



An Australian Government Initiative



Assessment of Central and South East Queensland 12-25 Year Old Farm Forestry Species Trials

By Greening Australia Queensland (Inc.)

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Foreword

There is a growing interest and increasing opportunity for private landholders to become involved in hardwood plantations in Queensland, as timber harvesting is phased out of native forests from crown land by 2025 and new plantation supply is needed.

There are few older-age species trials and it is rare for them to be re-measured and assessed – but this data is important to verify species suitability to sites and long term growth and yield. Likewise, information on species suited to lower rainfall areas of Queensland is limited. This project assessed long term tree performance by gathering information from old farm forestry trial plots, aged 12-25 years, from the drier rainfall areas of central and south east Queensland. The focus was on species suited to sawlog production. The research is intended to help landholders and rural decision makers make informed choices about species-to-site matching for timber production, and to identify forestry tree trials suitable for further research.

In central Queensland, *Corymbia citriodora* (spotted gum) performed well on a variety of soils in the Rockhampton and Yeppoon areas, with the best results coming from well managed, block trials on duplex soils around the higher rainfall area of Yeppoon. There were three sites containing *C. citriodora* identified as worthy of further monitoring. From limited data, *Eucalyptus argophloia* (western white gum) indicated good promise as a production species for the Biloela region. Further monitoring of recent trials is recommended for this species, to better understand its performance under plantation conditions in this region. Gympie messmate (*E. cloeziana*) performed well around the high rainfall Yeppoon area when well sheltered.

In south east Queensland, *C. henryi* (large-leaved spotted gum) performed well at a site near Tarome. This species may have plantation potential in this region, but the affects of *Ramularia* shoot blight on the species would need to be investigated. Most other sites showed average to below average performance. From the trials assessed in southeast Queensland, the Tarome site was the only one site worthy of revisiting.

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This report is an addition to RIRDC's diverse range of over 1700 research publications. It forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems. The JVAP, under this program, is managed by RIRDC.

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Peter O'Brien

Managing Director

Rural Industries Research and Development Corporation

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Howard Rogers (formerly of Greening Australia Queensland Inc) provided the assessments for the South East Queensland region and has contributed to several sections of this report.

The previous work carried out in south east Queensland by Geoff Borschmann, David Carr and Jim Johnston in 1991 and 2003 was a helpful reference for additional site details. David Carr also kindly lent Vertex measurement equipment for the central Queensland surveys.

Finally I would like to thank all the landholders involved in the early species trials who kindly welcomed us onto their properties, and who were able to provide details of the trials after such a long period.

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Executive summary

What the report is about

This report evaluates a range of older-age species trials established in central and south east Queensland low to medium rainfall zones. The report provides information on the success and failure of potential plantation species, and identifies which of the early forestry tree plantings are suitable for further research. The information is useful as there is little published data on older-age growth of species in low to medium rainfall regions on Queensland.

Who is the report targeted at?

This information will help primary producers, natural resource consultants, regional forest associations and researchers make informed choices about species-to-site matching for timber production.

Background

There is proximity to ports and processing, and suitable land and climate for growing hardwood species in plantation in central and south east Queensland. Forest industry investors are currently expanding in these regions. There are also opportunities for farm forestry. However long term growth data on which to predict yield, is limited for most species and sites.

Between 1980 and 1993, over 500 trial plots of native species were established across central and southeast Queensland. Some south east Queensland trials were re-measured in 2003, but otherwise none of the trials had been reviewed to determine their condition and tree growth. Revisiting these early species trials gave the opportunity to assess species performance on a range of sites.

Aims

The objectives of this current study were a) to locate, survey and report on the condition of species in these plantings, and b) identify which of the early forestry tree plantings are suitable for further research.

Methods

The database containing central Queensland site information was filtered with selection criteria based on target species and management history, in order to select suitable sites for further investigation. Ten sites in CQ were assessed based on the results of this selection process. After collating and analysing available data on the southeast Queensland sites, rapid-appraisal site assessments were carried out. From this region, seven sites had species showing at least reasonable performance which were worthy of measurement.

Trees were measured for their height, height to crown break, diameter at breast height and various form ratings such as stem straightness. Sites were also assessed in terms of management input, rainfall, soil type, planting layout and survival rates.

Results

From the central Queensland data, several observations were made:

- *Corymbia citriodora* (spotted gum) performed well on a variety of soils in the Rockhampton and Yeppoon areas, with the best results from well managed, block trials on duplex soils around the higher rainfall area of Yeppoon.
- From limited data, *Eucalyptus argophloia* (western white gum) indicated good promise as a production species for the Biloela region.
- *E. cloeziana* (Gympie messmate) performed well on sheltered areas around the high rainfall Yeppoon area.
- Most of the remaining unsuccessful species were strip-planted in low numbers for amenity.

In south east Queensland:

- *C. henryi* (large-leaved spotted gum) did well at a site near Tarome. This species may have plantation potential in this region, but the effect of *Ramularia* shoot blight on the species needs to be investigated.
- *E. argophloia* and *E. punctata* (grey gum) showed average performance, while most others species performed poorly

Recommendations

- In terms of future research, three well managed *C. citriodora* block trials in central Queensland and one site from south east Queensland containing *C. henryi* may be of interest for future monitoring.
- The effects of *Ramularia* shoot blight on *C. henryi* in south east Queensland needs to be investigated before it can be recommended for more widespread planting
- Further monitoring of Queensland Department of Primary Industries and Fisheries (DPI&F) trials is recommended for *E. argophloia*, to understand the performance of this species under plantation conditions in the Biloela region.
- A range of other species which were planted in narrow strips could not reasonably be assessed for growth performance. To deduce useful farm forestry information, well-managed, block trial assessments for these species need to be undertaken.

Introduction

The Queensland Government proposes to phase out timber harvesting of native forests from crown land by 2025. After this, hardwood sawlog production will come from private native forest and plantations. Consequently there is an increasing opportunity for landholders to become involved in hardwood plantations via farm forestry. Private landholders are currently benefiting from joint venture plantations with the Department of Primary Industries and Fisheries (DPI&F) and various forestry investment companies for both short-rotation hardwood pulp species and sawlog species.

However, opportunities are confined to a restricted number of species that have known site and climatic requirements. Development of new opportunities across a wider site and climatic range is partly dependent upon trialling new species and provenances. DPI&F have recently established an extensive tree species trial program over a range of sites and climates. However the results from these trials will not be known for some time (until trials reach maturity). There has been no comprehensive overview of old forestry tree trial plots and little research completed on the performance of possible plantation species in low rainfall regions of Queensland.

Greening Australia Queensland (Inc) (GAQ) established 500 native species trial plots across south east Queensland (Lockyer and Fassifern valleys) and central Queensland (Fitzroy basin) from 1980 to 1993. This work was part of the Commonwealth Government Community Employment Program with support from CSIRO Forests and Forest Products, the Queensland Department of Primary Industries and Lockyer Watershed Management Association. Plots were established for a variety of reasons including shade and windbreaks, alleviating water-logging, creating amenity and timber production.

This report details the growth and survival rates and tree form ratings of these trials, discusses aspects of the sites and reports on the success or otherwise of tree species on specific sites. Recommendations as to the suitability of tree species are provided along with recommendations for future research.

Objectives

The principal objectives of the study were to locate, record and report on early forest tree trials planted from 1980 to 1993 in Central and South East Queensland, and to identify early forestry tree plantings suitable for future research.

This study reviewed the large number of trials plots currently underway then selected and visited suitable sites. From the selected sites, tree measurements and site information were collected and summarised.

The information generated from this project aims to:

- assist rural decision makers such as primary producers, natural resource consultants, regional forest associations and researchers to make more informed choices about species-to-site matching for timber production
- provide direction for further research.

Methodology

The methodology for this project involved firstly collating and assessing trial information for south east Queensland (SEQ). Landholders were contacted and a rapid appraisal of SEQ sites was undertaken during January 2005. The SEQ data collection methods were reviewed and detailed selection criteria and a different data collection method was formulated for central Queensland (CQ) sites. CQ site assessments were undertaken in December 2005.

Site selection

SEQ sites were selected and assessed first. Information was collated on 59 sites based on original planting records (see Appendix 3), plot data entry sheets, and a report (Borschmann and Johnston, 1991) detailing results from an assessment of 25 of the original sites. For most of the SEQ sites the original planting maps and trial design information no longer existed. Moreover, several sites lacked any current contact information or site location details. A rapid appraisal approach was taken to visit and survey as many SEQ sites as possible that had documented site location details. Field measurements were carried out at sites where species showed milling potential.

For CQ there is a database of 443 sites involved in the Early Forest Tree Trials from 1980 to 1993. Selection criteria was developed by the reference group (refer to Acknowledgements section) after the SEQ rapid appraisal was carried out, in order to filter the CQ database to a smaller number of sites. The selection criteria were:

- plots containing *Eucalyptus* and *Corymbia* species
- trials established with the objective of timber production
- trial of a size sufficient to provide replicate samples for measurement
- trials in a block design

Contact with CQ landholders was then attempted on the 86 filtered sites, in order to determine current site condition. Sites that were known to have performed poorly (low survival and/or poor growth) were excluded. A short list of 15 sites was prioritised depending on the presence of key species (species where more research is required, as determined by the reference group), followed by site condition and performance.

The key species for CQ were:

- *Corymbia citriodora* (spotted gum), due to the large number of trees to be measured and time constraints this species was not identified to the sub species level.
- *Corymbia tessellaris* (carbeen)
- *Corymbia torelliana* (cadaghi)
- *Eucalyptus argophloia* (western white gum)
- *Eucalyptus cloeziana* (Gympie messmate)
- *Eucalyptus drepanophylla* (grey ironbark)
- *Eucalyptus moluccana* (gum topped box)

The following species were considered important, but of lower priority than those listed above:

- *Casuarina glauca* (swamp oak)
- *Eucalyptus camaldulensis* (river red gum)
- *Eucalyptus cambageana* (Dawson gum)
- *Eucalyptus crebra* (narrow leaved ironbark)
- *Eucalyptus sideroxylon* (red ironbark)

Field measurements

A more thorough assessment was required by the project reference group for CQ, the second region to be assessed. Because of this there are differences in the methodology used for CQ and SEQ.

For trees at both CQ and SEQ sites the following was recorded:

- Diameter at breast height (DBH) - measured at 1.3 m above ground level
- Height (to nearest 10 cm) using a Vertex
- Height to crown break (to nearest 10 cm) using a Vertex
- Position in the stand (edge or internal)
- Axis of persistence
- Stem straightness
- Branch habit
- Health

The tree form rating system used for the surveys is outlined below, and based on McLeod et al. (in press).

Tree axis of persistence

Axis of persistence describes whether the tree is single stemmed or multi-stemmed, and if both, where the change occurs. It is the 'persistence' of the single stem that is scored. The score is related to the quarter of the tree in which any change from single to multi stem takes place. The following rating system was used.

Rating	Code
6	Complete persistence
5	Axis loses persistence in the top or fourth quarter of tree
4	Axis loses persistence in the third quarter of the tree
3	Axis loses persistence in the second quarter of the tree
2	Axis loses persistence in the lowest or first quarter of the tree
1	There are double or multiple stems from ground level

Stem form and straightness

Stem form and straightness are only assessed for the main stem of trees with axis persistence score of 4 or greater. The following rating system was used.

Rating	Code
6	Excellent tree, very straight
5	Very good tree, one minor deviation from straightness
4	Good tree, two deviations from straightness
3	Average tree, three deviations from straightness
2	Poor tree, five deviations from straightness
1	Extremely poor tree with multiple deviations

Branching habit

The following scoring system for the branching habit of a tree can be adjusted according to the characteristics of the species being assessed. In the table, '<10% of stem diameter' means the tree's average branch diameter is less than 10% of the average diameter of the main stem (or trunk).

Rating	Code
6	Very light branching, <10% of stem diameter
5	Light branching, 10% of diameter
4	Moderate branching, 10–20% of stem diameter
3	Heavy branching, 20–30% of stem diameter
2	Very heavy branching, 30–50% of stem diameter
1	Extremely heavy branching, >50% of stem diameter

Tree health and vigour

Individual tree health and vigour was scored in conjunction with height measurements. The following rating system was used.

Rating	Code
6	Excellent health or vigour
5	Very good health or vigour
4	Good health or vigour
3	Poor health or vigour
2	Very poor health or vigour
1	Dying or dead

These measurements and form ratings provided a good snapshot of tree performance for both growth rates and appearance.

Other data

For each species at a site, survival rate was either estimated or calculated based on the original planting details. Soils were classified by appearance in the field, and then by desktop assessment using Natural Resources and Mines (NRM) *Interactive Resource and Tenure Maps* (Natural Resources and Mines, 2005) Atlas of Soils description. Rainfall data was collected from landholders. When this was not available, rainfall data from the closest Bureau of Meteorology (BOM) weather station was used.

Central Queensland specific methodology

The CQ survey aimed to gather at least three replicates of 20 plants of each key species at a site (or as many as possible if survival was low). The survey also aimed to gather information from at least three different properties as replicates for each key species. Only the top ten performing plants of each key species were assessed at each site. A photo was taken, and a score given for product potential (see below) for the top ten trees for each target species at each site. Product potential scores are only an indication of how the timber could be utilised at harvest.

Rating	Product
6	All pole
5	Sawlog or pole
4	All sawlog
3	Pulp/woodchip or sawlog
2	Pulp/woodchip
1	Useless (Not worth harvesting)

South East Queensland specific methodology

As part of the rapid appraisal for SEQ sites, five to ten representative individuals of each species that performed acceptably were measured. No product potential rating was allocated.

Data analysis

Where sufficient numbers of trees were sampled, the height and DBH measurements were converted to average growth per year in order to compare between sites of different age. The collected data was analysed for mean and standard deviation. When sites had less than five representatives of a species, measurements were recorded in the comments section for each site (refer Appendix 1 and 2), and results shown in Table 1, but the data was not summarised. There were three replicates of 20 trees for *C. citriodora* across three different CQ sites, but because plantings were carried out over a 13-year period (1980, 1991 and 1993) in-depth statistical comparisons were not made. Most other species had from five to 30 specimens per site.

Results

Limitations of results

Before selecting suitable sites, landholders were contacted. Due to the age of the trials (up to 25 years) many of the properties had changed hands over the years; some landholders had harvested or removed the tree plots while many other trials had died from drought. This limited the number of sites suitable for survey.

Historical details for some sites were also unavailable. Most commonly, details on management, species planted and number planted were missing. This restricts the interpretation of results.

Upon visiting sites, it was often discovered that some of the trials had not gone ahead, certain species recorded in the database were not planted, or species provided for the trial were different from those recorded on the database. In some cases previous trials were present and measured instead.

Central Queensland results

Of the 15 priority sites in CQ, ten were visited (Table 1). The sites varied considerably in age, regional conditions and management input. Of the ten visited sites, four had been planted in block design for timber production and six were planted mostly to address amenity or erosion control issues.

Average results for CQ measurements and survival rates and standard deviation are presented in Table 1. Average annual increment for height and DBH, and mean height to crown break measurements are shown in Figures 1 and 2. Detailed site profiles, form ratings and photos for each site are in Appendix 1.

In this report, sites are referred to by their location, rather landholder's name. The sites named Callide East and Callide West are north of Biloela. The sites Rockhampton, Glenmore and Alton Downs are in the Rockhampton area. Bungundarra, Farnborough, Cawarral and the Forestry Trial are around Yeppoon. Marmor is half way between Rockhampton and Gladstone (see Appendix 3).

Table 1. Survival, average height and diameter, and form ratings of key species planted on ten sites in Central Queensland (measurements taken December 2005).

						Averages											
Region and site name	Age (years)	Key Species	Number planted	Number surviving	Survival (%)	Ht (m)	Ht/year (m) (st.dev)	Crown break ht (m)	DBH (cm)	DBH/year (cm) (st.dev)	Axis of persistence	Stem straightness	Branch habit	Health	Product potential	% edge affected (top 10)	
Biloela																	
Callide East	19	<i>E. argophloia</i>	50*	11	22*	19.8	1.04 (0.19)	2.7	41.5	2.18 (0.28)	3.4	3.9	2.9	5.6	4.1	100	
		<i>E. camaldulensis</i>	50*	8	16*	11.0	0.58 (0.18)	2.0	29.5	1.55 (0.44)	2.6	2.8	2.4	3.8	2.4	100	
		<i>C. citriodora</i>	75	9	12	12.4	0.65 (0.21)	3.1	22.1	1.17 (0.41)	3.6	4.4	3.0	4.4	3.4	14	
		<i>E. crebra</i>	25*	8	32*	9.0	0.47 (0.12)	2.8	18.3	0.97 (0.41)	3.7	4.1	3.1	4.0	2.0	42	
		<i>E. moluccana</i>	75	35	46	11.5	0.60 (0.13)	2.7	22.9	1.21 (0.28)	2.8	3.5	3.3	3.9	2.3	8	
		<i>E. sideroxylon</i>	75	35	46	11.2	0.59 (0.13)	3.2	26.4	1.39 (0.37)	2.7	2.7	2.6	4.1	2.6	100	
		<i>C. tessellaris</i>	75	5	7	9.9	0.52 (0.23)	2.2	18.4	0.97 (0.47)	3.0	3.0	3.0	5.0	2.7	100	
Callide West	12	<i>E. argophloia</i>	40	1	NA	17.0		4.6	32		4.0	4.0	3.0	4.0	4.0	100	
		<i>E. crebra</i>	40	11	27	10.8	0.90 (0.14)	2.9	24.4	2.04 (0.36)	3.4	3.3	2.7	4.0	2.6	100	
Marmor																	
Marmor	12	<i>C. citriodora</i>	300	150	50	13.3	1.11 (0.20)	6.5	11.0	0.92 (0.30)	3.8	4.6	3.9	4.2	4.2	20	
Rockhampton																	
Alton Downs	20	<i>E. argophloia</i>	37	6	16	11.4	0.57 (0.10)	2.3	23.1	1.16 (0.32)	4.0	3.4	4.6	3.2	2.4	100	
		<i>E. citriodora</i>	37	9	24	9.6	0.48 (0.10)	3.4	12.7	0.64 (0.23)	3.2	2.3	3.7	3.7	2.0	100	
		<i>E. moluccana</i>	37	17	46	12.3	0.62 (0.09)	2.0	25.4	1.27 (0.18)	2.8	3.9	2.8	3.8	2.7	100	
		<i>C. torelliana</i>	37	16	43	6.3	0.32 (0.09)	1.4	15.0	0.75 (0.24)	2.5	3.4	2.3	3.8	1.9	100	
Glenmore	14	<i>C. citriodora</i>	10–30*	5	16–50*	10.0	0.71 (0.05)	3.4	14.7	1.05 (0.18)	3.4	4.0	3.6	3.8	1.8	80	
		<i>E. drepanophylla</i>	10–30*	5	16–50*	8.7	0.62 (0.16)	2.1	15.9	1.14 (0.33)	3.6	4.0	4.2	4.0	1.6	60	
		<i>E. moluccana</i>	10–30*	6	20–60*	15.5	1.10 (0.37)	2.0	23.6	1.69 (0.46)	2.8	3.7	2.8	3.8	2.5	0	
		<i>E. sideroxylon</i>	10–30*	3	10–30*	10.0		0.2	14.5		2.0	1.3	4.0	3.7	1.3	33	

Rockhampton	15	<i>C. citriodora</i>	100	90	90	11.6	0.77 (0.35)	6.1	11.4	0.76 (0.22)	4.4	4.4	4.5	4.1	4.3	20
Yeppoon																
Bungundarra	14*	<i>E. camaldulensis</i>	unknown	4*	–	14.9		3.6	19.3		3.0	3.0	3.0	3.6	2.7	0
		<i>C. citriodora</i>	unknown	14*	–	16.1	1.15 (0.32)	7.3	15.6	1.11 (0.38)	3.7	4.2	4.1	4.1	2.9	0
		<i>E. cloeziana</i>	unknown	16*	–	19.3	1.57 (0.20)	6.8	22.0	1.57 (0.49)	4.0	4.5	4.2	4.7	3.9	0
		<i>C. torelliana</i>	unknown	11*	–	10.6	0.76 (0.16)	2.0	14.7	1.05 (0.35)	3.0	3.3	3.1	3.9	2.3	0
Cawarral	25	<i>C. citriodora</i>	1000*	400	40*	19.7	0.79 (0.21)	8.9	20.9	0.84 (0.29)	3.5	4.5	4.2	4.1	5.0	80
Farnborough	14	<i>C. citriodora</i>	40*	24	60*	13.4	0.95 (0.22)	5.8	15.3	1.09 (0.31)	3.6	3.6	4.0	4.1	3.4	50
		<i>E. cloeziana</i>	20*	3	15*	8.7		1.5	14.2		2.3	3.7	3.3	3.3	1.7	100
		<i>C. torelliana</i>	20*	10	15*	6.7	0.48 (0.09)	2.2	11.7	0.84 (0.12)	2.8	3.5	3.2	3.6	1.3	100
Forestry Trial	4	<i>C. citriodora</i>	80	70	87*	9.3	2.32 (0.37)	4.7	10.0	2.51 (0.82)	3.7	4.5	4.7	3.9	1.9	20
		<i>E. cloeziana</i>	15	15	100	8.2	2.06 (0.32)	1.0	12.3	3.08 (0.51)	2.7	3.6	3.5	4.0	1.9	20
		<i>E. drepanophylla</i>	20	17	85	6.7	1.67 (0.31)	1.1	10.8	2.71 (0.47)	4.3	3.5	4.3	4.2	2.0	0
		<i>C. torelliana</i>	15	12	80	5.8	1.46 (0.44)	0.6	11.0	2.75 (0.69)	3.7	4.5	3.5	4.1	2.0	10

* specific detail unavailable, approximate number only.

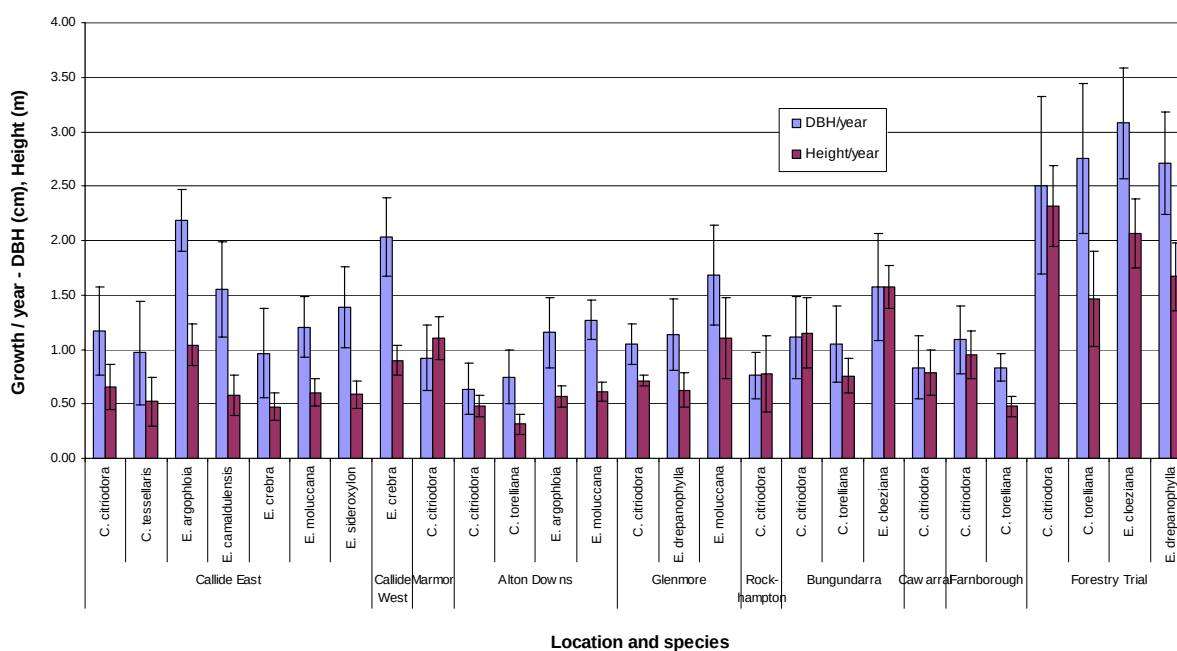


Figure 1. Mean annual increment for diameter at breast height and height for key species planted on ten sites in Central Queensland (tree age 4-25 years, measurements taken December 2005).

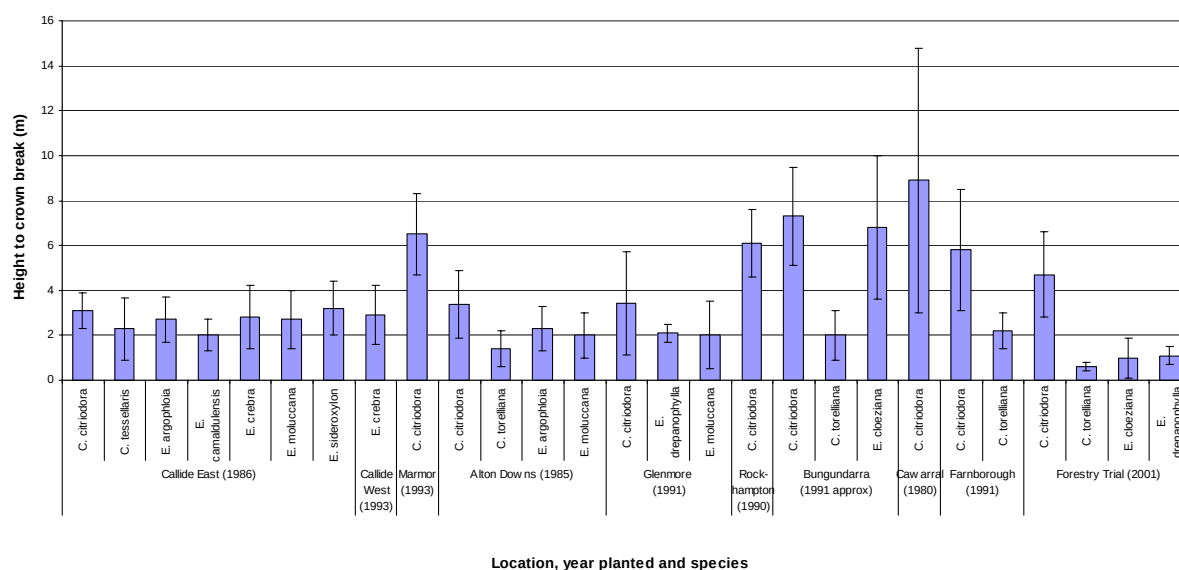


Figure 2. Mean height to crown break of key species planted on ten sites in Central Queensland (tree age 4-25 years, measurements taken December 2005).

Sites that performed well include:

- the Forestry Trial site – this planting had very good growth rates but a low average crown break (this planting was due for ground pruning).
- the 25-year-old planting at Cawarra, the Marmor site, and the Rockhampton *C. citriodora* plot. These sites had only an average growth rate but good form and high crown breaks.
- the *E. argophloia* at Callide East at also performed well with reasonable yearly growth rates, but a low crown break from lack of pruning.

- The Bungundarra scattered planting showed good results with tall, healthy trees, but the age of the planting could only been estimated.

Poor performing sites include Alton Downs and the Callide East strip plantings, the small block planting at Glenmore and the Strip plantings at Farnborough and Callide West showed average performance.

Appendix 1 contains detailed site profiles for CQ sites and graphs the results of tree form ratings.

Environmental conditions and regional variation in central Queensland

Table 2. Climatic conditions for trial site regions of Central Queensland taken from Bureau of Meteorology website, 2006.

Region	Site record number	Years of measurement	Elevation above sea level (m)	Averages / year			
				Rainfall (mm)	Max temp (°C)	Min temp (°C)	Humidity (%)
Biloela	Callide East, Callide West	1924–1996	175	683	28.3	12.9	64 at 9am
Rockhampton	Rockhampton, Alton Downs, Glenmore	1939–2004	10	805	28.3	16.6	69 (9am) 47 (3pm)
Yeppoon	Bungundarra, Garnborough, Cawarral	1891–2004	75	1312	25.5	17.3	73

The climatic conditions between these regions varies considerably. This can be expected to impact on species performance. Landholder records have shown that average rainfall for the last 10–15 years has been much lower than the Bureau of Meteorology averages provided above.

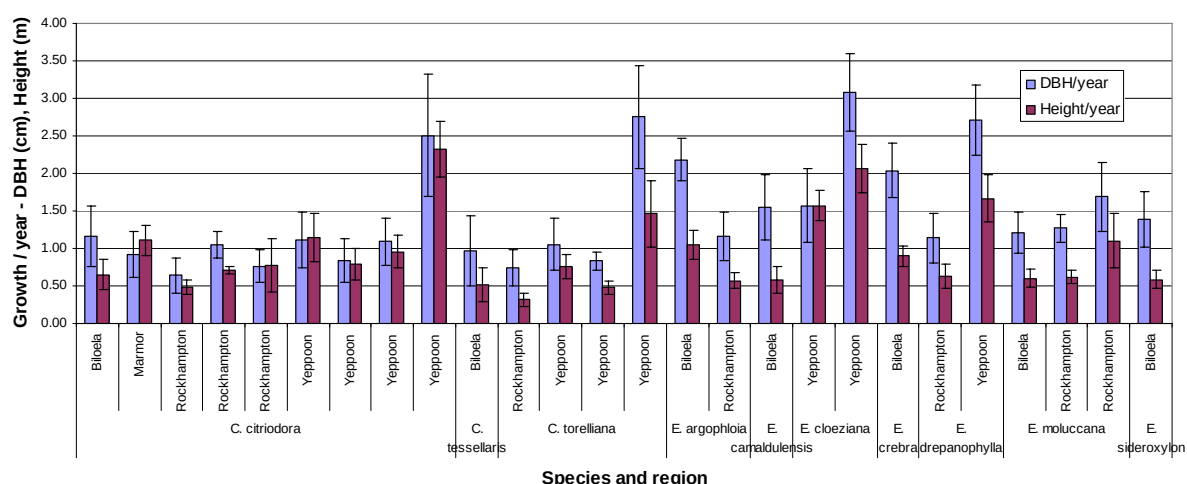


Figure 3. Regional variation in performance of key species (height and diameter at breast height per year) at ten sites of Central Queensland (tree age 4-25 years, measured in December 2005).

Overall, *C. citriodora* performed the best in the Yeppoon region in terms of mean annual height and DBH. *E. cloeziana* also showed good results in the Yeppoon region, at the Bungundarra and Forestry Trial sites. *E. argophloia* showed much better performance in the Biloela region than the

Rockhampton region. There were no outstanding performances for *C. tessellaris*, *E. camaldulensis*, *E. sideroxylon* and *E. moluccana*. *Corymbia torelliana* and *E. drepanophylla* performed well at the Forestry Trial Site in Yeppoon, but not in other regions where they were grown.

South East Queensland results

Of the 23 sites visited in SEQ, there were seven that showed promise of commercial timber value making them worthy of tree measurement. Most of these sites only contained one species that performed well. The Tarome site had three species with over 50% survival rate. The high survival rate may be attributed to a high level of maintenance by the landholder. The Mt Berryman and Gatton sites had 50–60% survival rate for two species.

The remaining 15 sites visited were rejected for measurement because they had no commercial timber value other than a small quantity of firewood. Failed sites were generally so poor that no detailed inspection was made. These sites were characterised by a few remaining widely-spaced trees with very poor form and no commercial timber value.

SEQ landholders considered drought to be the main factor causing high mortality in the establishment phase. Other reasons for tree mortality given by landholders include frost associated with drought, damage from hares, poor quality planting stock, poor quality planting and the use of inappropriate species for the site. Lack of suitable site maintenance is likely to have also contributed.

Environmental conditions

The SEQ trial sites are located in climatically similar areas, so relative growth rates are not expected to be greatly influenced by climatic differences.

Table 3. Climatic conditions for trial site regions of South East Queensland taken from Bureau of Meteorology website, 2006.

Region	Years of measurement	Elevation above sea level (m)	Averages / year			
			Rainfall (mm)	Maximum temp (°C)	Minimum temp (°C)	Humidity (%) at 9am
Gatton DPI	1968–2004	93	790	26.7	13.1	72
Ipswich	1870–2004	40	877	27.1	13.7	67

Rainfall for the region is between 790 mm and 877 mm/year (Gatton DPI Research station and Ipswich weather station respectively). Lockyer and Fassifern Valleys experience on average from one to three light frosts (–1°C) in most years. Sixty percent of rain falls during the summer months (December to March), with autumn and early spring often the driest periods. Gatton has on average eight frosts per year; these are more common in low lying alluvial areas (Harper et al., 1999).

The SEQ site results are shown below in Table 4. Average height measurements and DBH, height to crown break and form ratings are displayed in Figures 4, 5 and 6 respectively. Detailed site profiles are given in Appendix 2.

Overall, the mean annual increments for height and DBH were lower for SEQ, when compared to CQ. *C. henryi* at Tarome, *E. punctata* at Kalbar Showgrounds and *E. argophloia* at Kalbar North showed the best annual height and DBH for SEQ sites.

Table 4 Survival, average height and diameter, and form ratings for reasonably performing species planted at South East Queensland sites from 1984 to 1985 (measured in January 2005)

Site name and number	Species	Survival Rate (%)	Averages								
			Ht	Ht/year (m) (st.dev)	Ht to crown break	DBH	DBH/yr (cm) (st.dev)	Stem straightness	Branch habit	Axis of persistence	Health
Boonah	<i>C. cunninghamiana</i>	unknown	11.2	0.55 (0.06)	3.4	28.4	1.35 (0.19)	5.1	4.2	4.1	4.6
Gatton	<i>C. citriodora</i>	60	9.8	0.46 (0.08)	3.7	14.9	0.71 (0.17)	5.2	4.0	4.0	4.4
	<i>E. moluccana</i>	50	10.7	0.51 (0.10)	2.6	19.2	0.91 (0.26)	4.0	4.4	3.2	5.0
Forest Hill Sports Ground	<i>E. crebra</i>	unknown	11.3	0.53 (0.03)	4.7	19.9	0.94 (0.12)	5.0	3.0	3.0	5.0
Kalbar North	<i>E. argophloia</i>	59	18.3	0.87 (0.11)	8.6	30.0	1.43 (0.21)	5.0	4.0	4.4	4.8
Kalbar Showgrounds	<i>E. punctata</i>	unknown	17.9	0.85 (0.15)	10.6*	31.5	1.5 (0.28)	4.6	3.6	4.4	5.0
Mt Berryman	<i>C. citriodora</i>	60	13.1	0.62 (0.09)	4.5	24.1	1.15 (0.17)	5.8	4.2	4.0	4.6
	<i>E. drepanophylla</i>	60	11.0	0.52 (0.12)	4.0	26.8	1.27 (0.26)	5.0	4.3	4.0	4.7
Tarome	<i>C. henryi</i>	54	22.3	1.06 (0.06)	12.6 2003*	32.9	1.56 (0.11)	4.5	4.0	5.5	5.8
	<i>E. dunnii</i>	63	16.0	0.76 (0.09)	9.8 2003*	26.4	1.26 (0.24)	4.8	3.8	5.6	4.4
	<i>E. microcorys</i>	62	14.2	0.67 (0.18)	6.5 2003*	28.3	1.34 (0.12)	5.6	3.4	3.4	4.8

*measurements taken from Borschmann (2003).

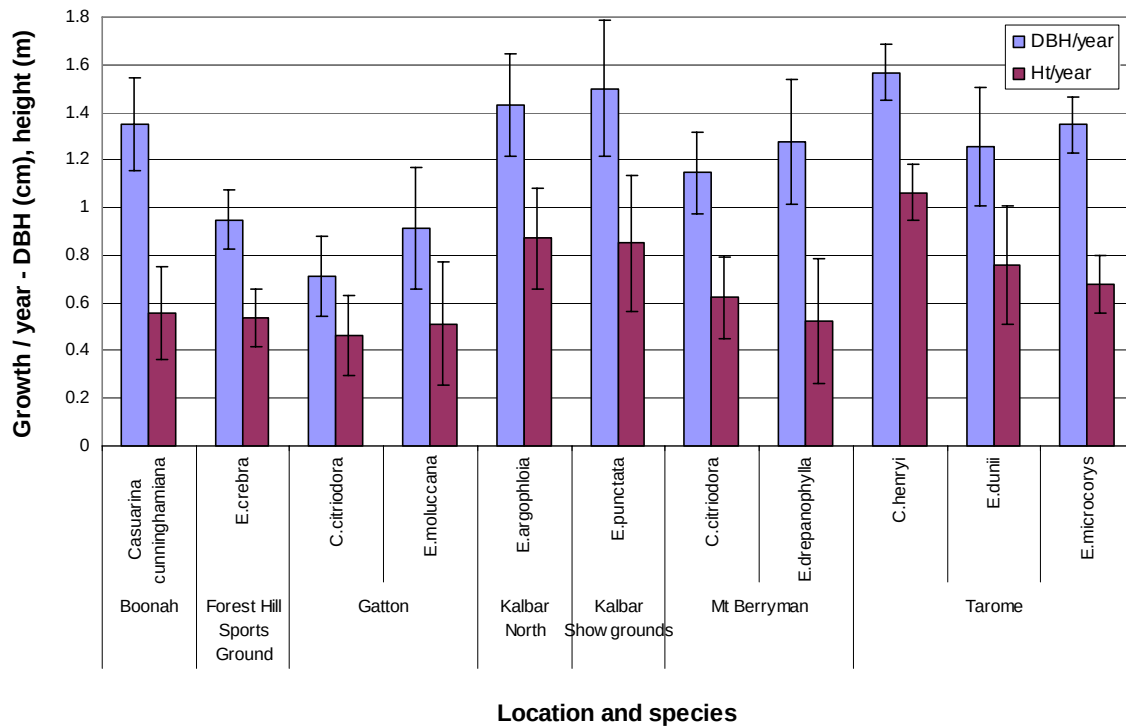
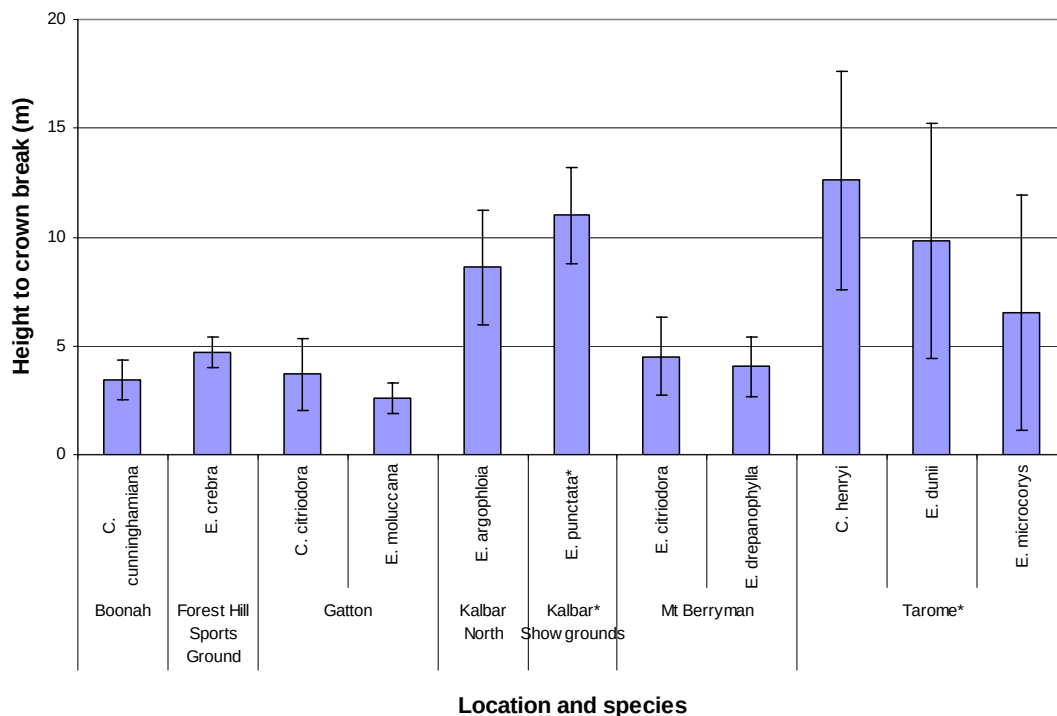


Figure 4. Mean annual increment for diameter at breast height and height of reasonably performing species planted on seven sites in South East Queensland (tree age 20-21 years, measurements taken January 2005).



*measurements taken from Borschmann (2003).

Figure 5. Mean height to crown break of reasonably performing species planted at seven sites in South East Queensland (tree age 20-21 years, measurements taken January 2005).

Figure 5 shows that the two sites at Kalbar, and the Tarome site reached the highest average crown break height. *C. henryi*, *E. punctata*, *E. argophloia* and *E. dunnii* all had an average height to crown break exceeding 8.5 m.

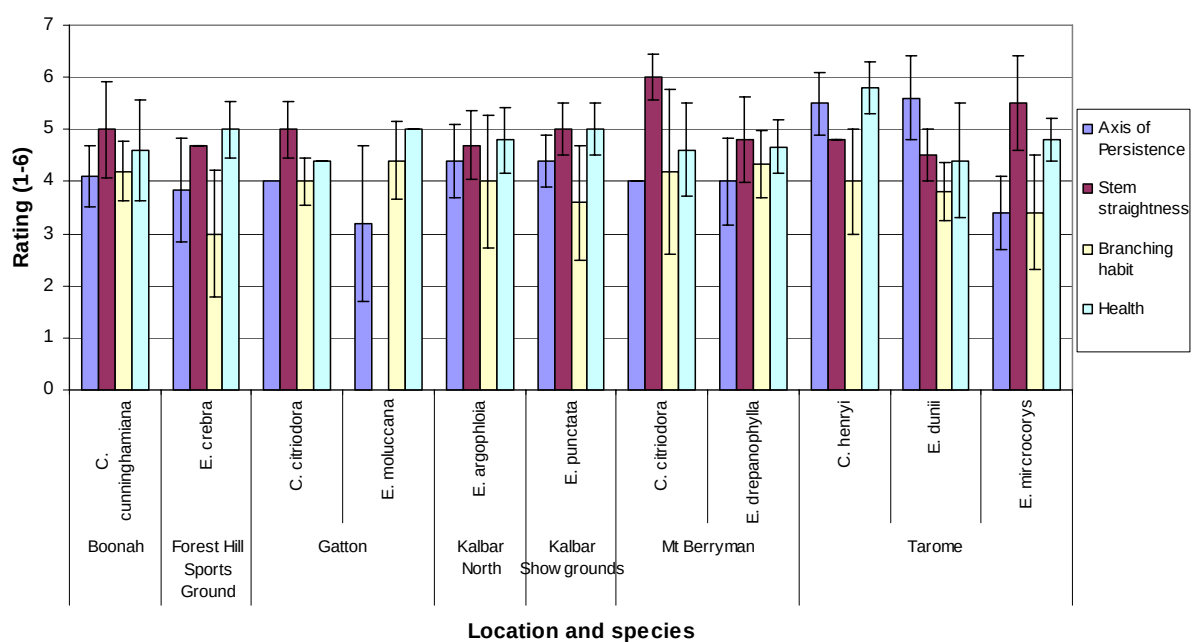


Figure 6. Average form ratings for reasonably performing species planted at seven sites in South East Queensland (tree age 20-21 years, measurements taken January 2005)

C. citriodora at Mt Berryman grew very straight stems. *E. microcorys* and *E. crebra* from Forest Hill Sports Ground had heavy branching. *C. henryi* and *E. dunnii* both had high axis of persistence.

Discussion

Site performance and management

The site results show a link between site management and tree performance. Those sites with a higher level of professional management and layout produced better performing trees. The block trials (Forestry Trial site, Cawarral, Rockhampton and Marmor) showed better survival rates, average to good growth rates, and produced a product with commercial potential as sawlogs or poles. In contrast, plantings with inappropriate layout performed poorly. For example, strip plantings, even when receiving a good weed control and site management (e.g. Callide West) yielded little product potential due to the edge effect (reduced height, low branching, crooked stems and/or double leaders) and lack of appropriate pruning and maintenance. Note that it is possible to grow quality, wide-spaced trees suitable for milling, providing they are carefully pruned and managed to achieve large diameter, knot-free heartwood and clearwood stems of 3.6 or more than 6 metres.

Most of the sites in SEQ that were worthy of measurement contained block designs. Again, this was due to a higher product potential produced at sites with a block layout, rather than those that were primarily edge. Unlike the block trials in CQ mentioned above, none of the SEQ sites were planted in sufficient numbers to harvest trees for profit.

Environmental variables

With large variations in management input and age of planting between sites in CQ, it is difficult to make definite conclusions on the effect of environmental variables on species performance. In general, the region around Yeppoon was able to grow a wider range of species with better timber potential, but the plantings in this area were also grown and managed more professionally compared with those at Rockhampton and Biloela. *C. citriodora* did well in both low and high rainfall areas at Marmor and Yeppoon, and performed well on hard pedal yellow and red duplex soils. A slower growth rate was achieved on grey, self mulching, cracking clay in an alluvial area of Rockhampton. *E. argophloia* performed well at Biloela where rainfall is low and temperatures are more extreme.

Unlike the CQ sites, all SEQ sites were planted around the same time (1984–1985), and are located a maximum of 80 km from each other in the Lockyer and Fassifern Valleys. The climatic conditions do not vary greatly between the SEQ sites. The relative success or failure of species here is related mostly to management input rather than environmental variations.

Species performance and failure

Casuarina cunninghamiana

The Boonah site in SEQ provided sufficient conditions for *C. cunninghamiana* to grow straight, thick stems. With a crown break height of 3.4 m, these trees could be harvested for sawlogs (Boxshall & Jenkyn, 2001). This species prefers a sandy soil and with either high rainfall or a supplementary water supply in low rainfall areas (>375 mm) but will grow in various soil types from acidic to near neutral clays, sands and silty loams (Boxshall & Jenkyn 2001). *Casuarina cunninghamiana* was also grown at the Kalbar Showgrounds and did not display product potential at this site due to edge effects.

Corymbia citriodora

Due to time constraints and number of trees to be measured, *C. citriodora* was not classified to the sub species level. It is most likely that *C. citriodora* subsp. *citriodora* was planted in CQ, while *C. citriodora* subsp. *variegata* was used in the SEQ trials.

This species is known to grow successfully in Queensland under a variety of conditions, and naturally has a tall straight stem with little branching. *C. citriodora* will cope with soils of low to high fertility, good to moderately impeded drainage, low to medium salinity, low to moderately high

pH, and sites that experience a moderate frequency of non-severe frosts (DPI&F, 2006). They typically do not perform well in cracking soil (black earth and grey clays) as the surface roots do not cope well with exposure caused by cracking (DPI&F, 2005a). Under good trial conditions growth rates of 6.4 m in two years were reached for *C. citriodora* subsp. *citriodora* at Miriam Vale (Dickinson et al., 2005b) and 6.1–6.8 in three years north of Monto (Dickinson et al., 2005a).

From the CQ sites, *C. citriodora* performed well at sites at Marmor, Yeppoon and Rockhampton. A 90% survival rate was reached at the Rockhampton site, crown breaks were high at an average of 6.1 m due to pruning and a dense, sheltered planting. The trees here had good form and will have a high product potential when they reach harvestable age. Located on a ridgeline in this low lying area, the trees have been less affected by frosts, contributing to the good survival rate. However, an average height of only 11.6 m in 15 years was reached with an average DBH of 11.4 cm. The soil at this site is mapped by Natural Resources Mines and Water (2005) as grey, self mulching, cracking clay. *C. citriodora*'s surface roots don't cope well with cracking soils and this may have contributed to the slower growth rate at this site compared to the yellow and red duplex soils at the Yeppoon and Marmor sites.

The Marmor site provided better growth rates on the infertile deep heavy clay/loam soils. Trees reached an average height of 13.3 m in 12 years, and a DBH of 11 cm, but only a 50% survival rate was achieved. Many of the deaths were caused by competition from larger native trees at one end of the trial. This part of the site was poorly drained, a characteristic not favoured by *C. citriodora* (DPI&F, 2005b). The performance of *C. citriodora* on this site is better than would be expected because Marmor has the lowest annual rainfall (landholder records 589 mm/year, with the last 10 years of the 12-year-old planting receiving only approx 330 mm/year). *C. citriodora* usually prefers greater than 600 mm/year (Jovanovic & Booth, 2003). The Cawarral site grew healthy 19 m trees at a 40% survival rate over 25 years, while the four-year-old Forestry site at Yeppoon has trees reaching 9.3 m, on shallow silty clay soils with a coffee rock underlay. Three of the past five years have been record drought in Yeppoon. The Marmor site has shown that *C. citriodora* can perform reasonably under much less rainfall than expected. *C. citriodora* performed poorly on the black, cracking clay at the Alton Downs site with a 24% survival rate and the 20-year-old trees averaged less than 10 m in height.

In SEQ, *C. citriodora* (most likely *C. citriodora* subsp. *variegata*) had a good survival rate at Mt Berryman and produced straight stems, but trees only reached a height of 13 m in 21 years. *C. citriodora* at Mt Berryman fared much better than those at the Gatton site. The lack of successful growth of this species and the many other species planted at the Gatton site would be attributed to a combination of minimal management, low rainfall and a fire in 1991.

Corymbia henryi

C. henryi grown at Tarome, was both the tallest and had the largest DBH on average for the trees measured in SEQ. Tree form was also good. The conditions at this Tarome site very much suited the species, with a clay/loam soil and sufficient annual rainfall (rainfall requirements of 830–1745 mm/year (Jovanovic & Booth, 2002). The resultant growth rate was over 22.3 m in 21 years. *C. henryi* is highly susceptible to *Quambalaria piterika* (Ramularia shoot blight, or RSB) and is not recommended for plantation establishment (Dickinson et al., 2004, Lee et al., 2005a). However, Dickinson et al. (2004) found that individual trees from the Gold Coast and Myrtle Creed provenances showed resistance to RSB in an assessment of 1-2 year old trees. In this same experiment, RSB infection was been found to be closely related to local climatic conditions, with areas with a mean annual rainfall of <750 mm generally less affected by RSB. The drought of recent years may have helped *C. henryi* at Tarome to avoid RSB infection.

Corymbia tessellaris

From a small sample set of five specimens at one CQ site (Callide East), it is difficult to derive good survival and growth assumptions for *E. tessellaris*.

Corymbia torelliana

C. torelliana achieved similar height and DBH measurement for all CQ sites despite up to 16 years difference in age. This is most likely due to variations in management input. *C. torelliana* performed best at the four-year-old Forestry Trial site at Yeppoon where it was planted as a single row amongst a block planting of other species. Here it averaged 5.8 m height in four years on shallow silty clay to 0.3 m with coffee rock below. Although age was undeterminable, specimens at Bungundarra showed very good form for a site that received very minimal maintenance. This was on hard pedal mottled, red duplex soils with a moderate westerly slope. The sheltered nature of this amenity planting would have contributed to the straight stems. All other sites showed only average form ratings (heavy, early branching with crooked stems), rendering the wood product only useful for pulp/woodchips.

Eucalyptus argophloia

E. argophloia performed well with tall, straight stems and good growth (19.8 m height and DBH 41.5 cm in 19 years) on the grey cracking clay soils at Callide East, and on black duplex soil on alluvial plains (Callide West). These results are similar to a 20-year-old planting at nearby Biloela DPI station where trees averaged a height of 24.3 m and DBH of 39.2 cm (Dickinson et al., 2005a). *E. argophloia* prefers lower than 900 mm/year rainfall, will perform well on a variety of soils, and is highly frost tolerant (Dickinson et al., 1998b; Lee et al., 2005b). The maintenance during establishment at both these sites was high, but both were strip plantings, with specimens suffering edge effect. The six surviving specimens at Alton Downs site did very poorly, most displaying signs of poor health. Most of the other species here performed poorly and may have been affected by spray drift.

In SEQ, *E. argophloia* performed reasonably at the Kalbar North site where the heavy clay soil is prone to waterlogging and mild salting. *E. argophloia* is endemic to Chinchilla's heavy clay soils and will grow on medium to heavy clays with a high pH (Lee et al., 2005b). It is also relatively tolerant of saline soils (12–20 dS/m) (Lee et al., 2005b). For these reasons *E. argophloia* showed a good survival rate of 59%, have obtained reasonable size measurements and form.

Eucalyptus cloeziana

E. cloeziana is performing well at the Forestry Trial site at Yeppoon (average height of 8.2 m in four years, DBH 12.3 cm), although drought is causing some dieback in the tips. Previous trials have shown this species can average 10.8 m at 2.5 years at 400–600 stems per hectare for the top 200 stems per hectare (Dickinson et al., 1998b). In other trials an average height of 5 m has been reached in two years (Dickinson et al., 2005b). By providing optimum weed control and fertilising, the height increment of *E. cloeziana* during the first three months after planting can be doubled compared to nil fertilising and weed control (Dickinson et al., 1998a). The Forestry plot would have received more weed control and fertiliser application, contributing to the good growth and survival rates.

The Forestry site at Yeppoon performed much better than the Farnborough site, where only three specimens remained from approximately 20 originally planted. This is possibly due to excessive exposure on the open hillside strip planting. The large specimens with straight stems and high branching seen at the Bungundarra site can provide an indication of ideal conditions for *E. cloeziana*; well drained red duplex soil on a moderate slope, protected amongst a thick planting.

At Mt Berryman in SEQ, *E. cloeziana* performed very poorly, this is likely attributed to insufficient rainfall for the species (<900 mm/year), and low fertility soils. *E. cloeziana* prefers more than 900 mm rainfall per year and moderate to high fertility soil (DPI&F, 2005a).

Eucalyptus crebra

E. crebra was trialled in two strip plantings sites north of Biloela in CQ. The Callide West site, despite being seven years younger and affected by Ergon trimming, grew taller, wider trees. A higher level of maintenance was provided by the landholders on the Callide West property which may have contributed to this result. Neither site developed a high standard of wood product because of edge effect and lack of pruning.

In SEQ, *E. crebra* was the only species to perform reasonably at the Forest Hill Sports Ground site, while others such as *C. citriodora* and *E. grandis* failed. The combination of low rainfall, and poor, shallow soil at this site may have favoured *E. crebra* which grows naturally in these conditions, *E. crebra* is both drought and frost resistant and can grow on a variety of soils, further adding to its chances of survival in this area (Sewell, 1997). The moderately alkaline, cracking clays would have impeded the success of other species such as *C. citriodora* at this site (DPI&F, 2005a).

Eucalyptus drepanophylla

The five remaining *E. drepanophylla* trees did poorly on the yellow duplex soils at Glenmore when compared to the four-year-old Forestry Trial site at Yeppoon. The Yeppoon site received higher rainfall, better management and protected surroundings, whereas the Glenmore planting was more exposed and received less rainfall and minimal management. In other trials *E. drepanophylla* showed low to moderate growth and good drought tolerance to age eight years on duplex soils west of Mundubbera (Dickinson et al., 2005a).

In SEQ, *E. drepanophylla* had a low average crown break at 4 m on the light clay soil at Mt Berryman. The average growth in height of 11m (0.52 m/year) for the 21 year old planting was far below the species potential of 1.7 m/year over four years as seen in the Forestry Trial site. Form and stem diameter were otherwise good.

Eucalyptus dunnii

E. dunnii is known for high growth rates and can tolerate frost but does not like poor drainage. Research carried out in South Africa on this species suggests an optimum mean annual temperature range of 15.5–18.5°C in drier regions. *E. dunnii* also prefers high fertility soils and performance declines when on poor soil types such as duplex soils or those with poorly drained subsoil (Lee et al., 2005c). Recent studies indicate this species has declining or variable growth and survival (up to the age of three) with less rainfall (e.g. 600–900 mm/year) and with less consistent rainfall over drier months (Lee et al., 2005c).

E. dunnii showed average results on the red duplex soil at Tarome reaching an average height of 16 m and a DBH of 26 cm for the 21-year-old planting. Growth rates of 6 m in two years, and 10 m in three years have been observed in other experiments near Aratula and Blackbutt respectively (DPI&F, 2005b). The growth rate of *E. dunnii* at Tarome was likely to have been impeded by insufficient rainfall and inappropriate soil type.

Eucalyptus microcorys

E. microcorys (tallowwood) is naturally found in hilly or mountainous country where humidity is high and rainfall averages 900–1500 mm/year with most falling in summer (Holliday, 1995). This species is also frost tolerant with branching naturally occurring at two thirds stem height (Holliday, 1995). The survival rate of 60 % for *E. microcorys* at the Tarome site in SEQ can be attributed to the high level of maintenance provided by the landholder. Stems were reasonably straight but low, heavy branching persisted, this may be a response to a low intensity fire in 2002–2003.

Eucalyptus moluccana

E. moluccana did poorly at all three CQ sites. The best growth (15.5 m height in 14 years, 23.6 cm DBH) was seen at the six remaining specimens at Glenmore, but low branching and poor form was common at all sites. Stems were straighter at Alton Downs and Biloela, but growth was very slow. In a trial by DPI&F, *E. moluccana* has shown good growth rates of 5–6 m height after three years on black earth soils in Monto. These trees showed high drought and frost tolerance, but were likewise prone to multi-stemming and crookedness (Dickinson et al., 2005a). The provenance of *E. moluccana* can affect stem straightness, unfortunately provenance details for this trial were no longer available.

Like *C. citriodora*, the growth of *E. moluccana* at the Gatton site in SEQ was considerably slower when compared to CQ growth rates, despite that fact that *E. moluccana* was planted in block design in SEQ which should have encouraged taller growth. Like *C. citriodora* at this site, the slow growth of *E. moluccana* at the Gatton site is probably related to the minimal management, low rainfall and the 1991 fire.

Eucalyptus punctata

Under good growing conditions, *E. punctata*'s form is generally good with a straight bole extending for one-half or two-thirds of the height of the tree (DPI&F, 2004). This species performed reasonably in a strip planting in black smooth ped earths at Kalbar Showgrounds, SEQ. All of these trees were subject to edge effect but stems have remained relatively straight.

Implications

The management of the visited CQ sites was of a considerably higher standard than the SEQ sites, with more plots planted in block designs and maintained in a professional manner. Thus, better conclusions are able to be derived from CQ.

Central Queensland

C. citriodora has performed well on a variety of soils in Rockhampton and Yeppoon, with the best results coming from well managed, block trials around the higher rainfall area of Yeppoon.

From the limited data gathered from the two strip planting plots, *E. argophloia* has indicated good promise as a plantation species for the Biloela region. Continued monitoring of current DPI&F trials of *E. argophloia* at Biloela is recommended to assess the product potential of this species under plantation conditions at Biloela.

E. cloeziana performed well in the managed Forestry Trial site near Yeppoon. Specimens of undeterminable age are showing excellent form and height at another protected site near Yeppoon. Exposed sites do not seem to suit this species.

From the sites visited at Yeppoon, the performance of *C. torelliana* seems to be mostly determined by good management input, with better results achieved at well managed, block trials.

Most of the remaining unsuccessful species of CQ were strip planted in low numbers for amenity. This greatly affected the amount of useful data collected. To deduce useful farm forestry information, well-managed, block trial assessments for these species need to be undertaken.

South East Queensland

C. henryi performed well at the Tarome site. This result was surprising as this species is commonly affected by RSB. The drought of recent years, or the provenance of the trees planted may have suppressed RSB.

E. punctata and *E. argophloia* showed only average performance on black smooth ped earths at the higher rainfall area of Kalbar, SEQ. While all other species measured in SEQ showed poor yearly growth.

Recommendations

Species to site matching

The results from this study indicate a good potential for *E. argophloia* to be grown for forestry timber purposes in the Biloela region. This study has confirmed results from previous trials (Dickinson et al., 2005a), that this species is adapted to low rainfall conditions, will grow successfully on a variety of soils, and is frost tolerant. This species will also grow reasonably well in the higher rainfall area at Kalbar.

C. citriodora (most likely *C. citriodora* subsp. *citriodora* for CQ) is also suited to a variety of soils and will grow under much lower rainfall areas than the >600 mm/year estimated by Jovanovic and Booth (2002). The low fertility grazing soils and low rainfall at Marmor did not greatly impede growth rates for this species. The block planting on grey cracking clays at the Rockhampton did not perform as well as other sites in terms of growth rate, confirming the species' aversion to cracking clays.

E. cloeziana performed well on duplex soils in well protected and high rainfall areas around Yeppoon.

Future work

From the CQ sites, the 25-year-old site at Cawarral which has *C. citriodora* trees nearing harvest, would be suitable for timber quality assessment. There are approximately 400 trees left on site.

The 12-year-old planting at Marmor showed reasonable rates on poor soils and although the site is small, it may be of interest for future monitoring, to track the progress of *C. citriodora* in the low rainfall Marmor region.

The four-year-old Forestry Trial site showed very good growth and survival rates for a variety of species (many more than the key species mentioned in this report). This site, although probably already being monitored by Forestry, may be of interest for future research or used as a comparison site.

In SEQ, the only site worthy of a revisit would be the Tarome site which had three species with good survival rates. Of interest, would be *C. henryi* which performed well despite this species generally not being recommended for forestry planting (because of its susceptibility to RSB).

In CQ, there are four remaining sites from the 15 prioritised that were not visited. These may offer additional results for species trials. There was a block planting of *E. argophloia* and *E. cambageana* amongst other species at Capella. There are also strip plantings at Rubyvale, a small planting at Bouldercombe, and a site at Emerald.

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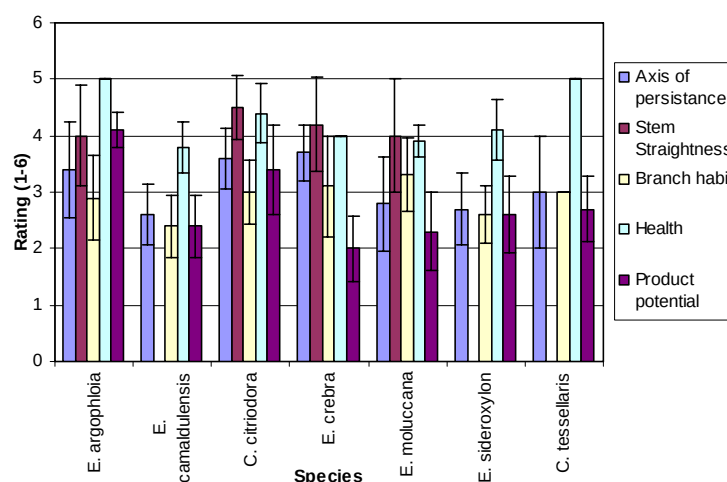
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Appendix 1 – Central Queensland site profiles

Site name	Callide East		
Location	Callide (10 km north of Biloela)		
Site design	Three separate windbreak rows Windbreak 1: located at drainage line at bottom of hill, initially four rows, since thinned to two rows (400 m × 15 m). Tree spacing 5 m × 10 m. Windbreak 2: located in a cropping paddock, two rows (200 m × 5 m). Tree spacing 7 m × 5 m. Windbreak 3: located near road and powerlines, three rows (200 m × 6 m). Tree spacing 3 m × 4 m.		
Site preparation	Site cultivated, holes dug with mattock.		
Site maintenance	Planting mulched with straw, watered with drip irrigation until established and mowed regularly for 1–2 years. Weeds controlled by cultivation along rows twice yearly.		
Site threats	Some smaller trees damaged by stock.		
Age	19 years	Rainfall	459 mm/year (from property records)
Trees planted	630 (approx)	Soil appearance	Brown light to medium clay with ironstone
Area planted	0.8 ha	NRM mapping	Grey, self mulching cracking clays
Aspect	Gentle southerly slope		
Successful species	<i>E. argophloia</i>		
Unsuccessful species	<i>C. citriodora</i> , <i>E. moluccana</i> , <i>E. sideroxylon</i> , <i>E. crebra</i> , <i>E. tessellaris</i> , <i>E. tereticornis</i> and <i>E. camaldulensis</i>		
Comments	The 1993 planting recorded in the database never went ahead due to poor site conditions according to the landholder. The previous planting in 1986 was measured instead. This planting supported a number of key species.		



Plate 1. *E. argophloia* at Callide East



Form ratings for key species at the Callide East Site

The Callide East planting is 19 years old. *E. argophloia* showed good results with 20 m height (an average yearly growth rate of 1.04 m) and 41 cm DBH (average yearly DBH of 2.18 m) for the 11 remaining plants. This species was commonly found with double leaders, which, with trimming or appropriate planting design, may have been alleviated. Other species on site performed poorly including *C. citriodora*, *E. crebra*, *E. sideroxylon* and *E. moluccana*, with heavy branching and crown breaks no higher than 4 m on average. *E. camaldulensis* and *C. tessellaris* performed very poorly.

Site name	Callide West			
Location	Callide (10 km north of Biloela)			
Site design	One windbreak row (2 m × 800 m) along road and powerlines. Tree spacing 4 m × 2 m.			
Site preparation	Tyres placed around trees for moisture and pest protection, mulched with hay.			
Site maintenance	Regular watering for over a year after planting, mowed regularly.			
Site threats	Trimming and culling by Ergon Energy			
Age	12 years	Rainfall	459 mm/year (from property records 1993-2005)	
Trees planted	505		Soil appearance NRM mapping	Fine alluvial clay/silt
Area planted	0.2 ha			Hard pedal black duplex soils on alluvial plains
Aspect	Flat			
Successful species	-			
Unsuccessful species	<i>E. crebra</i> showed reasonable growth rates but poor form.			
Comments	Survival rate was good due to high maintenance during establishment phase. Only one specimen of <i>E. argophloia</i> remained after trimming and culling (17 m tall, DBH 32cm). Other species planted include <i>E. tereticornis</i> , <i>Callistemon viminalis</i> , <i>Melaleuca bracteata</i> , <i>M. linariifolia</i> , <i>Casuarina cunninghamiana</i> . These species performed reasonably.			

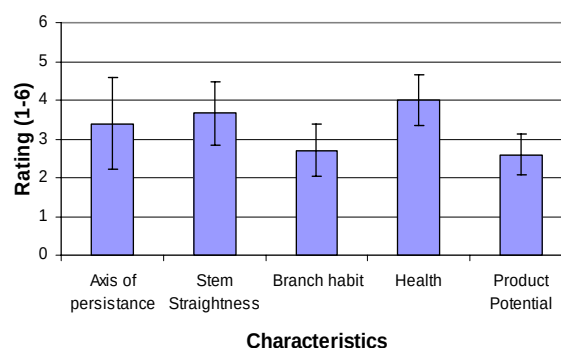


Plate 2. Strip planting at Callide West property

Form ratings for *E. crebra* at Callide West property

The Callide West planting from 1993 is alongside powerlines and has been significantly affected by recent trimming and culling by Ergon Energy. This has in turn affected the survival rate and height measurements. A high level of management was provided by the landholder, particularly during establishment. All plants on this strip planting were influenced by edge with most exhibiting low branching and crooked stems. *E. crebra* has reasonably good growth, with better height, crown break and DBH than the 19-year-old planting at Callide East. However, poor form (heavy branching, crooked stems) renders the product only useful for woodchips or short sawlogs. There was one remaining western white gum (*E. argophloia*) which had good form and impressive growth with a height of 17 m and a DBH of 32 cm. This specimen was possibly one of the smaller trees from the stand in order to survive culling, indicating a possible potential for this species. The planting performed well as an amenity screen to block the noise and view of a nearby road.

Site Name	Marmor		
Location	Marmor (50 km south of Rockhampton)		
Site design	Block, 40 m × 80 m. Tree spacing 2.5 m × 3.0 m		
Site preparation	Ripped rows, planted after rain.		
Site maintenance	Mowed occasionally. Site thinned by previous owner (Nagel) in 1994–1995 to encourage growth. Cattle now graze area.		
Age	12 years	Rainfall	Generally 589 mm/year, last 10 years only approx 330 mm / year. (landholder estimate)
Trees planted	300 (approx)		
Area planted	0.3 ha		
Aspect	Flat		
		Soil appearance	Duplex soil, deep heavy clay loam, low fertility
		NRM mapping	Hard pedal yellow duplex soils
Successful species	C. citriodora		
Unsuccessful species	No other species trialled here.		
Comments	Brachychiton spp., have been trialled by the original owner but failed due to the poor soils.		

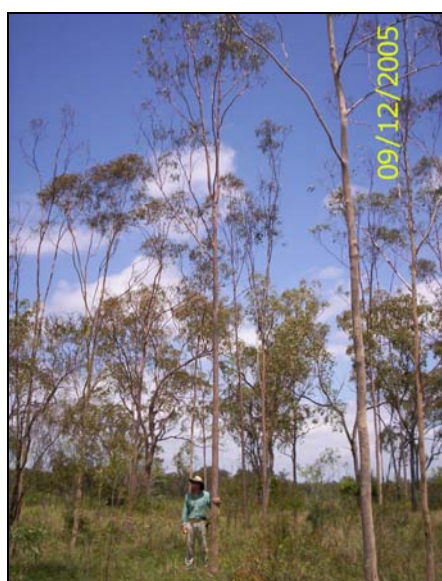
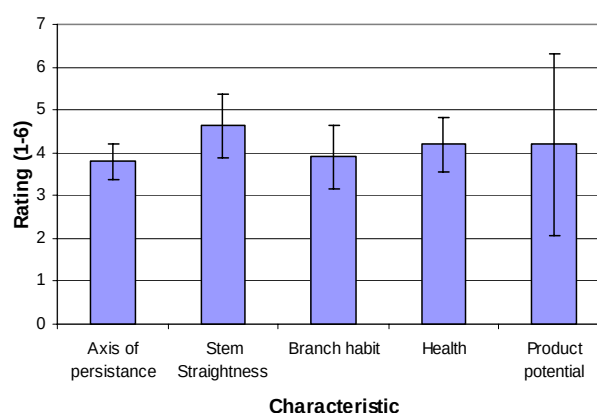


Plate 3. *C. citriodora* at Marmor



Form ratings for *C. citriodora* at the Marmor site

The *C. citriodora* site at Marmor was 12 years old, with an average height of 13.3m (yearly growth rate of 1.11 m) and an average crown break at 6.5 m. Average DBH was 11 cm (0.92 cm/year). Survival rate for the site was approximately 50%, with a lot of the losses occurring from competition from large native trees at one end of the trial. Straight stemmed, healthy trees with a high axis of persistence resulted in a product potential for sawlogs with the possibility that in time poles may be possible.

Site name	Alton Downs		
Location	Alton Downs (20 km north west of Rockhampton)		
Site design	Row of 2 (3 m × 500 m). Tree spacing 3 m × 4 m.		
Site preparation	Planting into cultivation by mattock.		
Site maintenance	Watered until established. Trees also receive water and nutrient runoff from adjacent cotton fields.		
Age	20 years	Rainfall	1973–1994 average 551 mm/year
Trees planted	370		1995–2005 only approx
Area planted	0.15 ha		320–330 mm/year
Aspect	Flat	Soil appearance	(from property records)
		NRM mapping	Heavy black cracking clay soils
			Hard pedal yellow duplex soils
Successful species	None		
Unsuccessful species	<i>C. citriodora</i> , <i>C. torelliana</i> , <i>E. argophloia</i> , <i>E. moluccana</i> .		
Comments	The 1989 planting recorded in the database showed poor growth and survival due to a lower level of maintenance, less runoff and nutrients and higher grass competition (Plate 5). The previous planting in 1985 carried out by Greening Australia and the landholder showed better results and was therefore measured.		

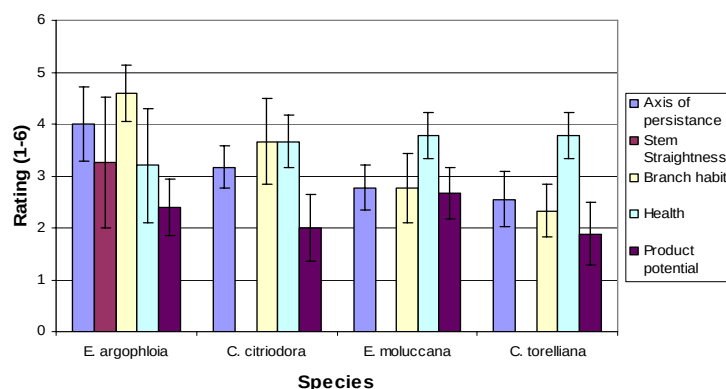


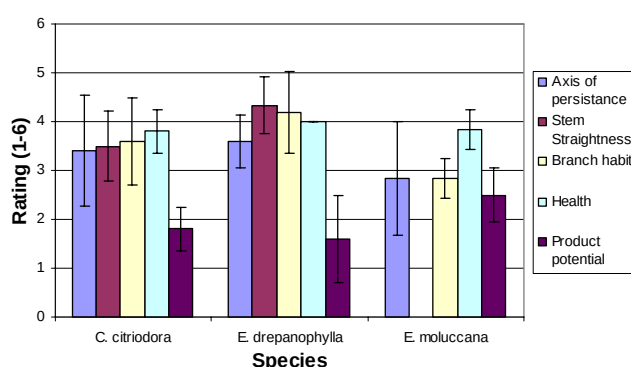
Plate 4. *E. argophloia* at Alton Downs. **Form ratings for key species at the Alton Downs site.**

All species at the Alton Downs site showed below average growth and form. *E. argophloia* and *C. torelliana* performed particularly poorly showing obvious signs of poor health. The results for all species on this cotton growing property may be attributed to spray drift, combined with a low level of management and edge affect on all trees.

Site name	Glenmore		
Location	Rockhampton township		
Site design	Block of 12 rows (60 m × 30 m). Tree spacing 3 m × 5 m.		
Site maintenance	Watered and mowed regularly during establishment. Mowed regularly since.		
Age	14 years	Rainfall	805 mm/year (65-year average
Trees planted	120		1939–2004 Rockhampton
Area planted	0.18 ha		BOM records)
Aspect	Flat		Alluvial clay/loam
		Soil appearance	Hard pedal yellow duplex soils
		NRM mapping	
Successful species	-		
Unsuccessful species	None were found in outstanding condition. <i>C. citriodora</i> , <i>E. drepanophylla</i> , <i>E. moluccana</i> , and <i>E. sideroxylon</i> appeared healthy but had low branching.		
Comments	Three <i>E. sideroxylon</i> remained with an average height of 10 m, DBH 14.5 cm and very low crown break at 0.2 m		



Plate 5. Block planting at Glenmore.



Form ratings for key species at Glenmore

The Glenmore planting is a small block of amenity trees planted in 1991 at a school. Of the four key species, none showed good form, with low crown breaks and axis of persistence resulting in suitability as woodchips or pulp only. *E. moluccana* reached a height of 15.5 m (yearly growth rate of 1.1 m); however, most of the trees were multi-stemmed from 0.2 m. There were also very few of each species remaining to generate good comparisons.

Site name	Rockhampton		
Location	Rockhampton township		
Site design	Block of 11 rows, 50 m × 400 m (tree spacing 2 m × 4 m)		
Site maintenance	Grown and maintained as a timber plot. Recent thinning by Forestry (2002–2004).		
Age Trees planted Area planted Aspect	15 years 400 2 ha Gentle westerly slope	Rainfall Soil appearance NRM mapping	805 mm/year (65-year average 1939–2004 Rockhampton BOM records) Alluvial loam Grey, self mulching, cracking clay
Successful species	<i>C. citriodora</i> , <i>E. tereticornis</i> .		
Unsuccessful species	<i>E. cloeziana</i> , <i>E. crebra</i> , <i>E. microcorys</i> , <i>E. drepanophylla</i> .		
Comments	Species planted: <i>E. citriodora</i> (100), <i>E. tereticornis</i> (100), <i>E. crebra</i> (100), <i>E. cloeziana</i> (10), <i>E. microcorys</i> (10), <i>E. drepanophylla</i> (10), <i>E. pilularis</i> (10) and an unknown number of <i>Melaleuca</i> , <i>Acacia</i> and <i>Flindersia</i> species.		

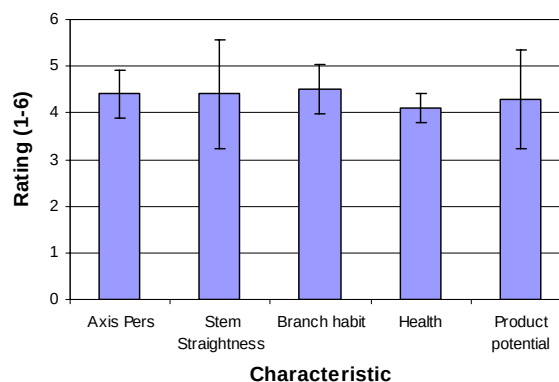


Plate 6. *C. citriodora* at Rockhampton. Form ratings for *C. citriodora* at the Rockhampton site

The 15-year-old forestry plot at Rockhampton grows *C. citriodora*. Other key species on this site performed poorly and were subsequently culled during thinning to the advantage of *C. citriodora*. Performance has been reasonable with 11.6m height (an average yearly growth of 0.77 m), and an average crown break of 6.1 m. Specimens had good form, with straight stems, axis of persistence to the fourth quarter and a small amount of branching. Edge effects were minimal. With age this stand will potentially be harvestable for sawlogs or poles. However, diameters were small (average 11.4 cm or 0.76 cm growth per year). Queensland blue gum (*E. tereticornis*) was also used at this planting, and survival rates appeared good, their form however, rendered them only suitable for chipping.

Site name	Bungundarra		
Location	Bungundarra (15 km north-west of Yeppoon)		
Site design	Scattered amenity planting, 400 m × 300 m. Tree spacing variable.		
Site maintenance	Trees were watered for a month after plating and then dry field farmed.		
Age	Not known (majority planted in 1991) not known 12 ha Moderate westerly slope	Rainfall	1312 mm/year (113 year average 1891-2004 Yeppoon BOM records)
Trees planted		Soil appearance	Red volcanic (rocky), deeply weathered.
Area planted		NRM mapping	Hard pedal mottled – red duplex
Aspect			
Successful species	<i>C. torelliana</i> , <i>E. cloeziana</i> , <i>C. citriodora</i>		
Unsuccessful species	<i>E. camaldulensis</i> , <i>Flindersia breyleyana</i>		
Comments	This site was a scattered planting of trees around the homestead mainly for amenity purposes. The elderly resident claims to have been planting on site since the 1980s. This made locating plants from the 1991 planting very difficult. There are also no records of the number of each species planted, making survival rates also undeterminable.		

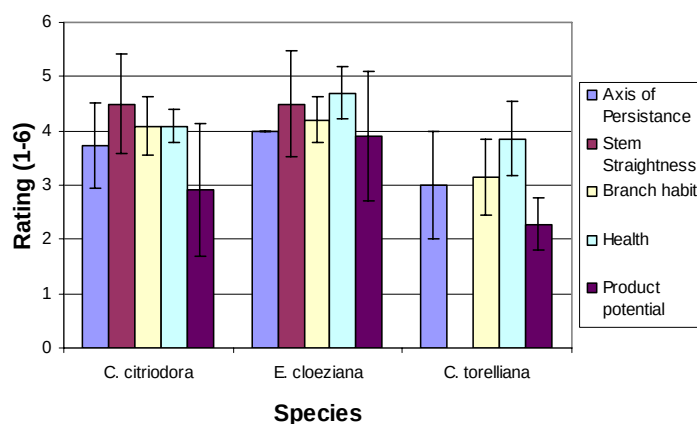


Plate 7. *E. cloeziana* at Bungundarra.

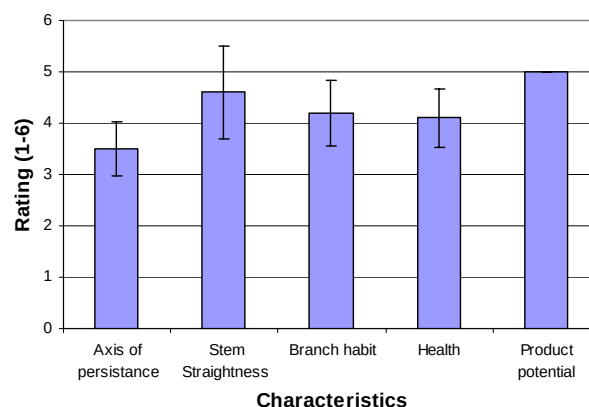
Form ratings for key species at the Bungundarra site

Only general observations can be made from the Bungundarra site because of the difficulty in determining the age of the trees in this scattered planting. With a yearly growth rate of 1.57 m *E. cloeziana* had the fastest yearly growth rate of all CQ sites. *C. torelliana* (0.76 m height and 1.05 cm DBH per year) and *C. citriodora* (1.15 m height and 1.11 cm DBH per year) also showed good growth, with tall, straight stems and high branching. However, because age was difficult to determine at this site, these figures may be inaccurate. The site was on red volcanic soil and required little maintenance. *E. camaldulensis* did poorly here.

Site name	Cawarral		
Location	Cawarral (15 km south west of Yeppoon)		
Site design	Three blocks. Tree spacing 4 m × 4 m. Block 1: 250 m × 25 m Block 2: 125 m × 20 m Block 3: 250 m × 30 m.		
Site Maintenance	Branches pruned to promote tall, straight growth. Cattle have grazed the plot for the last 5–10 years. Specific management details unavailable.		
Age Trees planted Area planted Aspect	25 years 2400 (recorded in database), possibly only 1000 planted. approximately 1.6 ha Easterly	Rainfall Soil appearance NRM mapping	1312 mm/year (113 year average 1891–2004 Yeppoon BOM records) Brown silty clay Hard pedal yellow duplex
Successful species	<i>C. citriodora</i>		
Unsuccessful species	No other species trialled here.		
Comments	Trees are large, and were well managed for the first 20 years.		



Plate 8. *C. citriodora* at Cawarral.



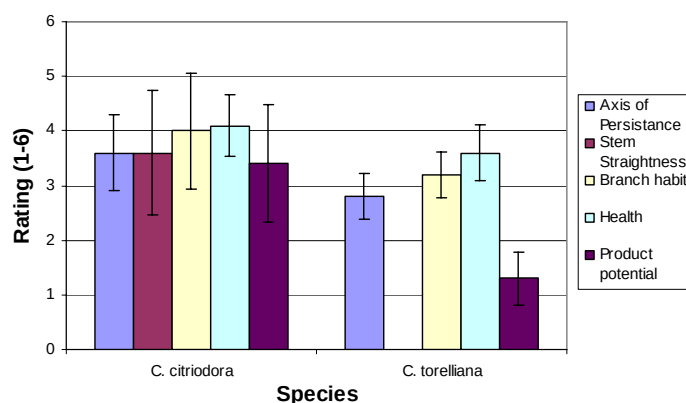
Form ratings for *C. citriodora* at Cawarral

The Cawarral property, south-west of Yeppoon, is the oldest surveyed site at 25 years. The *C. citriodora* stand has been well managed and is in a high rainfall area. Average yearly height growth of 0.79 m and DBH of 0.84 m shows a reasonable growth rate. Their current average height of 19.7 m height to crown break of 8.9 m and DBH of 20.9 combined with notable straight stems makes them suitable for sawlogs or poles.

Site name	Farnborough		
Location	Farnborough (15 km north west of Yeppoon)		
Site design	Two windbreak rows. Windbreak 1: three rows of <i>C. citriodora</i> and <i>E. cloeziana</i> (20 m × 4 m). Tree spacing 1.5 m × 3 m. Windbreak 2: single 20 m row of <i>C. torelliana</i> . Tree spacing 6 m.		
Site maintenance	Unknown		
Age Trees planted Area planted Aspect	14 years 150 0.01 ha Easterly slope	Rainfall Soil appearance NRM mapping	1312 mm/year (113 year average 1891-2004 Yeppoon BOM records) Stony red clay Hard, pedal, mottled red duplex.
Successful species	<i>C. citriodora</i>		
Unsuccessful species	<i>E. cloeziana</i> , <i>C. torelliana</i>		
Comments	Property was formerly grazing country. The planting was established to alleviate erosion problems. Estimated initial planting; 40 <i>C. citriodora</i> , 20 <i>C. torelliana</i> , 20 <i>E. cloeziana</i> .		



Plate 9. *C. citriodora* at Farnborough.



Form ratings of key species at the Farnborough site

The small 1991 planting at Farnborough, near Yeppoon showed good results for *C. citriodora* with 13.4 m height in 14 years (an average yearly height growth of 0.95 m), a high average crown break at 5.8 m, and DBH of 15.3 cm (an average yearly DBH increase of 1.09 cm). Form was reasonable, but due to the strip planting, most trees suffered edge effect. *C. torelliana* and *E. cloeziana* both performed poorly. Only three *E. cloeziana* remained at the site that had low crown breaks and an average height of 8.7 m and DBH 14.2 cm, the poor result may be attributed to too much exposure offered by the sloping hillside. Management was low at this site. This planting was originally established to help alleviate erosion problems, the soil here now appears stable and no evidence of erosion was noted.

Site name	Forestry Trial (Greening Australia Qld was directed to a Forestry trial plot planted in 2001).		
Location	Bungundarra (15 km north-west of Yeppoon)		
Site design	Block of 20-30 rows (300 m × 75 m approximately). Tree spacing 2.5 m × 3 m.		
Site preparation	Rows ripped and mounded, weeds sprayed on planting.		
Site maintenance	Thinning and trimming of <i>C. citriodora</i> has occurred recently.		
Age Trees planted Area planted Aspect	4 years 1000+ 2.25 ha Flat	Rainfall Soil appearance NRM mapping	1312 mm/year (113 year average 1891-2004 Yeppoon BOM records). Much less over last five years, with three of the last five years being drought (from property records) Shallow silty clay to 0.3m, coffee rock below. Grey massive earths
Successful species	<i>C. citriodora</i> , <i>E. cloeziana</i> , <i>E. drepanophylla</i> , <i>C. torelliana</i> .		
Unsuccessful species	None		
Comments	The site has a large variety of species including <i>E. grandis</i> , <i>E. robusta</i> , <i>Acacia spp</i> , along with the key species mentioned.		

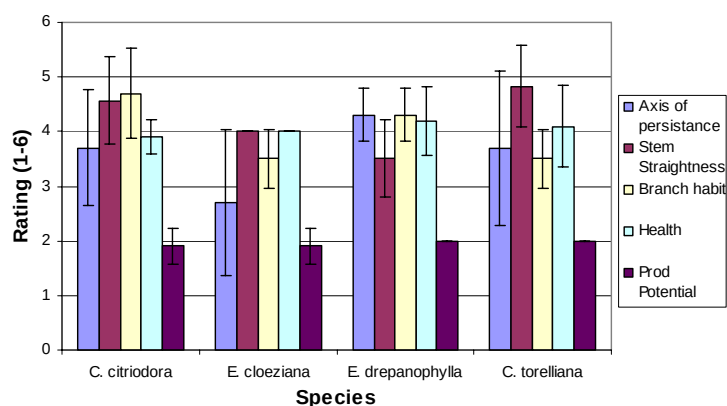


Plate 10. *C. citriodora* at the Forestry Trial. Form ratings for key species at the Forestry Trial.

The Forestry Trial Site, also at Bungundarra was a professionally grown and managed forestry plot planted in 2001. Up to 20 of each *E. cloeziana*, *C. torelliana* and *E. drepanophylla* were planted, these showed good form and very good growth rates for a young plot. Crown breaks for these species are low; they are due for ground pruning. *C. citriodora* has also done well here. This site receives a high level of management. The *C. citriodora* and *E. cloeziana* had approximately 60-70% survival and reached an average height of 10-15 m and DBH 30 cm.

Appendix 2 – South East Queensland site profiles

Site name	Boonah		
Location	Boonah township		
Site design	Block. Tree spacing 5 m × 5 m (approximately)		
Site preparation	Soil ripped and hoed.		
Site maintenance	Trees mulched on planting. Watered with travelling irrigation (duration and frequency unknown). Mown regularly and pruned.		
Age	20 years	Soil appearance	Heavy black soil
Trees planted	1000	NRM mapping	Black smooth ped earths
Area planted	Approximately 2.5 ha	Aspect	Flat
Successful species	<i>Casuarina cunninghamiana</i>		
Unsuccessful species	<i>E. grandis</i> , <i>E. citriodora</i> , <i>E. dealbata</i> , <i>E. camaldulensis</i> , <i>E. punctata</i> plus many other <i>Eucalypt</i> , <i>Corymbia</i> and <i>Acacia</i> sp.		
Comments	Little is known of the management history and numbers of each species planted.		



Plate 11. *C. cunninghamiana* at the Boonah site

The Boonah site had suitable conditions for *C. cunninghamiana* to grow straight, attaining an average height of 11.2 m and DBH of 28.0 cm. The average crown break was 3.4 m. Many other species failed to show product potential at this site due to crooked stems and low branching.

Site name	Gatton		
Location	4 km SE of Gatton township		
Site design	Block. Tree spacing 4 m × 4 m.		
Site maintenance	Watered after planting, slashed. Stock excluded, otherwise minimal management. Pasture competition low due to dry conditions.		
Site threats	Suffered from low rainfall. A fire burnt evenly through the trial in February 1991.		
Age	21 years	Soil appearance	Clay loam, pH 6.0
Trees planted	340 (estimate)	NRM mapping	Hard pedal mottled – yellow duplex soils.
Area planted	unknown	Aspect	Flat
Reasonable species	<i>E. moluccana</i> , <i>C. citriodora</i> .		
Unsuccessful species	<i>E. crebra</i> , <i>C. torelliana</i> , <i>E. camaldulensis</i> , <i>E. sideroxylon</i> and <i>E. resinifera</i> .		



Plate 12. *C. citriodora* at the Gatton site

At the Gatton site, *C. citriodora* and *E. moluccana* reached 9.8 m and 10.7 m respectively. Several other species did poorly on this site.

Site name	Forest Hill Sports Ground		
Location	8 km SE of Laidley township		
Site design	Block design, amenity planting		
Site maintenance	Mown regularly; evidence of irrigation pipes suggests supplementary watering was supplied.		
Age	21 years	Soil appearance	Heavy clay, top dressed loam pH 8–8.5
Trees planted	unknown (at least 65)	NRM mapping	Brown & red self mulching, cracking clays
Area planted	unknown		
Aspect	flat		
Reasonable species	<i>E. crebra</i> . Reasonable single specimens of <i>E. argophloia</i> and <i>E. moluccana</i> .		
Unsuccessful species	<i>C. citriodora</i> , <i>E. grandis</i> , <i>E. maculata</i> , <i>E. robusta</i> , <i>C. torelliana</i> , <i>E. argophloia</i> , <i>E. moluccana</i> .		
Comments	Only <i>E. crebra</i> survived in sufficient numbers to measure.		



Plate 13. *E. crebra* at Forest Hill Sports Ground

E. crebra showed reasonable results at Laidley, however growth rate has been slow at 11.3 m at age 21 years. The trees were heavily branching but had straight stems and a reasonable diameter of 20 cm.

Site name	Kalbar North		
Location	1 km north of Kalbar township		
Site Design	Block. Tree spacing 5 m × 4 m.		
Site preparation	Site ripped and rotary hoed.		
Site maintenance	Site mulched with barley stubble. Watered and slashed. Lower limbs have been pruned.		
Site threats	Some hare damage apparent in 1984–1985. Severe storm in 1991 twisted and split trees.		
Age	21 years	Soil appearance	Heavy clay, pH 8.5
Trees planted	140	NRM mapping	Black smooth ped earths
Area planted	0.4 ha	Aspect	Northerly slope <5°
Reasonable species	<i>E. argophloia</i>		
Unsuccessful species	<i>E. camaldulensis</i> , <i>E. robusta</i> .		
Comments	Soil prone to waterlogging and mild salting. Trees located on the upland slope of a dryland salinity discharge zone. Salinity problem downslope of plot was not evident in 1991 assessment (Borschman).		



Plate 14. *E. argophloia* amongst other species at the Kalbar North site.

E. argophloia did well at the Kalbar North site, with tall, straight stems. A good survival rate of 59% was achieved. Thirty-three *E. camaldulensis* were planted. These had performed well with a good survival rate when measured in 1991 but this species has since failed. Forty-three *E. robusta* were planted but these have also failed.

Site name	Kalbar Showgrounds		
Location	Kalbar		
Site design	E. punctata planted in a single row along roadside.		
Site preparation	Post holes dug, mulched and fertilised at planting. Tree guards used through winter 1984.		
Age	21 years	Soil type	heavy black cracking clay, pH 6.5 at surface
Trees planted	270 trees		
Area planted	0.8 ha	NRM mapping	Black smooth ped earths
Aspect	flat		
Reasonable species	E. punctata		
Unsuccessful species	Casuarina cunninghamiana did not exhibit plantation potential		
Comments	E. punctata all subject to edge affect. No planting plan available		



Plate 15. Strip planting of *E. punctata* at the Kalbar Showgrounds

E. punctata performed well at the Kalbar Showgrounds; stems were very straight with an axis of persistence into the fourth quarter. *Casuarina cunninghamiana* had a high degree of stem taper and did not possess product potential.

Site name	Mt Berryman		
Location	Mt Berryman township		
Site Design	Block		
Site preparation	Holes dug with mattock, plants fertilised.		
Site maintenance	Trees watered approx 15 times in the first 12 months. Considerable management input given to watering, hare protection and weed control. Site was grazed only occasionally.		
Site threats	Hares attributed to the loss of several trees.		
Age	21 years	Soil appearance NRM mapping Aspect	Light clay pH 6.5
Trees planted	250		Bleached sands – uniform, coarse.
Area planted	0.5 ha (approx)		North-east slope
Reasonable species	<i>E. drepanophylla</i> , <i>C. citriodora</i> .		
Unsuccessful species	<i>E. crebra</i> , <i>E. microcorys</i> , <i>E. tereticornis</i> , <i>E. cloeziana</i> .		
Comments	none		



Plate 16. *C. citriodora* at the Mt Berryman site.

At Mt Berryman, *E. drepanophylla* achieved a 60 % survival rate, with an average height of 11 m. *C. citriodora* grew to 13.1 m on average, with a DBH of 24.1 cm. *E. crebra* had good form but was small, *E. microcorys* had heavy branching, *E. tereticornis* was multi-stemmed with poor form while *E. cloeziana* was very small.

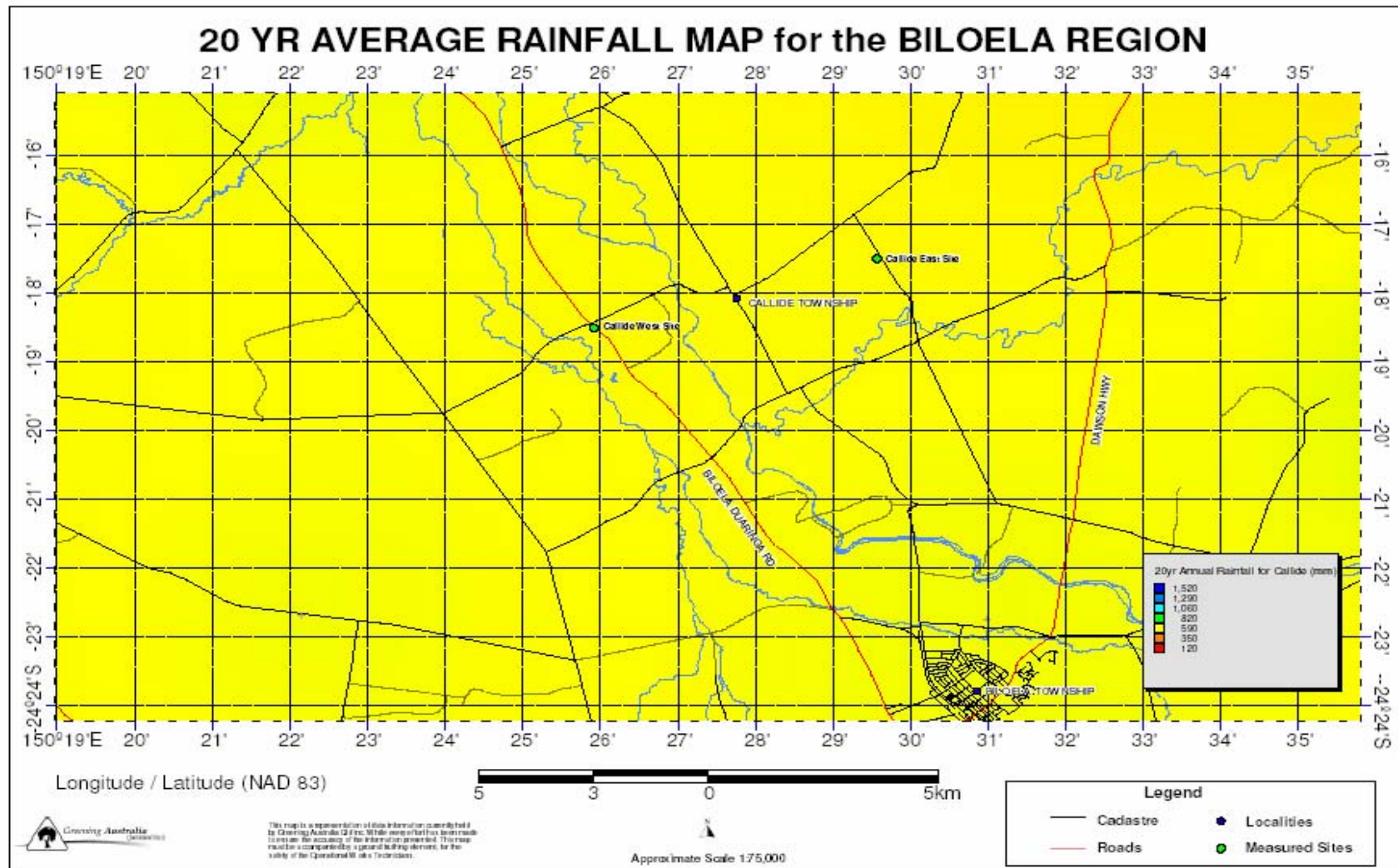
Site name	Tarome		
Location	Tarome		
Site Design	Block design. Tree spacing 5 m × 5 m		
Site preparation	Post holes dug, sides broken with crowbar.		
Site maintenance	Good establishment conditions after planting. Regularly slashed, mulched yearly, fertilised twice since establishment (500 g/tree, fertiliser type unknown).		
Site threats	Minor damage from cattle in July 1984, replanted 110 trees Nov 1984. Evidence of a fire passing through site around 2003 (Borschman, 2003), appeared to be low intensity, some trees killed, some scarred.		
Age	21 years	Soil appearance NRM mapping Aspect	Clay loam duplex, pH 6.0
Trees planted	800		Hard pedal red duplex soils
Area planted	2 ha		Southerly 5° slope
Successful species	<i>E. microcorys</i> , <i>E. dunnii</i> , <i>C. henryi</i> .		
Unsuccessful species	<i>E. camaldulensis</i> , <i>E. grandis</i> , <i>E. seeana</i> , <i>E. tessellaris</i> , <i>E. torrelliana</i> , <i>Casuarina cunninghamiana</i> and many other Eucalypt species.		
Comments	20–30 of each species planted.		

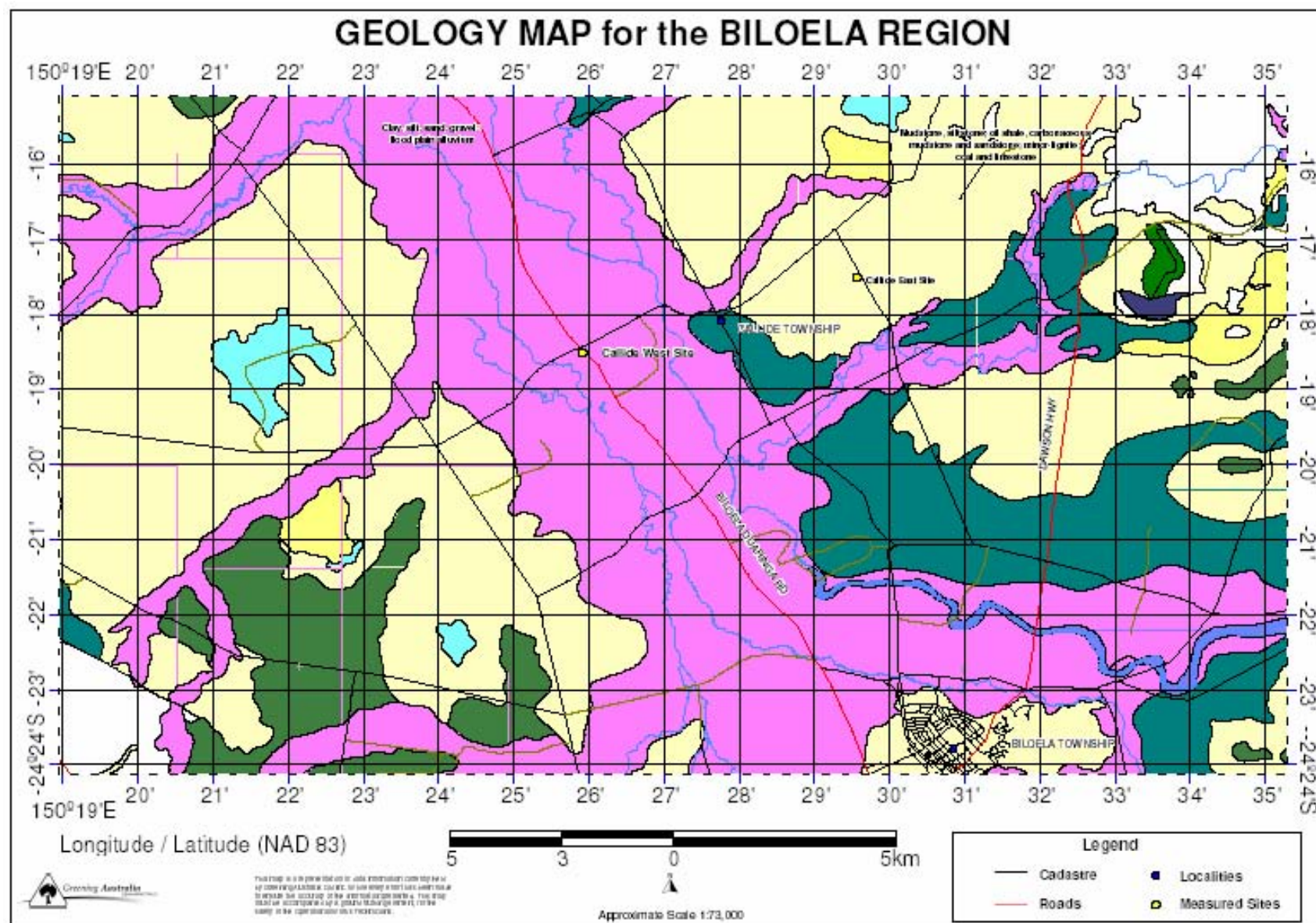


Plate 17. *C. henryi* at the Tarome site

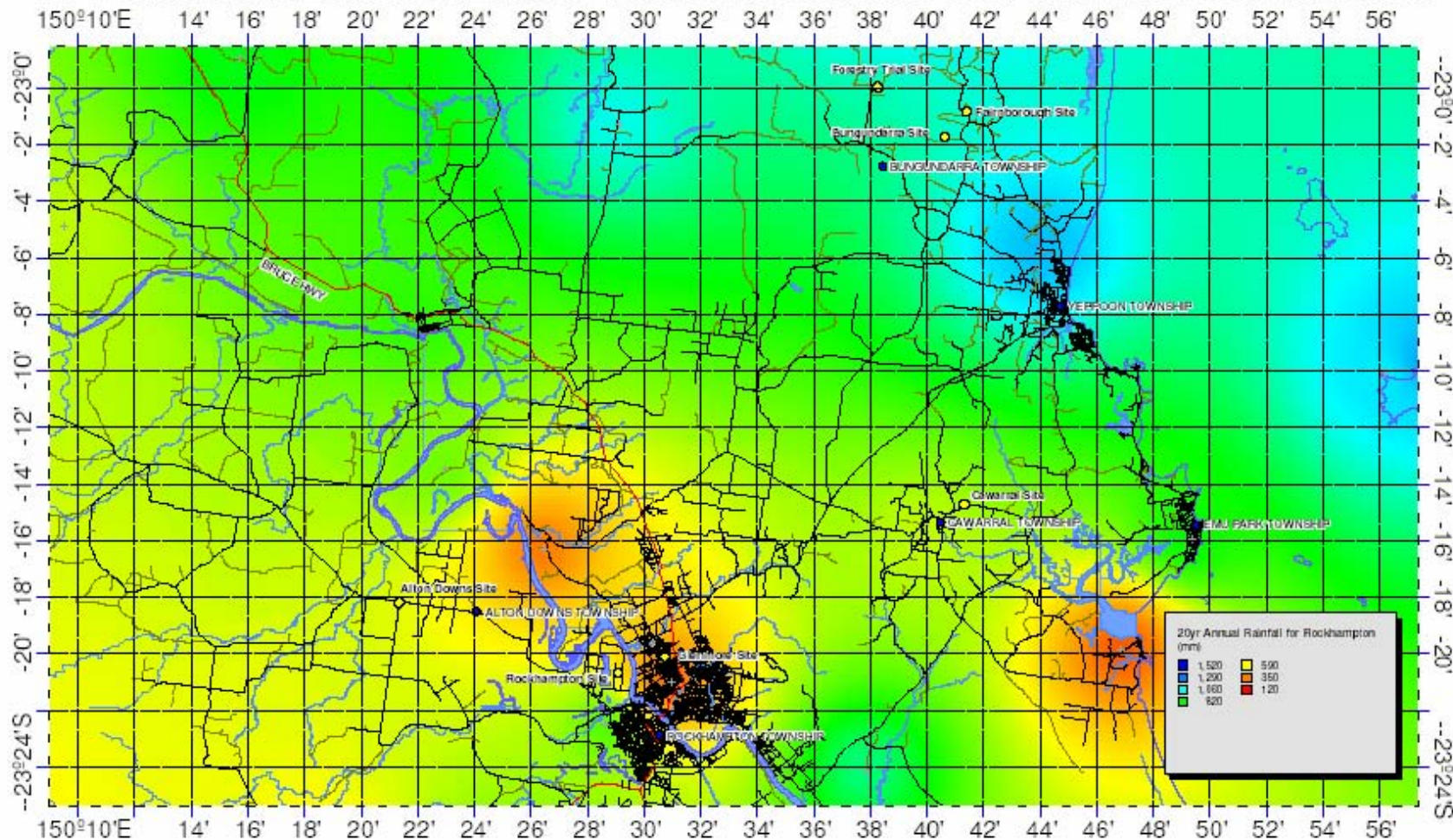
At Tarome *E. microcorys* had straight stems unfortunately combined with heavy branching at this site. Height was less than desirable at 14.2 m. The survival rate for the three successful species was 54–63 %. *C. henryi* was the tallest and had the largest DBH (32.9 cm) for the trees measured in SEQ. Tree form was also good. *E. dunnii* showed average results on the red duplex soil at this site reaching a height of 16 m and a DBH of 26 cm.

Appendix 3 – Rainfall isohyet and geology maps for regions where trials were located





20 YR AVERAGE RAINFALL MAP for the ROCKHAMPTON and YEPPOON REGION



Longitude / Latitude (NAD 83)



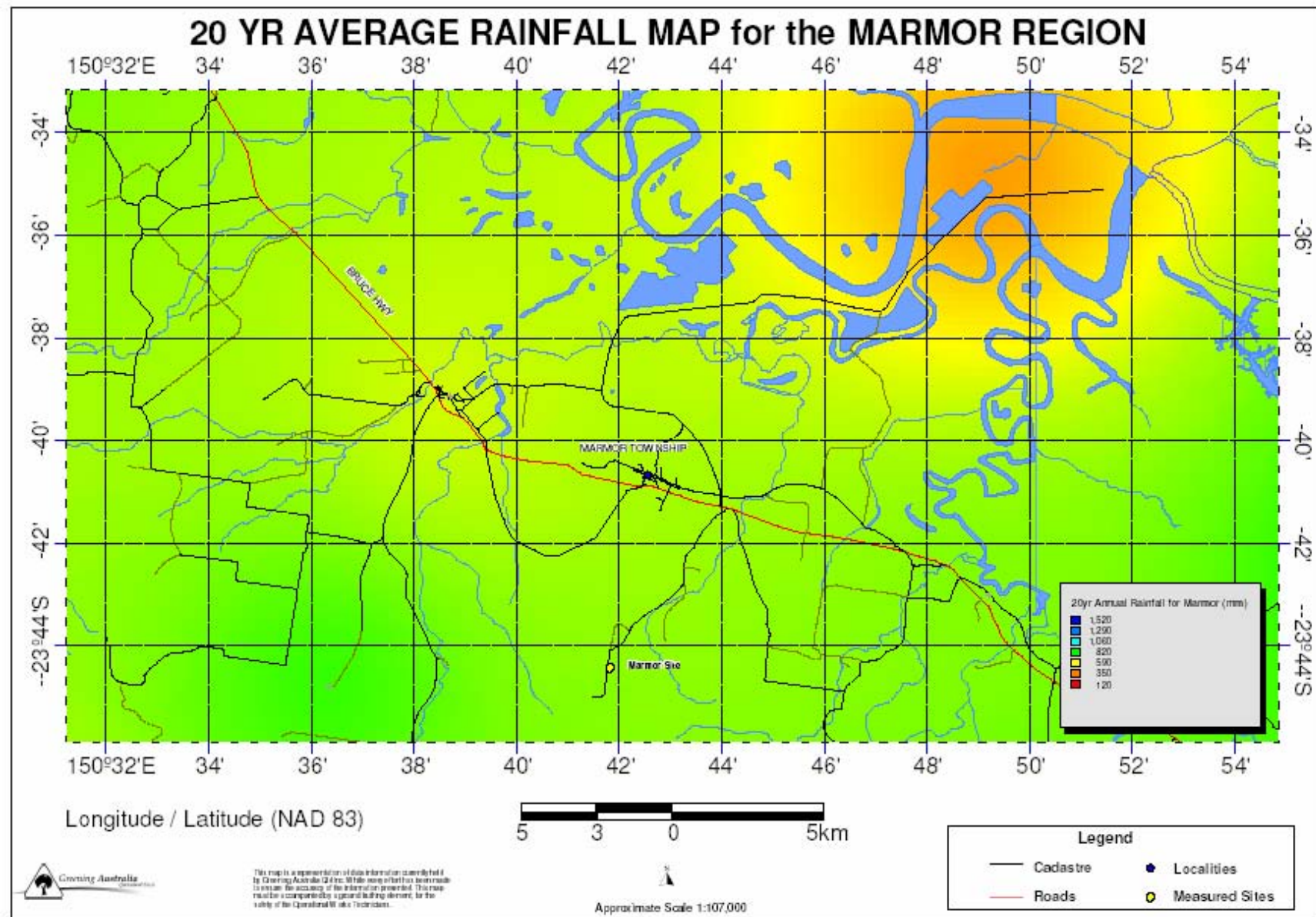
Approximate Scale 1:210,000



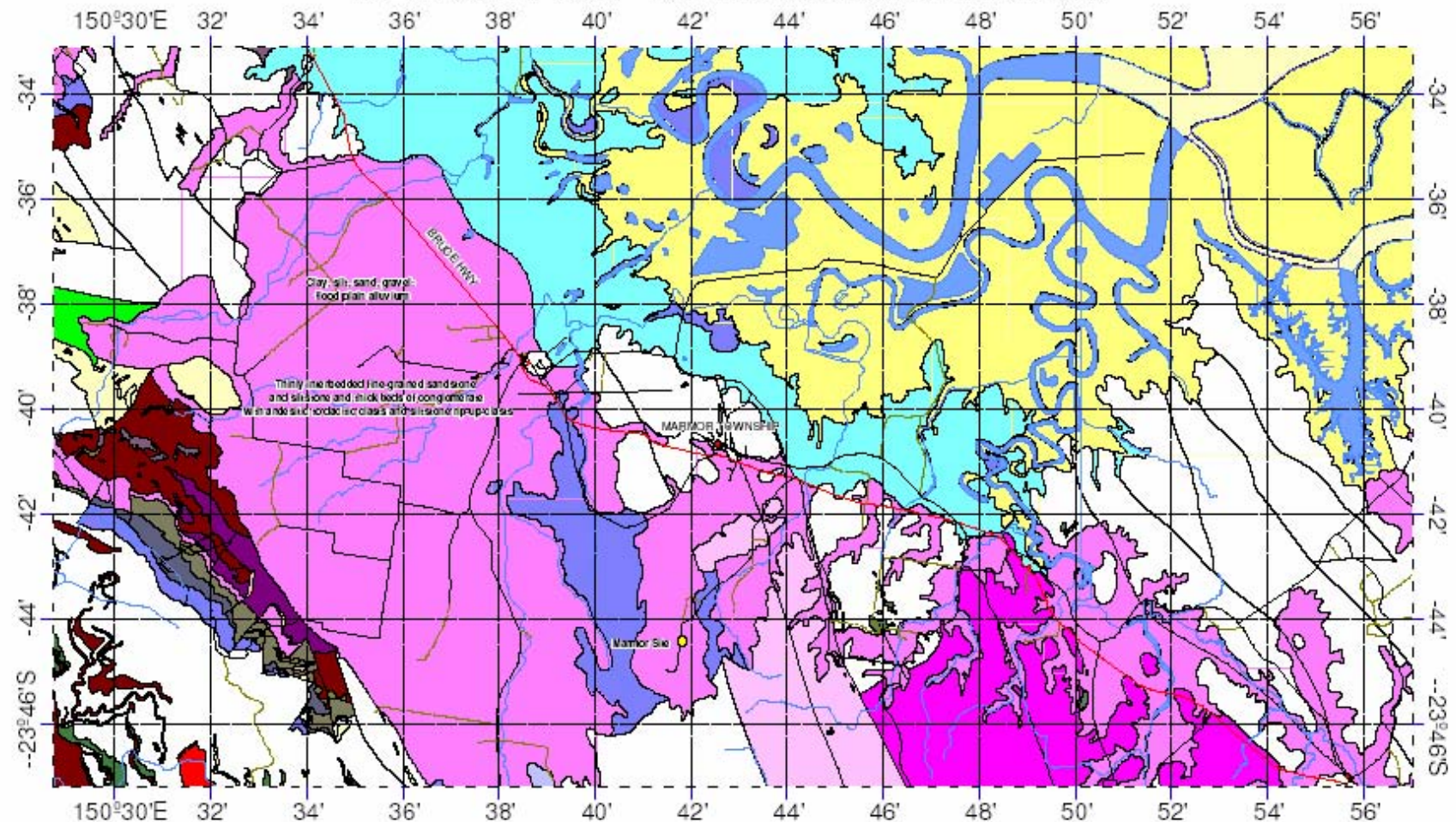
This map is a representation of data information supplied to Covering Australia 2010. While every effort has been made to ensure the accuracy of the information provided, this map must not be used as a substitute for professional advice, for the safety of the operational site or for the safety of the operational site or for the safety of the operational site.



[illegible]



GEOLOGY MAP for the MARMOR REGION



Longitude / Latitude (NAD 83)

5 3 0 5km

Approximate Scale 1:127,000



This map is a representation of data information compiled by Geosky Australia (2010). While every effort has been made to ensure the accuracy of the information presented, this map must be used in conjunction with a ground truthing exercise, for the validity of the Operational Risk Assessment.

Legend	
	Cadastre
	Roads
	Localities
	Measured Sites

20 YEAR AVERAGE RAINFALL for the SOUTH-EAST QUEENSLAND REGION

