of kauri (*Agathis australis*) show satisfactory natural pruning under normal growth conditions. Density of stocking will influence the size of branches but even with a spacing far closer than can be justified financially, branches are shed naturally only towards the end of the rotation, if at all.

The eight feet spacing which has been the general rule in the State Forest Service during the past 17 years allows the lower branches to reach a considerable size before being checked by lateral competition. In this connection it is to be noted that the Forest Service has now reverted to six feet spacing as the standard.

The following measurements indicate that the ultimate diameter growth of laterals is greatly affected by density of stand. Thus in *P. ponderosa* (age 13 years) at 8 feet spacing, the average diameter of the laterals is 1.32 inches; while at 4 feet (age 23 years), it is only .67 inches. *P. laricio* shows similar differences.

<table>
<thead>
<tr>
<th>Species</th>
<th>Spacing feet</th>
<th>Age Yrs</th>
<th>D.B.H ins.</th>
<th>Ft. ft.</th>
<th>No. of Whors to 6 ft.</th>
<th>No. of Branses per Whorl</th>
<th>Av. Diam. Branses</th>
<th>No. of Trees Measured</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. radiata</em></td>
<td>6x6</td>
<td>21</td>
<td>13.2</td>
<td>51.7</td>
<td>2.6</td>
<td>6.0</td>
<td>5.6</td>
<td>.87</td>
<td>10</td>
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<td><em>P. ponderosa</em></td>
<td>4x4</td>
<td>23</td>
<td>7.2</td>
<td>29.6</td>
<td>3.6</td>
<td>12.9</td>
<td>5.5</td>
<td>.67</td>
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<td>,</td>
<td>8x8</td>
<td>13</td>
<td>5.1</td>
<td>19.8</td>
<td>4.2</td>
<td>10.4</td>
<td>5.5</td>
<td>1.32</td>
<td>10</td>
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<tr>
<td>,</td>
<td>8x8</td>
<td>8</td>
<td>2.3</td>
<td>8.2</td>
<td>4.4</td>
<td>—</td>
<td>4.4</td>
<td>1.1</td>
<td>5</td>
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<tr>
<td><em>P. laricio</em></td>
<td>4x4</td>
<td>23</td>
<td>6.3</td>
<td>34.0</td>
<td>3.4</td>
<td>10.2</td>
<td>6.3</td>
<td>.69</td>
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<td>,</td>
<td>8x8</td>
<td>14</td>
<td>6.6</td>
<td>19.7</td>
<td>3.5</td>
<td>9.9</td>
<td>6.2</td>
<td>1.20</td>
<td>10</td>
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<td>8x8</td>
<td>8</td>
<td>2.8</td>
<td>15.1</td>
<td>3.5</td>
<td>—</td>
<td>8.0</td>
<td>1.0*</td>
<td>10</td>
</tr>
</tbody>
</table>

* Canopy not closed, growth of branch incomplete.

N.B.—*P. radiata* and *P. murrayana* are naturally multinodal, forming two sets of whors in one growth period, one consisting of smaller branches which are usually suppressed early. This phenomenon, which is distinct from extra whors due to two growth periods in one year, occurs to a less extent in other species. In this study the smaller have not been counted as separate whors and have been recorded in the number of branches per whorl only if they have made growth comparable with the main branches.
Assuming that our pruning aims at reducing the knotty core to six inches in diameter including the healing zone, obviously we cannot wait until the branches are dead or even checked, but must remove them while they are still making unrestricted growth.

**Physical and Biological Effects of Pruning.**

The effects of pruning on the individual tree depends so much on its health at the time and the extent of the operation that generalisations are liable to be misleading. Removal of dead branches can obviously have no effect on the physiology of the tree. Green pruning on the other hand is often condemned because, *inter alia*, it checks growth. This is undeniable, but that the check is significant and permanently injurious in our widely spaced stands, at a time when the trees are exhibiting their maximum growth vigour, seems most improbable.

The extraordinary vigour and recuperative power of young *Pinus ponderosa* were demonstrated in an experiment initiated by the authors in the winter of 1931. In an eight-year-old stand at 8 feet spacing in which the trees averaged 7 to 9 feet in height, rows were pruned with increasing intensity. In the first, only the lowest whorl was removed; in the next, two whorls; until, in the last, all laterals were removed. Examination after six growing seasons revealed that even with the severest treatment the check in height and diameter growth was small and soon overcome. No epicormic branches were thrown out, though in a very few cases small branches, apparently incompletely removed in pruning, persisted at the nodes.

This recuperative power of young *P. ponderosa* is well known and it is not suggested that any other species would react so favourably to such drastic treatment; (epicormic shoots are not uncommon on the north side of *P. murrayana*, even in unpruned stands). Nor is it intended to imply that the removal of more than half the green crown is ever desirable.

Pruning of young stands will postpone the closing of the canopy and the suppression of the ground cover; but this does not seem a great disadvantage except where gorse or other noxious growths must be suppressed.

Decay and staining caused by infection following green pruning must be considered. The rather limited material examined by the writers has not provided any evidence of the entrance of heart-rot, nor has staining due to fungi extended far from the wound caused by reasonably controlled green pruning. It has, however, been observed that in the dead branches of *P. austriaca* decay may be spread towards the stem until a resin impregnated zone was reached. This heavily impregnated area extended about 6 inches beyond the stem and formed an effective barrier to fungi. To what extent this protective plug develops in a vigorously growing green branch is not known, but apparently less than in one which has been suppressed and become moribund. Koster (5) states that the resin content of the
Fig. 3 *P. australis* showing dead branch broken off naturally near end of zone of heavy resin impregnation. X marks point at which branch died. Top side of branch shows infolding of bark and bottom side the loose nature of the knot after death of branch.

*Photo: S. Gibson*
spruce branch as a whole is no greater than that of stem wood, but near the base it may be as much as ten times as great.

In some cases at least it appears that this impregnation at the base of a branch may be induced artificially. Mayer-Wegelin (6) referring to spruce says that green branches should not be pruned flush with the stem, and on the rare occasions when green pruning is considered advisable the branches should be cut 6 to 12 inches from the stem and the stump re-pruned 3 to 10 years later, by which time the tree will have put down a protective layer against the entrance of rot. This practice is no innovation of the modern forester. In 1664 that great silviculturalist, John Evelyn (3), wrote: “Evergreens do not well support to be decapitated; side-boughs they freely spare in April and during the spring; and if you cut at first two or three inches from the body, and the next spring after close to the stem . . . . . the most tender may suffer such amputations without prejudice.”

The increased cost of such double pruning would, however, only be justified if serious infection occurred as a result of the single operation. Moreover, if the second pruning were long delayed, bark folding might occur, producing a loose knot.

So far there are insufficient data to show that pruning at any particular time of year is to be preferred. Any restriction of the period during which the work can be carried out is likely to cause administrative difficulties. However, summer pruning in those species which have prolific resin flows may cause resin pockets. At Hanmer there is no great exudation of resin even in the summer, probably on account of the low night temperatures.

Fig. 3 shows a dead branch of *P. austriaca* which has broken off naturally near the end of the zone of heavy resin impregnation. Prior to the death of the branch at the point (x), wood laid down on the stem and the branch was continuous so that a firm, though heavily impregnated knot was produced; thereafter the new wood laid on the stem had no connection with the branch and a loose knot resulted. On the top side infolding of bark occurred, producing a bark pocket, but on the bottom it was successfully occluded. If a branch is removed green or before bark folding has commenced, the bark covering the stub is usually pushed off by subsequent growth and wood is laid down adjacent to the cut surface. This is seen in Fig. 4. Here the branch was dead before pruning so that there is a short loose section. The external scar giving the impression of incomplete healing also shows. Involution of the new growth over the stub is often more pronounced than in this case.

Rate of diameter growth immediately after pruning will naturally influence the length of the healing period. For this reason pruning at least in the later stages should be integrated with thinning to ensure maximum growth. At Hanmer, *P. ponderosa*, which was pruned and given unrestricted growing space at 17 years of age, shows complete healing within three years and after eight years has laid on three inches of clean wood over the end of the stub.
Pruning Practice.

If the aim is to keep the knotty core within 6 inches diameter, the first pruning must be carried out when D.B.H. is 4 to 5 inches to allow $\frac{3}{4}$ to 1 inch of radius for healing. In *P. radiata* this will be in the 7th to 10th year, and in most other pines and in Douglas fir in the 10th to 15th year.

At this stage trees will have crowns of sufficient height to enable the lower six feet of branches to be removed without upsetting the crown/root ratio unduly. At 8x8 feet spacing this will mean that all the branches removed will still be green.

It is considered that in large scale operations pruning might be carried out in three stages giving ultimately a pruned stem of 18 to 20 feet. Pruning of the first six feet would be carried out on all stems, as even those to be cut in the first thinning, when they may have no market value, must be cleaned before felling. An exception might be made to this rule where weeds must be suppressed.

The next two stages of pruning to 12 and 18 feet would be confined to 100 to 250 trees per acre, depending on the species and site, selected for the final crop; unless it can be shown that pruning is also justified on trees to be removed as thinnings.

At Hanmer, pruning has been carried out during the past six years on selected stems in stands of *P. laricio*, *P. ponderosa* and *Larix decidua* up to 30 years old. Valuable data on tools and costs have been obtained, but the benefit of this delayed pruning is much less than that done on younger stands, as the central core will be much larger than necessary and will contain loose knots where dead branches have persisted.

Pruning above 18 or 20 feet is not considered justifiable at present as a routine operation. This is the maximum height that can be conveniently reached from the ground with pole saws. Pruning to this height will ensure one log being clean except for the knotty core of 5 to 6 inches diameter. In the case of a tree of 20 inches D.B.H. and 90 feet high, such a log would contain approximately 35 to 40 per cent. of the volume of sawn timber.

The second and third prunings would be executed at intervals sufficient to allow the retention of a safe proportion of crown, at least two-thirds; yet restrict the knotty core to six inches diameter.

Pruning Tools.

In the initial pruning to six feet, an axe (3½ lb.) or slasher is suitable if used by skilled workmen. Strong pruning shears are being experimented with and show promise of being a useful tool capable of cutting green or dead branches over an inch in diameter cleanly and close to the stem without great effort. Though slower than the axe or slasher, it is a safer tool in the hands of inexperienced men.

Above six feet the pruning saw has proved the only satisfactory tool. A crescent type 18 inches long with six teeth to an inch, set to cut on the downward stroke only, has been adopted at Hanmer. If higher pruning should be adopted, ladders and handsaws will probably be necessary.
Costs are apt to be misleading particularly in the case of pruning where there are so many variable factors. Species, spacing, height pruned, green or dead branches, distance between whorls, number and size of branches in a whorl, angle of branching and, of course, wage rate and efficiency of labour all influence costs. At Hanmer, pruning 30-year-old P. laricio, planted at four feet to 20 feet, in two operations costs approximately 6d. per tree with labour at 2/- per hour. This includes travelling time, care of tools and supervision. The first stage of the operation, pruning to seven feet with light axe or slasher, costs about 1½d.; the remaining 4½d. being absorbed in pruning the upper 13 feet with pole saws.

Summary.

1. The extensive exotic forests established in New Zealand since 1921 are now reaching a stage where pruning cannot be delayed if maximum benefits are to be obtained.
2. Enhanced value of timber from pruned trees is the only justification for large scale pruning. So far there has been no opportunity for differences in value between clean and knotty exotic timber to become established in New Zealand.
3. Other benefits derivable from pruning are the correction of malformations in young stands, the improvement of crown development on inferior sites, and the reduction of snow break.
4. Exotic conifers do not show satisfactory natural pruning.
5. Pruning should aim at reducing the knotty core to 5 or 6 inches in diameter on the lower 18 to 20 feet of bole.
6. To attain this object in plantations with a spacing of eight feet, green pruning is necessary.
7. Green pruning need not impair health or growth.
8. Pruning to six feet is best done with axe, slasher, or pruning shears; for higher work the pole saw is the only satisfactory tool.

Literature Cited.

(3) Evelyn, John (1664). Silva, Bk. III, Ch. II.