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DRAFT

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Comments Invited, including presentation and analysis of results. DM

COMPACTION STUDY

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In the late 1970's there was a lot of concern about the potential for soil damage on coupes harvested during winter, especially in areas of mixed karri and marri forest. The physical properties of podsol soils in these mixed forests make them more susceptible to damage under moist soil conditions than the red loams of the pure karri forests (Schuster,1979). The concern about soil damage potential was being raised because, with the advent of the Diamond Chipmill, it was now possible to harvest and successfully regenerate mixed stands.

The concern about soil damage led to a specification being drawn up to limit the extent of soil damage on any fallers block in a karri clearfell operation to 20% or less. This specification is still in use and forms part of the Manual of Logging Specifications (CALM,1993).

With advances in technology it has been possible to increase utilization from harvested areas because small regrowth material can now be utilized. To increase the efficiency of harvesting this small diameter material, many operations are now pre-logged with the use of forwarders. The damage caused by this machinery in winter is extensive. The damage is in the form of compaction.

WHAT IS COMPACTION

Soil compaction is the physical deformation of the soil structure caused by applying a force. Compaction results in:

- a reduction in the porosity of the soil ie. the amount of space occupied by voids relative to that occupied by the soil particles.

- a change in the pore size distribution ie. the effective size distribution of the void space of the soil.

- a change in the soil fabric ie. the relative geometry and orientation of the soil particles and the associated void spaces.

In the Code of Logging Practice (CALM,1993) one part of the soil damage definition is "severe compaction"; this is described as compaction which will affect germination or plant growth. The problem with this definition is that it is very subjective, making it difficult to make a decision as to what to include in damage surveys and what not to.

Due to the inability to objectively define a measure of which level of soil compaction affects plant growth, it has not been possible to include all compaction in damage assessments, subsequently the actual damage experienced in the field, due to compaction has in some cases been in excess of the limits specified in the Code of Logging Practice. Also due to the subjective definition of compaction, it has not been possible to direct contractors to rehabilitate these damaged areas.

HOW DOES COMPACTION AFFECT REGENERATION RESULTS

Compacted ground makes it physically difficult to place trees into the ground using the putti-put-ki tree planter. CALM workers at Manjimup District advised supervisors that after prolonged use with the treeplanter on "hard" ground soreness was experienced around wrists and elbows. Supervisors acknowledged that compacted ground posed a hazard to workers. As a consequence workers have been advised to try the ground if it is too hard to move on until suitable ground is encountered.

Stocking levels on compacted ground left untreated are lower than target levels. This is caused by:

1.) inability to plant the hard ground and

2.) deaths of trees through drought after not being buried deeply enough and dying in the first summer following planting.

Those plants that do not die on the compacted ground appear to be stunted by the adverse growing conditions.

In order to ensure that areas are regenerated to the target stocking levels it has been necessary in previous years to identify understocked areas and then go back and rip the areas to control the scrub and prepare the soil.
This procedure was clumbersome and not always successful. As it was consistently the hard ground that was understocked these areas are now identified prior to planting and ripped. The regeneration results on these areas has been very successful and there has been no need to go back and retreat these areas.

WHY WOULD COMPACTION REDUCE PLANT GROWTH?

The definition used to describe "severe compaction" implies that compaction at some level will affect the growth of plants in a detrimental manner. Why should this be the case?

A reduction in the pore size distribution via compaction means that the number of large voids are reduced this results in the plant root experiencing more resistance to penetration when trying to grow. The plant root has to penetrate pores of a smaller diameter therefore the rate of root elongation and subsequently root length is reduced. A reduced more compact root system has a reduced access to water and nutrients. Compaction can therefore influence plant nutrition.

The reduction in the porosity of a soil by means of compaction means that there is less space in the soil which can be filled by air. Compaction can reduce the ability of root growth especially when wet by limiting
oxygen availability ie. if the oxygen requirements for respiration in the soil exceed the rate at which oxygen in the soil air can be replaced.

AIM

The aim of this study was to:

- ascertain how to objectively measure compaction quickly and simply in the field;
- determine at what level, compaction detrimentally affected plant growth.

METHOD

HOW CAN COMPACTION BE MEASURED?

Dry bulk density is one of the parameters used to measure the state of compaction. It provides a measure of how close soil particles are packed.
It involves determining the accurate measurement of the weight of the dry soil that occupies a known volume.

Determination of the bulk density of a soil involves destructive sampling which makes it an inappropriate parameter to use when trying to ascertain the effect of compaction on tree growth.

Penetrometer resistance relates directly to the bulk density of a soil. However, care has to be taken when using a penetrometer because penetrometer resistance declines as the moisture content increases on a soil with a given density. Penetrometer readings should be specified at a given moisture content.

PROCEDURE USED

Bulk density samples were taken on random points in Wheatley 2 together with adjacent penetrometer measurements prior to planting. A regression analysis was performed to determine how well a penetrometer
could predict soil density.

The penetrometer used was one borrowed from the M.R.D. it consists of a 8 kg weight falling 60 cm onto a 12 mm blunt probe. Another penetometer was devised for use as an operational tool as the M.R.D. one was too heavy and awkward to be practical for field use. The 'Manjimup Penetrometer' consists of a 2 kg weight falling 60 cm onto a 6 mm sharpened probe.

A sample area was delineated in Wheatley 2 to exclude it from rehabilitation by ripping. This area was planted and fertilized with tablets as was the current operational standard.

The Manjimup Penetrometer was used to assess this area one growing season after planting. The height of each tree was measured in the summer of 1992 along with two measurements soil strength taken with the Manjimup Penetrometer at 20 cm from the base of the plants. Presence of ashbed conditions were noted against individual tree readings. If a position in the planting grid had been omitted, 2 penetrometer readings were taken at that position. A sample of soil was also taken for soil moisture determination.

DATA ANALYSIS

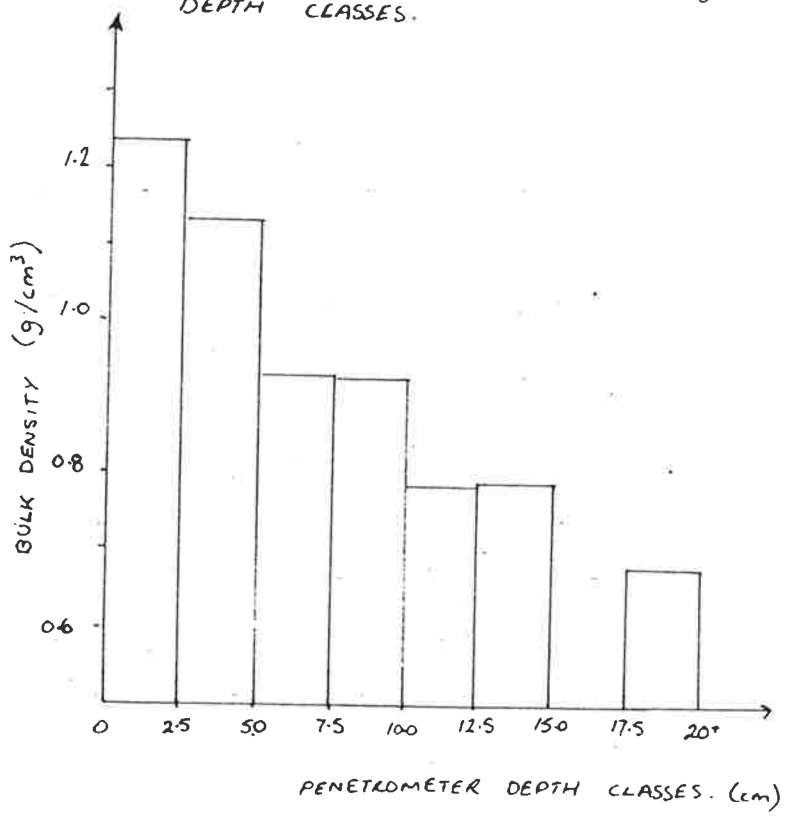
All trees growing on ashbed conditions were excluded from the data as was data for which the difference between the two penetrometer readings was greater than 10 cm. This data was deemed to be unreliable due to the variable growing conditions present at these positions.

The data was divided into classes based on average of the two penetrometer readings taken at each tree position. The classes used were: <10 cm ,10.5-15 cm, 15.5-20 cm, 20.5-25 cm, >25 cm.

RESULTS

The analysis between penetrometer resistance and dry bulk density suggested that the penetrometer was an effective tool for the measurement of soil strength. This relationship is shown in Figure 1. All penetrometer measurements are based on a soil with a moisture content between 20 and 30%.

FIGURE 1: AVERAGE BULK DENSITY OF SOILS BY PENETROMETER DEPTH CLASSES.



In the Wheatley 2 plot there was 11 positions in which seedlings had not been planted. The penetrometer readings for these positions were between 7 and 13 cm.

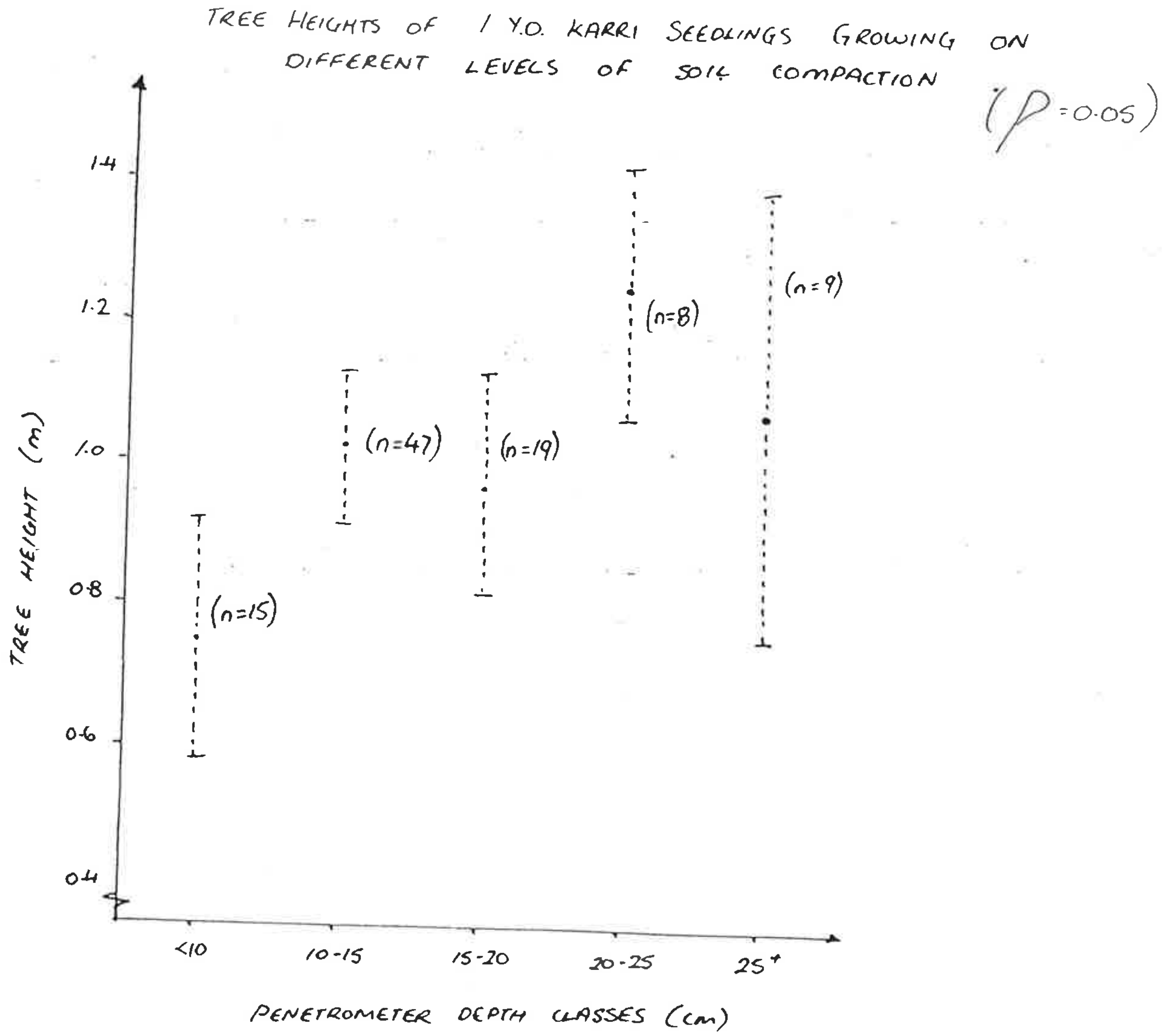
FIGURE 2. SUMMARY OF PENETROMETER READINGS IN POSITIONS NOT PLANTED

PENETROMETER READING	NUMBER OF POSITIONS NOT PLANTED
7 cm	5
8 cm	-
9 cm	-
10 cm	1
11 cm	1
12 cm	2
13 cm	2
TOTAL	12

Individuals involved with planting have different strengths and experience difficulty in planting at different levels of soil compaction. However, it appears that a soil having a strength measured with the 'Manjimup Penetrometer' of 7 cm is generally difficult to plant and some planters have difficulty with soils having a reading between 8 and 13 cm. It should be noted that in some instances other planters managed to plant seedlings over the entire range of soil strengths mentioned above.

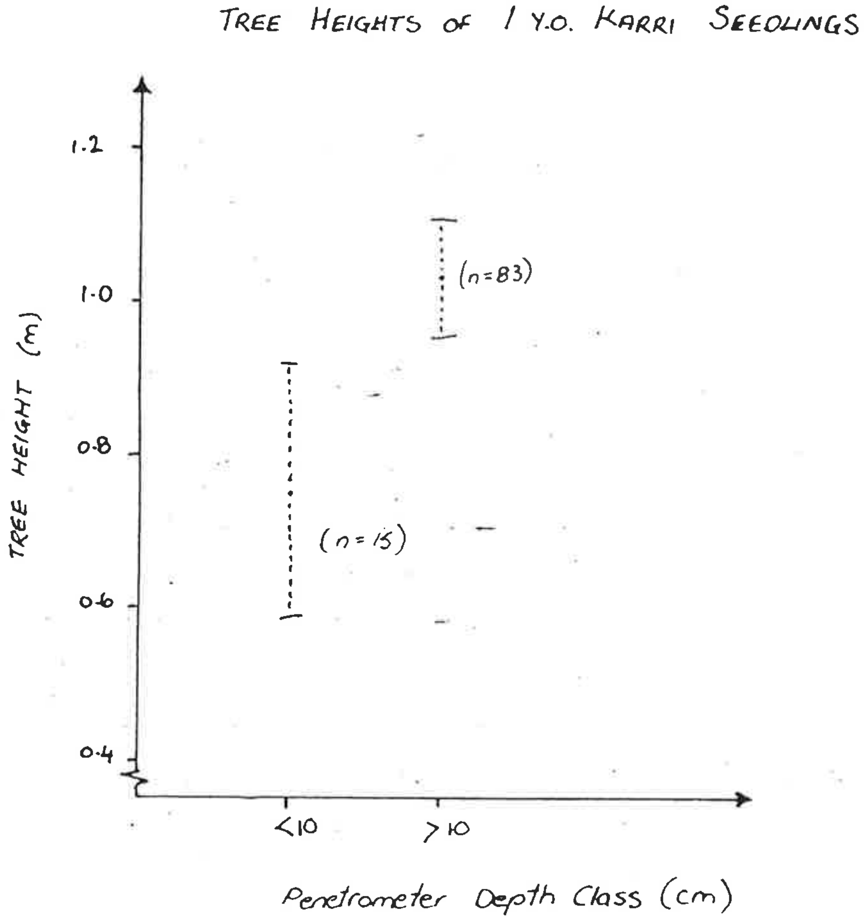
Average tree height and confidence limits were calculated for each of the classes used. T tests showed that there was no significant difference in height between the classes greater than 10cm (as shown in Figure 3.).

FIGURE 3. AVERAGE TREE HEIGHT FOR SOIL STRENGTH CLASSES



When the data for classes greater than 10 cm was pooled the t-test indicates that there is a significant reduction (P=0.05) in plant growth of karri trees growing on ground in the 10cm and less class when compared to those plants growing on ground with a >10 cm penetration resistance, after one years growth, as shown in Figure 4.

FIGURE 4.



CONCLUSION

Soil compaction can be measured quickly and objectively using an impact penetrometer.

This preliminary study indicates that a penetration depth of at least 10cm in dry soil (moisture content below 30%) needs to be achieved in order for seedlings not to be adversely influenced in their height growth in the first growing season.

Further study is required to enable field staff to be able to assess soil under moist soil conditions so that they may then keep soil damage within the limits set in the Manual of Logging Specifications.

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