Survival and growth of *Pinus brutia* and *Pinus pinaster* on high pH, rendzina soils

Progress Report 1

October 2008

Prepared by Clinton Sim, PIRSA Forestry

1.1. Summary

Survival of *Pinus brutia* at three sites was a good result in the dry first year with over 90 percent survival. The only *Pinus pinaster* has recorded greater than 95 percent survival after a dry growing season. One site had significantly poorer survival than the other sites.

There were significant differences in height growth after one year. *P. pinaster* was significantly taller than the *P. brutia*. The *P. brutia* planted in the deep rendzina soils performed better than shallow soils, although higher pH had a significant effect above a value of 8. Weed growth at one site is suspected of contributing to induced height growth from light competition.

One treatment, Byrnes 1, was significantly less healthy than the other treatments. This site was also recorded the lowest significant survival and tree height. There is no known reason for this as this site was expected to perform because the *P. radiata* that grew on the site prior to establishment was better than any of the other Byrnes sites.

Site preparation and soil moisture had an impact on survival. Initial indications suggest that *P. pinaster* is performing better than *P. brutia,* but longer term monitoring will be needed to validate this. Deeper soils have a greater impact on growth followed by pH. However pH is expected to have a greater impact in the next few years.

1.2. Aims and Objectives

- To measure the survival and growth of *P. brutia* and *P. pinaster* on black clay rendzina soils that have a naturally high pH.
- To evaluate whether an increase in the pH unit and or soil depth has a significant effect on the survival, growth and form of *P. brutia* and *P. pinaster.* If there is an effect, determine a relationship between pH unit and/or soil depth and survival, growth and form.
- To evaluate if there is a significant difference in survival, growth and form between *P. brutia* and *P. pinaster* on black clay rendzina soils.

1.3. Introduction

This progress report highlights the results of one year past establishment. Height measurements were recorded, which was not scheduled, but were easily captured.

1.4. Project Location

The site locations varied from the near coastal location at the Green Triangle Forest Products (GTFP) - Kongorong North site to seasonally inundated sites at the Auspine sites, Figure 1.

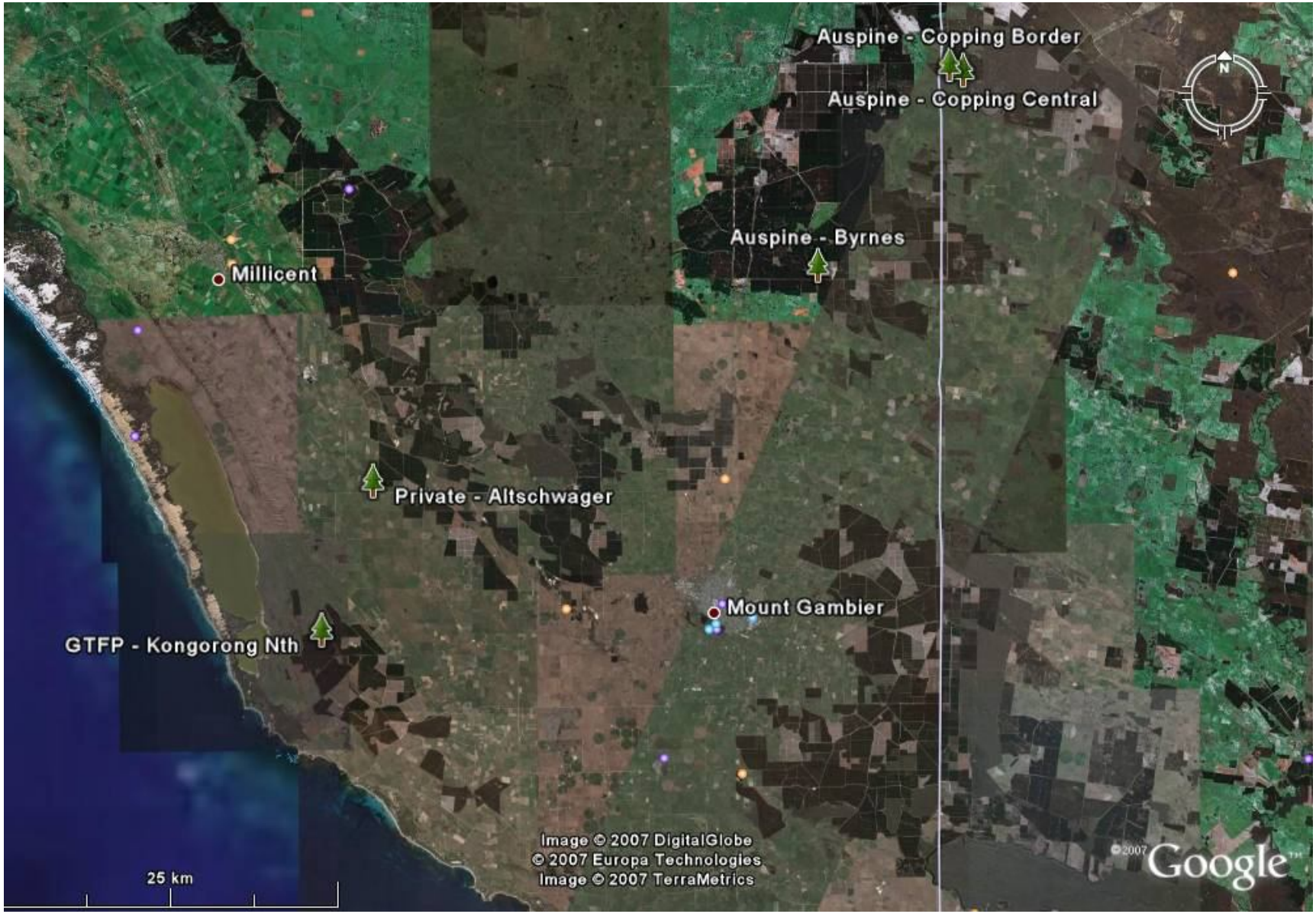


Figure 1 Localities of the trial sites indicated with pine trees and large centres named.

1.5. Methodology

1.5.1. Site Establishment

P. brutia was planted at three sites belonging to Auspine Ltd., Copping Border, Coppings Central and Byrnes and at one site belonging to Green Triangle Forest Products (GTFP) at Kongorong Nth. *P. pinaster* was planted at Auspine Ltd's Copping Central site only.

Site preparation for all sites was in accordance with grower's normal practice, which included ripping, mounding and pre-plant and residual weed control at the Auspine Ltd sites. The GTFP site had been prepared the previous year, 2006, for planting, which included weed control. The areas established where those where the radiata pine had not survived. This site had residual weed control, but no further management was undertaken.

1.5.2. Soil holes

Extensive soil holes were dug in the centre of each treatment to determine soil depth and pH across the sites and to locate positions for plots. Plots were located across the range of pH and soil depths at all sites as shown in Table 1. There is a range of soil pH, 6 – 8.1, and soil depths, 0.2 – 2m plus.

1.5.3. Trial Establishment

The number of treatments was based on the variation in pH, soil depth and size of the planted area. Annual rainfall is similar for the four sites ranging from 650 to 750mm. Each treatment had 6 replicated plots to provide statistical variance to analyse the results based on ANOVA. There are 12 *P. brutia* treatments and 2 *P. pinaster* treatments.

The number of treatments and number of plots for each site:

- Byrnes, 5 *P. brutia* treatments, 30 plots, annual rainfall 700 mm;
- Copping Border, 2 *P. brutia* treatments, 12 plots, annual rainfall 650 mm;
- Copping Central, 4 treatments, 2 *P. brutia* and 2 *P. pinaster*, 24 plots, annual rainfall 650 mm;
- Kongorong North, 3 *P. brutia* treatments, 18 plots, annual rainfall 750 mm.

Measurement plots 0.015 ha in size, 4 rows wide have been established in 2007 after planting had been completed. Plots have been located at each site to account for a range of different pH and soil depths across the site. The centre of each plot is located with a GPS waypoint, and one soil hole representing the treatment has been sampled (Table 1). To create a buffer around the plots no plot is located within two trees of the compartment edge, which includes any other unplanted area, age class or tree species.

Table 1 Soil holes showing depth (cm) and soil pH for each soil texture change at each site.

Byrnes – Auspine; Locality, Tarpeena; Annual Rainfall, 700mm.

Treatment 1	0 - 25	25 - 70	70 - 90	90 - 110	110 - 120	120+
Large trees previously	7.9	8.2	8.2	8.0	8.1	8.1
Treatment 2a	0 - 10	10 - 40	40 - 80	80 - 110	110 - 120	120+
Medium trees previously	7.5	7.8	8.1	8.0	8.1	8.0
Treatment 2b	0 - 10	10 - 30	30 - 80	80 - 170	170 - 190	190+
Medium trees previously	7.6	7.6	7.8	7.9	8.1	7.7
Treatment 3	0 - 10	10 - 50	50 - 90	90 - 180	180+	
Small trees previously	7.5	7.7	7.6	7.9	7.8	
Treatment 4	0 - 10	10 - 25	25 - 70	70 - 100	100 - 120	120 - 230+
No trees previously –deep soil	7.3	7.5	7.6	7.7	7.7	7.8
Treatment5	0 - 20	20 - 50	50 - 110	110 - 230+		
No trees previously – shallow pan	7.2	7.4	7.5	7.6		

Copping Border – Auspine; Locality, Lake Mundi; Annual Rainfall, 650mm

Treatment 6	0 - 25	25 - 35	35 - 100+	
Deep rendzina	7.5	7.5	7.3	
Treatment 7	0 - 15	15 - 50	50 - 90	90 - 120+
Shallow limestone pan < 0.5m	7.2	7.3	7.4	7.5

Copping Central – Auspine; Locality, Lake Mundi; Annual Rainfall, 650mm

Treatment 8	0 - 15	15 - 20	20 - 120+		
Deep limestone pan > 1.2m	8.1	8.0	8.1		
Treatment 9	0 - 10	10 - 50	50 - 60	60 - 100	100 - 130+
Shallow limestone pan < 0.5m	8.1	7.8	8.0	8.2	8.1
Treatment 13 (*P. pinaster)*	0 - 50	50 - 70	70 - 80+		
Deep rendzina	7.8	7.6	7.7		
Treatment 14 (*P. pinaster)*	0 - 25	25 - 45	45 - 60	60 - 90	90 – 110+
Shallow sandy rendzina	8.1	7.9	7.5	7.6	7.8

Kongorong Nth – GTFP; Locality, Kongorong; Annual Rainfall, 750mm.

Treatment 10	0 - 10	10 - 20	20+	
Shallow, limestone pan at 0.2m	6.4	6.3		
Treatment 11	0 - 5	5 - 20	20+	
Flinty, limestone pan at 0.2m	6.1	6.3		
Treatment 12	0 - 10	10 - 50	50 - 90	90 - 120+
Deep rendzina	7.6	7.4	7.4	7.3

1.5.4. Measurements

Seedlings' heights were recorded along with comments about seedling health one year after planting.

The tree health score was assigned by visual inspection using the following procedure (Figure 2).

Tree Health Scale

1. No effect: tree perfectly healthy.
2. Very slight effects: some yellowing or stunting visible.
3. Yellowing or stunting: effects reversible.
4. Substantial chlorosis and/or stunting: loss of growth expected.
5. Increasing severity of damage.
6. Total loss of growth and plant death

Figure 2 From left to right the health score is 1 through to 6, 6 being dead.

Height was measured using a height stick calibrated to 0.02m Figure 3.

Future measurements are scheduled as follows:

Tree Health, Survival	P+3yrs, P+6yrs, P+9yrs
Height	P+3yrs, P+6yrs, P+9yrs
Dbh	P+6yrs, P+9yrs
Photo	P+3yrs, P+6yrs, P+9yrs

The next set of measurements will be collected in 2010, three years after planting with an interim report produced.

Figure 3 measuring heights of seedlings

1.5.5. Data Analysis

Analysis of the health scores of the sites have been statistically analysed using ANOVA Fisher's LSD test[1] to assess whether there is any significant differences between treatments.

[1] Source http://biology.leidenuniv.nl/~zandee/statistiek/syllabus/LSD.pdf last viewed August 12, 2008.

1.6. Results

The Private – Altschwager site was overcome with grass two months after planting and the owner decided to re-establish it the following year it was therefore removed from the trial. This left four sites available for measurement and comparison.

1.6.1. Survival

There was a significant difference in survival at the 95% confidence limit, Table 2, which was mainly due to the survival of the Byrnes treatments compared with the other treatments. This could be explained because site cultivation was a few days before planting so the mound did not have time to wet up. Further establishment was late in the season with dry conditions at the end of August through to November. The other sites did not have the same soil condition stress.

Table 2 Anova table and ranking of survival between *P. brutia* and *P. pinaster* treatments.

ANOVA

	df	SS	MS	F	P-value	F crit
Between treatments	13	2.76486	0.21268	34.6984	2.5E-25	1.86266
Within treatments	70	0.42906	0.00613			
Total	83	3.19392				

	Treatment	Survival %	Ranking	pH	Soil depth (m)
Kongorong	10	99	A	6.4	0.2
Copping Central Pinaster	13	99	A	7.8	0.8+
Copping Central Pinaster	14	99	A	8.1	1.1+
Copping Border	6	98	A	7.5	1.0+
Copping Central	8	97	A	8.1	1.2+
Kongorong	11	97	A	6.1	0.2
Kongorong	12	96	A	7.6	1.2+
Copping Border	7	92	A	7.2	1.2+
Copping Central	9	92	A	8.1	1.3+
Byrnes	5	75	B	7.2	2.3+
Byrnes	4	68	BC	7.3	2.3+
Byrnes	2	61	C	7.5	1.5+
Byrnes	3	61	C	7.6	1.8+
Byrnes	1	43	D	7.9	1.2+

Fishers LSD (P = 0.05) = 0.0903

Within the Byrnes location there was a significant difference at the 95% confidence limit between Byrnes treatment 1, the treatment with the highest pH and the other four treatments (Table 2). Byrnes treatment 1 also had phalaris infestation at time of measurement at year one, Figure 4, compared with the other Byrnes treatments. Byrnes treatment 5 was significantly greater survival at the 95% confidence limit than Byrnes

Figure 4 Phallaris at Byrnes treatment 1

treatment 1 as noted above as well as Byrnes treatment 2 and 3. Again this is probably due to lower pH.

Of particular interest is the high survival of the Kongorong treatment with no residual weed control. There was considerable weed growth, Figure 5, but there was no significant difference in survival in the first year compared with the other high survival sites.

1.6.2. Height

There were significant differences at the 95% confidence limit in tree height, Table 3. *P. pinaster* was significantly taller at the 95% confidence limit than the *P. brutia.* There was a significant difference between the two *P. pinaster* treatments with the shallow sandy rendzina site (treatment 14) significantly taller at the 95% confidence limit than the deep rendzina site (treatment 13).

Figure 5 An example of the weed growth at the deep rendzina treatment (12) at Kongorong.

The *P. brutia* deep rendzina treatments at Copping Border (treatment 6) and Kongorong (treatment 12) where significantly taller at the 95% confidence limit than the other *P. brutia* treatments. The *P. brutia* deep rendzina treatment at Copping Central (treatment 8) was significantly shorter at the 95% confidence limit than these two deep rendzina treatments possibly because of the higher pH, but still significantly taller at the 95% confidence limit than the other *P. brutia* treatments.

Figure 6 The weed growth that possibly induced increased height growth at the flinty rendzina treatment (11) at Kongorong

The flinty limestone pan treatment at Kongorong (treatment 11) was significantly taller at the 95% confidence limit than the other shallow rendzinas treatments at Copping Border (treatment 7), Copping Central (treatment 9) and Byrnes (treatment 1-5). This is possibly because the Kongorong site had significant weeds on site; Figure 6, forcing the trees to grow tall to compete for light.

Treatment 1 at Byrnes was significantly shorter at the 95% confidence limit than the other treatments (Table 3). This is possibly due to the poor survival, high pH and the significant weed loading on the site at time of first year measurement.

Please note that initial heights at planting were not taken into consideration for these height results because there was no significant difference between height of seedlings immediately after planting.

Table 3 Anova table and ranking of tree height between *P. brutia* and *P. pinaster* treatments.

ANOVA

	df	SS	MS	F	P-value	F crit
Between treatments	16633.2	13	1279.48	100.003	8.2E-40	1.86266
Within treatments	895.607	70	12.7944			
Total	17528.8	83				

	Treatment	Tree height (mm)	Ranking	pH	Soil depth (m)
Copping Central Pinaster	14	63	A	8.1	1.1+
Copping Central Pinaster	13	53	B	7.8	0.8+
Copping Border	6	34	C	7.5	1.0+
Kongorong	12	34	C	7.6	1.2+
Copping Central	8	26	D	8.1	1.2+
Kongorong	11	25	D	6.1	0.2
Kongorong	10	20	E	6.4	0.2
Copping Border	7	19	E	7.2	1.2+
Byrnes	4	19	E	7.3	2.3+
Copping Central	9	18	E	8.1	1.3+
Byrnes	3	18	E	7.6	1.8+
Byrnes	5	17	E	7.2	2.3+
Byrnes	2	16	E	7.5	1.5+
Byrnes	1	12	F	7.9	1.2+

Fishers LSD (P = 0.05) = 4.12

1.6.3. Health

There was a significant difference in tree health, Table 4. Trees at Byrnes treatment 1 were significantly poorer in health at the 95% confidence limit than all the other treatments. This reflects the significantly lower survival and height growth of this treatment compared to the other treatments. This result is possibly due to the high pH and high weed loading on the site at the time of first year measurement.

Overall the health of the *P. brutia* is excellent compared with the *P. radiata* established a year earlier than the *P. brutia* (Figure 7).

Table 4 Anova table and ranking of tree health between P. brutia and P. pinaster treatments.

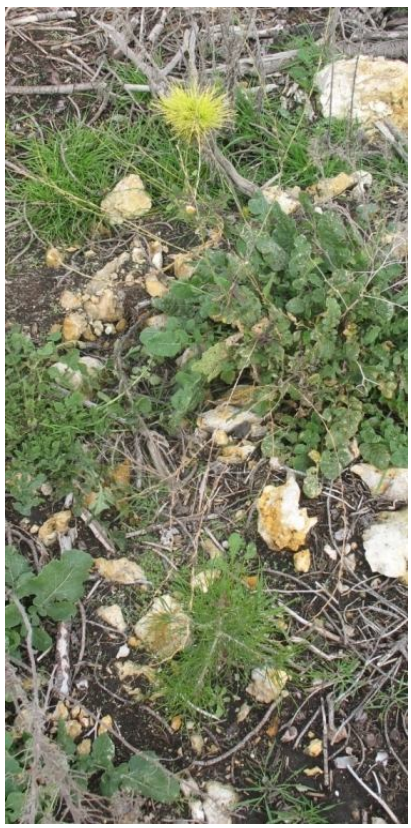
ANOVA

	df	SS	MS	F	P-value	F crit
Between treatments	8.98354	13	0.69104	19.6876	2E-18	1.86266
Within treatments	2.45702	70	0.0351			
Total	11.4406	83				

	Treatment	Tree health (1-6)	Ranking	pH	Soil depth (m)
Copping Central Pinaster	14	1.00	A	8.1	1.1+
Copping Border	6	1.01	A	7.5	1.0+
Kongorong	12	1.01	A	7.6	1.2+
Copping Central Pinaster	13	1.01	A	7.8	0.8+
Kongorong	10	1.02	A	6.4	0.2
Byrnes	4	1.03	A	7.3	2.3+
Copping Central	8	1.03	A	8.1	1.2+
Byrnes	3	1.07	A	7.6	1.8+
Kongorong	11	1.07	A	6.1	0.2
Byrnes	5	1.09	A	7.2	2.3+
Copping Border	7	1.11	A	7.2	1.2+
Copping Central	9	1.17	A	8.1	1.3+
Byrnes	2	1.19	A	7.5	1.5+
Byrnes	1	2.31	B	7.9	1.2+

Fishers LSD (P = 0.05) = 0.959

Figure 7 Difference in health between a P. radiata seedling planted in 2006 (top) and a P. brutia seedling planted in 2007. Image taken 3 July, 2008.



1.7. Discussion and conclusion

The 2007 planting year was dry with less than average rain falling at planting time, between June and September. This tested all plantations established in the region. Poorer survival resulted where the site was cultivated immediately prior to planting and followed by hot dry conditions. Overall the containerised seedlings of both *P. pinaster* and *P. brutia* have very high survival rates.

Survival will be a useful indicator of the stress of shallow soils even in ripped soils due to the large percentage of flinty or rocky calcrete material. The pH of the soil will also be more important as the trees grow and require nutrients, which will be limiting at higher pH. As the trees get larger there is likely to be reductions in survival, which may be observed in future measurements. Overall survival of containerised seedlings of both species of pines is very promising.

Assessing tree height is a good indicator determining whether soil depth and pH are important growth factors. The impact of weeds on competition for light may have distorted some results as competition for light would force the seedlings to concentrate on growing tall. Future measurements will determine if soil depth is a negative effect upon growth on rendzina soils.

Tree health has not been a significant assessment due to the limited influence of pH and nutrient availability on seedling health due to their small size. It only highlighted the poor performance of one treatment. It may be that this treatment is expressing the effects of high pH, as the pH deeper in the profile, which was ripped and mounded is the highest pH of all the treatments at 8.2. Health may become a more valuable observation in future measurements to evaluate the effect of pH on the treatments.