forest industry research cooperatives

MANAGEMENT OF EUCALYPTS

REPORT NO. 39 MAY, 1998

DAMAGE TO YOUNG *E. nitens* AND *E. fastigata* FOLLOWING APPLICATION OF RESDIUAL HERBICIDES

by
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forest research

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Management of Eucalypts Cooperative

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FOREST RESEARCH/INDUSTRY RESEARCH COOPERATIVES

Executive Summary

Eucalyptus nitens and *E. fastigata* are being planted on former pasture sites to produce pulp wood. Weed control is accepted as mandatory for successful eucalypt establishment in pasture but there is limited knowledge on the effect of weed management regimes on the growth, both in the short term and also long term productivity. A trial was established to quantify the effect on tree growth of maintaining different levels and duration of weed control using a mixture of the residual herbicides terbuthylazine (Gardoprim), clopyralid (Versatill) and haloxyfop (Gallant), or the non-residual herbicide glyphosate compared with no weed control treatments. Damage caused by a February post-plant application of residual herbicides led to high mortality of *E. fastigata* and damage to *E. nitens* and the trial was abandoned. Damage to *E. nitens* was assessed. Survival of *E. nitens* was significantly lower in the treatment where complete weed control was maintained with residual herbicides, compared to where weed control was maintained in smaller spots around the trees or where total weed control was maintained with non residual herbicides. Where residual herbicide was used, tree growth was significantly less than with non residual herbicide usage. A leaf "Scorch Factor" calculated on a scale of 0 for no damage and 2000 for total mortality, was minimal for plots with non-residual herbicides but progressively increased with the area of application of residual herbicide to reach 974 for total weed control. The herbicides were never applied over the foliage so the phytotoxic effect was as a result of root uptake of the residual herbicide. The results of this trial indicate that the use of a mixture of terbuthylazine, clopyralid and haloxyfop at label rates for post-plant weed control in *Eucalyptus nitens* and *E. fastigata* trees in February two to three months after planting may cause severe damage or death. Possible reasons for the root uptake and consequent damage are discussed. A new trial is required to quantify growth without the use of residual herbicides to control weeds.

Keywords: *Eucalyptus nitens, Eucalyptus fastigata*, establishment, weed control, herbicides, tree growth, phytotoxicity

INTRODUCTION

There is a continued expansion of the area planted with exotic non pine species, particularly *Eucalyptus nitens* and *E. fastigata* in the central North Island and *E. nitens* in Southland. These species are being promoted for diversification into superior quality, high recovery pulp wood, as well as for other end uses. Much of the planting of these species is currently being undertaken on former pasture sites.

On most sites there is a need to manage the growth of competing vegetation to maximise the growth of tree crops (Richardson 1991). There is a limited but increasing knowledge base on the effect of weed management regimes on the growth of exotic crop species on different sites (Richardson *et al.* 1996). It has been reported (Nicholas *et al.* 1991) that a weed free area of 1 metre diameter around Eucalyptus seedlings, maintained for one year, resulted in increased height growth. The effect on volume growth of Eucalyptus species, through increasing the area and duration of weed control around individual trees, needs to be further quantified. Not only does the effect of different weed control procedures on survival and early growth need to be investigated, but also, there is a need to determine their effect on long term productivity, so that an economic evaluation can be made of the cost benefits of weed control. The significance of initial weed control may vary through time, as canopy closure causes a suppression of competing vegetation. As there are differences in growth rates between species, and a change from juvenile to mature foliage in some species, eg *E. nitens*, the suppression of weeds by the crop due to shading may vary with crop species and with tree age.

A trial was established to investigate the optimal duration of weed control, the minimum weed free area required around newly planted Eucalyptus seedlings to maximise tree growth and the maximum productivity over a 10 year rotation, using the commonly used residual herbicides terbuthylazine (Gardoprim), clopyralid (Versatill) and haloxyfop (Gallant), to maintain long term control of competing vegetation in the weed free areas.

Post-plant application of the herbicides terbuthylazine, clopyralid and haloxyfop around *E. nitens* and *E. fastigata* seedlings on this site in late summer of 1997 resulted in significant mortality, leaf loss, and a reduction in tree growth. This report covers the establishment of the original trial and an analysis of the damage caused by the February application of residual herbicides around the trees.

METHOD

Site:

A fertile pasture site, typical of the sites currently being established in eucalypts, was selected for the trial at Tasman Forest Industries Matawhaura Block, Rotoehu Road, north east of Rotorua. The location of the trial area is shown in Appendix 1. The predominant vegetation on the site consisted of improved pasture grasses and clover, with a latent understorey of thistles, yarrow, sorrel and broadleaf weeds.

Tree establishment

Bare-rooted *E. nitens* seedlings were planted on 9 November 1996 and container-raised *E. fastigata* seedlings on 3 December 1996. Seedlings were sourced from Te Teko Nursery. Fertiliser was applied in the week 9-15 December.

Trial Layout

Treatment plots 17 x 21 metres in size were laid out in a randomised block design. Each treatment was replicated five times for each species receiving that treatment. The layout of the plots is shown in Appendix 2. Forty two planting spots were marked in each plot, in 6 rows of 7, at a spacing of 2.8 x 3 metres (1190 spots per hectare). One tree was planted at each planting spot. Separate trials were laid out for each tree species.

Treatments:

The treatments consisted of different weed free areas maintained for different periods of time. The treatment regimes are listed in Table 1. All treatment regimes were established in the *E. nitens* trial. Treatments 1, 2 and 9 were not included in the *E. fastigata* trial due to shortage of space. In order to be assured that the herbicide regime used to maintain weed free plots was not having an effect on tree growth, one treatment was duplicated using non residual herbicides (Treatment 9).

TABLE 1: Weed Free Area Maintained Around Seedlings, And Duration Of Weed Control From Time Of Planting

Treatment No	Year 1	Year 2	Years 3-10
1	nil	nil	nil
2	$1m^2$	nil	nil
3	1m	$1m^2$	nil
4	$2.25m^2$	nil	nil
5	$2.25m^2$	2.25^2m	nil
6	$4m^2$	nil	nil
7	$4m^2$	$4m^2$	nil
8	$4m^2$	8.4^2m	nil
9*	$8.4m^2$	8.4^2m	8.4^2m
10	$8.4m^2$	8.4^2m	$8.4m^2$

* No residual herbicides used

Note; $8.4m^2$ is equivalent to complete weed control over the whole plot

Pre-plant herbicides were applied to the prescribed area on each planting spot in treatments 2 to 10 on 23-24 September 1996. The herbicide treatment consisted of a mixture of terbuthylazine at 7.5 kg/ha (Gardoprim 15 litres/ha), clopyralid at 0.45 kg/ha (Versatill at 1.5 litres/ha), glyphosate at 1.8 kg/ha (Roundup 5 litres/ha), Pulse at 0.2 litres/ha, and dye at 0.75 litres/ha, or in the case of the non residual herbicide treatment, with glyphosate at 1.8 kg/ha (Roundup 5 litres/ha), Pulse at 0.2 litres/ha, and dye at 0.75 litres/ha. The herbicides were applied in 200 litres of water per hectare using a C-Dax Pine Starta sprayer fitted with XR11002VS (Spraying Systems) fan nozzles.

Spot Maintenance

The spots were inspected periodically, and the specified herbicides used to maintain the weed coverage below 25% total ground cover

On December 3 1996 the plots treated pre-plant with non residual herbicide (glyphosate) were again treated with glyphosate at 1.44 kg/ha to control emerging weeds. A knapsack sprayer fitted with a drift guard was used to avoid damage to the trees from spray drift.

The entire block was treated with an aerial application of clopyralid 0.18 kg/ha to combat thistle regrowth, in early December.

On February 3 1997, plots initially treated with residual herbicides were retreated with a mixture of terbuthylazine at 5 kg/ha (Gardoprim 10 litres/ha) clopyralid at 0.225 kg/ha (Versatill at 0.75 litres/ha), haloxyfop at 0.35 kg/ha (Gallant at 3.5 litres/ha) and dye. Plots initially treated with non residual herbicide (glyphosate) were again treated with glyphosate at 1.44 kg/ha (Roundup 4 litres/ha). Applications were made in a total spray volume of 200 litres/ha using a C-Dax Pine Starta sprayer. Spray was applied to the weeds and ground only, and not to the foliage of the trees.

Tree Assessments

On December 18 1996 an initial measurement was made of tree height and root collar diameter of all trees in the central 20 spots (four rows of five) in each plot. The surrounding buffer strip of 22 trees, which had received the same treatment, were not measured.

An inspection of the trial on 17 March 1996 revealed extensive damage to the *E. fastigata* trees. Damage was so comprehensive that no further assessment was undertaken and the trial was abandoned.

By 27 March it was apparent that there was significant damage to the *E. nitens* plantings. As there appeared to be a treatment affect, the trial was assessed for tree health and growth on 16 April 1997. Tree height, root-collar diameter tree mortality and foliar damage were assessed. Foliar damage due to herbicide application was assessed by calculating a Scorch Factor from an assessment of the percentage of the tree damaged (tree score) and the degree of damage on the leaves (leaf score) (Appendix 3). Some degree of judgement in assigning scores was required so assessments were standardised between observers to eliminate observer variation and ensure consistency.

Analysis

Data from plots which had received the same spot size treatment (Table 1) was combined giving a total of 6 weed control treatments. A two factor analysis of covariance using a covariate for the December measurement testing for the effects of block and weed control treatment was performed using plot means for each of the following variables:

- Tree height increment from December to April.
- Tree diameter increment from December to April.
- Tree volume index (height x diameter^2) increment from December to April.

A two factor analysis of variance testing for the effects of block and weed control treatment was performed using treatment means for each of the following variables:

- Tree survival (live trees in April as a percentage of live trees in December).
- Leaf damage score
- Tree health score
- Scorch Factor

All analyses were performed using the general linear models procedure (PROC GLM) in SAS (SAS Institute Inc., 1994). For the tree volume data a log transformation was used to correct for differences in variance between the treatment groups.

RESULTS

- ***Eucalyptus fastigata***

Post plant applications in February of the herbicides terbuthylazine at 5 kg/ha, clopyralid at 0.225 kg/ha and haloxyfop at 0.35 kg/ha to the ground surrounding *E. fastigata* seedlings planted 2 months previously resulted in death or extensive damage to the majority of the seedlings

- ***Eucalyptus nitens.***

The *E. nitens* mean tree survival, growth from December to April and tree damage recorded in April, for each of the weed control treatments, are summarised in Table 2. Tree size was significantly different in December for both height (p=0.001) and diameter (p=0.0121), the trees planted in untreated plots being significantly different in size to trees planted in plots where residual herbicides were applied. Therefore least squares means, adjusted for the December measurement, are presented for tree height, diameter and volume increments. Tests for differences between means were performed and those values followed by the same letter indicate treatments which are not significantly different at the 95% confidence level.

Survival of *E. nitens* was lowest (70 %) in the treatment where complete weed control was maintained with residual herbicides. Survival rates were significantly higher in plots receiving no herbicide treatment or where an area of 4m^2 was maintained weed free by the post plant application of residual herbicides. The highest survival rates were recorded in plots where total weed control was maintained with non residual herbicides, or where residual herbicides were applied to areas of 1m^2 or 2.25 m^2 around the trees

Mean tree height increment was least in the plots not treated prior to planting with herbicide, where trees were subjected to intense competition from grasses and broadleaf weeds. Tree height increment was significantly greater when competing vegetation was controlled. Where herbicides were applied to maintain total weed control in the plot, height growth was significantly less where the residual herbicide mix was used, than when the non residual herbicide was used. There was no significant difference in tree height growth between plots treated with glyphosate to maintain complete weed control and trees growing in plots receiving spot weed control with residual herbicides.

Likewise, mean tree diameter increment in plots where no weed control had been applied was significantly smaller than in trees where weed control had been maintained. Complete weed control using residual herbicides resulted in trees with a significantly smaller diameter than trees growing in plots where complete weed control was achieved using glyphosate, a non residual herbicide. There was no significant difference between tree diameter growth in plots where trees were planted in spots of different sizes, although there was a trend of greater diameter growth with increased spot size. The same trends are mirrored in the tree volume index, which is an indicator of tree size

Table 2: Tree Survival and Growth from December to April and Damage recorded in April in a trial of Trees Growing in Spots of Different Sizes Treated With Either Residual or Non-residual Herbicides.

Spot Size	Herbicide Type*	Tree Survival %	Leaf damage Score	Tree health Score	Scorch Factor	Tree Height Increment (cm)	Tree Diameter Increment (mm)	Tree Volume Increment (cm^3)**
nil		86 b				39.7 a	4.3 a	6.7 a
total	n	96 c	0.17 a	0.01 a	6.1 a	72.6 c	20.4 c	79.3 c
1 m^2	r	95 c	1.34 c	2.59 b	398.6 b	73.0 c	17.6 bc	58.1 bc
2.25m^2	r	95 c	1.53 c	2.64 b	471.2 b	74.5 c	18.4 c	58.7 bc
4m^2	r	92 bc	1.66 c	2.77 b	546.2 b	71.7 c	19.4 c	67.4 c
total	r	70 a	2.42 d	2.89 b	974.3 c	52.1 b	14.3 b	37.1 b

Note: Values for each variable followed by the same letter are not significantly different at the 95% confidence level.

* r = residual herbicide; n = non residual herbicide

** Tree volume index (final d^2h minus initial d^2h)

The Scorch Factor provides an indicator of the foliar damage caused by the uptake of the herbicide. The Scorch Factor can range from zero (no herbicide damage) to 2000 (all trees dead). The damage occurring on the trees in the plots where total weed control was attained through the use of glyphosate, a non residual herbicide, was minimal (Scorch Factor 6.1), and significantly less than where total weed control was maintained using the residual herbicide mix (Scorch Factor 974.3). Foliar tree damage on trees planted in spots was significantly greater than that observed on trees growing in the glyphosate treated plot where complete weed control was maintained.

DISCUSSION.

The first measurement of the *E. nitens* trees was delayed until the *E. fastigata* was planted and there was time for the soil to settle around the trees. This meant that there was a period of 38 days between planting and the initial measurement. The analysis showed that differences in tree growth between treatments were significant (P = 0.01) in December, although trees growing in plots to which residual herbicides were applied were not significantly different from one another. It is unlikely that the treatment differences are due to trees of the same size being planted in the same plots, as the seedlings came from one nursery and they were planted by forest workers who had no knowledge of treatments in the trial. As *E. nitens* is a fast growing tree, and there was a significant difference between treatments in the initial measurements, it is probable that there was already a treatment effect on growth 38 days after planting. Thus it is imperative that initial tree measurements of fast growing species are made as soon as possible after planting

Extremely poor tree growth occurred in the plots with no weed control. Tree survival was significantly lower than in plots where a non-residual herbicide glyphosate was used as a treatment to control competing vegetation. This result was expected as control of weeds, particularly grass, is known to be essential for successful establishment.

Tree growth from December to April was not significantly different for any of the three different spot sizes but there is a trend for trees to have a larger diameter and a higher index in the larger spots. The long term impact on growth could not be assessed as the trial was abandoned.

The relative effect on tree growth and survival of the residual herbicide and non-residual herbicide can be compared in the two treatments with total weed control. The survival and height and diameter growth of trees in plots where total weed control was maintained with a non-residual herbicide was significantly greater than that of trees in plots where weeds were treated with the residual herbicide mix. Thus it can be concluded that the residual herbicide had a detrimental effect on plant survival and growth.

The reason for the lower height and diameter growth in trees receiving total weed control, compared with that of trees receiving spot weed control is a surprising result. The reasons could be that

- The roots of the grass around each spot absorbed some of the residual herbicide, acting as a herbicide sink, resulting in less herbicide being available to the trees.
- The roots of trees in the total weed control plots were more extensive, and absorbed a greater total amount of herbicide.
- A physiological factor related to tree exposure resulted in greater susceptibility to the herbicide.
- The trees were more stressed, with less shelter from wind and cold than trees in growing in spots where surrounding vegetation was up to 0.5 metres high.

The first possibility is supported by the fact that the Scorch Factor was lower in the smaller plots where there is a bigger interface for the herbicides to be absorbed from the treated area. Although the growth does not match this pattern, the growth increment comes as a result of the interaction between the spot size effect and the damaging effect of the herbicide.

Although it is unlikely, it cannot be ruled out that the roots of the trees in the total weed control plots will have grown more than roots of trees growing in spots of different sizes, and the larger root system has absorbed more herbicide, causing greater damage.

If shelter from the elements alone were the cause of reduced growth, the significant increase in the Scorch Factor in the total weed control plots treated with residual herbicide would not have been expected. It would have also been anticipated that the reduction in growth would have been manifested in both the residual and non residual total weed control treatments.

Despite the risk of drift damage from the glyphosate during application, the Scorch Factor was least in the non residual total weed control treatment. The amount of leaf damage recorded, and the tree health score were progressively worse as the size of spot treated with residual herbicide increased, with the most severely affected trees being those growing where there was 100% weed control over the whole plot.

The long term impact of herbicide damage on growth has not been evaluated as assessments were undertaken only 10 weeks after application. Following assessment the trial was replanted.

The death, reduction in growth and foliar damage to young *E. nitens* trees due to the phytotoxic effect of residual herbicides may have been as a result of the build up in accumulated residues from both the pre-plant and post-plant herbicide applications. However, trees were planted seven weeks after the initial pre-plant herbicide application, and no subsequent foliar damage was observed after planting. Weed regrowth 19 weeks after the pre-plant application, necessitated a post-plant herbicide application, indicating that the herbicides applied initially had broken down and dissipated. The absence of severe foliar damage on the trees until after the post-plant application would imply that the post plant application of residual herbicides caused the majority of damage.

At no stage over the course of the trial were the herbicide sprays applied over the foliage. Thus the phytotoxic effect was as a result of root uptake of the residual herbicide.

Residual herbicide sprays containing terbuthylazine, clopyralid and haloxyfop have been generally recommended for post-plant weed control over Eucalyptus seedlings at rates higher than that used in this trial. At the time the trial was undertaken, there were suggestions from field observations that post plant applications over the foliage may cause some damage, but no comparisons had been made of the effects on growth of residual and non residual herbicides, where there was no foliar uptake. The reasons for the damage are not known. The high temperatures may have affected the chemical or the physiological condition of the trees, reducing the tolerance of the trees. Likewise, the reasons for the increased severity of damage in the plots receiving total weed control with residual herbicides cannot be definitively explained. The total rate of herbicide applied per hectare was the same in all treated areas, independent of the size of area treated.

CONCLUSION

The results of this trial indicate that the use of a mixture of terbuthylazine, clopyralid and haloxyfop at label rates for post-plant weed control in *Eucalyptus nitens* and *E. fastigata* trees in February two to three months after planting may result severe damage or death with, consequent loss of potential productivity. The damage may occur even if the herbicides are not applied over the foliage. Pre-plant weed control is essential to successful establishment and 5 months after planting trees in the larger spots tended to be larger despite suffering severe damage from herbicide 3 months after planting. A new trial is required to quantify growth without the use of residual herbicides to control weeds.

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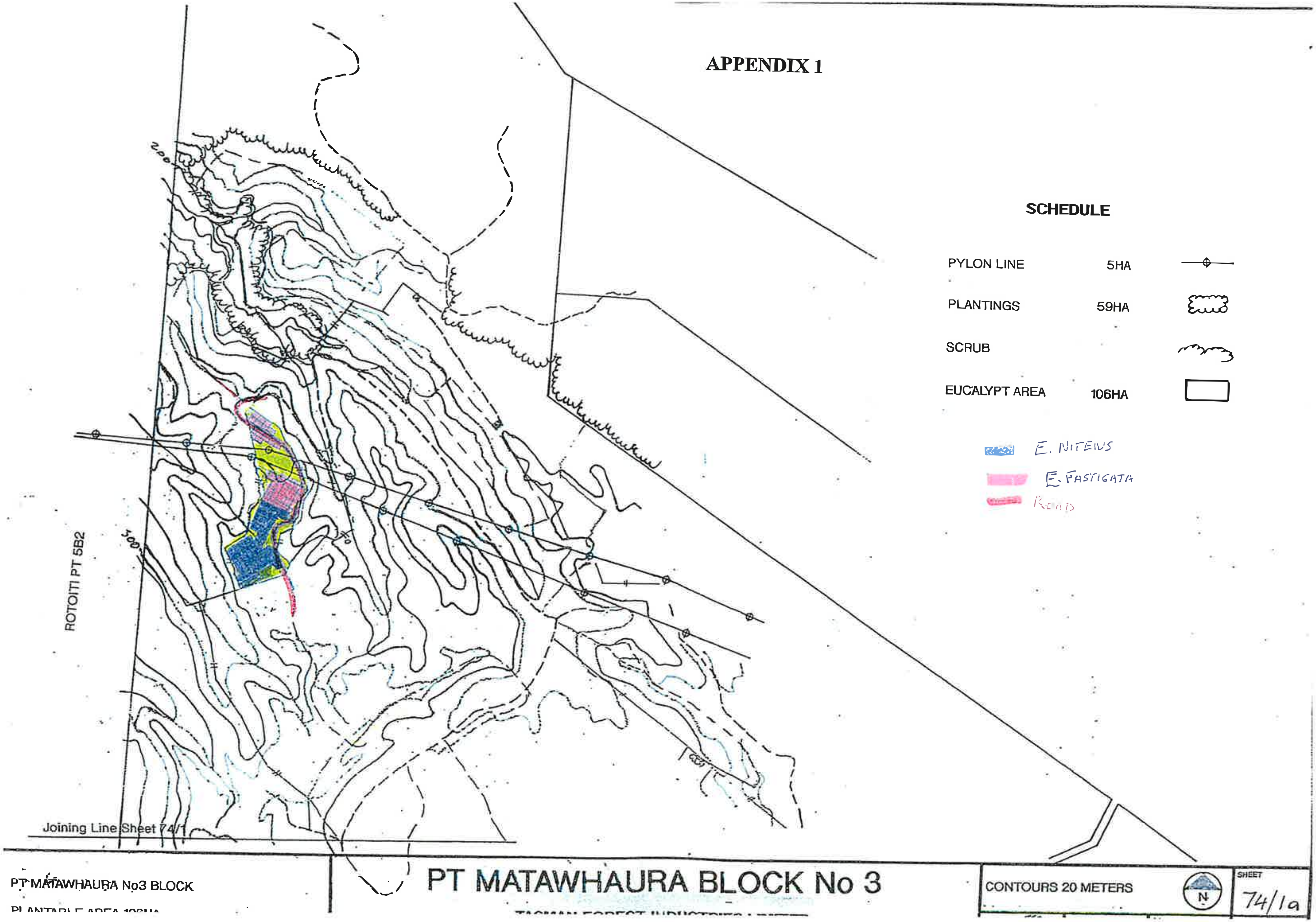
APPENDIX 1

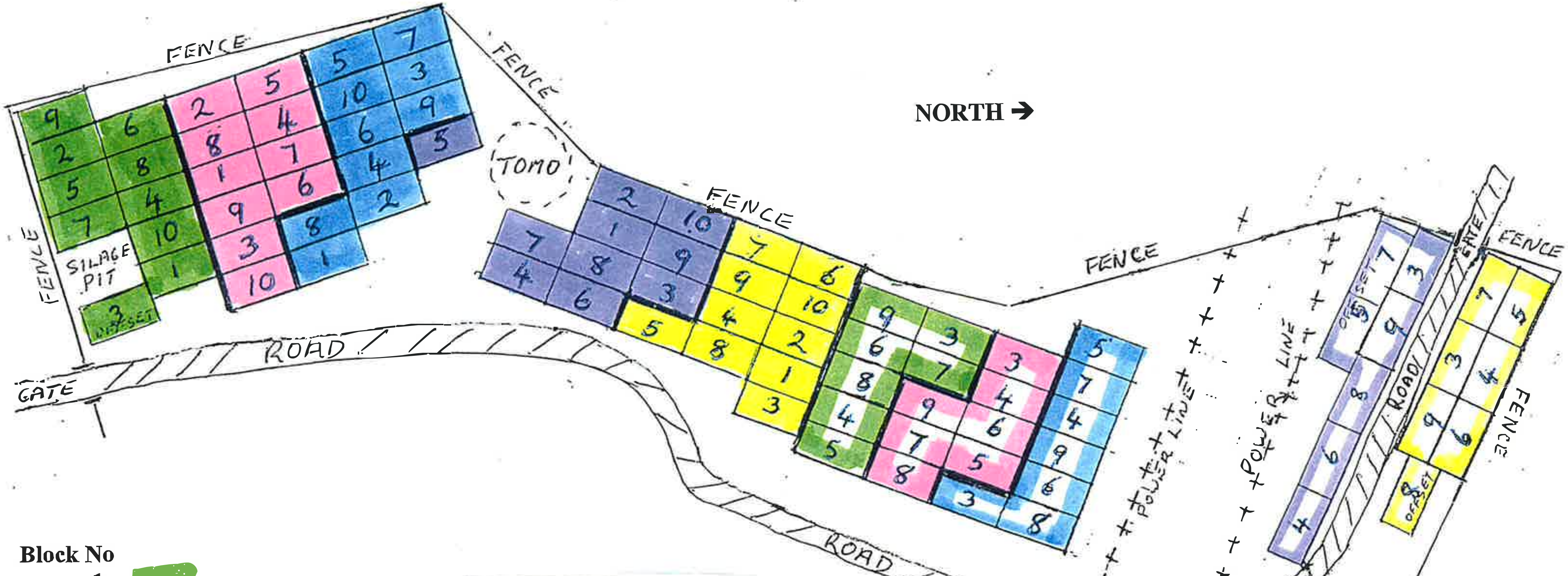


SCHEDULE
PYLON LINE 5HA
PLANTINGS 59HA
SCRUB
EUCALYPT AREA 106HA
E. NITENS
E. FASTIGATA
ROAD
ROTOITI PT 5B2
Joining Line Sheet 74/1
PT MATAWHAURA No3 BLOCK
PT MATAWHAURA BLOCK No 3
CONTOURS 20 METERS
N
SHEET
74/1a

APPENDIX 2

MATAWHAURA BLOCK EUCALYPTUS SPOT SIZE DURATION TRIAL

PLOT LAYOUT



Block No

1

2

3

4

5

Solid colour block *Eucalyptus nitens*

Outline colour block *Eucalyptus fastigata*

Treatment No	Year 1	Year 2	Years 3-10
1	nil	nil	nil
2	1m²	nil	nil
3	1m	1m²	nil
4	2.25m²	nil	nil
5	2.25m²	2.25²m	nil
6	4m²	nil	nil
7	4m²	4m²	nil
8	4m²	8.4²m	nil
9*	8.4m²	8.4²m	8.4²m
10	8.4m²	8.4²m	8.4m²

* No residual herbicides used

APPENDIX 3

A method of assessing herbicide phytotoxicity (scorching) on a sample of broadleaf tree seedlings.

On each individual of seedling

1. Assign the seedling a Tree Score according to the percentage of the leaves on the seedling affected (scorched), according to the following table:

Tree Score	
0	No Damage
1.	Less than 10% of tree leaves damaged
2.	10 - 25% of tree leaves damaged
3.	25-50% of tree leaves damaged
4.	Greater than 50% of tree leaves damaged
5.	Dead tree

Note: Sometimes damage can take different forms, eg yellow veining or tissue death. In this situation a judgement will need to made regarding where in the Tree Score one type of damage fits in relation to the other, depending on their relative severity. For example where slightly affected trees exhibit yellow veining, which leads to dead patches forming on the leaves as symptom severity increases, complete yellow veining on the leaves might be given a score of 1 and partial yellowing a score of 0.5: The rule is to be consistent in the scale used.

2. Estimate the average proportion of individual leaves damaged on the seedling and assign a Leaf Score according to the following table:

Leaf Score	
0.	no damage
1.	small spots; smaller than 2 mm in diameter
2	medium sized spots; < ½ leaf in size
3.	large spots; > ½ leaf in size
4.	dead leaves

Note: On any given seedling, damaged leaves will exhibit a range of scores. Judgement should be used, and a Leaf Score assigned reflecting the greatest number of leaves with a particular level of damage. If assessment is being undertaken some time after treatment, care should be taken to note whether leaves have died (Leaf Score 4) and subsequently fallen off

3. Multiply the Tree Score by the Leaf Score to give the Scorch Index for the seedling.

For every seedling in the sample repeat steps 1 to 3 .

Then for every sample of seedlings

4. Calculate the Mean Scorch Index by calculating the average of the Scorch Index for the sample (the sum of the Scorch Indexes for each seedling divided by the number of seedlings in the sample)

5. Calculate the percentage of seedlings exhibiting signs of phytotoxicity (multiply by 100, the number of seedlings in sample with a grade of either 1, 2, 3, 4, or 5, and divide by the total number of seedlings in the sample,)

6 For each sample, calculate the Scorch Factor by multiplying the Mean Scorch Index by the percentage of seedlings exhibiting signs of phytotoxicity