VicForests Report

Monitoring Soil Compaction on Landings for Coupe Finalisation

Report One
October 2008

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TABLE OF CONTENTS

1. Introduction

Soils are the foundation of forest ecosystems. Soils provide the structural support medium within which tree roots can establish, and are the primary source of water and nutrients for forest health and growth. The most important soil physical properties are bulk density, porosity and water-holding capacity. Harvesting operations have the potential to impact these properties by disturbing soil profiles and exposing deep subsoils, changing organic matter content, and compacting soil structure.

Soil compaction influences soil infiltration rates, hydraulic conductivity and root growth, and can lead to reduced eucalypt regeneration success, poor understorey recovery, and lower forest productivity. High levels of compaction generate unnecessary costs to the environment and industry, and may also lead to expensive restoration requirements.

Soil compaction is known to occur at high levels on landings due to the high incidence of heavy machinery and the frequency of their passes in the confined area. VicForests undertakes landing rehabilitation by re-disturbing (loosening) compacted areas and spreading topsoil that was previously stockpiled prior to the operation. Some landings are also fertilised to enhance vegetation establishment.

VicForests constructs landings using either of two techniques; standard, or corded and matted. For conventional coupes (*C*), construction is undertaken directly on soil. For corded and matted coupes (*CM*) landings are lined with forest materials to create a barrier between soil and machinery upon which machines can "float", thus reducing compaction. Where possible, CM landings should be established on flat sites so that CM material can be applied directly onto vegetation without prior soil disturbance (CM_1). No later soil rehabilitation is generally required in this scenario. In contrast, establishing a CM landing on steeper slopes requires benching, which disturbs soil (CM_2). Thus conventional rehabilitation is required for CM_2 landings.

There is a need for VicForests to monitor the level of soil compaction resulting from its harvesting operations on both landings and snig tracks to understand the impacts on soil health and tree growth, and whether current harvesting prescriptions and procedures are sufficient to minimise significant soil compaction (Rab and King 1997).

At present, VicForests rehabilitates the top 40 cm of C and CM_2 landings, and the specific management objective is to successfully reduce compaction in this zone to acceptable levels across at least 60% of the landing area. Successful rehabilitation is defined as resulting in penetration through soil to at least 40 cm depth using no more than 300 psi of force when inserting a static penetrometer at the time soil is at field capacity (fully wetted). This time coincides with late winter or early spring (Duiker 2002). In theory, compaction on CM_1 landings should be no greater than natural forest floor levels.

VicForests will monitor soil compaction within two projects, (1) long term monitoring of snig tracks and landings, and (2) short term monitoring of landings on coupes ready for hand-back to DSE (this report) in order to demonstrate success of rehabilitation operations. In general, a coupe is ready for hand-back once the harvested area is finalised and regenerated to prescribed standards detailed in NFSG #10 (DSE).

Objectives of monitoring

- For coupes ready for hand-back to DSE, to measure the level and extent of soil compaction on landings following rehabilitation.
- To evaluate current landing rehabilitation techniques and revegetation success.
- Along with Project 1 above, to measure the level of compaction on CM_1 landings and compare to natural forest floor levels to test the "no greater than natural forest floor levels" assumption.

2. Methodology

The Methodology used to carry out this stage of the monitoring project is outlines in the VicForests' document, *Monitoring Soil Compaction on Landings for Coupe Finalisation*, written by Owen Basset. As the monitoring project is in the early stages of development, some aspects of the methodology were altered during the initial data collection stage. Changes were only made after discussion with the VicForests' Forest Scientist, to ensure that all requirements of the project would still be met. The changes in the initial methodology were:

- The force on the static penetrometer was altered to 300psi, to be in line with published literature and to better simulate typical root growth forces (Duiker 2002).

- Control readings were initially only taken on one site within the Toolangi State Forest, adjacent to the CM_1 site. After discussion it was confirmed that control readings should be taken on all sites in order to build up our data sets. In this case the measurements at the control site are a good example of all three sites in the Toolangi district, with very similar soil types and vegetation.

- Once the penetrometer had reached 40cm depth it was recorded as simply being >40cm. This meant during analysis of the data we had two data sets to work with, one that is a set of accurate measurements up to 39 cm, then a sub-set of data 40 cm or greater.

Other than these changes, the data was collected and recorded as outlined in the instruction.

The coupes chosen for monitoring were selected from a list of coupes that are nearing the hand back stage. This means they have either had a regeneration survey completed, or are due for a regeneration survey and will shortly be handed back to DSE. Three coupes were chosen at random from each of the Toolangi and Orbost forest management areas, with the following coupes selected:

District	Coupe name	Coupe address	Landing Type	Code
Toolangi	Boardwalk	297-832-0001	C	T1
	Black Snake	307-504-0027	CM_2	T2
	Tanglefoot Knoll	297-845-0005	CM_1	T3
Orbost	Just Around the Corner	825-512-0002	C	O1
	Sedges Mess	827-519-0011	C	O2
	Water Point	827-502-0004	C	O3

The coupe Water Point was included as a replacement once in the field, as one of the previously selected coupes was inaccessible. Water Point was chosen as it was a neighbouring coupe that was of a very similar age and had similar soil type, vegetation and landing set up.

3. Results

Figures 1 and 2 and Table 1 summarise analysis of the data for each district. Averages and measures of variation, including standard errors, where calculated for comparison of data sets.

3.1 Toolangi

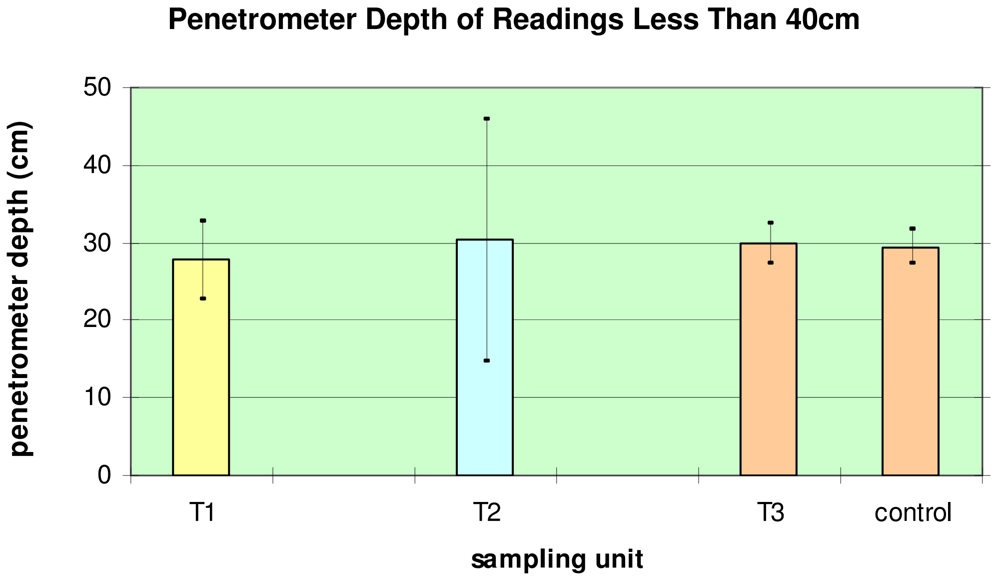

Figure 1. Summary of penetrometer depth readings less than 40 cm at 300 psi on three coupes in the Toolangi District, Central Highlands. The data indicates no significant difference within treatment. There also seems to be no significant difference between treatment and control. Error bars are 95% confidence limits.

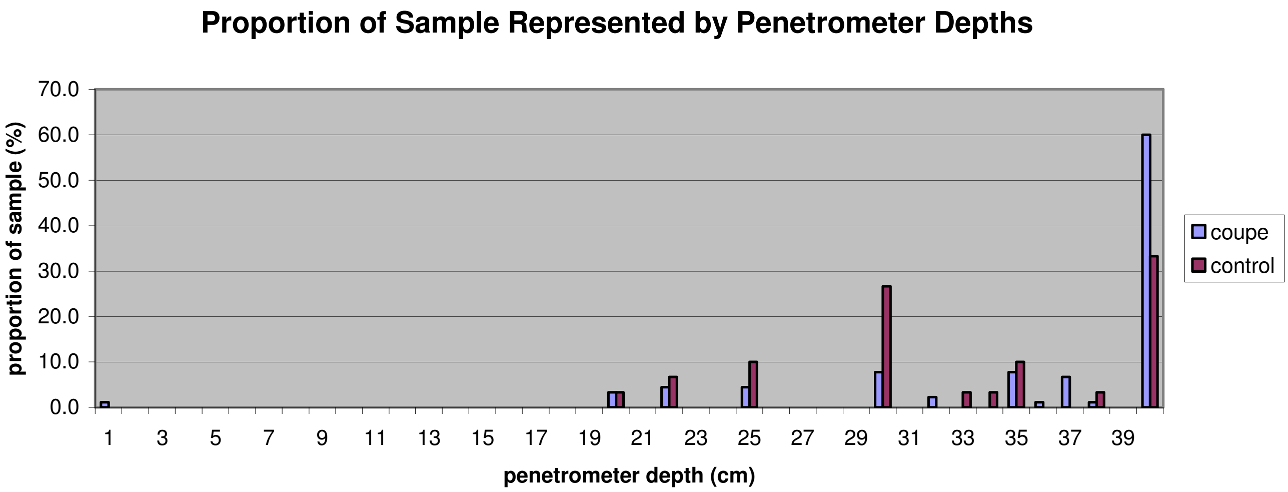

Figure 2. Frequency distribution of pooled coupe penetrometer depth data and control for Toolangi. A higher frequency of penetrometer depths 40 cm or greater were achieved on coupe landings, indicating a rehabilitation treatment effect. On average 60% of sample points reached 40 cm or greater at 300 psi, equalling VicForests' operational target.

Coupe	% Depth above 40cm
Boardwalk (T1)	70
Black Snake (T2)	80
Tanglefoot Knoll (T3)	30

Table 1. Percentage of landing that showed penetrometer readings of greater than 40cm.

3.2 Orbost

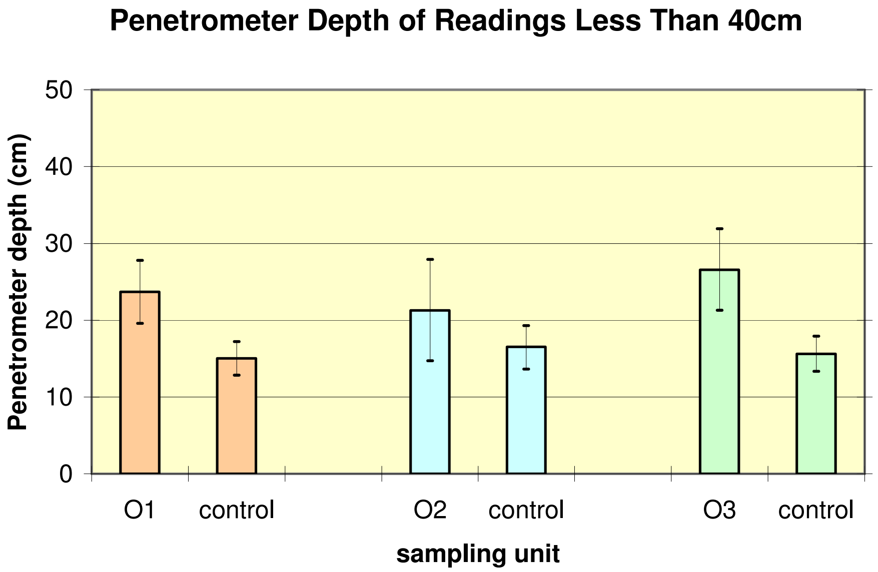

Figure 1. Summary of penetrometer depth readings less than 40 cm at 300 psi on three coupes in the Orbost District, East Gippsland. The data indicates no significant difference within treatment. For O1 and O3, depths achieved on landings were significantly greater than in controls, indicating a rehabilitation effect. Error bars are 95% confidence limits.

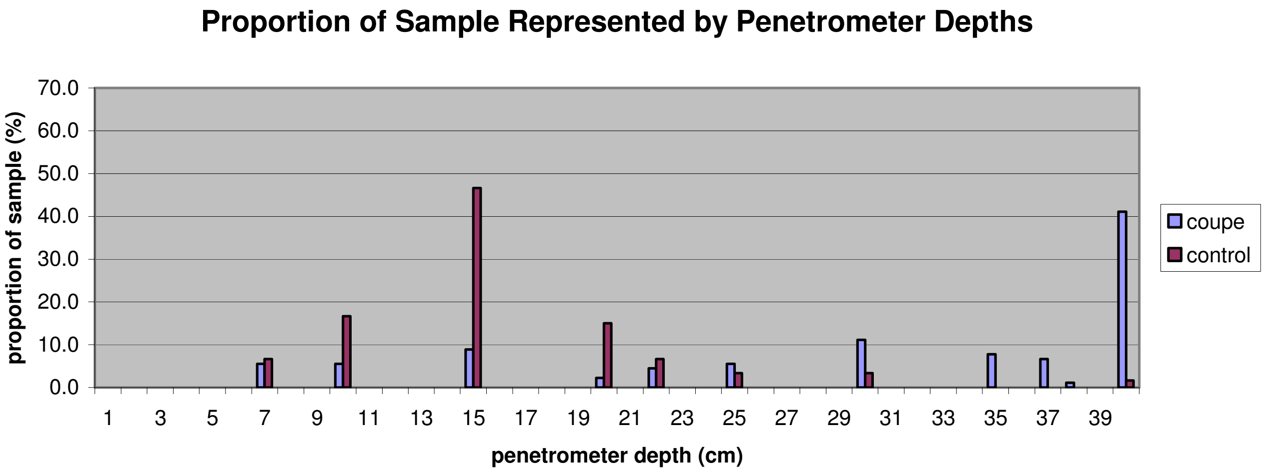

Figure 2. Frequency distribution of pooled coupe and control penetrometer depth data for Orbost. Higher penetrometer depths were achieved on coupe landings, indicating a rehabilitation treatment effect. On average 41% of sample points reached 40 cm or greater at 300 psi.

Coupe	% Depth above 40cm
Just Around the Corner (O1)	23
Sedges Mess (O2)	50
Water Point (O3)	50

Table 1. Percentage of landing that showed penetrometer readings of greater than 40cm.

4. Discussion

The two forest management areas of Toolangi and Orbost provided two contrasting soil types on which to begin looking at soil compaction on landings. The sites at Toolangi contained dark organic soils that support large Mountain Ash forests, while the Orbost sites were lighter rocky soils containing less organic matter and supporting mixed species forests.

4.1 Toolangi

The three Toolangi coupes presented three different types of harvesting operations, with a conventional landing (T1), corded and matted landing with conventional rehabilitation (T2) and corded and matted landing with no rehabilitation (T3).

The pooled data for penetrometer readings < 40 cm for the Toolangi landings showed an average of 29.5 ± 2.6 cm, which is not significantly greater than that of the single control data average of 29.4 ± 2.3 cm (p=0.05). It also indicates no significant difference between each of the landing operations and subsequent treatments.

The two treated sites, while operationally very different, had very similar treatments during the rehabilitation operations; both were ripped with some topsoil respread. Both landings indicated compliance with the current operational prescriptions ie. penetration depths of over 40cm (70% & 80% of landings). This indicates that the rehabilitation process undertaken by the contractors was effective in reducing the impacts of high traffic flow and compaction caused during harvesting.

Alternatively CM_1 effectively had no rehabilitation works carried out and the results indicated no significant difference to the control site. While only one control site was tested in this case (T3), the soils across the Toolangi forest are uniform, and presented very similar properties at each site. In this case, it was most important to have the control site adjacent to the corded and matted landing (CM_1), and results indicated no significant difference to natural forest floor levels.

Landing rehabilitation works on the T1 and T2 Toolangi coupes have been successful in achieving VicForests' operational objective of 60% of coupe landings showing =/>40 cm penetration at 300 psi. Cording and matting on coupe T3 also successfully protected landing soils from compaction, evidenced by no significant difference from the control.

Soils in Toolangi were at field capacity when tested, and this similarity between treatment and control indicates that soil compaction on landings has been successfully treated, achieving the operational objectives.

4.2 Orbost

The three Orbost sites were conventional landings on seed tree coupes and were ripped at the conclusion of harvesting operations. There was very little sign of any topsoil respread across the landings, but there was also little evidence of topsoil on the control sites which suggests that gathering large stockpiles of topsoil would have been very difficult.

The pooled data for penetrometer readings <40 cm average for Orbost landings was 23.8 ± 2.8 cm which on trend seems to be significantly greater than the pooled control data of average 15.7 ± 1.3 cm (p=0.05), indicating a strong rehabilitation effect.

Each landing had penetrometer readings higher than the surrounding control sites (significant at O1 and O3). While the percentage of the landings that had an average depth of over 40cm was lower than in Toolangi, it was a far better result than on the control sites which produced only one result greater than 40cm, again indicating a treatment effect.

The soils in this case were far less organic and also very rocky on both the landings and controls, and was limiting when trying to push the probe into the soil. As a result of ripping, the landings contained soil which was far looser in comparison to the control sites, allowing the probe to easily enter the soil. While the difference between Toolangi and Orbost coupes can be explained in some part by the difference in soil type, the dryer conditions in Orbost would have also had an effect. Soils should ideally be at field capacity for meaningful penetrometer readings and it is suspected that soils were too dry during the monitoring. The measurements were deliberately taken at the end of winter, when soils would be expected to contain the most moisture. Prolonged drought in the area has meant that conditions were very dry and certainly did not compare to the soils in the Toolangi area which had experienced closer to average rainfalls over the winter.

Although the above data indicates a strong rehabilitation effect, figure 2 indicates that only 41% of landing sample points reached 40 cm at 300 psi. No entire landing met the current prescription for ripping in the Utilisation Procedures. This shows a shortfall in the current operational target of 60% penetrating to 40 cm at 300 psi across the landing.

5. Conclusions

While this initial stage of the monitoring program only provides limited results, they do provide some conclusions in addition to cementing the methodology of data collection for the coming years. The results indicated that each of the landing treatments delivered a compaction reading no less than the control. It also showed that the CM_1 landing was not significantly different to the natural forest floor. This suggests current harvesting prescriptions and procedures are sufficient in minimising significant soil compaction, leaving sites suitable for seedling establishment.

In the case of the less fertile soils, the treatment would appear to improve the growing conditions from the surrounding soils in terms of compaction. However in this case, landings did not meet the present management objectives. Given the condition of the soil, a more reasonable target such as matching or improving the control site should be aimed at in future. In this case having a single operational objective across all soil types may not be good science, and some future thought will need to go into this.

This first round of assessments also allowed us to review and improve our methodologies, giving us a solid base from which to continue data collection over the coming years.

In relation to continuation of the project, it would be expected that each year data would be collected on no less than 6 coupes, as was done this year, and the data collated and results reviewed and reported annually.

6. References

- *Utilisation Procedures for all commercial harvesting managed by VicForests. Version 5.0 (VicForests 2008)*
- *Forest Management Procedures 2007 (DSE 2007)*
- *Code of Practice for Timber Production* (DSE 2007)
- *Rab and King (1997) "Soil physical and hydrological properties" In Evaluation and development of sustainable silvicultural systems for mountain ash forests. Knowledge Base. Report by CFTT for Department of Natural Resources & Environment (DNRE), Victoria.*
- *Duiker, S. W. (2002) Diagnosing soil compaction using a static penetrometer. Agronomy Field Sheet 63. Pennsylvania State College of Agricultural Sciences, USA.*
- VicForests' Instruction – Monitoring Soil Compaction on Landings for Coupe Finalisation.
- Monitoring of Soil Compaction Field Sheets – Toolangi and Orbost