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REPORT

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# LOGGING EXTRACTION TRACK REHABILITATION

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*Figure 1 - Contour tracks for ground-based extraction on steep terrain*

*ABSTRACT*

*The production rates and costs of rehabilitating major logging extraction tracks with ripping, and ripping and returning soil and slash to the track surface were collected from two forest sites - Omataroa in the Bay of Plenty and Golden Downs in Nelson. On a per hectare of track surface basis, rehabilitation costs appeared high. However, when costs were spread over the entire area harvested using a specific section of track, costs were substantially reduced. The area occupied by tracks and the area logged by way of those tracks were measured. Soil compaction levels were recorded and profiles of the* *ripping treatment were measured. Soil compaction sufficient to restrict root growth was found on all tracks except at the extreme ends furthest from the skid at the Omataroa site.*

*Based on soil samples collected for nutrient analysis, there were substantial differences between the cutover, track and returned soil material in the levels of N, C, P, K, Ca and Mg at both sites.*

*Growth trials were established in the treated areas for long term monitoring of the effects of the treatments.*

## INTRODUCTION

Extraction tracks created by ground-based logging operations can occupy from 5% to 15% of the potentially productive land area of a forest. This is in addition to the land used for roads and landings which can be a further 5% to 8 % of the total land area (Hall, 1993). The amount of tracking used depends on a number of factors, including; slope, evenness of contour, roading access and the number or density of landings (Krag, 1984).

There are two major categories of tracking for ground-based logging systems. The first is the random arrangement of tracks created by extraction machines where the terrain is flat and is not a limiting factor. The closer these tracks get to the skid, the more obvious they become. The second type is contour tracking, where benched tracks are created on which the extraction machines work (Figure 1). For these tracks, the amount of damage to the soil is similar regardless of the location due to the need to sidecast material the entire length of the track. Damage to the soil from tracking is usually in the form of removal of topsoil, compaction and rutting of the track surface. It has long been recognised that trees planted on extraction tracks do not perform as well as those on the adjacent cutover (Murphy, 1984). Given the high area of land loss incurred in most logging operations where tracking is used, the rehabilitation of these tracks to a level of production similar to that of the surrounding cutover is desirable (Shuster, 1979).

In 1993, two trials were established by LIRO to assess the effectiveness of a range of treatments for rehabilitating extraction tracks.

*ACKNOWLEDGMENTS*

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## METHODS

The two sites chosen for the trials were:

- Omataroa Forest, Bay of Plenty, which is characterised by scoria and pumice soil with rolling to steep broken terrain
- Golden Downs Forest, Nelson, which is typically Moutere gravels with steep terrain.

The trial design was the same for both sites, and consisted of nine replications of the following treatments:

(1) untreated track
(2) ripped track
(3) ripped and fertilised track
(4) ripped and sidecast soil and slash returned to track surface
(5) cutover
(6) cutover without weed control.

Spot release weed control will be carried out on treatments 1 to 5 as necessary.

The plots for each of these treatments are 30m long. The tracks are approximately 4m wide. Two double rip lines were put in for all the ripping treatments. The ripping and the returning of soil were both carried out with hydraulic excavators. Both machines had rippers and buckets. They were also fitted with "quick hitch" fittings for changing from one attachment to the other. Growth plots were established and will be measured annually for the next ten years to monitor growth differences. Data collected during the establishment of the trials were:

- machine production rates for ripping and returning sidecast material
- soil shear strength
- soil samples for nutrition analysis
- rip profiles
- depth of the spread debris
- the amount of tracking in relation to the size of the area logged.

## RESULTS

### Site Characteristics

The two trial sites were logged in different ways. The Omataroa site was logged by using a two staging system. That is where a hauler extracted the wood to the ridge tops and from there the tree lengths were taken by skidder along tracks to a central skid. The Golden Downs site was logged entirely by ground-based machines using contour tracks.

The higher proportion of land lost in Golden Downs was due to a higher tracking density, more skid sites and more roads (Table 1). This was because of the steeper terrain in Golden Downs.

*Table 1 - Area logged and amount of tracking*

| | Omataroa | Golden Downs |
|---|---|---|
| **Area logged.** | **13.5 ha** | **16.4 ha** |
| **Area of track.** | **1.0 ha** | **1.6 ha** |
| **% of area in track** | **7.2 %** | **9.7 %** |
| **% of area in tracks, roads and skids** | **12 %** | **23 %** |

The methods used to establish the trials at both sites were the same. Due to the very soft volcanic scoria soil at Omataroa, it was possible to use a 10 tonne excavator (PC 100). However, because of the naturally hard soil (Moutere gravels) in Golden Downs, a 20 tonne excavator (EX200) was used.

The ripping technique used in both trials was the same. For each of the two ripped lines created on the tracks a double rip was used because a single rip tended to leave a slot in the ground rather than the desired shatter.

### Effect of Ripping on Soil Physical Characteristics

The rip shatter zones show that the Omataroa shatter zone was slightly narrower overall, generally had less above-ground heave and had better shatter between the two rips than Golden Downs (Figures 2 and 3). The reason for the greater width, heave and reduced inter-rip shatter at Golden Downs can be attributed to several factors. There was a number of large boulders in the Golden Downs soil which caused above-ground heave when moved by the ripper.

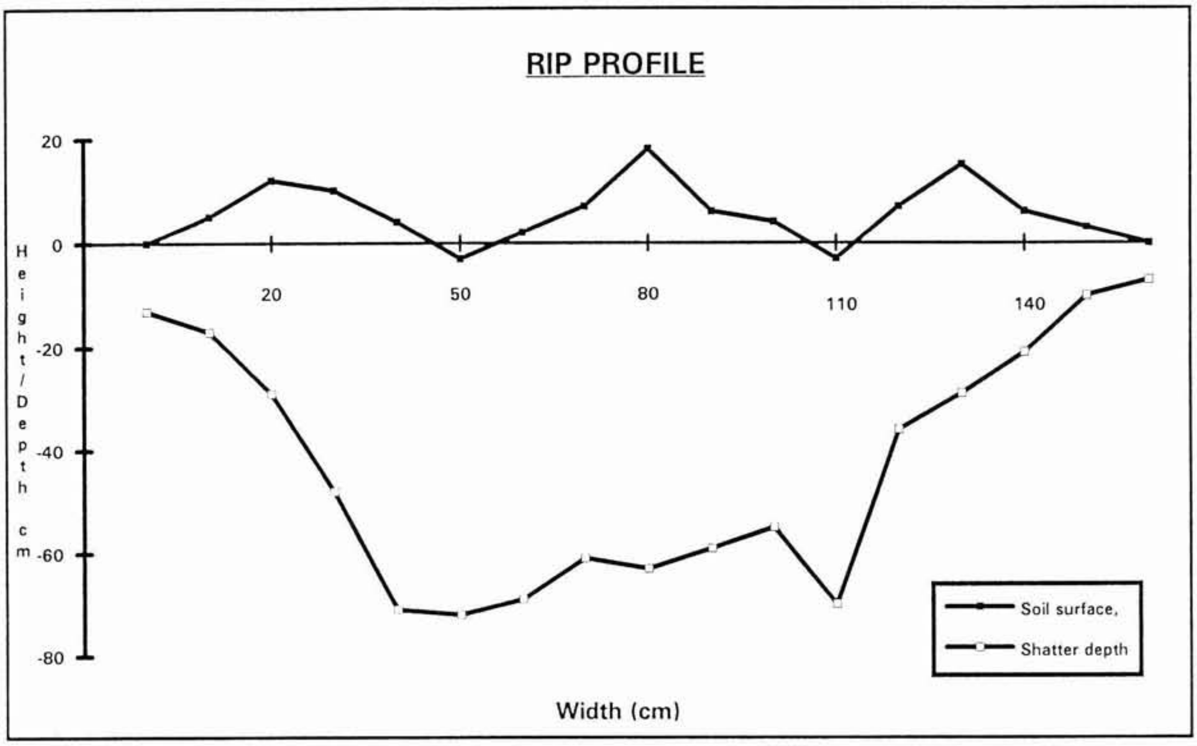


*Figure 2 - Typical rip shatter profile - Omataroa Forest*

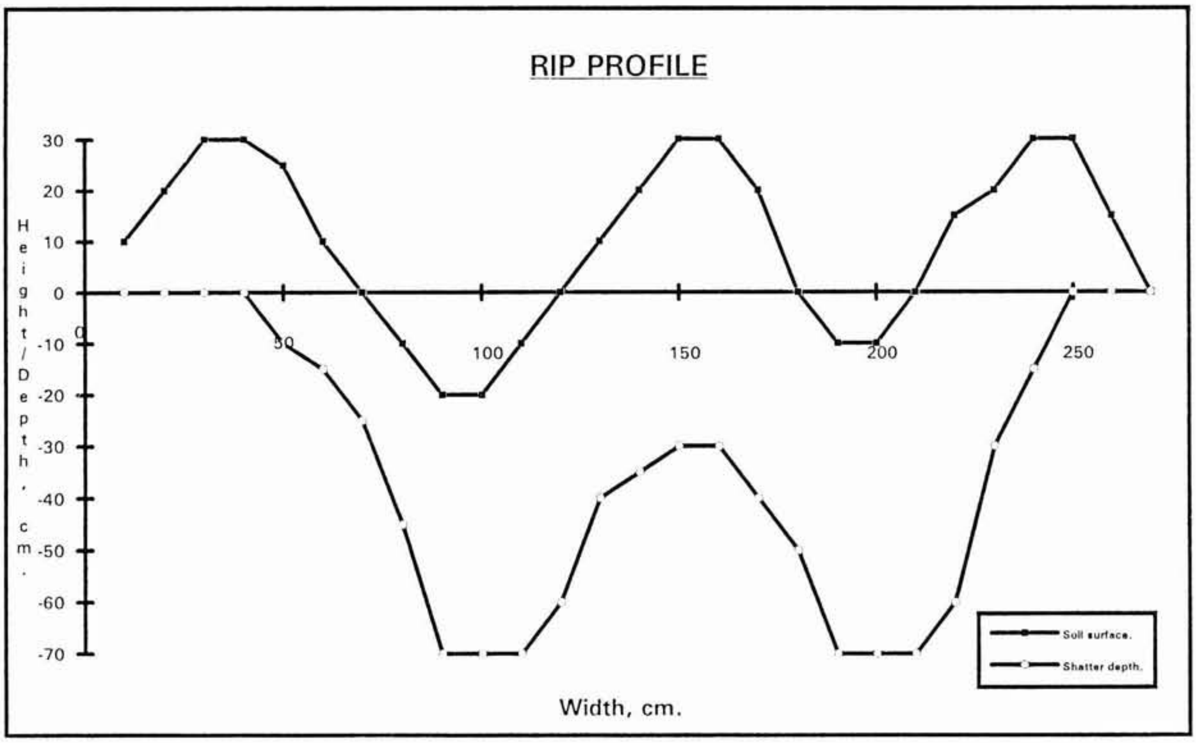


*Figure 3 - Typical rip shatter profile - Golden Downs Forest*

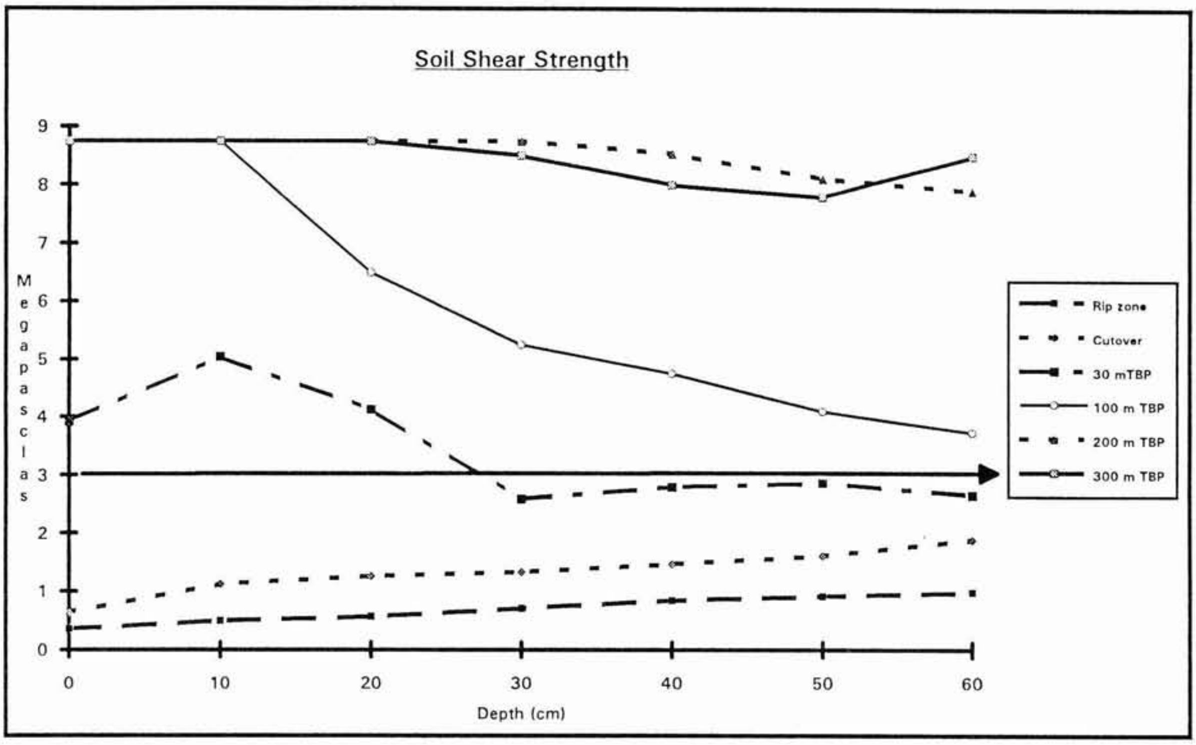


*Figure 4 - Soil shear strength - Omataroa Forest*

Note - TBP in legend = length (m) of track beyond the plot. The greater the distance beyond the plot from the skid the more traffic has passed over it. The arrow line marks the 3 megapascal level for soil resistance to penetration, which is the approximate point beyond which radiata pine roots tend not to grow (Mason & Cullen, 1986).

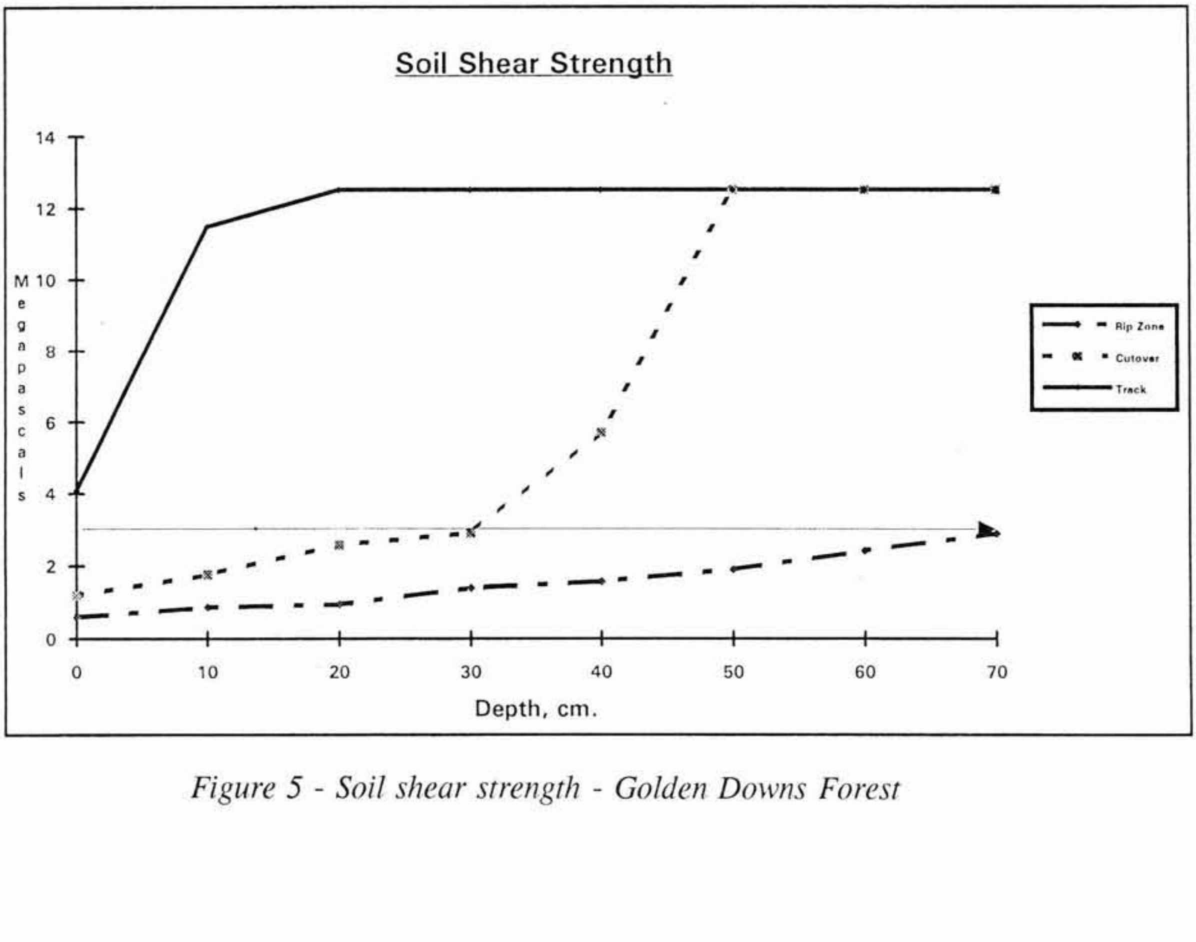


*Figure 5 - Soil shear strength - Golden Downs Forest*

The soil was also naturally much more compact and it was very gravelly. This caused some difficulty in keeping the rip lines as close together (500mm approximately) as was possible at Omataroa because when the second rip was being made, the ripper tended to run into the first rip. The compact nature of the soil meant that if the rips were kept apart, complete shatter between the rips did not occur.

**Effect of Ripping on Soil Shear Strength**

Figure 4 clearly shows that the rip zone was very soft, as was the cutover soil. The greater the amount of traffic, or closer to the skid site the plot was located, the greater the level of compaction; however, there was little increase after the 120m point was reached.

The horizontal arrow (Figure 5) marks the 3 megapascal line; the rip zone falls well under this. The cutover line shows that root penetration will become difficult at around 20cm to 30cm. However, due to the gravelly nature of the soil, the roots may penetrate this level by taking advantage of cracks. The theory that the roots would not penetrate much beyond 30cm was supported by the observation of the root systems of several windthrown trees in an adjacent block. These root systems had no substantial roots going further than 40cm below ground level.

The level of soil shear strength did not vary with the plot location. This was because the tracks were benched or dug into the hillside. The cut banks on the uphill side of the tracks were 0.5m to 2.0m high, so the surfaces of the tracks were naturally very hard. There was also some surface loosening due to weathering.

**Soil Nutrient Status**

The removal of topsoil from the track surface by side-casting during construction caused large reductions in all soil nutrients. Some amelioration of this would be a prerequisite for crop re-establishment.

The soil in the material spread over the track in the "rip and return soil and debris" treatment had nutrient levels that fell between the cutover and track surface levels for all cases except K at Golden Downs (Table 2). In particular, soil N had been reduced to a critical level for radiata. Soil P levels, although low for radiata had also been further reduced. There have been marked reductions in soil cations.

The levels of nutrients in the returned material were much lower at Golden Downs than at Omataroa. This was because the tracks at Golden Downs were formed mid-slope and much of the topsoil was buried in the side-casting. Most of the material returned was subsoil. At Omataroa, the tracks were formed on ridge tops and the topsoil was much easier to access and return.

The levels of P have also been noticeably affected, with levels below the margin for adequacy (Ballard, 1973; Skinner et al, 1991).

In summary, the levels of N and P are the most likely to cause problems for the re-establishment of tracks as productive forest. These findings follow a similar pattern to those in two skid site rehabilitation trials established in Kaingaroa (Hall, 1993) and Golden Downs. Replacing some of the displaced topsoil has partially improved the nutrient status. However, tree growth could still be considered at risk, particularly with N since there is woody

*Table 2 - Soil nutrient status*

| | Omataroa Forest | | | | | | | Golden Downs Forest | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | N% | C% | P(2) | Ca | Mg | K | pH | N% | C% | P(2) | Ca | Mg | K |
| Cutover | 5.86 | 0.180 | 2.53 | 9.48 | 5.14 | 1.70 | 0.256 | 5.36 | 0.289 | 8.92 | 7.34 | 12.08 | 2.93 | 0.240 |
| Track surface | 5.99 | 0.082 | 1.31 | 4.65 | 2.37 | 0.49 | 0.213 | 4.91 | 0.077 | 3.37 | 4.53 | 1.37 | 0.99 | 0.190 |
| Return soil | 6.16 | 0.117 | 2.11 | 5.31 | 4.59 | 1.48 | 0.225 | 4.96 | 0.102 | 2.63 | 6.52 | 2.81 | 1.66 | 0.169 |
| Cutover Return Ratio | N/A | 65% | 83% | 56% | 89% | 87% | 87% | N/A | 35% | 29% | 73% | 23% | 56% | 70% |

**NOTE:**
N = Nitrogen
C = Carbon
P = Phosphorous
Ca = Calcium
Mg = Magnesium
K = Potassium

*Table 3 - Production rates and costs (PMH = Productive Machine Hour)*

| Forest | Category | Units | Rip. | Return soil. | Rip and return soil. |
|---|---|---|---|---|---|
| Omataroa | Production (PMH) | Per km of track | 3.3 | 5.0 | 8.3 |
| | | Per ha of track surface | 8.2 | 12.5 | 20.7 |
| | Cost ($) | Per km of track | 250 | 375 | 620 |
| | | Per ha of track surface | 615 | 940 | 1550 |
| Golden Downs | Production (PMH) | Per km of track | 7.7 | 8.3 | 16.0 |
| | | Per ha of track surface | 19.3 | 20.7 | 40.0 |
| | Cost ($) | Per km of track | 731 | 788 | 1520 |
| | | Per ha of track surface | 1830 | 1970 | 3800 |

debris incorporated in the soil spread over the track surface. The presence of this material may result in a "lock-up" of soil mineral N in the decay process.

## Production Rates and Costs of the Treatments

On a per hectare basis these production levels and costs (Wells, 1981) may be

*Table 4 - Average cost of treatments spread over the logged area*

| | Omataroa Forest | Golden Downs Forest |
|---|---|---|
| Normal Site prep | $160/ha - Roller crush | $210/ha - Excavator windrow |
| | | |
| Track rehab per ha of track | $615 - rip | $1830 - rip |
| | $1550 - rip+soil | $3800 - rip+soil |
| Area serviced by track | 13.5 ha | 16.4 ha |
| Length of track | 1.0 km | 1.6 km |
| Track rehab per ha logged | $46 rip+soil | $150 - rip+soil |
| Total average site prep cost | $206 - rip+soil | $360 - rip+soil |

considered high, "especially the rip and return soil" in Golden Downs (Table 3). However, if the costs of these track treatments are spread over the area served by the tracks, the average cost per hectare for mechanical site preparation appears more reasonable (Table 4).

Three reasons that the costs are higher for Golden Downs are:

- the soil is much harder (Figures 4 and 5)
- the soil also had to be retrieved from where it had been sidecast downhill
- the layer of material returned over the track surface at Golden Downs (74cm) was much thicker than that at Omataroa (38cm). This was because there was more material to work with and because the top soil was buried under the sidecast material.

## DISCUSSION

### Costs

The costs of these rehabilitation treatments appear high. Although the ripping was carried out with the excavators, this was not because it was seen to be the best way of doing it, but because the machines were already on site for the returning of soil to the track surface.

If these treatments were to be used on an operational scale and large amounts of ripping were involved, it would be possible to considerably reduce the cost of ripping by using a bulldozer, which would rip more efficiently than the excavator.

### Options for Cost Reduction

Changes that would reduce the cost would be:

- to have only one double rip line per track instead of two
- to limit the amount of material returned to the surface of the track to a depth of 0.3m to 0.5 m.

These changes would substantially reduce the time involved and therefore the cost of the rehabilitation treatment, especially in the hard Nelson soil.

If a 150 kW bulldozer was used for ripping one double rip line per track and a 20 tonne excavator was used for the returning of the soil to a maximum of 0.5m over the track surface, an estimate of the cost for the Golden Downs operation would be as follows:

Rip = 1.0 PMH/km or
2.5 PMH per ha of track
Spread soil = 6.5 PMH/km or
16.3 PMH per ha of track
Rip and spread soil = 7.5 PMH/km or
18.8 PMH per ha of track.

In this case, each km of track serviced 10.25 ha of logged area, so if the cost of treating the track is spread over this area, the total cost of the "rip and spread soil" treatment per hectare logged would be $73.

The combined total of the rehabilitation of the tracks and the existing mechanical site preparation treatment would be approximately $285 per hectare.

Another option that could be considered at Golden Downs would be the use of an excavator to form the contour tracks. The excavator would be able to place the topsoil separately from the subsoil making it easier to retrieve in rehabilitation operations.

It would also be possible to make some reductions in cost at Omataroa. If a medium sized bulldozer (120 kW) was used to create a single line of double ripping and the same small excavator was used to return the soil to the track surface as in the trial, the costs could be summarised:

Rip = 1.0 PMH/km or
2.5 PMH per ha of track
Spread soil = 4.5 PMH/km or
11.3 PMH per ha of track
Rip and spread soil = 5.5 PMH/km or
13.8 PMH per ha of track.

In this case, 1 km of track served 13.5 ha of logged area, so again if the cost of treating the track is spread over the area logged by those tracks, the cost of the "rip and spread soil" treatment would be $35 per hectare. If this cost is added to that of the existing mechanical site preparation treatment, the total would be $195 per hectare.

**Cost Justification**

Soil compaction on the Omataroa tracks may cause some problems for tree growth if left uncultivated, even at the end of the tracks furthest from the skids which have had the least traffic. Due to the benching of the tracks at Golden Downs, compaction from machine traffic was not an issue as the soils were naturally so consolidated that it was limiting root growth.

The ripping at both sites was to a depth of 70cm. The shatter zone width varied considerably. At Omataroa, it was approximately 1m wide, whilst at Golden Downs it was 1.4m to 2.0m wide. Ripping to this extent will allow roots to develop and the trees to grow.

At both sites there were differences in the levels of soil nutrition between the cutover, track surface and returned soil and debris. These differences were sufficiently large that some growth differences can be expected.

The area of land lost to major extraction tracks was considerable - 7.2% at Omataroa and 9.7% at Golden Downs. It could be argued that if the tracks were left untreated and trees were planted close to the track edges, the site would still be fully occupied and the tracks would remain for use at the harvest of the next rotation. However, there is no guarantee that these tracks would be used in subsequent logging operations as the harvesting methods and equipment may not be the same. Even if the same method is used, it is possible that new tracks would be made for at least some of the site.

The planting of trees on the tracks on steep sites will also have the effect of stabilising the tracks, reducing water run-off and erosion, once the trees reach age 3 to 4 years.

Ultimately, whether the level of cost involved in rehabilitating tracks can be justified will only be determined when sufficient long term growth data from the trials are available to enable a cost benefit analysis to be carried out.

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*The costs stated in this Report have been derived using the procedure shown in the LIRA Costing Handbook for Logging Contractors. They are an indicative estimate only and do not necessarily represent the actual costs for this operation.*

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