SKIDTRAILS AND THEIR EFFECT ON THE GROWTH AND MANAGEMENT OF YOUNG PINUS RADIATA

J. FIRTH and G. MURPHY
Ministry of Forestry, Forest Research Institute,
Private Bag 3020, Rotorua, New Zealand

(Received for publication 12 July 1988; revision 15 May 1989)

ABSTRACT

Growth of **Pinus radiata** D. Don trees growing on and just off four major skidtrails in Tairua Forest was compared. Those growing on the skidtrails were markedly inferior in height, diameter, and form. This significantly affected the selection of trees for thinning and pruning so that, by age 7.5 years, only 4% of the trees planted on the skidtrails remained to form the final crop compared with 15% of those planted off the trails. Trees left on the trails were 2 cm smaller in diameter and 1 m shorter than those left off the trail. These results suggest that, for soils similar to the clays of Tairua, consideration should be given to either leaving major skidtrails unplanted, or carrying out some sort of site amelioration.

Keywords: soil disturbance; skidtrails; **Pinus radiata**.

INTRODUCTION

Each year, about 15 000 ha of exotic forest are logged in New Zealand using crawler and skidder tractors. The result is an extensive network of skidtrails which, depending on the machinery used, the logging plan, and site factors, may cover 50% or more of the logging area (Murphy 1984). Sometimes these skidtrails are subsequently replanted and sometimes they are not.

Awareness of the effects of harvesting equipment and logging operations on forest soils and tree crops is rapidly expanding and has been summarised by such authors as Carter (1980), Murphy (1982), and Wingate-Hill & Jakobsen (1982).

In order to help the forest manager decide whether or not to replant on skidtrails, the Forest Research Institute has established trials to determine the relationship between the degree of soil disturbance caused by logging and the growth of the subsequent crop of trees. One of these trials was established in 1982 in Cpt 128, Tairua Forest, to compare the survival, growth, and form of *Pinus radiata* trees planted on the skidtrail with those planted just off the trail and to determine the effect on management practices (Murphy 1983).

SITE DESCRIPTION

The soil on the study site has been described as Tangatara (127b) – stoney and bouldery clay loam (New Zealand Soil Bureau 1954). The profile consisted of eroded Whangamata lapilli overlying light brown and greyish clay loam on weathered rhyolite and dacite. The terrain on the site was gently undulating. Its main features have been classified, using the FRI terrain classification system (Terlesk 1983), as Class 2 ground condition, Class 2 ground roughness, and Class 1 slope. The mean absolute slope was 5°.

The annual rainfall in the Tairua region is 1800–1900 mm. This is spread throughout the year, with a slight increase for the months of May to August.

The area was logged downhill to roadside landings using a skidder/tractor combination in the summer of 1977–78. The logging officer remembers the soils as being quite wet at the time of harvesting (T. Carter, pers. comm.).

The area was replanted in 1978 at a stocking rate of 1176 stems/ha with a mixture of *P. radiata* bulk seed and seed orchard stock. Serpentine superphosphate fertiliser was applied by hand at a rate of 170 g/tree at the time of planting and applied from the air at 1 tonne/ha 4 years after planting. No rehabilitation of skidtrails was attempted

Only the main skidtrails could be positively identified and measured when the trial began 4 years after planting. These would be assessed as damage classes DC3 and DC4 under the five-class (DC0 to DC4) visual damage classification system described by Murphy (1982) – i.e., the litter layer and much of the topsoil had been removed and the subsoil had been compacted.

METHODS

Four neighbouring skidtrails within the selected compartment were chosen for the study. Along each skidtrail, as far as it could be recognised, each tree on the skidtrail (191 trees) and two trees, within the same row, off the skidtrail (327 trees) (*see* Fig. 1)

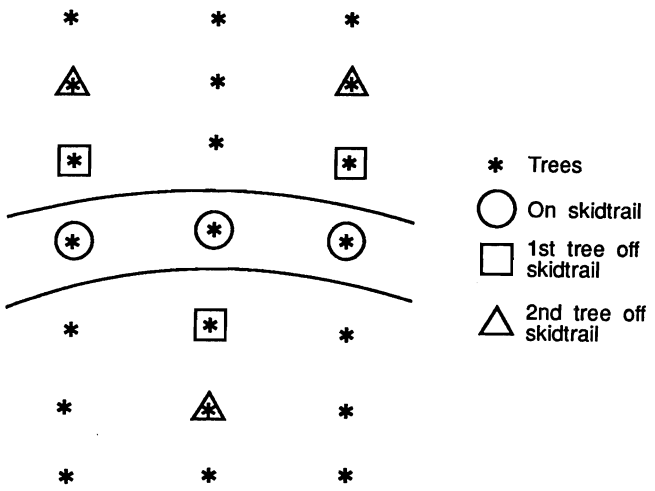

FIG. 1—Arrangement for selection of trees.

were measured. An exact 2 : 1 ratio was not achieved. In some places the skidtrail was wide enough to have had two trees planted on it. Also, near adjoining skidtrails only one tree off the skidtrail could be measured. The following were recorded initially:

- Stem height, to the nearest decimetre, was measured with height poles.
- Diameter at breast height, to the nearest centimetre, was measured with calipers. If the tree height was less than 1.4 m, dbh was recorded as zero.
- Survival – trees were recorded as alive, dead (but not yet decomposed), or missing.
- Form was assessed on live trees only. The form classes recognised were:
  (i) good form, healthy
  (ii) double leader
  (iii) multiple leader
  (iv) top missing
  (v) severe butt sweep or toppled
  (vi) dying or unhealthy
- Distance from the measurement point to the landing, along the skidtrail, was measured with a stringe gauge (Hip Chain M-25). This distance was later used to calculate the length of skidtrail behind the measurement point as an indication of the amount of traffic over that point (Fig. 2).

The trees on the trail were tagged and the measurements repeated at age 5.5 years, age 6 years, age 7 years, and age 7.5 years.

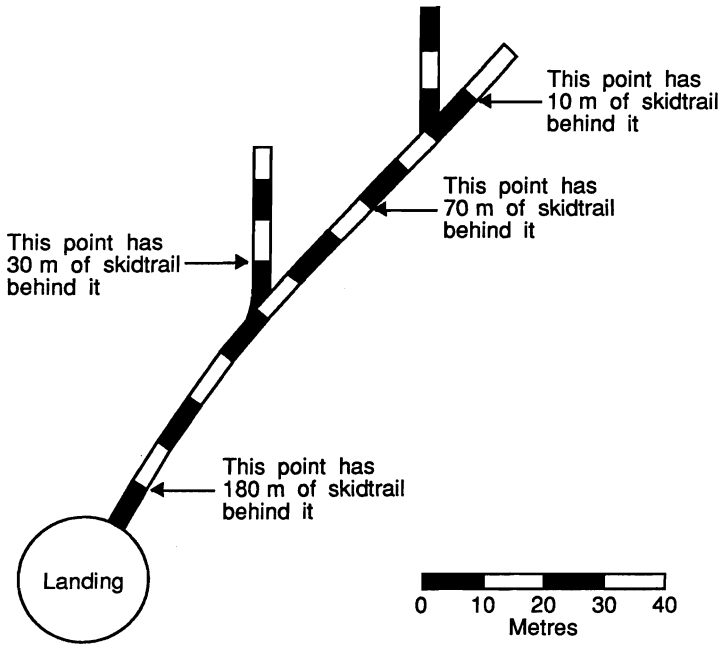

FIG. 2—Calculation of skidtrail length.

RESULTS

Stocking

The stockings at various stages in the history of the trial are given in Table 1. Until the time of the first thinning, the survival rates on and off the skidtrails remained more or less the same, at about 75%.

Malformation

At age 4 years, each tree was assessed for form. Of those trees alive on the trails, 49% were malformed compared with only 38% of those growing off the trails. There appeared to be no relationship between the extent or type of malformation and the length of skidtrail – that is, malformation was just as bad on a 50-m as a 500-m-long trail.

By far the most prevalent type of malformation found on the skidtrails was severe butt sweep or toppling. There was significantly ($p < 0.01$) more toppling on the skidtrails (37%) than off (19%) and this could be attributed to the physical problems of planting tree seedlings on compacted soils.

Pruning and Thinning

After low pruning at age 5.5 years, 42% of the off-skidtrail trees survived and had sufficiently good growth and form to warrant low pruning, compared with 20% of the on-skidtrail trees (Table 1). When the compartment was thinned at age 6 years, 43% of the trees off the trail remained, compared with only 28% of the trees on the trail. Medium pruning was carried out at age 7 years (Table 1). Only 7% of the

TABLE 1–Stocking

Stocking		On skidtrail		Off skidtrail	
		No. of trees	Percentage of original stocking	No. of trees	Percentage of original stocking
Stocking at planting		191		327	
Age 4 years	Alive	143	75	254	78
	Good form	73	38	158	48
Age 5.5 years	Alive	138	72	241	74
	Low pruned	38	20	137	42
Age 6 years –after first thinning	Alive	54	28	141	43
Age 7 years	Alive	54	28	138	42
	Unpruned	14	7	8	2
	Low pruned	27	14	77	24
	Medium pruned	13	7	53	16
Age 7.5 years	Alive	7	4	49	15
	Unpruned	0	0	0	0
	Low pruned	0	0	0	0
	Medium pruned	3	2	8	2
	High pruned	4	2	41	13

trees planted on the skidtrails had potential as final-crop trees and were medium pruned and another 7% were left unpruned as gap fillers. This compares with 16% and 2% respectively for the trees planted off the skidtrails.

A second thinning was carried out at age 7.5 years to bring the compartment down to a final-crop stocking of 250 stems/ha. Approximately 15% of the trees planted off the trails survived to make the final crop but only 4% of the trees on the trails did so (Table 1). At the time of high pruning at age 7.5 years, 43% of the residual on-skidtrail trees and 16% of the residual off-skidtrail trees were not high pruned because of poor growth or form.

Height and Diameter Growth

On trail v. *off trail*

At each measurement, the skidtrail trees were significantly shorter and thinner than the off-trail trees (Table 2). At age 4 years, the height difference between the on- and off-trail trees was 1.0 m. Two years later this had increased to 1.5 m, only to be reduced to 1.2 m as the poorer trees were thinned out. By age 7.5 years, the gap had increased to 1.4 m but was reduced to 1.1 m after the second thinning.

TABLE 2–Height and diameter growth

Age (years)	On skidtrail		Off skidtrail	
	Height (m)	dbh (cm)	Height (m)	dbh (cm)
4	2.0 **	NA	3.0	NA
6				
–before first thinning	4.1**	5.3**	5.6	8.8
–after first thinning	5.2**	7.6**	6.4	10.2
7	6.8**	11.2**	8.4	14.3
7.5				
–before second thinning	8.4**	13.0**	9.8	16.4
–after second thinning	9.0*	14.3**	10.1	16.5

NA = Not assessed as many trees below 1.4 m high.
* = Difference between on-trail and off-trail trees significant at p=0.05.
** = Difference between on-trail and off-trail trees significant at p=0.01.

Length of trail behind

When the trees were measured at 4 years, there was a small decrease in tree height as the length of skidtrail behind the tree increased (Murphy 1983). In other words, the closer the tree was to the landing, the greater the amount of traffic the skidtrail had to carry and the slower the tree growth in the following rotation. The first thinning, at age 6 years, had the effect of removing all the trees on the skidtrail between 180 m and 350 m behind the measuring point and 61% of those between 0 and 180 m. A regression analysis of the remaining trees showed that, by age 7 years, the trend which Murphy (1983) had first noticed was no longer apparent (Fig. 3).

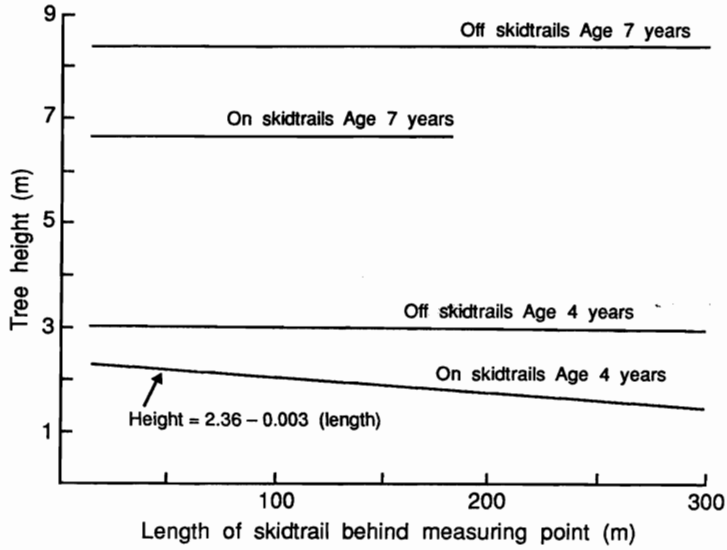

FIG. 3—Height of *Pinus radiata* on and off skidtrails.

The second thinning, when the trees were 7.5 years old, reduced the number left on the skidtrails even further with the result that there are now too few left to obtain a reliable measure of the long-term relationship between trail length and tree growth.

First off v. *second off*

The difference in growth between trees first off and second off the skidtrail after each pruning lift is indicated in Table 3. At no stage was there any significant difference between the first-off and second-off trees ($p = 0.01$). This means that, up to age 7.5 years at least, the skidtrails did not have a detrimental effect on the growth of the trees next to them.

CONCLUSIONS AND RECOMMENDATIONS

The height, diameter, and form of trees growing on four skidtrails in Tairua Forest was found to be markedly inferior to that of trees growing off the trails. This affected the selection of trees for thinning and pruning to the extent that, by age 7.5 years, only 4% of the trees planted on the skidtrails remained to form the final crop compared with 15% for the off-trail trees. Furthermore, compared to the trees off the trails, those

TABLE 3–Growth of trees off the skidtrail

	First off		Second off	
	Mean height (m)	Mean dbh (cm)	Mean height (m)	Mean dbh (cm)
After low pruning	6.4 NS	10.1 NS	6.4	10.5
After medium pruning	8.4 NS	14.2 NS	8.4	14.5
After high pruning	9.9 NS	16.4 NS	10.3	16.6

NS = No significant difference between first-off and second-off values (p=0.01).

trees left on the trails were on average 1 m shorter (10%), 2 cm smaller (13%) in diameter (dbh), and 33% lower in volume ($dbh^2 \times$ height). There is little indication that this gap is narrowing over time.

These results suggest that, for Tairua soils:

(a) It is probably not worth the expense of planting and tending trees on skidtrails which have Class 3 and 4 soil disturbance because their survival, growth, and form will be such that few of them ever make the final crop. However, if it is considered necessary to plant on the skidtrails, some form of fertiliser/site-amelioration treatment may bring the trees up to an acceptable standard. Further research is recommended in this area.

(b) The area occupied by skidtrails should be kept as low as possible by careful planning and control during the logging phase. Logging systems such as skylines or low-ground-pressure extraction machinery may be viable alternatives on sensitive sites.

It is not known how long it takes for nature to rehabilitate heavily damaged skidtrails in New Zealand but North American studies (Froehlich *et al.* 1985; Vanderheyden 1981; Wert & Thomas 1981) indicate that it would not be unreasonable to measure the time in decades. Until firm data on rehabilitation become available, it would seem prudent to record the location of the main skidtrails (ideally by aerial photography) before the vegetation obscures them. They can then be relocated and reused when logging next takes place. In this way the area of disturbed soil should not increase from rotation to rotation.

REFERENCES

CARTER, P. R. 1980: Some aspects of the impact of logging on the forest and its environment – a literature review. **Forestry Commission of NSW Report.**

FROEHLICH, H. A.; MILES, D. W. R.; ROBBINS, R. W. 1985: Soil bulk density recovery on compacted skid trails. **Soil Science Society of America, Journal 49:** 1015–7.

MURPHY, G. 1982: Soil damage associated with production thinning. **New Zealand Journal of Forestry Science 12:** 281–92.

——— 1983: **Pinus radiata** survival, growth and form 4 years after planting off and on skidtrails. **New Zealand Journal of Forestry 28(2):** 184–93.

——— 1984: A survey of soil disturbance caused by harvesting machinery in New Zealand plantation forests. **New Zealand Forest Service, FRI Bulletin No. 69.**

NEW ZEALAND SOIL BUREAU 1954: General survey of the soils of North Island, New Zealand. **Department of Scientific and Industrial Research, Soil Bureau Bulletin No. 5.**

TERLESK, C. J. 1983: A proposed terrain classification for harvesting in New Zealand. **New Zealand Journal of Forestry 28(1):** 43–57.

VANDERHEYDEN, J. 1981: Chronological variation in soil density and vegetative cover of compacted skid trails in clearcuts of the Western Oregon Cascades. M.S. Thesis, Oregon State University.

WERT, S.; THOMAS, B. R. 1981: Effects of skid roads on diameter, height and volume growth in Douglas fir. **Soil Science Society of America, Journal 45:** 629–32.

WINGATE-HILL, R.; JAKOBSEN, B. F. 1982: Increased mechanisation and soil damage in forests – A review. **New Zealand Journal of Forestry Science 12:** 380–93.