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Micro-Site Effects on Early Tree Growth

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Figure 1 - Large healthy tree on right, small unhealthy trees' on left. Same age, same site - which micro-site factors affect the trees performance?

Abstract

Radiata pine seedlings were assessed one year after planting at four central North Island sites to determine the effects of seven micro-site factors on tree growth and health.

At all sites, seedling growth and health were reduced by increased levels of slash volume, weed competition, shade and soil disturbance.

However, only a very small percentage of the trees assessed were in conditions of high slash volume, dense weed competition heavy shade or severe soil disturbance and therefore only small overall growth and health losses occurred.

Based on the results, instructions could be prepared to improve planting spot selection by tree planters.

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Introduction

The objective of this study was to assess and determine the effects of micro-site factors such as soil disturbance, weeds, shade, slash, aspect and topography on early tree growth from an operational perspective.

It is apparent from observation of recently planted sites, that trees of the same stock type, planted by the same person, into an apparently uniform site, often end up performing quite differently in terms of early growth and health.

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For any given site, it is desirable to have the crop as uniform as possible, as this minimises growth losses and selection problems and can lead to reduced initial stockings. If a higher proportion of planted trees perform well, fewer are needed to get a viable crop.

In order to improve forest managers' ability to plan site preparation operations and for planters to make good decisions about exactly where to plant individual trees, it is necessary to have a good understanding of what micro-site factors are having significant effects on early tree growth (Bedford and von der Gonna, 1993).

Both New Zealand and overseas research has tended to focus on the comparisons of growth between different site preparation treatments, rather than what factors cause the variation within a single treatment. However, there is some work which recognises that micro-site factors can influence tree growth, especially on sites with extreme climate or soil conditions (Macadam 1990).

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Methods

Four forest sites with radiata pine seedlings of one year of age, where no soil cultivation treatments had been carried out, were selected. Two were in Kaingaroa Forest (one flat, one steep) and two in Omataroa Forest (one steep, one rolling).

Within each of the these sites, over 800 trees were assessed for a number of factors:

- height
- root collar diameter
- health (scale 1 to 5: 1 = healthy, 5 = dead)
- form (scale 1 to 5: 1=good form, 5 = poor form)

For each individual seedling, the following site factors were also assessed:

- slash volume within 0.5m radius (scale 1 to 5, nil to heavy)
- general topography (scale 1 to 5, hill top to gully bottoms)
- micro topography (scale 1 to 5, top of small mounds to bottom of small dips)
- general aspect (scale 1 to 5, 1 = North, 3 = East/West 5 = South)
- micro aspect (scale 1 to 5, as per general aspect)
- weeds (scale 1 to 5, nil to very heavy)
- soil disturbance (scale 1 to 5, nil to very heavy = track surface)
- distance to nearest stump (scale 1 to 5, < 10cm to > 50 cm)
- shading (scale 1 to 5, 0 % to 100 %)
- general slope (actual degrees)
- micro slope (actual degrees)

Some of the assessments were subjective (for example, slash volume) but, as all assessments were made by one person, they should be consistent.

Analyses of variance were used to assess the significance of micro-site factors on tree growth and health measurements. Separate analyses were performed for each study site. In the following graphs, slash, weeds, and shade means were adjusted to a common soil disturbance level.

Results

Significant effects

The variables that were found to have consistent significant effects ($P < 0.05$) on tree height, diameter and health were; slash level (Figures 2 to 4), weeds (Figures 5 to 7), shading (Figures 8 to 10), and soil disturbance (Figures 11 to 13).

For all growth parameters, tree performance decreased with increasing slash, soil disturbance, weeds and shade (Table 1). The number of trees in the sites with heavy slash, soil disturbance, weeds and shade (class number 5) was very small (Table 2).

	Slash			Soil Disturbance			Weeds			Shade		
Class	Dm	Hgt	Hlth	Dm	Hgt	Hlth	Dm	Hgt	Hlth	Dm	Hgt	Hlth
1	17 0.6	74 1.8	1.8 0.1	11 0.7	53 3.1	2.1 0.3	17 0.7	73 1.9	1.9 0.1	18 0.9	75 1.2	1.8 0.1
2	17 0.7	75 1.7	1.9 0.1	11 0.8	53 3.0	2.2 0.2	17 1.1	73 2.7	1.8 0.1	15 1.0	71 2.3	2.1 0.2
3	16 0.6	73 2.6	1.8 0.2	11 0.8	54 2.3	2.4 0.2	14 0.3	70 2.9	2.1 0.1	12 0.6	57 3.8	2.5 0.2
4	13 0.6	60 3.2	2.4 0.2	11 0.8	51 2.6	2.7 0.2	9 0.3	55 3.7	2.8 0.2	10 1.3	53 3.7	2.9 0.2
5	9 0.6	48 5.3	3.3 0.3	8 0.6	39 1.9	3.2 0.2	7 0.5	44 6.1	3.2 0.2	7 1.0	44 4.9	3.2 0.2

Table 1 - Averages (standard errors) across all four sites by class for variation in diameter height and health for Slash, Soil Disturbance, Weeds and Shade

Assessment class	1	2	3	4	5
Slash	31	47	17	5	1
Weeds	66	24	7	3	1
Shade	79	14	5	1	1
Soil Disturbance	5	39	37	13	4

Table 2 - % of trees in each assessment class

Site Key for Graphs

KS = Kaingaroa Forest, steep terrain
KFR = Kaingaroa Forest, flat to rolling terrain
OS = Omataroa forest, steep terrain
OR = Omataroa Forest, rolling terrain

Slash

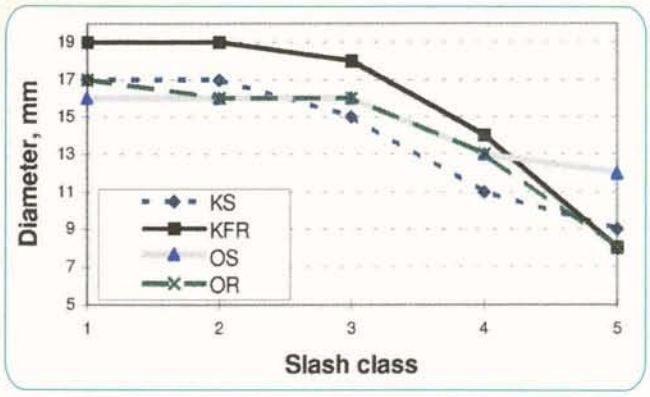

Figure 2 - Influence of slash on diameter

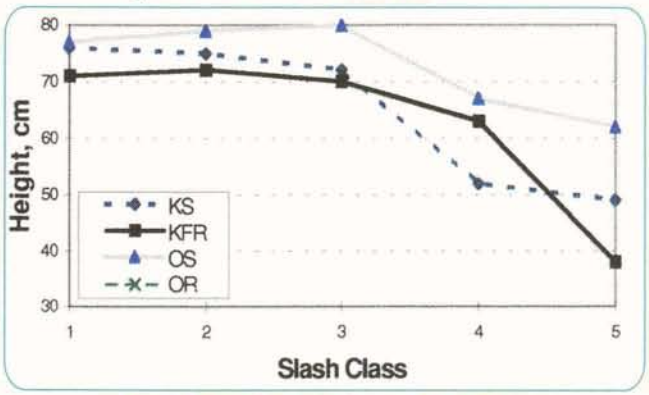

Figure 3 -Influence of slash on height

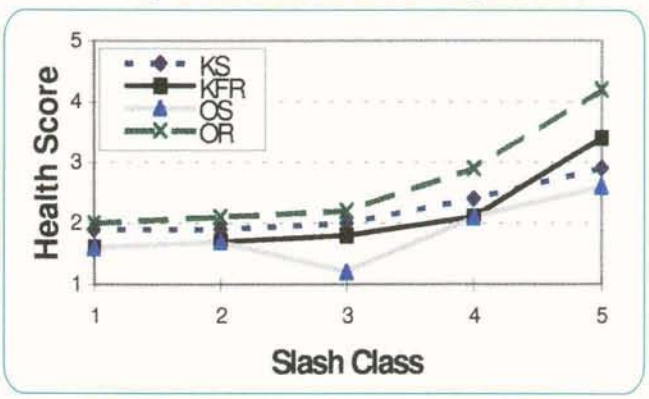

Figure 4 - Influence of slash on tree health

Note : the health score is on a scale of 1 = very healthy, to, 5 = very unhealthy, a higher score indicates inferior performance.

It can be seen from the trend lines in the three graphs, that increasing slash level has had a negative effect on diameter and height growth and health. The health score can be used as a predictor of future performance. Trees with poor health will not grow as well over the next season as trees with good health.

Weeds

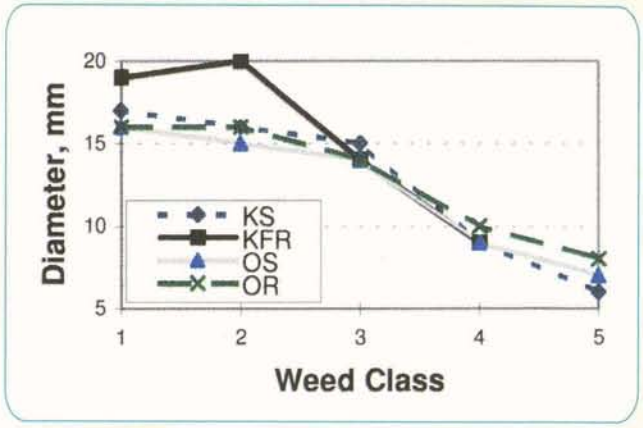

Figure 5 - Influence of weed competition on diameter

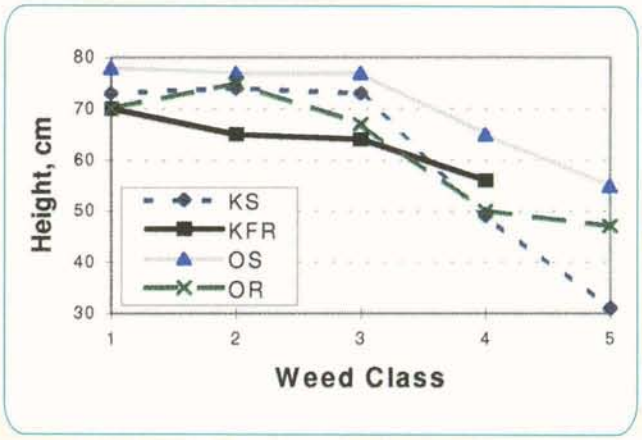

Figure 6- Influence of weed competition on height

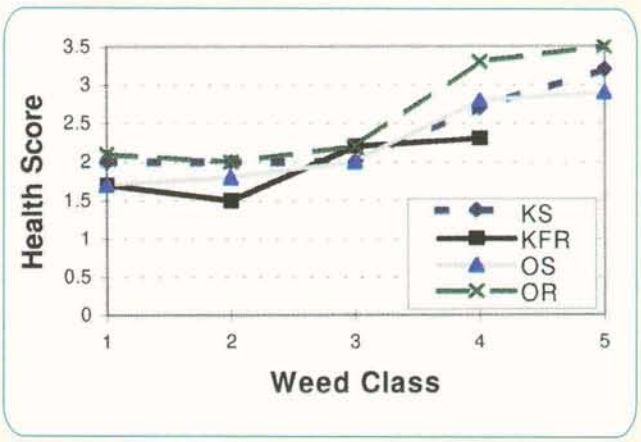

Figure 7 - Influence of weed competition on health

Not surprisingly, weed competition also has a strong trend for decreased growth in height and diameter and reduced tree health with increasing weed competition.

The level of weed competition varied from site to site. KS (steep terrain) had received an aerial broadcast release spray and there were very few weeds on the site. KFR, OS and OR had received spot releasing treatments. Whilst the vast majority of the trees had been released, the effectiveness varied considerably from tree to tree. Getting consistently good spot releasing will improve crop uniformity.

Shade

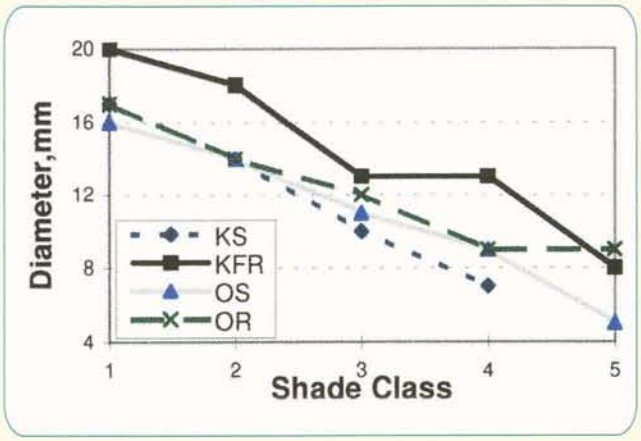

Figure 8 - Influence of shade on diameter

Note: a low score (1) indicates no or low shading, a high score (4 or 5) indicates heavy shading.

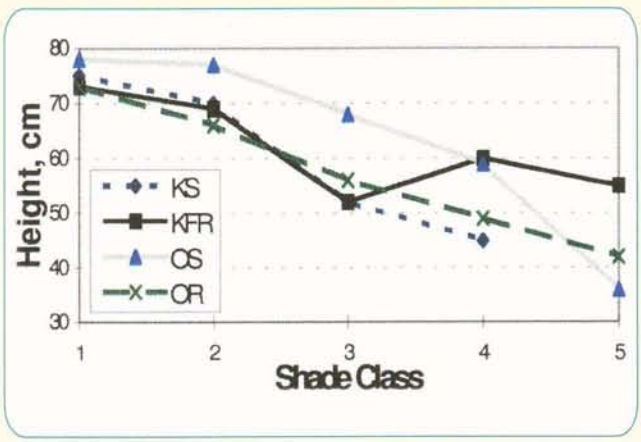

Figure 9 - Influence of shade on height

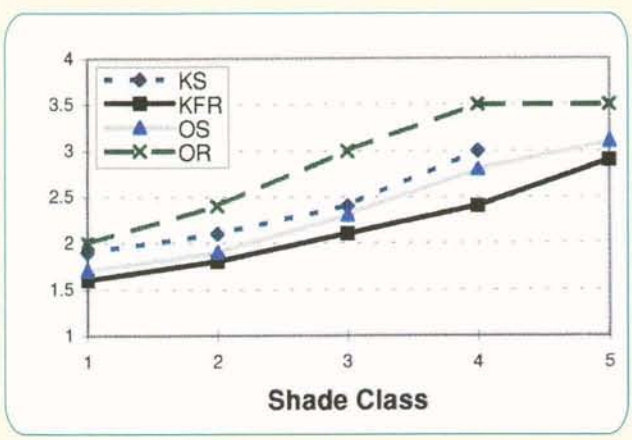

Figure 10 - Influence of shade on health

Increasing shade was also related to decreased diameter and height growth and declining health.

Shade on the trees came from a variety of sources: weeds, slash, stumps and banks. The majority of the shade was associated with weed competition.

Soil disturbance

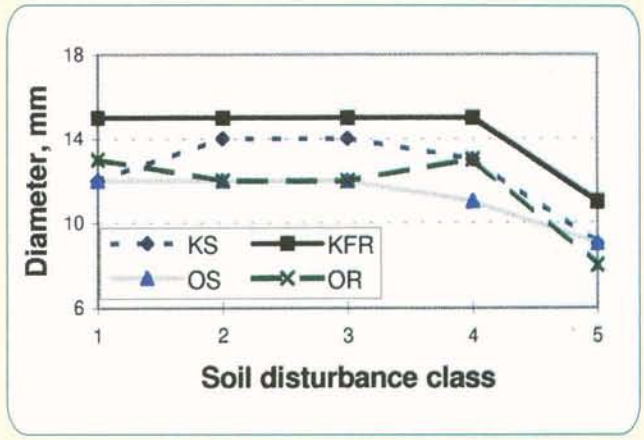

Figure 11- Influence of soil disturbance on diameter

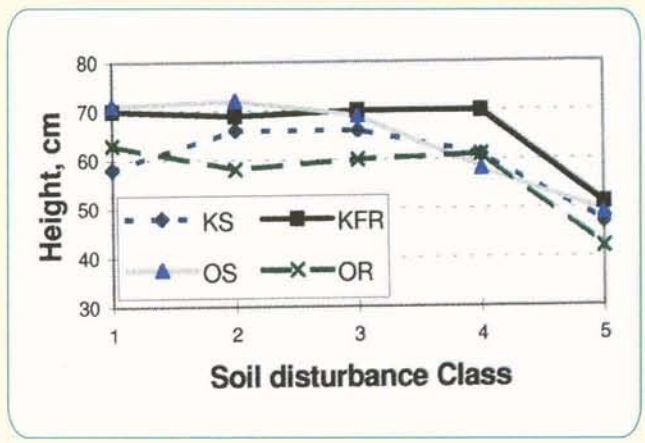

Figure 12- Influence of soil disturbance on height

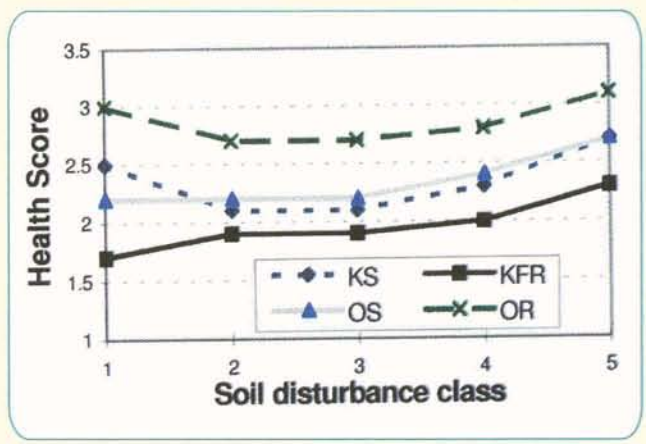

Figure 13- Influence of soil disturbance on health

The negative influence of soil disturbance on growth and health was largely limited to class 5 disturbance. This was severe disturbance such as ground-based extraction tracks, hauler line ruts and other earth works. This disturbance class was typically a combination of topsoil removal and subsoil compaction. The logical conclusion of this is that planters should plant up to the edge of areas of major soil disturbance such as tracks, but not on them.

Frequency of class occurrence

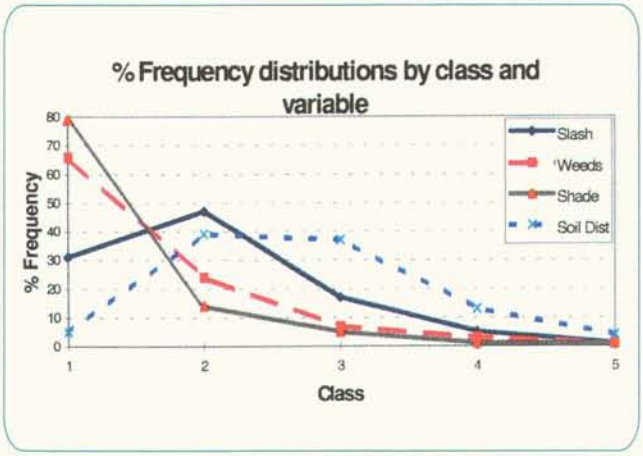

Figure 14 - Severity of variables influence on overall site

Whilst the increasing of the severity of slash, weeds, shade and soil disturbance had a marked influence on individual trees, the effects on the entire site was quite small. There were only small percentages of the trees in the critical classes (4 and 5) for most of the variables (Figure 14). When the percent of trees in each class was combined with the percentage growth loss associated with each class (derived from the height and diameter data), the total loss of growth could be derived. This was carried out for the combined data for all sites (Table 3).

	Slash	Weeds	Shade	Soil disturbance
Diameter	2.5%	3.2%	4.7%	3.0%
Height	2.0%	1.4%	2.9%	3.8%

Table 3 - Total effect of micro-site factors on tree growth (% loss)

From Table 3, it can be seen that shade was having the largest influence on growth. There was also a positive correlation between weeds and shade ($P<0.05$). There was obviously a relationship between weed competition and shading, although it was possible to have heavy weed competition that was not shading the tree. From this table, it is possible to rank the importance of the various factors.

The effects of the micro-site factors in Table 3 are independent for the individual factors and are not cumulative.

Shade, and its association with weeds, ranks first in its level of effect on site growth. Soil disturbance was second and slash was third.

For the sites studied, the number of trees in classes 4 and 5 for all factors was very small, indicating that the establishment has been generally successful. However, it is worth bearing in mind the factors that are having a measurable effect, when instructing and training planters.

The results also highlight the need for consistent good quality spot weed control.

Factors which did not show consistent significant differences were micro topography, distance to nearest stump, general or micro slope, micro and general aspect and general and micro topography.

However, one of the sites studied, KFR, was a flat to rolling compartment and both general and micro topography showed significant effects on growth (Table 4).

	Micro topography			General topography		
# 1,2	Diameter, mm	Height, cm	Health	Diameter, mm	Height, cm	Health
1	15	54	2.0	11	54	2.6
2	10	51	2.6	11	49	2.7
3	9	47	2.6	10	41	2.5
4	9	49	2.6	8	36	3.6
5	8	42	3.0	9	36	3.6

Table 4 - Diameter, height and health trends for Micro and General topography - for KFR site only

#1 Micro-topography, Scale 1 to 5: 1 = planting micro-site raised above surrounds, 5 = planting micro-site sunken below surrounds

#2 General topography, Scale 1 to 5: 1 = hill or ridge top, 3 = mid-slope, 5 = gully bottom.

The trend was quite distinct, that tree growth and health decline with a lower topographical position (both micro and general) topography. This is consistent with long term evidence from Kaingaroa that mounding is required on flat sites to establish a good crop. There is little that can be done to counter general topography. However, planters do have options about where individual trees are placed in terms of micro topography. They should be encouraged to plant the trees on the more elevated terrain where possible.

General topography had an effect on tree height and diameter on site KS. This was a steep site with long slopes and deep gullies. Trees in the gully bottoms (class 4 and 5), which were 1% of the trees, were not performing as well (- 47% of height and -37% of diameter) as those on more elevated spots within this compartment.

Discussion

Whilst the results presented here explain some of the variation in tree growth, it was observed during the study that there were substantial differences in tree growth between trees planted in what appeared to be uniformly "good" sites. Some of these trees were performing well and others poorly.

The causes of this variation were not visibly apparent. They may be soil physical properties, soil chemical properties or individual tree characteristics related to genetics. Measurement of soil factors (micro-site moisture, and nutrition) or destructive sampling of the trees may be the only way to determine what is causing the differences.

Further research in this area would improve understanding of the obvious variations in tree crop growth.

Conclusions

Of seven micro-site factors assessed, four had significant effects on the growth and health of one year old radiata pine seedlings at four sites in the Bay of Plenty.

These factors were:

- shade
- weed competition
- soil disturbance (severe)
- slash volume

These findings could be used to train and instruct tree planters, with the aim of improving their micro-site selection when planting individual trees.

Specifically, unless there is no other option, do not plant trees:

- on areas with severe soil disturbance such as extraction tracks
- in areas of heavy slash
- in heavily shaded spots, i.e. under banks, near high stumps

It also highlighted the need for consistent good quality spot release weed control. Trees with poorly targeted releasing suffer growth losses in comparison to well released trees.

References

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