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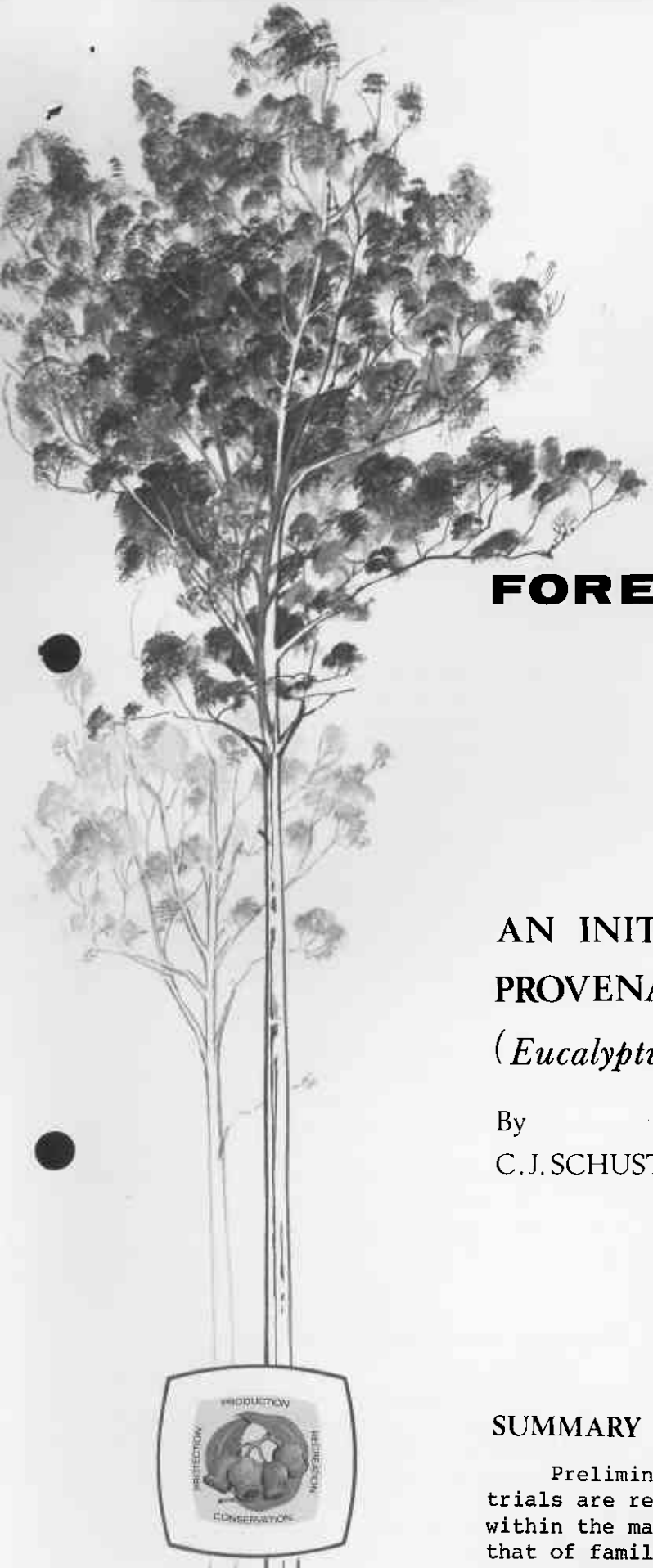

**FORESTS DEPARTMENT**
*OF WESTERN AUSTRALIA*

# AN INITIAL STUDY OF PROVENANCE VARIATION IN KARRI (*Eucalyptus diversicolor* F.Muell.)

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## SUMMARY

Preliminary growth data from karri provenance trials are reported. The growth of families from within the main karri range is generally superior to that of families from outlying areas of the species' range. The exceptions to this are seedlings from the Porongurup Range.

# INTRODUCTION

Karri (*Eucalyptus diversicolor* F. Muell.) is a dominant tree species in the extreme south-west of Western Australia. The species ranges over approximately 180 000 ha, both in pure stands and in association, mainly with marri (*E. calophylla* R. Br.). Consequently, the karri forests are an important facet of both recreational and timber production activities in the region.

Maximum timber production from the species is an important forest management objective. One procedure used to increase production is the application of tree breeding and seed orchard systems to improve future growing stock.

Very little information on provenance variation and breeding of karri has been reported. However, Palzer and Rockel (1973) provided some detail of variation in height growth between provenances, with respect to infection by the root fungus *Phytophthora cinnamomi* Rands.

This paper reports results from a karri progeny experiment established in 1972 and 1973 using open-pollinated progeny of families from throughout the karri range. A "family" here refers to the seedlings grown from seed obtained from a single selected tree.

These trials also formed the basis of a karri seed orchard programme in which the seedlings were thinned to the superior families at age six years. Seed from these orchards will be used to plant second generation stands, through which genetic gains in form and vigour may be possible.

# METHOD

## Family collection

The parent trees from which seed was collected were selected on phenotypic characteristics. The selection criteria were those used for karri seed trees. The major criteria for selection were height dominance, a high, branch-free bole, tree vigour, and the absence of stem defect, although this last was overlooked if the defect was caused by an external agency such as fire.

A capsule-bearing branch from each tree was shot down using a .22 calibre rifle, and the capsules were collected for seed extraction and storage. Each tree from which seed was collected was measured for certain variables, including total height, bole height and stem diameter, and these were recorded.

It was planned to collect and plant 300 families, using a system of proportional representation from the river systems of the karri range, but only 121 families have been planted to date.

The families were placed into categories according to forest blocks within the river systems from which the seed was collected. The locations of collection sites, trial areas and river valleys are shown in Figure 1.

Seed from South African families was sown in the 1973 trials. This seed was collected from open-pollinated progeny grown in South Africa from seed originally collected within the Western Australian karri range.

## Planting locations

The trial plantings were established on two sites, formerly farmlands, which are shown in Figure 1. They are located in the Warren and Gardner Valleys, two of the major river valleys within the karri range.

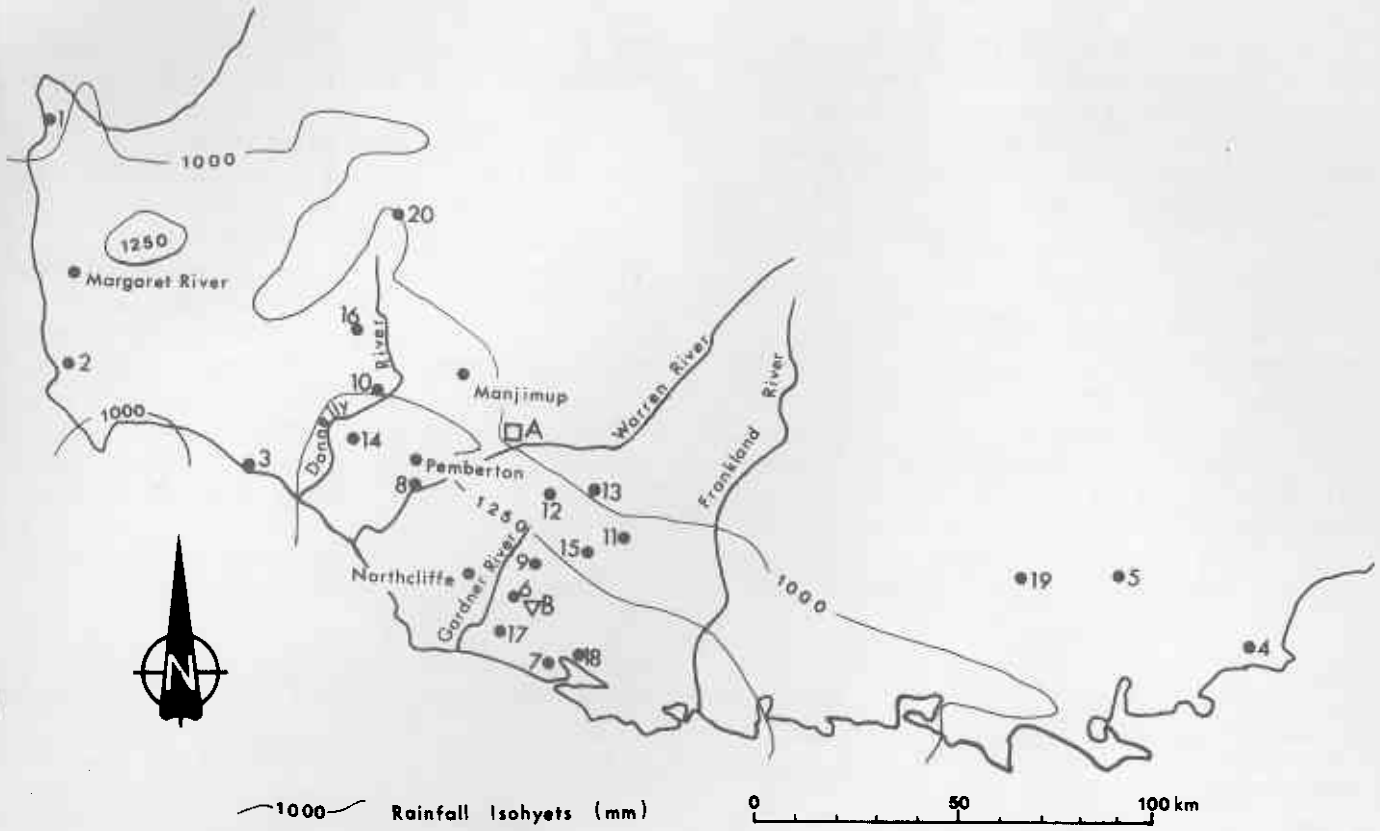
In 1972, 62 of the families were planted on the Warren Valley site, and some families from each sampled valley were planted at the Gardner Valley site.

In 1973 the remaining 59 families were also planted at the Warren Valley site, and some families from each sampled valley were planted at the Gardner Valley site.

## Planting design and techniques

The planting sites were all totally cleared, and ploughed twice before planting. After planting each tree was fertilised with 100 g of phosphorus/nitrogen fertiliser.

The planting stock was germinated in seed trays containing a sand and peat mixture. At age one month the seedlings were replanted into peat "Jiffy" pots, containing a mixture of sand and "blood and bone" fertiliser.




Locations of seed collection sites and trial planting sites

| | | | | |
|---|---|---|---|---|
| 1 Yallingup | 5 Porongurup Range | 9 Jane | 13 Mindinup | 17 Gardner |
| 2 Boranup | 6 Boorara | 10 Gray | 14 Carey | 18 Pingerup |
| 3 Black Point | 7 Maringup | 11 Mattaband | 15 Weld | 19 Mt.Barker |
| 4 Mt.Many Peaks | 8 Warren | 12 Poole | 16 Gordon | 20 Dalgarup |

A □ Warren Valley trial planting site

B ▽ Gardner Valley trial planting site

FIGURE 1: Locations of karri seed collection and provenance trial sites

All plantings were based on a completely randomized block design with five replications. The family replicates were line plots of ten trees planted at a spacing of 2.7 x 2.7 m. This gave a plant stocking of approximately 1300 trees per ha.

Sections of both sites have suffered poor tree survival and some depressed growth, owing mainly to competition from grasses, and browsing by rabbits.

## Assessment

The 1972 plantings were measured in spring 1976 at four years of age, and the 1973 plantings were measured in spring 1978 at five years of age.

In all cases the height and diameter of the five superior trees in every plot of ten trees were measured, as well as plot survival. The five trees were selected on the basis of total height and stem form.

# RESULTS

In the analysis of results, because of excessive deaths within some families, growth data from individual families have been grouped according to the forest block of their origin. The data were subjected to an Analysis of Variance and, where statistically significant differences were found, Duncan's Multiple Range Test (Duncan, 1955) was then used. As there were few real differences the results can be used only to indicate trends in growth differences between progeny from outlying areas and progeny from areas within the main karri range.

Height growth and survival of each family, grouped according to forest blocks or areas, are shown in Tables 1a and 1b. In the tables each forest block is identified according to the major river valley in which it is situated. Areas without a river valley classification lie outside the main range.

Because of constraints of the trial design and the poor survival there can be only limited analysis of differences in height growth between families. Generally, in all four trial plantings, the families exhibiting superior growth came from within the main higher rainfall range of the species, with the exception of the Porongurup families in the 1972 trials.

Few differences exist between progeny from different blocks and between the two planting sites for the 1972 trials. However, families from Black Point exhibited decreased growth and families from Mattaband increased growth in the Gardner Valley trial. This difference within the Mattaband families, from a forest block which contains many high-quality karri stands, was caused largely by extreme grass competition on the plots in the Warren Valley trial, which reduced their growth.

TABLE 1a

Height growth and survival at age 4 years of families from each forest block (1972 plantings)

| Location of trial planting sites | Forest block from which families of seed were collected | Height (m) (95% confidence interval for population mean) | Survival (per cent) | Mean height of parent trees (m) |
|---|---|---|---|---|
| Warren Valley | Warren (Warren)** | 8.11 ± 0.87*a | 83 | 75 |
| | Poole (Warren) | 7.95 ± 0.70a | 80 | 65 |
| | Maringup (Gardner) | 7.75 ± 0.49a | 100 | 65 |
| | Gray (Donnelly) | 7.61 ± 1.10ab | 89 | 65 |
| | Boorara (Gardner) | 7.51 ± 0.90ab | 80 | 55 |
| | Black Point | 7.36 ± 1.08ab | 100 | 50 |
| | Porongurup Range | 7.30 ± 1.38ab | 84 | 55 |
| | Boranup | 7.28 ± 1.22ab | 90 | 40 |
| | Jane (Shannon) | 7.18 ± 1.29ab | 73 | 70 |
| | Mindanup (Shannon) | 7.09 ± 0.82ab | 96 | 65 |
| | Mt. Many Peaks | 6.75 ± 1.71ab | 85 | 40 |
| | Mattaband (Deep) | 6.46 ± 1.56ab | 60 | 70 |
| | Yallingup | 5.31 ± 1.91b | 70 | 40 |
| Gardner Valley | Mattaband | 7.31 ± 0.56a | 95 | 70 |
| | Porongurup Range | 7.18 ± 0.52a | 97 | 55 |
| | Warren | 7.02 ± 0.58a | 95 | 75 |
| | Poole | 6.85 ± 0.81a | 94 | 65 |
| | Jane | 6.79 ± 0.86ab | 90 | 70 |
| | Boorara | 6.65 ± 0.75ab | 88 | 55 |
| | Maringup | 6.56 ± 0.77ab | 87 | 65 |
| | Boranup | 6.00 ± 0.79abc | 90 | 40 |
| | Mindanup | 5.91 ± 0.94abc | 90 | 65 |
| | Yallingup | 5.36 ± 0.63bc | 85 | 40 |
| | Black Point | 4.55 ± 1.17c | 75 | 50 |
| | Mt. Many Peaks | 4.55 ± 1.03c | 65 | 40 |

* Data notated with the same letter are not significantly different at $p < 0.025$

** Locality in brackets refers to the river valley in which the block is situated. Areas without a river valley classification are outliers from the main range

No large differences were found among survival figures, except for the Mt. Many Peaks families in the 1972 plantings at the Gardner Valley site. This difference was caused mainly be competition from uncontrolled shrub species.

Diameter growth for families in the four trials is shown in Tables 2a and 2b.

Diameter growth data show trends similar to those of height growth data in Tables 1a and 1b. The families collected within the main karri range show a trend towards greater diameter growth, as well as greater height growth.

One exception to this trend was exhibited by the Pingerup families which, in the 1973 Warren Valley trial, showed poor height growth but excellent diameter growth.

However, within-family and within-block variations were as great as any between-block variations evident in this analysis for diameter growth.

## DISCUSSION

These preliminary trials showed some variation in diameter and height growth between open-pollinated families of karri from within and outside the main range of the species.

Early results indicate that breeding from superior families may effect some

TABLE 1b

Height growth and survival at age 5 years of families from each forest block (1973 plantings)

| Location of trial planting sites | Forest block from which families of seed were collected | Height (m) (95% confidence interval for population mean) | Survival (per cent) | Mean height of parent trees (m) |
|---|---|---|---|---|
| Warren Valley | Warren (Warren)** | 9.36 ± 1.43*a | 90 | 75 |
| | Gardner (Gardner) | 8.42 ± 1.65a | 88 | 60 |
| | Mattaband (Deep) | 8.40 ± 0.58a | 91 | 75 |
| | Weld (Weld) | 8.26 ± 0.96a | 70 | 70 |
| | Boorara (Gardner) | 8.26 ± 1.61a | 78 | 60 |
| | Lindsay (Donnelly) | 8.05 ± 0.89a | 90 | 70 |
| | South Africa | 7.77 ± 1.22a | 88 | N.A. |
| | Pingerup (Shannon) | 7.66 ± 0.79a | 87 | 65 |
| | Dalgarup (Blackwood) | 7.63 ± 0.94a | 90 | 60 |
| | Boranup | 7.23 ± 1.92a | 75 | 40 |
| | Mt. Barker | 6.91 ± 1.49a | 74 | 45 |
| Gardner Valley | Carey | 7.26 ± 2.30ab | 90 | 70 |
| | Boorara | 6.96 ± 0.70a | 86 | 60 |
| | Weld | 6.95 ± 0.87ab | 96 | 70 |
| | Gordon | 6.69 ± 0.75ab | 80 | 65 |
| | Warren | 6.53 ± 0.50ab | 97 | 75 |
| | Mattaband | 6.14 ± 0.43ab | 92 | 75 |
| | South Africa | 5.95 ± 0.75ab | 92 | N.A. |
| | Gardner | 5.88 ± 1.05ab | 80 | 60 |
| | Pingerup | 5.51 ± 0.59b | 80 | 65 |
| | Mt. Barker | 5.39 ± 0.80b | 91 | 45 |
| | Dalgarup | 5.25 ± 0.67b | 90 | 60 |

* Data notated with the same letter are not significantly different at $p < 0.025$.

** Locality in brackets refers to the river valley in which the block is situated. Areas without a river valley classification are outliers from the main range

N.A. South African height data not available.

TABLE 2a

Diameter growth at age 4 years of families from each forest block (1972 plantings)

| Location of trial planting sites | Forest block from which families of seed were collected | Stem diameter over bark (cm) measured at breast height (1.3 m) (95% confidence interval for population mean)* |
|---|---|---|
| Warren Valley | Warren (Warren)** | 10.77 ± 1.81*a |
| | Poole (Warren) | 10.02 ± 2.62a |
| | Gray (Donnelly) | 9.99 ± 2.35a |
| | Jane (Shannon) | 9.72 ± 1.77a |
| | Boorara (Gardner) | 9.64 ± 1.78a |
| | Porongurup Range | 9.55 ± 1.81a |
| | Mindanup (Shannon) | 9.50 ± 1.81a |
| | Mattaband (Deep) | 9.38 ± 2.26a |
| | Black Point | 9.19 ± 2.49a |
| | Maringup (Gardner) | 8.70 ± 1.14a |
| | Boranup | 8.43 ± 2.48a |
| | Mt. Many Peaks | 7.87 ± 2.54a |
| | Yallingup | 7.34 ± 2.65a |
| Gardner Valley | Mattaband | 9.99 ± 1.04a |
| | Poole | 9.42 ± 1.77a |
| | Porongurup Range | 9.22 ± 1.39a |
| | Warren | 8.93 ± 1.08a |
| | Jane | 8.95 ± 2.36ab |
| | Boorara | 8.78 ± 1.57ab |
| | Maringup | 8.37 ± 1.57ab |
| | Mindanup | 7.95 ± 1.79ab |
| | Yallingup | 7.43 ± 0.78ab |
| | Boranup | 7.36 ± 1.58ab |
| | Black Point | 7.15 ± 2.80ab |
| | Mt. Many Peaks | 5.17 ± 2.80b |

* Data notated with the same letter are not significantly different at $p < 0.025$.

** Locality in brackets refers to the river valley in which the block is situated. Areas without river valley classification are outliers from the main range.

increase in timber volume production. However, care is required when comparing growth characteristics between progeny at an early age (Giertych, 1974).

With the exception of the families from the Porongurup Range the families exhibiting superior growth in these trials generally came from the major river valleys within the main karri range, principally the Warren, Donnelly, Deep and Gardner Valleys. As both the trial sites reported here were within the main karri range, this result has implications for an operational regeneration programme.

The families from the Porongurup Range performed well on both the 1972 trial sites. The average annual rainfall in the Porongurup Range is approximately 800 mm, whereas that in the four valleys mentioned above is over 1000 mm.

Tables 1a and 1b show the mean heights of the parent trees for all areas and it appears that height growth, at least up to age five years, is well correlated with the height of the mature parent tree. Consequently, families from the Mattaband and Warren Blocks, collected from trees with a mean height of 75 m, exhibit

TABLE 2b

Diameter growth at age 5 years of families from each forest block (1973 plantings)

| Location of trial planting sites | Forest block from which families of seed were collected | Stem diameter over bark (cm) measured at breast height (1.3 m) (95% confidence interval for population mean)* |
|---|---|---|
| Warren Valley | Warren (Warren)** | 11.89 ± 3.20*a |
| | Pingerup (Shannon) | 11.73 ± 1.13a |
| | Lindsay (Donnelly) | 11.67 ± 1.01a |
| | Mattaband (Deep) | 11.42 ± 0.83a |
| | Weld (Weld) | 11.24 ± 1.30a |
| | Boorara (Gardner) | 10.87 ± 2.31a |
| | Gardner (Gardner) | 10.84 ± 1.29a |
| | South Africa | 10.39 ± 1.79a |
| | Dalgarup (Blackwood) | 10.26 ± 1.15a |
| | Boranup | 9.53 ± 3.05a |
| | Mt. Barker | 9.41 ± 2.08a |
| Gardner Valley | Weld | 10.51 ± 1.72a |
| | Gordon | 10.24 ± 1.23a |
| | Boorara | 10.03 ± 1.93a |
| | Warren | 9.32 ± 0.86a |
| | Carey | 9.00 ± 1.24ab |
| | Mattaband | 8.87 ± 0.67ab |
| | South Africa | 8.35 ± 1.29ab |
| | Gardner | 8.32 ± 2.26ab |
| | Pingerup | 7.62 ± 1.53ab |
| | Dalgarup | 7.59 ± 1.67ab |
| | Mt. Barker | 6.80 ± 1.43b |

* Data notated with the same letter are not significantly different at $p < 0.025$.

** Locality in brackets refers to the river valley in which the block is situated. Areas without a river valley classification are outliers from the main range.

growth trends superior to those of families from the Mt. Barker, Mt. Many Peaks and Boranup areas, where parent trees ranged from 40 to 45 m in height. However, Boranup is not yet a mature forest, and height will possibly increase here with time.

The absence of large variations between provenances may be attributed partly to the lack of environmental and other extremes within the range (Palzer and Rockel, 1973). Large variations between provenances in other *Eucalyptus* species have been exhibited where extremes of latitude, altitude, soils and climate existed. Green (1971) reported significant variations between provenances of *E. obliqua* l'Herit, a species with a wide range of latitudinal and altitudinal variation.

## CONCLUSION

Early growth results show the existence of superior provenances within the major valleys of the karri range. Seed collections should be made in these areas for regeneration operations within the main karri range.

Currently within-provenance variation is as important as between-provenance variation in most cases. There are few variations in family growth between the two sites.

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