MANAGEMENT OF CONTORTA PINE REGENERATION IN KARIOI FOREST FOR PRODUCTION

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SYNOPSIS

Some 2 000 hectares of Pinus contorta *were planted in Karioi Forest, Central North Island, in 1928-33, and seed from this source has regenerated naturally over large areas of tussock lands adjoining the forest. These stands, predominantly of "green strain" (coastal provenances), could be managed for production of pulpwood or sawlogs if properly tended. Accordingly pruning and thinning were started in 1959 and some 300 ha had been treated up to 1972, at relatively low cost. These operations are described in detail.*

INTRODUCTION

Contorta Pine as an Exotic in New Zealand

Contorta pine is considered a minor exotic production forest species which could become of greater significance in future on frosty sites and at higher altitudes. The total area of this species planted in New Zealand is 8 175 ha in pure stands and 1 781 ha in mixtures (Weston, 1957), most of this being in Kaingaroa and Karioi Forests. Two strains are recognized; the "yellow" strain is often of poor form and has a relatively slow growth rate, while the "green" (coastal) strain grows rapidly in early years and is often of excellent form. As the species has been considered of minor importance, few stands have been properly tended, but where thinning has been undertaken *(e.g.,* in Waiotapu Forest) response in diameter growth has been rapid.

The species is generally considered one of the most hardy and frost-resistant exotic pines, which grows adequately on a wide range of sites up to an altitude of at least 2 000 m a.s.l. (Hinds and Reid, 1957). It is essentially a pioneer species, with relatively rapid early growth. On favourable sites height growth can reach 1 m/yr. Weston (1957) suggested that reasonable sawlog crops could be obtained by adopting a rotation of 40 to 45 years, with two thinnings at 14 m and 23 m top height for the green strain. Expected production would be 575 to 700 m^3/ha. The rotation for the yellow strain, for a comparable yield, would be 15 or 20 years longer.

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The timber from the green strain is of good quality (Harris, 1973) for sawtimber and also produces satisfactory pulp (Uprichard, 1971; Uprichard and Gray, 1973). The sapwood takes preservatives well (Carter, 1967) but fencing timber from untended stands contains too great a quantity of heartwood for satisfactory preservative treatment.

Contorta pine often produces seed in the third year after planting; the green strain appears to seed rather earlier and more prolifically, with less serotinous cones, than the yellow strain. For this reason, the species has been considered a weed in certain circumstances (Benecke, 1967) although moderate grazing by sheep will keep regeneration under control. Areas adjoining Karioi Forest, including National Park land and the Waiouru Military Reserve, are ungrazed and regeneration has been readily established. Methods to eradicate it from these areas are being studied.

Contorta Pine in Karioi Forest

Karioi Forest (10 554 ha) is located on the south-east slopes of Mount Ruapehu, and consists of a number of fans and terraces of easy contour between 640 and 1 160 m above sea level. The parent material is mainly detritus from Ruapehu, overlying Pliocene sandstones and mudstones. It is derived from andesitic rocks and rhyolitic pumice ejected from the three main volcanic cones (Ruapehu, Tongariro and Ngauruhoe). The recent Ngauruhoe ash was the last deposit and is an important component of the forest soils. Soils vary from fine sandy loams to coarse sand and fine gravel. They are free-draining and allow free rooting of trees, apart from some swampy areas at lower altitudes. At higher levels of the forest the main soil type is Ngauruhoe sand, which consists of 30 cm of dark grey sand over pumice sand and gravel; it is fertile, but site conditions are fairly harsh and exposed at this altitude.

The climate is characterized by long, cold winters and short, warm summers. Frosts may occur at any time of the year, and it has sometimes proved difficult to establish plantations because of damage by late spring and summer frosts. However, once established, tree growth is fairly rapid. Climatic details are as follows:

Mean annual rainfall	1 212 mm
Growing season rainfall (Sep. to Feb. inclusive)	610 mm
Mean annual temperature	9.6° C
Mean temperature of coldest month	4.8° C
Mean temperature of hottest month	14.3° C
Annual number of screen frosts	79

The planted area at Karioi Forest is 6 475 ha; the main species (with areas in parentheses) are *Pinus ponderosa* (2 005 ha), *P. contorta* (2 017 ha), *P. nigra* (979 ha), *P. radiata* (386 ha) and *Pseudotsuga menziesii* (242 ha) and mixtures (mostly of these species) totalling 769 ha. The upper altitude of planting is 945 m a.s.l. with some experimental plots above this. Nearly all planting was undertaken in the late 1920s and early 1930s.

The contorta pine plantings consist of two strains — green, including a sub-strain recognized as "Waiotapu" (Harris, 1973) and yellow, details of which are given in Table 1.

TABLE 1: AREAS OF FIRST ROTATION STANDS OF CONTORTA PINE

Type of Stand	*"Green" (ha)*	*"Waiotapu" (ha)*	*"Yellow" (ha)*
Pure	181.7	—	1 692.4
Mixtures with other strains	—	142.9 (with "Yellow")	142.9 (with "Waiotapu")
Mixtures with ponderosa pine	356.9	—	161.9

In the 1950s it was felt that the yellow strain stands were so poor that they should be converted to more productive species. There were sporadic attempts to poison them standing and to underplant them. However, in the early 1960s there was an increase in demand for fencing material which allowed an outlet for these stands, and they are being felled, with a yield of 140 to 160 m^3/ha. On the other hand, green strain stands have displayed good development throughout, and are currently being felled with a yield of 625 to 650 m^3/ha. A well-tended plot, part of a species trial at 732 m altitude, yielded 67 m^3/ha in thinnings at 25 years of age, and at 43

FIG. 1: *Altitude 1085 m. Looking south-east over regeneration area above the upper limit of planted stands. Regeneration extends to line of planted trees behind the small hill in the centre of the photograph.*
N.Z. Forest Service photograph by J. L. McQuarrie

TABLE 2: SILVICULTURAL TREATMENT OF CONTORTA PINE REGENERATION*

Cpt.	Year Estab.	Area (ha)	Alti-tude (m)	P.M.H. (m)	Treatment P = prune T = thin (stems/ha)	Year Treated	Mean dbh after Treatment (cm)
20/25	1939	10.1	762	12.8	P 290: 0-4.3 m P 390: 0-6.1 m	1959	11.9
				23.5	T to 700	1971	26.7
32	1949	2.0	792	7.9	P 1 700: 0-3.0 m T to 1 700	1964	c. 7.6
				16.5	T to 500	1971	19.3
33	1949	2.4	792	7.9	P 2 000: 0-3.0 m T to 2 000	1963	c. 7.6
				17.1	T to 625	1971	18.5
42	1949	2.0	853	6.7	P 3 000: 0-2.1 m T to 3 000	1964	Not known
				14.6	P 450: 2.1-4.3 m T to 750	1971	17.3
47	1958	4.9	945	9.0	P 340: 0-3.0 m T to 1 250	1969	10-15
48	1958	26.5	945	9.0	P 410: 0-3.0 m T to 1 250	1969	10-15
49	1958	12.1	945	9.0	P 375: 0-3.0 m T to 1 250	1969	10-15
50	1958	14.2	945	10.6	T to 750	1972	10-15
55	1958	32.4	975	9.0	P 400: 0-3.0 m T to 1 250	1968	10-15
		51.0	975	10.0	P 350: 0-3.0 m	1969	10-15
		47.0	975	10.0	T to 1 250	1970	10-15
		7.7	975	11.0	P 375: 0-3.0 m	1970	10-15
		11.7	975	12.0	T to 1 250	1972	10-15
		32.4	975	12.0	P 300: 3.0-4.9 m	1972	10-15
56	1958	27.1	975	9.0	P 400: 0-3.0 m T to 1 250	1970	10-15
70	1958	20.6	1035	9.0	P 375: 0-3.0 m T to 1 250	1970	10-15

*All stands except Cpt 32 and 33 are "green" strain. Cpts 47, 48, 49, 50, 55, 56 and 70 are all above the uppermost planted stands. These cpts (except 50) were thinned to a nominal stocking of 1 250 stems/ha but in practice this varied between 1 750 and 2 000 stems/ha.

years had a mean dbh of 48 cm, predominant mean height of 29 m, and a merchantable volume of 850 m^3/ha.

There has been some regeneration at Karioi Forest from most species, but contorta pine has been regenerating vigorously for about 30 years, colonizing mainly the upper parts of the forest above the plantations and the adjoining undeveloped land (Fig. 1). The oldest regeneration occurs on firebreaks adjacent to the plantations, but the main area, about 1 300 ha in size, was formerly occupied by mountain tussock grasses, and species of *Hebe* and *Dracophyllum*. Stocking of trees varies from 50 to 7 500/ha, and in size from small seedlings to trees 15 m tall.

SILVICULTURAL TREATMENT OF CONTORTA PINE REGENERATION

Operations — 1959 to 1972

The possibility of managing these regenerated stands for a productive crop were first considered in the late 1950s. It was felt that this "gift from nature" should be utilized rather than neglected, especially as such a crop carried no establishment costs, and no interest over a period of 10 to 15 years. Pruning was deemed desirable for the improvement of timber quality, and thinning was thought to be required in order to remove unsatisfactory stems and so maximize growth on trees of good form and vigour. Investigations into silvicultural regimes had not been undertaken, so that the methods adopted were tentative, and have varied according to location and to current ideas at the particular time the operations were carried out. Details are given in Table 2.

Treatment was initially concentrated on the oldest areas adjacent to plantations, starting in 1959 and continuing sporadically up to 1965, but in 1968 it was decided to treat the extensive areas with 2 500 to 5 000 stems/ha above the planted area (see Fig. 2). The original prescriptions were to select the best stems at a spacing of 2.4 to 3.0 m and prune them to 3 m, and then to thin the stands to 1 250 stems/ha, leaving trees of good form and removing "wolves" so as to even up the crop to within a mean height range of 7.5 to 9.0 m. This was calculated to provide flexibility for future treatment (for example, production thinning) and to maintain stability. (Planted contorta pine stands are sometimes considered to be susceptible to windthrow — *e.g.*, see Hinds and Reid, 1957 — although this trouble has not arisen in Karioi Forest.)

In practice the average stocking of pruned stems was 450/ha, and the thinning regime was modified by removing only those stems competing with pruned trees, thus allowing larger areas to be treated. It was appreciated that a further thinning to waste would be needed to remove new regeneration occurring in gaps in the stands, and that non-competing stems could be removed at that time. With this modification, stocking after thinning varied from 1 750 to 2 000 stems/ha. This treatment continued for three years, by which time it was apparent that future utilization of thinnings was unlikely,

FIG. 2: *Compartment 42; altitude 853 m. Green strain which regenerated in 1949. Pruned to 4.3 m and thinned to 450 stems/ha in 1971.*
N.Z. Forest Service photograph by J. L. McQuarrie

and that the thinning already undertaken had not resulted in windthrow or instability. A much heavier thinning, to 750 stems/ha, was therefore undertaken in an area of 14 ha.

By that time, the stands pruned and thinned in 1959-65 required further treatment, mainly thinning. A small area was pruned from 3.0 to 4.9 m in the older stands, while 32.4 ha of younger regeneration was also given a second pruning (see Fig. 3).

The response to thinning has been excellent in terms of diameter growth. Measurements taken from assessment plots

TABLE 3: RESPONSE OF REGENERATED STANDS OF CONTORTA PINE TO THINNING

		After Thinning in 1959		*1971*	
Plot details	*Treatment*	*Stems/ha*	*Mean dbh (cm)*	*Stems/ha*	*Mean dbh (cm)*
Green strain, regenerated in 1939, at 762 m altitude	Unthinned	3 375	11.9	2 312	19.0
	Thinned	1 350	16.5	1 075	27.2
Yellow strain regenerated in 1949, at 792 m altitude	Unthinned	29 375	5.1	7 625	9.1
	Thinned	1 175	10.4	1 187	19.6

are given in Table 3. This shows that mean diameter growth over the 12 years following thinning can be 50 to 100% greater than in unthinned stands.

Costs of silvicultural treatment of regeneration compare favourably with conventional treatment of planted stands. Low pruning costs have averaged $37.50/ha (450 stems/ha to 3.0 m) and thinning to 1 250 stems/ha has averaged $40.00/ha. Both operations were carried out by labour on bonus incentive schemes, using Porter pruners and short saws for pruning and light power saws for thinning.

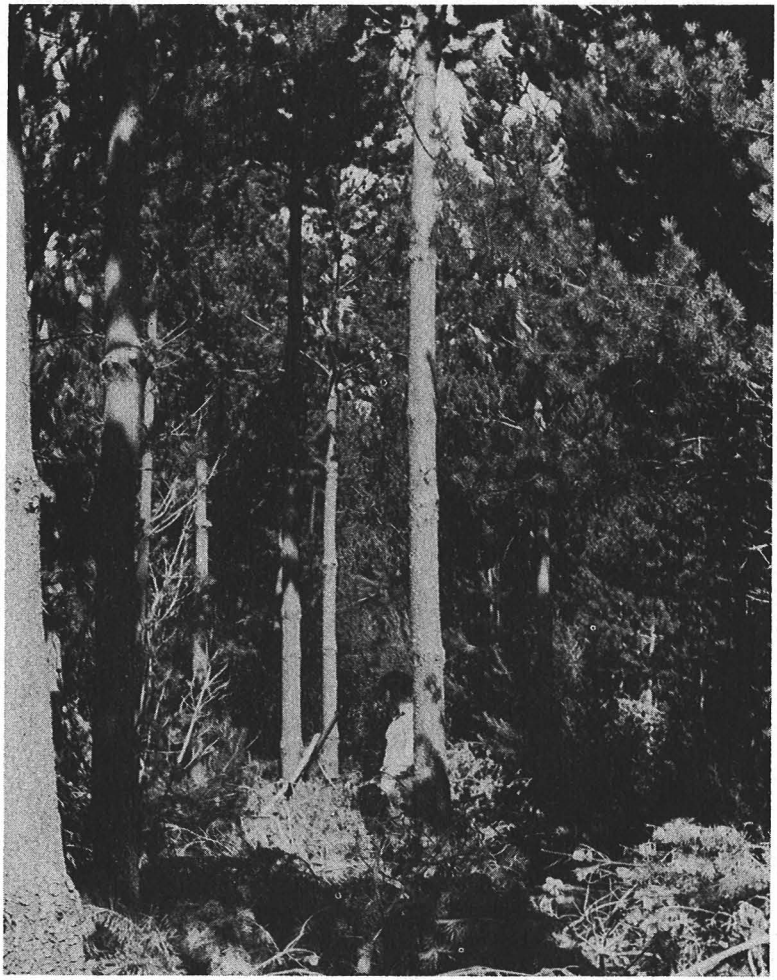

FIG. 3: *Compartment 55; altitude 975 m. Green strain which regenerated in 1958. Pruned to 4.9 m and thinned to 300 stems/ha in 1972.*
N.Z. Forest Service photograph by J. L. McQuarrie

Future Tending

The treatment of the older regenerated stands at lower elevations should be relatively straightforward as they are now similar in structure to plantations of the same mean height. The next treatment could be a utilization thinning, or the stands could be left for clearfelling when the yield has reached 575 to 625 m^3/ha.

The younger treated stands in the upper parts of the forest would need a further thinning to waste to deal with new regeneration in open gaps, and to remove the non-competitor trees left from the first thinning. At this stage a further pruning lift could also be considered.

It is also apparent that the silvicultural regime which has been evolved here could be applied to remaining untreated stands, probably with an initial thinning to leave 750 stems/ha.

A full evaluation of the work carried out would doubtless give a reliable guide to the most suitable regime, but it may be best to delay this until the stands are approaching the utilization phase.

CONCLUSION

It has been demonstrated that silvicultural treatment of regenerated contorta pine stands at fairly high altitudes is feasible and not costly, that response in terms of increased diameter growth is good, and that stands can be brought into a uniform condition approaching that of plantations of the same mean height. A full evaluation may not be possible until the stands approach the utilization phase, but enough has been learnt to allow application of the treatment to additional stands of a similar type, so that they can be developed into a useful asset.

In view of the weed potential of the species, however, there may be some objections to maintaining these stands as a possible seed source from which regeneration may spread into adjacent undeveloped areas.

ACKNOWLEDGEMENTS

The writer is grateful for discussions on the subject of contorta pine regeneration at Karioi Forest with many visiting Forest Service officers over a period of four years. The encouragement and assistance of the Officer-in-Charge, I. Glennie, has been considerable. Also, the interest and enthusiasm of many workmates on the job has played a great part.

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