SOIL DAMAGE WINTER LOGGING

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13.7.1978

SOIL DAMAGE AND WINTER LOGGING

1. INTRODUCTION

This report is prepared as background material for a visit by Chiefs of Division to inspect logging damage in the field. Its purpose is to define the problem, its effects and significance; to define terms and make recommendations for its prevention. The sources of data and opinions expressed here are mainly from the group which has been investigating winter logging but the concern expressed reflects that of most officers in the southern region.

2. THE PROBLEM AND ITS CAUSE

Snigging logs from the forest can cause damage to the soil by

2.1 Compaction of the soil in situ by the wheel pressure of the machine and to some extent the log.

2.2 Removal or displacement of the topsoil by the gouging effect of the log.

2.3 The mixing and puddling of the topsoil and subsoil by the repeated movement of the skidder and the log when the soil is very wet.

2.4 The subsequent erosion of the topsoil by the action of water along the snig tracks.

Since the worst example of erosion which has occurred to date (Graphite 8) resulted in the loss of or displacement of less than 1% of the topsoil, this source of damage will not be considered further in this report. The discussion will instead be confined to the other aspects of soil damage which commonly accounts for 20 - 40% of a logging coupe.

The degree of compaction which occurs is a function of the weight of the load, the number of passes and the soil type and moisture content. As soil moisture increases, so fewer passes are needed to achieve the same degree of compaction.

As the soil becomes wetter still, its strength decreases, the surface breaks through and gouging, puddling, rutting and mixing occurs.

Damage of the types described will occur at any time of the year depending on the soil moisture and significant levels of damage do occur in summer in low lying areas. However, significant levels of damage will occur on virtually all sites during the winter, increasing very rapidly during periods of actual rain - the exception is the laterite caps and sands, both of which are largely irrelevant in the context of Karri and chipwood logging. Soil moisture has been shown to be the overriding factor.

It must therefore be accepted that the process of removing logs from the forest will cause some damage to the soil.

In this context landings are invariably damaged, even in summer, but provided their combined area is not excessive they are accepted as inevitable consequences of logging and are not really at issue. The questions which need to be considered are

What is the effect of this damage on plant growth, water, nutrients etc?

How much of what types of damage is acceptable?

Can it be repaired and how?

3. WHY HAS THE PROBLEM ARISEN NOW?

Soil damage has always occurred during logging and evidence of this can still be seen in areas logged 45 years ago. A number of factors have contributed towards the change in scale of the problem in recent years.

3.1 Logging of 45 years ago was done with steam haulers which undoubtedly caused dramatic damage but this seems to have been confined to the main haul lines which were relatively few and narrow and of the type described in 2.2

3.2 Tractor logging which followed caused the same types of damage as at present, but on a lesser percentage of the coupe due to several factors.

3.2.1 Logging for sawlogs only involved the snigging of fewer, though larger logs.

3.2.2 The choice of winter sites was high and was made full use of.

3.2.3 Tractors generally bellied before excessive damage levels occurred and the operation tended to move to more favourable sites rather than persist in an unsuitable area.

3.2.4 Tractor logging on very bad sites was rare simply because it was unnecessary to do so.

They couldn't operate efficiently and the areas generally contained a high proportion of marri, which was avoided.

3.3 Chipwood cutting, wheeled skidders and an absence of good winter sites virtually coincided. Extensive damage is more common now because

3.3.1 Combined chipwood and sawlogging involves a somewhat greater volume, but many more stems.

3.3.2 More stems means more of the forest floor is traversed. The highly mobile skidders are very suitable for the purpose.

3.3.3 Skidders will continue to operate and cause damage where tractors could not.

3.3.4 Well drained pure Karri sites are virtually exhausted and logging is now confined to less well drained Karri sites and the shallower podsols. Nevertheless, the best of these sites have generally been selected for cutting in the last few years so that the situation deteriorates each year. It is worth reiterating here, that except for laterite caps and sands, ther are virtually no sites which can be fully logged in mid winter without extensive damage.

The type or severity of soil damage has not changed over the years but rather the percentage of the coupe so affected. Area damage levels of 50% have been recorded, and would be commonplace and higher if left uncontrolled.

4. HOW IMPORTANT IS IT?

The answer to this is in two parts :

What is the effect of the various types of damage on plant growth, nutrient cycling, water, soil microfauna etc. and how long term are these affects?

How much of the area can we afford to affect in this way, and what is the overall significance?

None of these questions have been fully answered at this stage because of the absence of any long term measurements or records. It will therefore be necessary, for the present, to make decisions on the basis of short term data, observations and judgement. However, the data which is available is summarised in the following sections.

4.1 Definition of Damage

Three types of soil disturbance are recognised.

4.1.1 Primary characterised by :

removal or displacement of topsoil by gouging.

puddling and mixing of the soil profile.

rutting into the B horizon.

4.1.2 Secondary - characterised by

topsoil compacted in situ.

minor rutting confined to the A horizon may occur.

4.1.3 Tertiary

disturbance of the topsoil in a similar way to ploughing and is not classed as damage in the process of picking up a single log.

By their nature these areas are generally associat with lack of debris or ashbed.

(See figure 2)

4.2 Effects of the Damage

4.2.1. Soil - the effects of compaction and soil puddling on the structure of the soil will be found in most text books on soils. Briefly it causes a reduction in pore space, water penetration, and microfauna activity.

(See Table 1)

TABLE 1

SOIL BULK DENSITY

ON DAMAGED AND UNDAMAGED SITES

8 YEARS AFTER LOGGING

Soil Depth (cm)	Bulk Density gms/cm^3	
	Primary Damage	Undamaged
10	1.35	0.82
20	1.38	0.90
40	1.43	1.15
80	1.32	1.30
160	1.38	1.50

C. Schuster, 1977

FIG 2.

PRIMARY
DAMAGE

SECONDARY
DAMAGE

TERTIARY
DAMAGE

In a natural situation the original structure would be restored by frost heave (an important element which is absent in our forests), the accumulation of litter, and the gradual breaking up of the profile by soil microfauna and the roots of plants which established. All of this would be assisted by some form of cultivation.

It is reasonable to assume that with primary damage, where the B horizon is exposed or mixed with the A horizon, that these processes would take longer. Evidence from the US and from a sample taken in Treen Brook indicate that this effect is still evident after 40 years (See Table 2)

TABLE 2

SOIL BULK DENSITY TREEN BROOK

40 YEARS AFTER LOGGING

Depth (cm)	Bulk Density (gm/cm^3)	
	On Snig Track	Off Snig Track
0 - 10	0.253	0.181
10 20	0.250	0.209
20 30	*	0.173
30 - 40	*	0.203
40 - 50	*	0.198

* No sample due to soil hardness.

C. Schuster, 1977

Although there is no data to support it observations of vegetation recovery would seem to indicate that there are marked differences in the recovery time with soil type, vegetation and climate. eg. recovery seems to be quicker on red loams than on podsols in karri types. Podsols in karri types seems to recover quicker than podsols in jarrah types.

4.2.2 Plant Growth

The effects on plant growth are in two stages

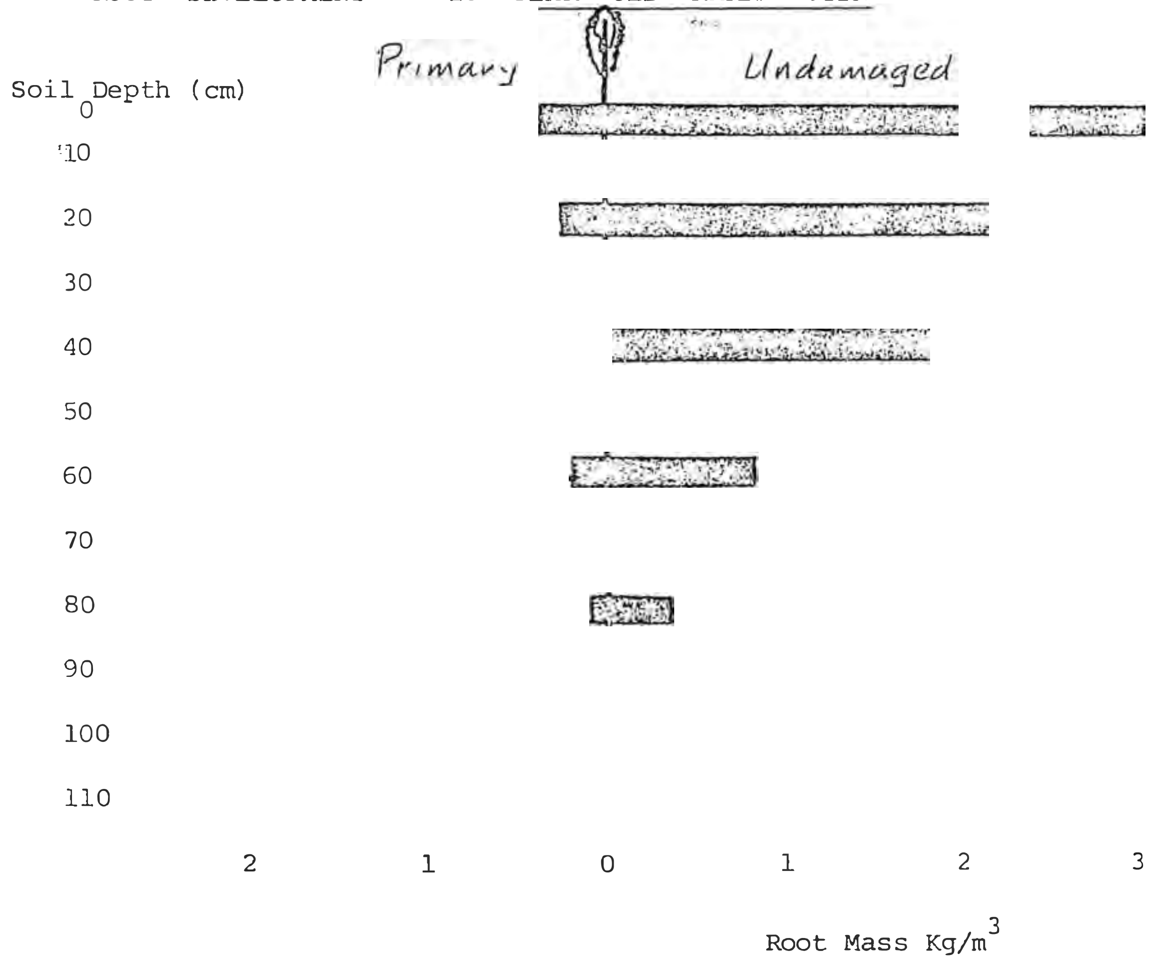
Germination is influenced by the structure of the top 1 cm of soil or less, so that even minor compaction will reduce germination success.

Subsequent growth is influenced by all the factors which affect the soil.

Root development is strongly influenced by pore size and poor root development will affect both stability and the ability of the plant to tap the nutrients which are in the compacted soil. Fig 3 shows the relative root development in undamaged and primary damaged soil from three 10 year old Karri stems growing at the edge of a snig track.

FIGURE 3

ROOT DEVELOPMENT 10 YEAR OLD KARRI STEM



C. Schuster, 1977

Objective measurements of the effect of damage on plant growth have been obtained from past logging operations, but with limited success. This is because

- most of the sites were originally pure Karri with higher site qualities.
- it is difficult to determine the exact nature of the damage, 2 or more years after the event.
- many areas had seed trees removed after germination, making some comparisons invalid.

Tables 3 - 8 illustrate the effect of damage on both Karri and scrub using the data which is considered to be valid.

TABLE 3

HEIGHT GROWTH ON KARRI ON

DAMAGED AND UNDAMAGED SOIL

Site	Age (yrs)	Karri Ht (m) Primary Damage	Undamaged
Quartz rd	8	2.5	17.5
Wallace rd	4	1.4	4.2
Wallace rd	8	3.3	9.0
Harris rd (planted)	7	1.8	9.0

C Schuster, 1977

TABLE 4

DIAMETER GROWTH OF KARRI

ON DIFFERENT DAMAGE TYPES

AGE 9 13 YEARS

Diameter class (cm)	% of Stems by Diameter classes		
	Primary Damage	Secondary Damage	Undamaged
0 - 5	100%	23%	18%
5 - 10		47%	57%
10 - 20		30%	25%

TABLE 5

STOCKING LEVELS OF 1 YEAR OLD KARRI

BY SITE CLASSES

Sowing Rate Seed/ha	% Stocked by 4 m^2 quadrants		
	Primary and Secondary Damage	Undamaged and Tertiary	
	(No Ashbed)	(No Ashbed)	(Ashbed)
36,000	33%	67%	79%
55,000	25%	63%	78%
59,000		62%	83%
60,000	27%	69%	53%
100,000		59%	81%
127,000	44%	58%	73%

C. Schuster.

TABLE 6

STOCKING LEVELS OF KARRI

SECONDARY DAMAGE AND UNDAMAGED SITES

1 & 2 YEARS OLD

Stems/Ha

Secondary Damage	Undamaged
9000 S/HA	15000 S/HA

C. Schuster

TABLE 7

KARRI CROWN COVER & VIGOUR

ON SECONDARY DAMAGE AND UNDAMAGED SOIL

9 13 YEARS OLD

COVER & VIGOUR	PERCENTAGE OF SAMPLE SITES Secondary Damage	Undamaged
Nil - Light	66%	54%
Mod - Heavy		46%

TABLE 8

SCRUB COVER - VIGOUR

ON VARIOUS DAMAGE TYPES

1 2 YEARS OLD

COVER & VIGOUR	PERCENTAGE OF SAMPLE SITES PRIMARY DAMAGE	SECONDARY DAMAGE	UNDAMAGED
Nil - Light	100%	75%	42%
Mod - Heavy	0%	25%	

C. Schuster, 19

It is evident from the data presented, that without special treatment, logging damage of the type described has a serious affect on plant germination and growth. (Fig 5). While primary damage results in almost total lack of growth, secondary damage is somewhere in between and seems to have a greater effect on stocking than on growth. This is partly due to the difficulty of accurately differentiating between the borderline of secondary and undamaged sites, particularly some years later. It should also be borne in mind that this data represents karri loams in the main, where the effect on plant growth is postulated, though not proven, to be less severe than on the podsols.

4.2.3 Water, Nutrients, and Microfauna.

No data is available on the significance of these aspects.

4.3 Overall significance

As the percentage of the area affected increases so does the significance of the problem. Where is the limit? This is the most important question to answer, and also the most difficult. It seems evident that the effect on the productivity of the stand will depend not only on the percentage of the area damaged but also on the distribution of that damage. It is often asserted that since snig tracks are only 5 m wide, then trees planted either side will occupy the site and no effective growing space will be lost. This has some merit where the percentage of damage is relatively low and the snig tracks widely or evely spaced, but is less true as snig tracks become closer, and also ignores the implications illustrated in Fig 3. There is also the added implication that the area must be planted to ensure that optimum use is made of those areas which are suitable for growth, making the seed tree option less efficient.

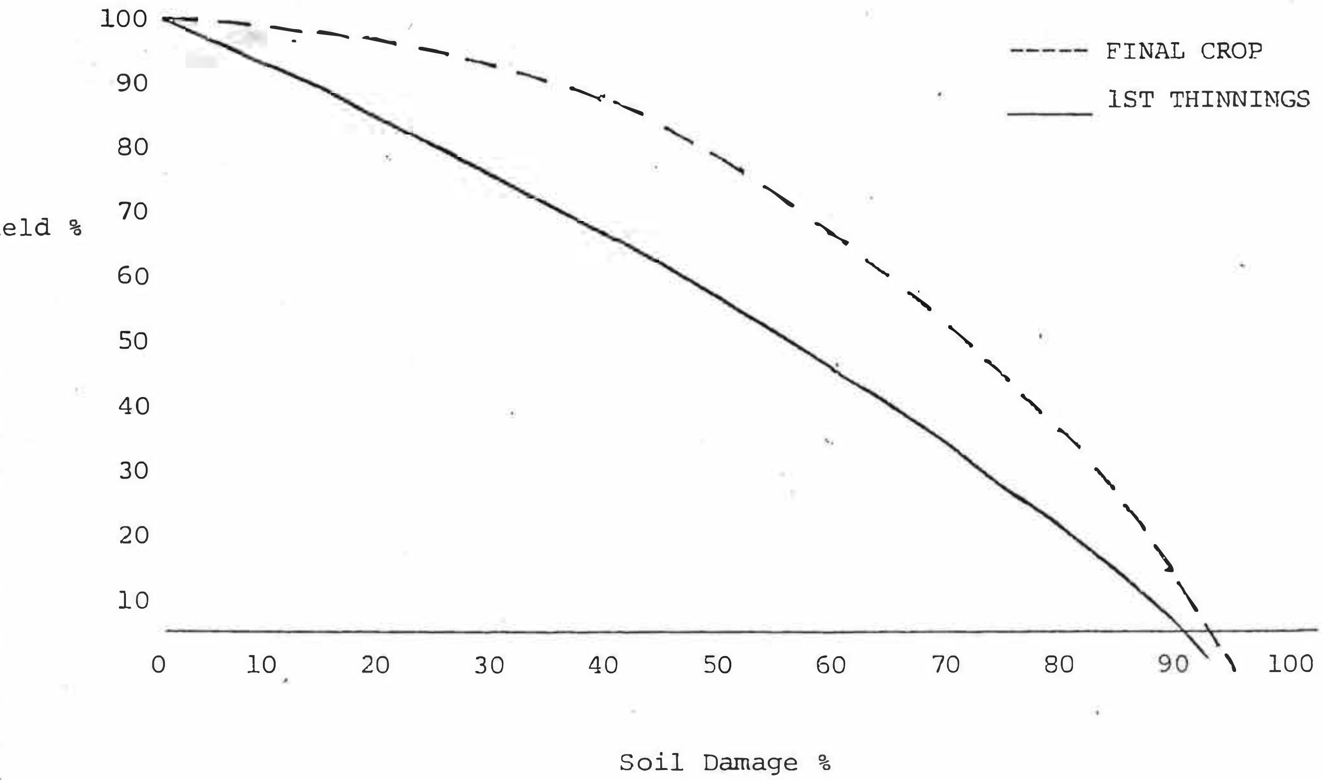
In an attempt to quantify this potential loss in productivity two landings were selected and theoretically 'planted' 'thinned' and 'clear felled' using the method and assumption mentioned in Appendix 1. Given the somewhat dubious assumptions made this exercise illustrates that with soil damage 40%, thinning yield will be 67% of optimum and final crop 86% of optimum. (See Figure 4)

Reductions of potential yield of this order are unacceptable as is the unrepaired damage of 20%.

While it may be argued that the final crop yield is marginally reduced, thinning yield is an important future source of chipwood, and on a cost/benefit basis is critical to the economics of karri cultivation. It must also be considered that if the effects on the soil last for 45 years, then thinning itself will add to the damage levels and a gradual deterioration of the site is inevitable.

FIG 4

THE EFFECT OF SOIL DAMAGE ON KARRI FOREST PRODUCTIVITY



5. PREVENTION

Several alternative methods have been suggested to prevent or alleviate the problem. The major ones are listed below with comments on their success or prospects of success.

5.1 Select more suitable winter areas - this has always been the practice in the past, and to a large extent is still the practice. The result of this is, that there are now no known areas which will support full scale logging in mid winter. The exception would be small pockets of a few hectares, throughout the forest, the selective cutting of which would be counter to every other management aim. These areas would have to be selected on a trial and error basis. This is no longer a valid option.

5.2 Partially log coupes in the winter period.

This would require twice the area for winter cutting (in other words two years winter bush in one). The remainder of the volume would need to be removed in the summer, together with the normal summer wood - this is impossible to achieve with consistent hauling rates. This would leave behind incomplete coupes and rapidly lead to an increase in the difficulties for the industry in a short space of time. (Experience this year has shown that even partial logging has exceeded the recommended level of damage.)

5.3 Pre log smaller stems to provide a bed of tops for subsequent operations.

This has been tested (and is the subject of a detailed report), and undoubtedly resulted in some improvement. It is estimated that in the early part of winter this could "make safe" an area for a further two weeks. While it is an improvement therefore, it is insignificant in the total problem period. (June - October)

5.4 Alternative Logging methods.

This area has not yet been given serious attention though the possibilities are limited, basically requiring machines of very low ground pressure, and which are capable of lifting the nose of the log. Variants of high lead are also possible. Even so, short term answers are unlikely here especially as industry is disinclined to consider dramatic changes during the life of existing and proven machines.

Different snigging patterns are possible. One suggested is to snig direct to continuous road side landings. This would almost certainly reduce primary damage but increase secondary damage by a greater amount. At this stage of our knowledge it could not be considered a 'safe' alternative. Recent trials have shown however that 'controlled' skidding and the use of a swamper could provide a reduction in damage and improved snigging efficiency. This showed that with a swamper it was possible to double the time spent in effective snigging.

5.5 Summer Stockpiling

Summer stockpiling is considered to be the only means of providing a major improvement in the situation. The advantages to the forest are obvious and would enable either :

5.5.1 cessation of skidding for the winter period.

5.5.2 reduce the level of snigging in winter.

5.5.3 confine snigging to dry periods in winter.

Further advantages would be improved efficiency when machines are used (skidding in dry weather is up to 3 times more productive than in wet weather), reduced maintenance costs, and security of operations. Objections to stockpiling are many and varied, some of which are valid, but others have yet to be demonstrated, or are readily overcome. Objections include :

- inability to load from bush stockpiles; an undoubted problem until knuckleboom loaders are available.

- costs incurred well before the return.

- social disruption to employees.

- degrade of stockpiled sawlogs.

- disrupted use of machinery.

- added cost due to double handling in some cases.

It is regrettable that prejudice has prevented an objective joint study of stockpiling problems, and their solutions.

Present data indicates that serious difficulties are experienced with an accumulated rainfall of 450 mm, and this situation does not ease until the end of October (this stage was reached in June 1978 and July 1977). Appendix 2 shows levels of stockpile achieved to date.

6. REHABILITATION

Prevention rather than rehabilitation has been the preferred approach (to date) because any rehabilitation work requires a reasonable time scale before results can be stated with assurance.

Several rehabilitation trials have been conducted and the results are illustrated in tables 9 and 10.

This data clearly illustrates the value of ripping, ashbed, fertiliser and mulch to obtain very satisfactory growth up to two years of age, the oldest of such detailed trials. Similar trials have also shown that the survival rate of seeded A. pulchella is doubled by ripping - the establishment of scrub is expected to further assist with natural soil rehabilitation.

Early indications are that rehabilitation of the optimum type gives every reason for optimism. The questions remain .

- will the effects continue and has the soil been returned to its original condition?

- how much of the area should receive this treatment?

TABLE 9

SNIG TRACK REHABILITATION

APRIL ROAD

(Karri survival and 24 month height increments in centimetres).

Type of Damage	Treatment	Natural seedlings		Planted (Normal fertilizer)	
		No./ha	Increment(cm)	Survival %	Increment(cm)
Secondary	Nil	2170	28	92	54
Primary	Nil	600	12	30	27
Primary	Ripped	16625	86	89	81
Primary	Burnt	6200	207	60	161
Primary	Ripped & Burnt	8500	289	75	195

C. Schuster, 1978

TABLE 10

LANDING REHABILITATION

WALLACE ROAD

PLANTED STOCK - 12 MONTH INCREMENT (cm)

	NF. NM	NF. M	F. NM	F. M.
Ripped	6	1	16	30
Unripped	3	7	10	22

NF = No fertiliser F = Fertiliser

NM = No mulch M = Mulched .

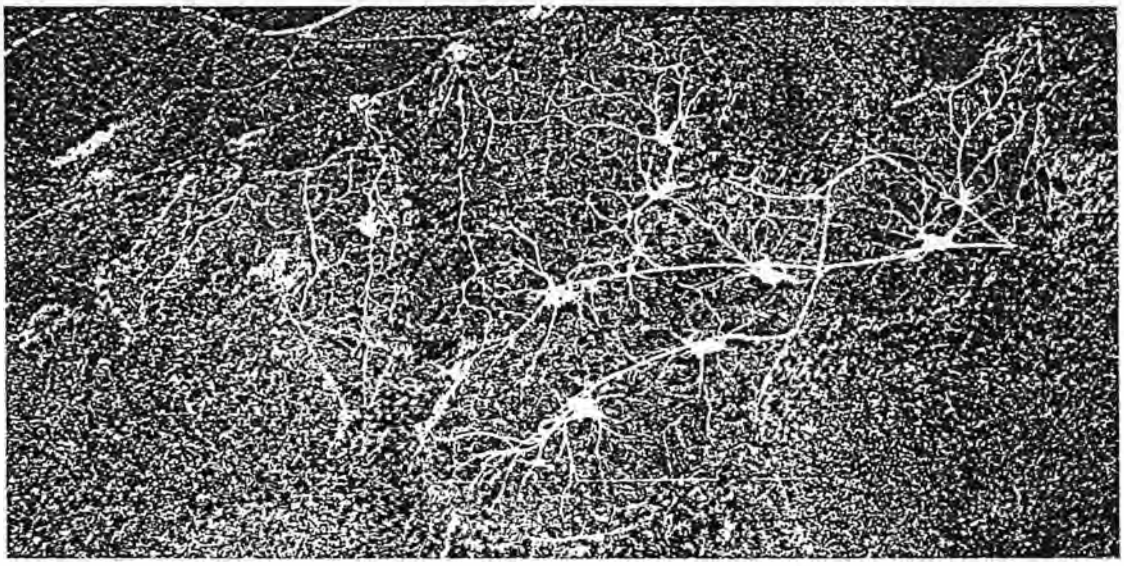


Fig 5. Lack of cover on snig tracks 3 years after clear felling for sawlogs.

BEFORE RIPPING

Fig 6. April Road rehabilitation trial.

AFTER RIPPING

The answer to the first question can only be obtained with time and further investigation, but until that time it would be prudent to restrict the level of damage which requires such treatment. The answer to the second is largely a question of judgement, and is based on the amount of forest soil, if any, which we are prepared to sacrifice. This point is considered later in the recommendations.

Ripping has been carried out by the industry and the Forests Department in some areas but has been confined to landings and major primary snig tracks within 50m of the landings. The costs of this treatment are of the order of $7/hectare of coupe. The remainder of the primary and the secondary damage is untreated at present. (Under this prescription, in a coupe with 20% damage, 1/3 would be ripped, in a coupe with 40% damage, 1/4 would be ripped).

7. FURTHER RESEARCH

7.1 It is clear from the data presented that there are serious deficiencies in some of the basic data. This is particularly so with respect to the importance of secondary damage. To this end a series of detailed plots are being established to determine growth rates on the full range of sites. This will cover some observed anomalies including good growth on damaged ashbed, and poor growth on undamaged non ashbed. Types to be covered are :

Primary	On and off ashbed
Secondary (heavy compaction)	On and off ashbed
Secondary (light scuffing and compaction)	On and off ashbed
Tertiary (ligth scuffing and some compaction)	On and off ashbed
Undisturbed	On and off ashbed

7.2 Field trials to monitor the build up of soil damage as logging progresses, and to determine the predisposing conditions (eg rainfall etc) To attempt to further define machine efficiency under these conditions. One trial is complete and others are programmed.

7.3 Practical field trials to establish costs and methods of ripping etc, and debris manipulation.

7.4 Detailed fertiliser trials which will cover rehabilitated areas as well as normal forest conditions.

8. RECOMMENDATIONS

8.1 Basis for recommendation

8.1.1 the philosophy that prevention is better than cure at present.

8.1.2 recognizing the fact that some damage is inevitable if logging is to take place at all.

8.1.3 the fact that there is little point in restricting winter damage to a lower level than that which could be achieved in summer.

8.1.4 the principle that the 'polluter pays", this being the best method of providing an inbuilt incentive for prevention.

8.2 Recommendation

That the maximum level of damage which will be permited on a coupe at any time is 15% + landings (expected to be 20% in total); that <u>all</u> of this damage be rehabilitated at the cost of the industry using the optimum techniques which are known at the time.

Should it in time be shown that techniques are available to <u>fully</u> rehabilitate the soil, then this damage limit could be lifted and the decision to prevent damage or cause it and rehabilitate the soil, could be left with the industry. (There is however insufficient evidence to adopt this practice at present).

8.3 Consequences

The consequences of this recommendation is that significant stockpiling of both sawlogs and chiplogs will be required.

Present indications are that the equivalent of three months cutting would be required, since it is highly unlikely that other techniques will have any significant effect on reducing the damage. Additional cost to industry for soil rehabilitation would be in the order of $40,000/ annum.

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13th July, 1978

APPENDIX 1

EFFECT OF SOIL DAMAGE ON CROP YIELD

In developing this yield/soil relationship the following assumptions were made :

1. Germinants on sites with primary or secondary damage will not develop into merchantable logs.

2. Germinants on sites with tertiary or nil damage will develop normally.

3. Full stocking at time of thinnings is taken to be 625 stems per hectare. (Stems above this number are surplus).

4. Full stocking for final crop is taken to be 125 stems per hectare.

Two separate plots form the basis of the sample. Each comprised of a strip forest logged for chiplog and sawlog, commencing at a loading ramp within a landing and traversing forest directly away from the loading ramp.

	Length	Area
Plot 1	356.65 m	2.30 ha
Plot 2	710.2 m	8.97 ha
TOTAL	1066.85 m	11.27 ha

Within each plot a series of sub plots were established at progressively greater distances from the loading ramp. Both plots were photographed from the air using 70 mm colour transparency film, viewed stereoscopically and interpreted to determine the distribution and area of primary and secondary, tertiary , and nil damage within each sub plot. The damage type and distribution was mapped at 1:1000 scale and potential stocking levels determined using square grids, drawn at the same scale to represent stockings of 625 and 125 stems per hectare respectively.

With an initial stocking of 625 s.p.ha, each tree will occupy an average space of $16m^2$, or an area 4m square. To determine the initial stocking of each sub plot, the transparent 625 square grid was placed over its map, and all grid squares containing at least 4 m^2 (2 m square) of tertiary or nil damage were considered stocked.

Stocking was similarly determined for all sub plots using the 125 square grid to represent the potential final crop.

Knowing area of primary and secondary damage, initial stocking and final stocking for each sub plot, yields for a first thinning and final cut were determined and graphed.

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(1978)

APPENDIX 2

SUMMARY OF STOCKPILE LEVELS

FOR 1977 & 1978

	Weeks of Cutting	
	1977	1978
BUNNINGS		
Deanmill	4	7
Northcliffe	2	3
Pemberton	3	6
Walpole	2	6
MILLARS		
Quininup/Jardee	3	8
WHITTAKERS		
Greenbushes	8	9
WORSLEY		
Palgarup	24	24
GANDY	7	5
W.A.C.A.P.	3	3

APPENDIX 3

Officers involved in the group investigating winter logging.

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