Appendices

Appendix 1: Commencement reports for private native forest trial sites and monitoring plots

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Introduction

For private landholders, a combination of grazing and managed timber production can provide significant benefits. Landholder interest in land management for both timber production and grazing has been increasing, generated in part by the various extension programs run by staff from a range of organisations (e.g. Private Forestry Service Queensland, PFSQ). In 2016 a research project investigating productivity of the private native forest resource was initiated. This follows on from a previous project (2007-2010) that established a series of 13 experimental or monitoring sites in the private native forest resource (Lewis et al. 2010). The current research programme aims to:

1. Determine the influence of forest management (i.e. thinning regimes) on tree growth rates, carbon stocks and ecological attributes across a number of PNF sites.
2. Undertake a resource analysis to identify the spatial extent, resource condition and productive capacity of the PNF resource and establish a framework for ongoing inventory.
3. Undertake economic analyses of the potential return on investment associated with silvicultural management for thinning overstocked stands.

To provide the necessary advice to support the management of private native forests there is a need for the collection, collation and analysis of existing and new data on private land. Monitoring plots (e.g. silvicultural experiments) need to cover the range of site and climatic types typical of the sub-tropical private native forest resource. This report describes one of a series of experiments established on private land to address the current lack of data.

The following series of reports summarise the permanent monitoring plots that have been established in private native forest. This includes sites with an experimental design to determine the effects of different thinning treatments, and sites where a series of plots have been established on a property to cover a range in tree densities, associated with previous management. Each site is given an ‘experiment number’ which links to the DAF Forestry Science database. The information provided in these reports provides the necessary details to allow plots to be re-visited for future assessments.

Establishment and/or measurement of these trials was funded by Forest & Wood Products Australia and DAF Forest Industries (Improving productivity of the sub-tropical private native forest resource, PNC370-1516). Detailed commencement reports (with site location details) can be requested from Tom Lewis in DAF.

COMMENCEMENT REPORT: Experiment 1 NFQ

OBJECTIVE

To establish a network of native forest growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth vegetation dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

Experiment 1 NFQ was located in the Queensland and New South Wales border ranges. The experiment was established at two locations (replicates 1 and 2) on a property in the Rathdowney district south of Brisbane.

The forest cover generally is contiguous both within the property and within the broader landscape, consisting of mixed dry sclerophyll forest dominated by spotted gum. The site was previously owned by a mining company and harvested for mining timber in the 1970's. It was logged again in 2007 prior to establishment of the current trial. The 2007 logging operation initiated significant regeneration.

Replicate 1 is mapped as being non-remnant forest (Sattler & Williams 1999) while replicate 2 is mapped as regional ecotype (RE) 12.9/10.2 (Sattler & Williams 1999) which is described as an open-forest or woodland of *Corymbia citriodora,* usually with *Eucalyptus crebra* on sedimentary rocks.

Topography

Aspect - Replicate 1 - south
- Replicate 2 - north

Slope - Replicate 1–5 degrees
- Replicate 2–13 degrees

Vegetation and land use

Land use - Forestry and grazing
Surrounding vegetation type - Native forest on the upper slopes and hills with cleared areas for grazing and cultivation on the lower slopes and plains.

Soils and geology

Soil type - Red and Yellow Kurosols (Isbell 1996)
Geology - sandstone, siltstone and mudstone

Rainfall

Annual rainfall - 889 mm (Long term mean annual rainfall (MAR) Rathdowney Post Office[1])

[1] Source, Australian Government Bureau of Meteorology, site 40178

EXPERIMENTAL LAYOUT

The continuous forest cover enabled the use of large square plots. Gross and nett plot areas were surveyed and the corners were marked with steel pickets. Nett plot corners were recorded using a GPS with an accuracy of 5–10 m. The plots were laid out in randomised blocks (layout maps are shown in Appendix 1.1.1).

Number of treatments	- 3 (see Table 1 for listing of each treatment).
Number of replicates	- 2
Number of plots	- 6
Gross plot area (treated)	- 1 ha (100 × 100 m, 25 m isolation)
Nett plot area (treated)	- 0.25 ha (50 × 50 m)
Gross plot area (control)	- 0.4225 ha (65 × 65 m, 20 m isolation)
Nett plot area (control)	- 0.0625 ha (25 × 25 m)

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The site was heavily stocked and contained a large percentage of suppressed stems. There was a commercial logging operation in 2007 which removed some of the overwood prior to trial establishment.

The trial aims to investigate the effects of two stocking treatments, these being 50–75 st/ha (stems per hectare) and 100–150 st/ha. Prior to thinning, selection of retained stems was carried out. All stems to be removed (treated) and all stems ≥10 cm DBH[*] were measured (measure variables are listed in Table 2).

The treatment operation for this trial was undertaken on 7/02/2008. Treatment was carried out with a combination of chainsaw and brushcutter thinning followed by the application of Tordon DS ™ mix (20:1). Parts of replicate 2 had trees treated using a 1:4 mix of Tordon DS ™ with 1 ml applied per cut.

The retained trees were identified with a stainless steel tag which has a unique number. New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. Trees were measured using the variables shown in Table 2. Retained trees <10cm DBH were also measured as per Table 2, but were not uniquely identified. The control plots had all stems >5 cm DBH uniquely identified and measured as per Table 2.

Table 1 – Plot treatment layout. Stems per hectare for the control plots are provided below (Table 3).

Replicate	Plot Number	Treatment (st/ha)
1	1	50–99
1	2	100–150
1	3	Control
2	4	50–99
2	5	100–150
2	6	Control

Photographs of each plot are shown in Appendix 1.1.2.

[*] DBH – diameter at breast height (1.3 m)

Table 2 describes the variables measured on the different tree classes, the methods employed and the recommended frequency for future measurements. In 2016, merchantable height (m) was also measured, where merchantable height could be reasonably estimated (generally for trees with a DBH>20cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Grimes crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm.

Table 2 – Variables measured in treatment plots.

Stand Component	**Count**	**DBH**	**Species**	**Grimes Crown Assess***	**Crown Break***	**Total Height***	**Merch Class**	**Unique I.D.**
Retained Tree. ≥10 cm DBH (treatment plots)	–	✓	✓	✓	✓	✓	✓	✓
Retained Tree. <10 cm DBH (treatment plots)	–	✓	✓	–	–	✓	✓	–
Retained Tree. ≥5 cm DBH (control plots)	–	✓	✓	✓	✓	✓	✓	✓
Retained Tree. <5 cm DBH (control plots)	✓	–	✓	–	–	–	–	–
Removed Tree. ≥10 cm DBH	–	✓	✓	–	–	–	✓	–
Removed Tree. <10 cm DBH	✓	–	✓	–	–	–	–	–

* Variables only assessed on trees ≥10.0cm DBH

DATES OF ESTABLISHMENT

Plot survey and pegging - 04/02/2008
Initial measurement - 06/02/2008
Application of stand treatment / thinning - 07/08/2008
This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

An electronic copy of all data is stored on the DAF Forestry Science database. A summary of the plot data is provided in Table 3.

Table 3 – Plot summary data from the initial measure (2008) and the latest measure (2016).

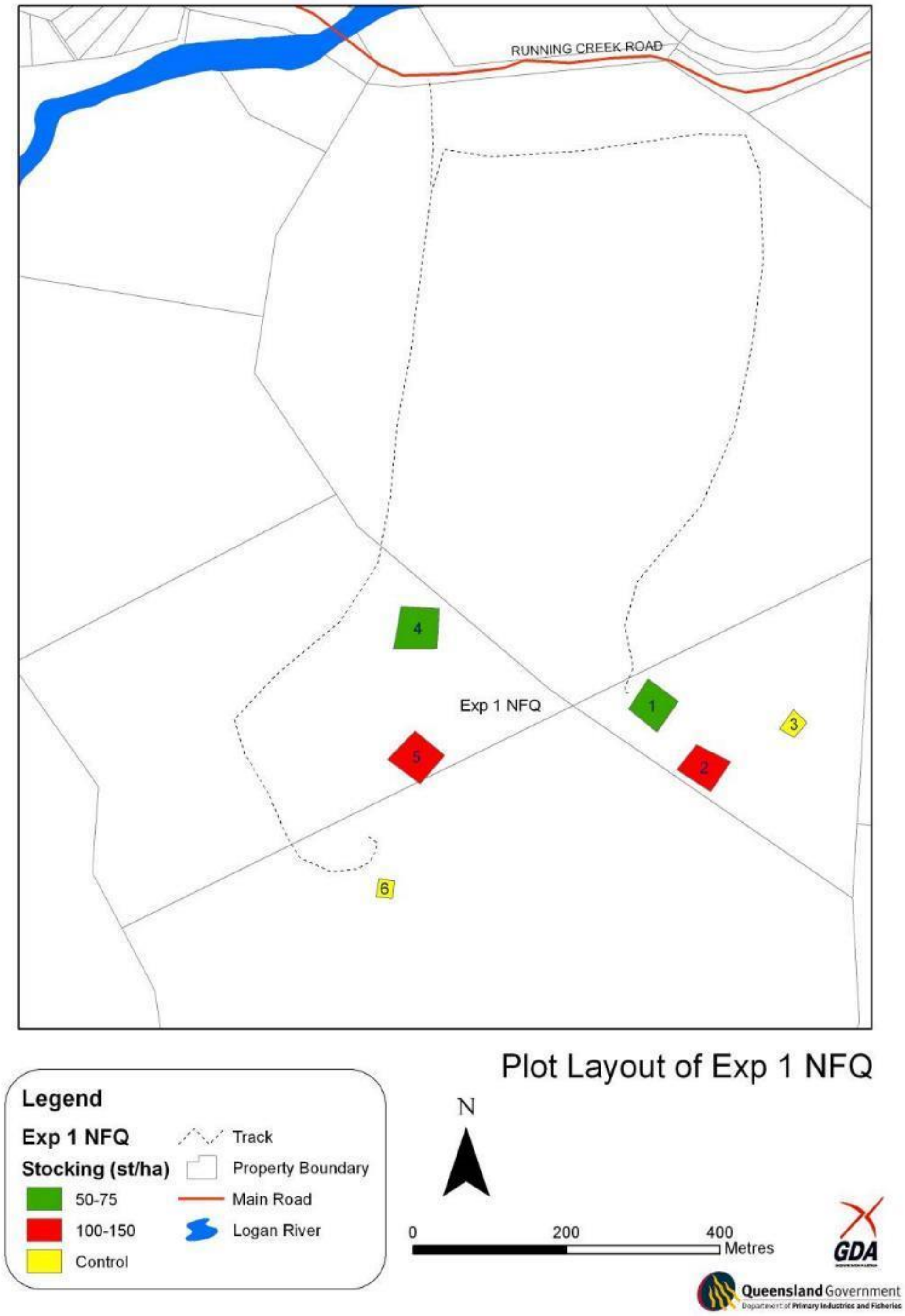
2008				2016		
Plot Number	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**
Plot 1	88	9.7	1.0	128	17.2	3.6
Plot 2	124	14.1	3.0	200	17.9	6.8
Plot 3	832	9.1	7.9	1168	10.7	14.6
Plot 4	72	17.9	3.0	84	25.1	5.0
Plot 5	132	18.4	4.5	136	24.1	7.4
Plot 6	816	11.8	11.9	832	13.4	15.0

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.1.1 – SITE LAYOUT MAP



APPENDIX 1.1.2 – PLOT PHOTOGRAPHS (POST TREATMENT)
Photographs taken June 2008

Plot 1 (88 st/ha)

Plot 2 (124 st/ha)

Plot 3 (832 st/ha)

Plot 4 (72 st/ha)

Plot 5 (132 st/ha)

Plot 6 (816 st/ha)

Photographs taken May 2016

Plot 1 (128 st/ha)

Plot 2 (200 st/ha)

Plot 3 (1168 st/ha)

Plot 4 (84 st/ha)

Plot 5 (136 st/ha)

Plot 6 (832 st/ha)

COMMENCEMENT REPORT: Experiment 2 NFQ

OBJECTIVE

To establish a network of growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth forest dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

Past management practices have resulted in dense regeneration development and the landowner, recognising the potential for timber production given correct management inputs, was keen to allow experimental work on the property.

Topography

Aspect - South
Slope - Less than 8 degrees

Vegetation and land use

Land use - Grazing and forestry
Surrounding vegetation type **-** Native forest (regional ecosystem (RE) RE12.9-10.2 which is spotted gum, ironbark open forest on sedimentary rock) on the upper slopes and hills with cleared areas for grazing and cultivation on the lower slopes and plains (Sattler & Williams 1999).

Soils and geology

Soil types - Range from a Red Kandosol (Isbell 1996) at the top of the ridge to a Yellow Kurosol (Isbell 1996) on the lower slope.
Geology - Sandstone, siltstone, shale conglomerate (Helidon sandstone)

Rainfall

Annual rainfall - 921 mm (Long Term MAR – Esk Post Office[2])

EXPERIMENTAL LAYOUT

The continuous young forest cover enabled the use of square plots. The gross and nett plot areas were surveyed and the plot start corners were marked with steel pickets. Nett plot corners were recorded using a GPS with and accuracy of 5–10 m. The plots were laid out in randomised blocks (Appendix 1.2.1).

Number of treatments - 4 (see Table 1 for listing of each treatment).
Number of replicates - 3
Number of plots - 12
Gross plot area (treated) - 0.49 ha (70 × 70 m, 15 m isolation)
Nett plot area (treated) - 0.16 ha (40 × 40 m)
Gross plot area (control) - 0.25 ha (50 × 50 m, 15 m isolation)
Nett plot area (control) - 0.04 ha (20 × 20 m)

[2] Source, Australian Government Bureau of Meteorology, site 40075

Total nett experiment area - 1.56 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The site was previously cleared to encourage pasture growth and grazing production. It was mapped under the RE mapping system as 'remnant forest', however requests by the landowner to have the mapping re-assessed resulted in the site being re-mapped as 'cleared'.

The experiment was designed to compare four stocking regimes (stocking treatments are shown in Table 1). Due to the dense stocking and young age of the stand, an initial thinning was undertaken to allow the development of the remaining stems, prior to imposing the final treatments. For this reason the thinning of this experiment was under taken as a two stage process.

The first thinning to approximately 300 st/ha occurred on 12/09/2006 using a combination of chainsaw and brush cutter, leaving stumps no higher than 15 cm (Appendix 5 shows photographs of plots before and after the first thinning stage). The stumps were allowed to coppice until 21/11/2006 when a foliar application of Garlon®™ (4.4 ml/l) and Spraymate LI 700®™ penetrant surfactant (3.6 ml/l) was carried out under dry conditions. This application resulted in a successful kill of the smaller sized coppice. A second foliar spray of the surviving coppice occurred on 01/03/2007 using Garlon®™ (5.9 ml/l) plus Spreadwet 600®™ wetting agent (0.14 ml/l).

The final thinning operation to reduce stocking to that required (Table 1) was carried out by PFSQ in 2009.

No individual tree assessments were conducted prior to the first thinning. Following the first stage thinning, all trees with a DBH[*] ≥2.0 cm were measured. Trees were identified with a stainless steel tag with a unique number at the start of the trial (after thinning in the thinned treatments). New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. Trees with desired form and vigour were assessed for total height at the initial measure.

[*] DBH – diameter at breast height (1.3 m)

Table 1 – Plot summary data from the initial measure after thinning (2009) and the latest measure (2016).

2009 Rep	Plot number	Stocking (st/ha) after final thinning	Intended stocking (st/ha)	2016 Stocking (st/ha)
1	1	75	75	100
1	2	200	200	200
1	3	119	100	118
1	4	1975	Control	2250
2	5	131	100	150
2	6	75	75	118
2	9	200	200	212
2	10	1225	Control	2225
3	7	650	Control	2300
3	8	194	200	200
3	11	75	75	112
3	12	119	100	168

Variables measured are shown in Table 2. In 2016 merchantable height (m) was measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm. Plot photographs are provided in Appendix 1.2.2.

Table 2 – Variables assessed in treatment nett plots prior to second thinning stage

Stand Component	DBH	Species	Total Height*	Merch Class	Unique I.D.
Retained Tree. >5 cm DBH (treatment plots)	✓	✓	✓	✓	✓

* Total height was only measured on stems over 10 cm DBH.

DATES OF ESTABLISHMENT

Plot survey and pegging - 15/03/2006
Initial measurement - 16/05/2007
Application of stand treatment/thinning - 12/09/2006 and 2009
Follow up coppice spray - 21/11/2006
Second follow up coppice spray - 01/03/2007 and following 2009 thinning

This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the 2009 and 2016 plot data is shown in Table 3.

Table 3 – Summary of retained stand details of Experiment 2 NFQ following treatments in 2009. Stocking details are provided in Table 1.

Plot Number	Replication	Mean DBH (cm) 2009	Retained BA (m^2/ha) 2009	Mean DBH (cm) 2016	Retained BA (m^2/ha) 2016
1	1	12.8	1.0	20.9	3.7
2	1	11.5	2.3	19.8	6.3
3	1	11.6	1.3	21.0	4.2
4	1	6.4	8.4	7.8	14.9
5	2	10.9	1.3	18.5	4.3
6	2	11.7	1.1	16.5	3.0
7	3	8.8	7.3	7.3	11.2
8	3	11.2	2.1	18.6	5.8
9	2	11.4	2.2	18.0	5.6
10	2	6.5	4.7	7.7	12.3
11	3	11.2	0.8	15.9	2.4
12	3	11.6	1.3	18.5	4.8

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.2.1 – LAYOUT MAP

Plot layout (intended final stocking shown in brackets).

APPENDIX 1.2.2 – PLOT PHOTOGRAPHS

Photographs taken March 2006 and February 2016

Plot 1 (250st/ha) 2006

Plot 1 (100st/ha) 2016

Plot 2 (350st/ha) 2006

Plot 2 (200 st/ha) 2016

Plot 3 (262 st/ha) 2006

Plot 3 (118 st/ha) 2016

Photographs taken March 2006 and February 2016

Plot 4 (1975 st/ha) 2006

Plot 4 (2250 st/ha) 2016

Plot 5 (306 st/ha) 2006

Plot 5 (150 st/ha) 2016

Plot 6 (312 st/ha) 2006

Plot 6 (118 st/ha) 2016

Photographs taken March 2006 and February 2016

Plot 7 (625 st/ha) 2006

Plot 7 (2300 st/ha) 2016

Plot 8 (268 st/ha) 2006

Plot 8 (200 st/ha) 2016

Plot 10 (1225 st/ha) 2006

Plot 10 (2225 st/ha) 2016

Plot 11 (287 st/ha) 2006

Plot 11 (112 st/ha) 2016

Plot 12 (238 st/ha) 2006

Plot 12 (168 st/ha) 2016

COMMENCEMENT REPORT: Experiment 3 NFQ

OBJECTIVE

To establish a network of native forest growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in forest dominated by spotted gum.

LOCATION / DESCRIPTION

General

The majority of the property is gently undulating with slopes less than 10 degrees. The research site was classified under the Regional Ecosystem (RE) classification as 12.9/10.3 '*Eucalyptus moluccana* (grey gum) ± *Corymbia citriodora* (spotted gum) on Cainozoic and Mesozoic sediments (Sattler & Williams 1999). The conservation status of this ecotype is classed as 'of concern'. This trial was initially established as a demonstration site in July 1999, researching sustainable management in private native forests. This was part of a series of demonstration sites established by the Mary Valley and Sunshine Coast Farm Forestry Association (MVSCFFA) and the Qld Forestry Research Institute (QFRI).

Topography

Aspect - Plots 7–9 and 11–13 are northerly; Plots 10 and 14 are southerly
Slope - Undulating, but less than 10 degrees

Vegetation and land use

Land use - Grazing and timber production
Surrounding vegetation type - Native Forest (RE12.9/10.3 – Sattler & Williams 1999)

Soils and geology

Soil type - There are 2 soil types on this site, with an area near plot 13 having a more intense red B2 horizon. The soils described are both acid duplex soils (Kurosols) (Isbell 1996).
Geology - sandstone, siltstone, shale, coal (Tiaro Coal Measures)

Rainfall

Annual rainfall - 975 mm (Long Term MAR – Theebine[3])

EXPERIMENTAL LAYOUT

The continuous forest cover enabled the use of large square plots. Gross and nett plot areas were surveyed and the corners marked with 50 × 50 mm white timber pegs. Nett plot corners were recorded using a GPS with an accuracy of 5–10 m. The experiment was originally established with a randomised block design, however, the plots have a range of stockings due to problems with initial treatment kill and a lack of follow-up treatment over time. As such, data from these plots will be more suited to analysis by regression methods.

Number of initially proposed treatments - 4 (see Table 1).
Number of replicates - 2
Number of plots - 8

[3] Source, Australian Government Bureau of Meteorology, site 40200

Gross plot area - 1 ha (100 × 100 m, 30 m isolation)
Nett plot area - 0.16 ha (40 × 40 m)
Total nett experiment area - 1.28 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

There is some evidence (anecdotal and the remains of standing ring barked trees) that the property was mostly cleared for grazing, probably in the early 1900's. Due to the even age of the stand it appears likely that farming was abandoned around the 1930's and since ringbarking ceased, forest cover has re-established. The gazetted road reserves running through the property contain the only remaining areas of mature forest.

In the late 1980's to early 1990's the block was logged to a diameter limit regime of 35+ cm and was also cut for fence posts in some areas. However, this ceased in 1997. The cutters recall large numbers of poles were removed during the operation.

The property was purchased by the present owners after this logging, with the intention to manage it for timber production and habitat values.

When the plots were established in 1999, the property comprised of timber stands in two growth stages:

- Areas of very heavy regeneration (>3,000 st/ha) 4 to 6 m tall with a sparse overstorey of residual suppressed or defective stems.
- Areas of 'advanced regrowth' (20–30 cm DBH*, 250–320 st/ha), including substantial numbers of trees rejected at logging due to bad form, defects or because they were non-commercial species.

Experiment 3 NFQ was located in advanced regrowth forest. This forested area was typical of many of the private forests in the region that have been subjected to a heavy harvesting with little or no subsequent management.

Thinning treatments used three methods:

1. Cut and swab;
2. *Woody Weeder*® injection hammer; and
3. tomahawk and calibrated tree injection gun using *Tordon Tree Killer*® and *Roundup*®. Tordon was diluted in water at a ratio of 1:1.5 and applied at a rate of 1.5 cc per cut. Each cut at waist height was approximately 8 cm apart. Roundup was used at full strength and applied at the same rate and technique as Tordon.

The treatments were applied in September 1999 with the aim of obtaining four stocking rates (Table 1). There were problems with finding enough suitable stems in the 200 st/ha treatment and the retained numbers were closer to the 100 st/ha treatment. In July 2006, trees that had not been killed by the 1999 treatment were retreated with Tordon®. Following the thinning treatment all trees $\geq$10.0 cm DBH were measured. Retained trees were identified with a stainless steel tag with a unique number. The plot series in this experiment has retained the original identification given to it under the previous experiment (532TCA). This was done to allow easy field identification and a seamless transition from the old experiment data set to the current data set. There has been some recruiting of stems since initial establishment and a number of the treatments now have a similar stocking (see Table 2).

* DBH – diameter at breast height (1.3 m)

Table 1 – Proposed initial stockings in 1999. Note that these differ substantially from the post-treatment stockings.

Replicate	Plot Number	Intended stocking (st/ha)
1	7	200
1	8	Control
1	9	100
1	10	70
2	11	Control
2	12	100
2	13	200
2	14	70

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging - 08/09/1999
Initial measurement - 14/09/1999
Application of initial stand treatment - 13/09/1999
Second assessment - 03/08/2000
Third assessment - 04/02/2002
Fourth assessment and re-treatment - 19/07/2006
This experiment was measured by DAF in 2010, PFSQ in 2013, then subsequently measured by DAF in 2016.

MANAGEMENT
Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA
An electronic copy of all data is stored on the DAF Forestry Science database. A summary of the 2006 and latest measure (2016) data are presented in Table 2.

Table 2 – Plot summary data from 2006 (after the second thinning) and the latest measure (2016). Due to a lack of follow-up treatment many of these plots had similar stocking in 2016

2006				2016		
Plot Number	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**
7	112	27.5	7.04	187	26.0	11.9
8	300	22.8	13.7	281	25.0	15.5
9	100	28.0	6.6	287	18.5	10.5
10	100	29.3	8.1	287	19.3	12.2
11	193	26.7	12.2	268	24.8	15.8
12	112	22.0	4.9	181	20.0	7.0
13	143	28.3	10.2	206	26.6	13.7
14	106	25.8	6.0	225	23.6	13.7

Photographs of each plot are attached as Appendix 1.3.1.

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.3.1 – PLOT PHOTOGRAPHS

Photographs taken November 2008.

Plot 7 (112 st/ha)

Plot 8 (300 st/ha)

Plot 9 (100 st/ha)

Plot 10 (100 st/ha)

Plot 11 (193 st/ha)

Plot 12 (112 st/ha)

Photographs taken November 2008.

Plot 13 (143 st/ha)

Plot 14 (106 st/ha)

Photographs taken November 2016.

Plot 8 (281 st/ha)

Plot 11 (268 st/ha)

Plot 12 (181 st/ha)

Plot 13 (206 st/ha)

COMMENCEMENT REPORT: Experiment 4 NFQ

OBJECTIVE
To establish a network of native forest growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in forest dominated by spotted gum.

LOCATION / DESCRIPTION

General

The majority of the research site was classified under the Regional Ecosystem (RE) classification as 'non-remnant' with two plots (2 and 4) located in an area classified as RE12.3.11 - *Eucalyptus tereticornis*, *E. siderophloia* and *Corymbia intermedia*, sometimes with spotted gum as a minor species on alluvium or flat to undulating plains with sandy surfaced texture contrast soils (Sattler & Williams 1999). The conservation status of this ecosystem is classed as 'of concern'. All plots were situated in spotted gum dominant forests.

Topography

Aspect - Plot 1 – Easterly
Plot 2 – North westerly
Plots 3, 4, 5 and 6 – South easterly
Plots 7 and 8 – South westerly
Slope - Undulating, 6 degrees or less

Vegetation and land use

Land use: - Grazing and timber production
Surrounding vegetation type: - Native forest (non-remnant, RE12.3.11 and RE12.9-10.3, Sattler & Williams 1999) on the surrounding landscape.

Soils and geology

Soil type - Soil types are Brown Kurosols (plots 1, 2, 3, 4, 7 and 8) and Red Dermosols (plots 5 and 6) (Isbell 1996).
Geology - Tiaro Coal Measures

Rainfall

Annual rainfall - 1043 mm (Long Term MAR – Gundiah[4])

EXPERIMENTAL LAYOUT

The continuous young forest cover enabled use of large square plots. Gross and nett plot areas were surveyed and corners were marked with 50 × 50 mm white timber pegs. Nett plot corners were recorded using a GPS with an accuracy of 5–10 m. This trial aimed to measure the range of stockings across the property. Tree stocking varied in 2007 and 2008 varied from 12 st/ha to 425 st/ha (Table 1).

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[4] Source, Australian Government Bureau of Meteorology, site 40092

Number of plots	-	8
Gross plot area	-	0.25 ha (45 × 45 m, 5 m isolation)
Nett plot area	-	0.16 ha (40 × 40 m)
Total nett experiment area	-	1.28 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

This property has been managed for over 60 years for both timber and grazing production. Management of the spotted gum forests has been cross-generational with the potential for timber sales to offset grazing downturns realised by the property owners.

Typical management of the forest has included: (i) removal of acacia and non-commercial species to favour the development of spotted gum; and (ii) silvicultural treatment of dense spotted gum regeneration to a stocking believed suitable by the landowner. Prescribed burning has also been commonly used (typically at intervals of 2–4 years) to enhance grazing and timber production (by reducing understorey development).

Harvesting on the property has been of low intensity, with a single tree selection method being adopted to periodically remove the dead and senescing trees as they are identified. The landholder harvests trees as they become available and provides them at a ramp for hauling to mill. Three trees from plot 6 were logged on 4/08/2007.

Plots 5, 6, 7 and 8 form part of a pasture management trial being undertaken by PFSQ in collaboration with DPI&F, Bundaberg. These four plots were fenced in 2007 to exclude cattle grazing. It is expected that the fence will have an effect on pasture growth and tree regeneration.

All trees with a DBH of ≥10.0 cm were tagged and measured for DBH. Trees are identified with a stainless steel tag with a unique number. Tree heights were recorded in 2007 and 2016, on trees with a DBH ≥20.0 cm. Grimes crown scores were measured in 2007 and 2016, but only on trees with a DBH ≥10 cm. In 2016 merchantable height (m) was also measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >20cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Photographs of each plot are provided in Appendix 1.4.1.

DATES OF ESTABLISHMENT / MEASUREMENT

Plot establishment and initial measurement	-	25–26/07/2006
Application of stand treatment / thinning	-	Continuous (Plot 6 – 04/08/2007)
Second assessment	-	08/09/2008
Third assessment	-	29/09/2010

This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

An electronic copy of all data is stored on the DAF Forestry Science database. A summary of the 2008 and 2016 plot data is shown in Table 1.

Table 1 – Plot summary data from 2008 measure and the latest measure data (2016).

2008				**2016**		
Plot	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**
1	144	18.3	4.1	144	22.4	6.0
2	206	23.4	11.5	206	25.4	13.2
3	175	19.2	7.0	181	20.9	8.2
4	425	15.5	11.8	387	17.4	13.0
5	31	20.7	1.3	181	13.4	3.7
6	206	21.5	11.8	225	21.8	12.4
7	12	34.6	1.5	31	22.1	2.0
8	88	41.6	12.7	75	43.4	11.9

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.4.1 – PLOT PHOTOGRAPHS

Photographs taken September 2008.

Plot 1 (144 st/ha)

Plot 2 (206 st/ha)

Plot 3 (175 st/ha)

Plot 4 (425 st/ha)

Plot 5 (31 st/ha)

Plot 6 (206 st/ha)

Photographs taken September 2008.

Plot 7 (12 st/ha)

Plot 8 (88 st/ha)

Photographs taken October 2016

Plot 1 (143 st/ha)

Plot 2 (206 st/ha)

Plot 3 (181 st/ha)

Plot 4 (387 st/ha)

Photographs taken October 2016

Plot 5 (181 st/ha)

Plot 6 (225 st/ha)

Plot 7 (31 st/ha)

Plot 8 (43 st/ha)

COMMENCEMENT REPORT: Experiment 5 NFQ

OBJECTIVE

To establish a network of native forest growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth forest dominated by spotted gum.

LOCATION / DESCRIPTION

General

Sites were classified under the Regional Ecosystem (RE) classifications (Sattler & Williams 1999) as non-remnant forest and consist mostly of spotted gum dominant open woodlands to open forests with a mixture of other species including *Eucalyptus crebra* (narrow-leaved red ironbark), *Alphitonia excelsa* (red ash) and understorey dominated by acacia (at varying density).

Topography

Aspect - Predominantly north (plots 3–11 and 13) with westerly influences on plots 1, 2 and 12
Slope - Varies among plots. Landscape was low hilly terrain with undulating to moderately steep slopes in some gully areas. Generally less than 10 degrees.

Vegetation and land use

Land use - Grazing and timber production
Surrounding vegetation type **-** Surrounding vegetation was regrowth forest mapped as non-remnant. Surrounding ranges and upper slopes are native forest mapped as RE 12.12.3 (open-forest complex in which spotted gum is a relatively common species with *Eucalyptus siderophloia* or *E. crebra*) and RE 12.12.5 (open-forest to woodland of *Corymbia citriodora*, usually with *E. crebra*. (Sattler & Williams 1999).

Soils and geology

Soil type - Plots 3–11 are on decomposing granite soils. Due to the amount of included rock it was very difficult to auger a hole for descriptive purposes. The soil was therefore described in a cutting near the site and classified as a Clastic Rudosol (Isbell 1996). Plots 1, 2, 12 and 13 are on a different soil type which appears more consolidated. These soils were unable to be described.
Geology - Granite, granodiorite, diorite and gabbro (Permian-Triassic intrusions in Yarrol, Calliope and Coastal Blocks)

Rainfall

Annual rainfall - 937 mm (Long Term MAR – Moolboolaman[5])

EXPERIMENTAL LAYOUT

The broken nature of the forest cover at this site required the use of circular plots. In most cases these plot centres were pegged with a steel fencing post. Where wider contiguous patches of forest persisted, larger square plots were used. The square gross and nett plot areas

[5] Source, Australian Government Bureau of Meteorology, site 39218

were surveyed and corners marked with 50 × 50 mm white timber pegs. All plot pegs were recorded using a GPS with an accuracy of 5–10 m. This trial aimed to measure a range of stockings across the property.

Number of plots	-	13
Gross plot area circular	-	0.1 ha (17.8 m radius, 5 m isolation)
Gross plot area square	-	0.36 ha (60 × 60 m, 10 m isolation)
Nett plot area circular	-	0.05 ha (12.6 m radius)
Nett plot area square	-	0.25 ha (50 × 50 m)
Total nett experiment area	-	1.05 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The research area was previously cleared for grazing. Past and current management aims to integrate timber production with grazing in suitable areas. In the productive areas of the property, spotted gum regeneration has been allowed to develop for the purposes of timber production. The forest was previously logged *circa* 1998 and the resulting stand was silviculturally treated in November 2006. Fire has been used infrequently on the property.

The silvicultural treatment (thinning) used a tomahawk and calibrated tree injection gun using the chemical *Tordon DS*®. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1 cc per cut. Each cut at waist height was no further than 2 cm apart.

Following the thinning treatment, the DBH and height of all trees ≥10 cm DBH[*] were measured (variables measured are listed in Table 1). Trees over 10 cm DBH had merchantable height assessed, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Grimes crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm). Retained trees were identified with a stainless steel tag with a unique number. Photographs of each plot are provided in Appendix 1.5.1.

The measure details are listed in Table 1. Unless required for retained stocking rates, only trees ≥10 cm DBH were assessed, however all non-retained trees were treated. New recruits (trees ≥10 cm DBH) into each plot were tagged and measured.

Table 1 – Variables measured/assessed in treatment nett plots.

Stand Component	DBH	Species	Merch Height*	Total Height[#]	Merch Class	Unique I.D.
Retained Tree. >20 cm DBH	✓	✓	✓	✓	✓	✓
Retained Tree. ≥10 cm DBH	✓	✓	–	✓	✓	✓

* Merchantable height only assessed on retained trees ≥20.0 cm DBH
\# Total height measured on all retained trees.

DATES OF ESTABLISHMENT / MEASUREMENT

[*] DBH – diameter at breast height (1.3 m)

Plot survey and pegging	- 6/11/2006	Plots 1–9, 12, 13
	- 16/01/2007	Plots 6–8, 11
Initial measurement	- 7/11/2006	Plots 1–9, 12, 13
	- 17/01/2007	Plots 6–8, 11
Application of stand thinning treatment	- 5/11/2006	

This experiment was re-measured in 2008, 2010, 2012, 2013 and 2016.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. Summary of the 2008 and 2016 plot data is shown in Table 2.

Table 2 – Summary of retained stand details following establishment (2008 and 2016).

2008				2016		
Plot Number	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**
1	120	16.5	2.6	120	22.8	4.9
2	180	17.2	4.8	200	21.3	8.1
3	120	11.1	1.2	120	14.2	2.1
4	80	15.4	1.8	80	19.8	2.8
5	160	22.7	9.5	140	21.4	6.1
6	902	9.0	6.8	761	10.4	7.6
7	1203	9.6	9.8	781	11.4	9.2
8	1243	10.0	12.5	942	11.8	13.2
9	120	18.8	3.4	120	24.3	5.6
10	200	13.2	2.9	200	17.2	4.9
11	1403	4.9	5.8	842	9.7	7.5
12	192	10.9	3.7	196	15.6	5.3
13	252	10.9	5.1	412	12.9	8.1

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.5.1 – PLOT PHOTOGRAPHS

Plot 1 (120 st/ha)

Plot 2 (180 st/ha)

Plot 3 (120 st/ha)

Plot 4 (80 st/ha)

Plot 5 (160 st/ha)

Plot 6 (902 st/ha)

Plot 7 (1203 st/ha)

Plot 8 (1243 st/ha)

Plot 9 (120 st/ha)

Plot 10 (200 st/ha)

Plot 11 (1403 st/ha)

Plot 12 (192 st/ha)

COMMENCEMENT REPORT: Experiment 6 NFQ

OBJECTIVE

To establish a network of native forest growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth forest dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

The property was located 22 km south east of Gayndah in the South Burnett region. The landscape consists of undulating low hills with slopes of up to 10 degrees.

The research sites have been classified under the Regional Ecosystem classifications (Sattler & Williams 1999) as either non-remnant (replications 1, 2 and 4) or regrowth (replication 3) and consists mostly of spotted gum dominant open woodlands to open forests with a mixture of other species including *Eucalyptus crebra* (narrow-leaved red ironbark) and *E. moluccana* (grey box).

Topography:

Aspect - North, east and south
Slope - Varies across the site but all slopes were less than 10 degrees

Vegetation and land use

Land use - Grazing and timber production
Surrounding vegetation type - Native forest (RE12.9–10.3, Sattler & Williams 1999) on the surrounding landscape.

Soils and geology

Soil type - Brown Kurosol/Sodosol (Isbell 1996) (replicates 1, 3 and 4)
Replicate 2 was on a very rocky knob and soil was unable to be described.
Geology - Sandstone, shale (Aranbanga Volcanic Group, Gayndah Formation)

Rainfall

Annual rainfall - 692 mm (Long Term MAR – Brian Pastures[6])

EXPERIMENTAL LAYOUT

The broken nature of the forest cover at this site required the use of circular plots. Plot centres were pegged with a steel fencing post and their locations were recorded using a GPS with an accuracy of 5–10 m. At the request of the landholder each replicate consisted of two treatment plots of the same stocking and a control plot[7]. These treatments were randomised at each location (layout map provided in Appendix 1.6.1). Variable nett plot sizes were used, depending on the treatment (ensuring a minimum of 10 trees per plot).

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[6] Source, Australian Government Bureau of Meteorology - site number 40428

[7] The land owner preferred that the more productive grazing areas (replicates 3 and 4) be reduced to 50 st/ha while the more marginal grazing areas (replicates 1 and 2) managed for timber production with a stocking of 100 stems / hectare.

Number of treatments - 3 (see Table 1 for listing of each treatment).
Number of replicates - 4
Number of plots - 12
Gross plot area - 0.24 ha (27.8 m radius with10 m isolation)
Nett plot area - 0.1 ha (17.8 m radius) and 0.5 ha (12.6 m radius)
Total nett experiment area - 1.2 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The site was previously cleared for grazing. Past and current management aims to integrate timber production with grazing in suitable areas. In the productive areas of the property, spotted gum regeneration has been allowed to develop for timber production.

Replicates 1, 2 and 4 were last treated in 1987, while replicate 3 was last treated in 1970. This difference in past treatment should have no effect on current treatment regimes. Trees that were removed were treated using a tomahawk and calibrated tree injection gun using the chemical *Tordon DS*®. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1 cc per cut. Each cut at waist height was no further than 2 cm apart.

The experimental thinning treatments were applied from the 10–13 June 2008, at the three stocking rates shown in Table 1. Unless required for retained stocking rates, only trees ≥10 cm DBH were assessed, however all non-retained trees were treated. Following the thinning treatment, the DBH* and height of all trees ≥10 cm DBH were measured (variables for measure are listed in Table 2). Merchantable height (m) was measured, where merchantable height could be reasonably estimated (trees with a DBH >20cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Grimes crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm. Retained trees were labelled with a stainless steel tag with a unique number at the start of the trial. New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. Photographs of each plot are provided in Appendix 1.6.2.

Table 1 – Plot treatment layout.

Replicate	Plot Number	Treatment (st/ha)
1	1	100
1	2	100
1	3	Control
2	4	100
2	5	Control
2	6	100
3	7	50
3	8	50
3	9	Control
4	10	50
4	11	50
4	12	Control

* DBH – diameter at breast height (1.3 m)

The measured variables are listed in Table 2. Unless required for retained stocking rates, only trees ≥10 cm DBH were assessed, however all non-retained trees were treated.

Table 2 – Variables assessed in treatment nett plots.

Stand Component	**DBH**	**Species**	**Merch Height***	**Total Height#**	**Merch Class**	**Unique I.D.**
Retained Tree. >20 cm DBH	✓	✓	✓	✓	✓	✓
Retained Tree. ≥10 cm DBH	✓	✓	–	✓	✓	✓
Removed Tree ≥10 cm DBH	✓	✓	–	–	✓	–

* Merchantable height only assessed on retained trees ≥20 cm DBH
# Total height measured on all retained trees.

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging - 21/05/2008
Initial measurement - 11/06/2008
Application of current stand treatment - 13/06/2008
This experiment was re-measured in 2010, 2011, 2013 and 2016.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA
A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the plot data measure is shown in Table 3.

Table 3 – Plot summary data from the initial measure after thinning (2008) and the latest measure (2016).

2008					**2016**		
Plot Number	**Replication**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**
1	1	100	19.9	4.4	110	25.5	6.9
2	1	100	19.6	4.2	100	25.1	6.1
3	1	320	15.0	5.9	380	17.7	10.0
4	2	100	12.7	1.3	110	18.4	3.1
5	2	581	15.7	13.2	621	18.0	18.4
6	2	100	16.7	2.3	100	23.0	4.3
7	3	50	23.4	2.3	50	30.3	3.8
8	3	50	23.5	2.2	60	29.7	4.4
9	3	481	16.9	12.5	501	19.0	16.3
10	4	50	19.1	1.5	50	29.2	3.5
11	4	50	15.9	1.0	60	21.6	2.3
12	4	601	13.7	9.3	681	16.3	15.1

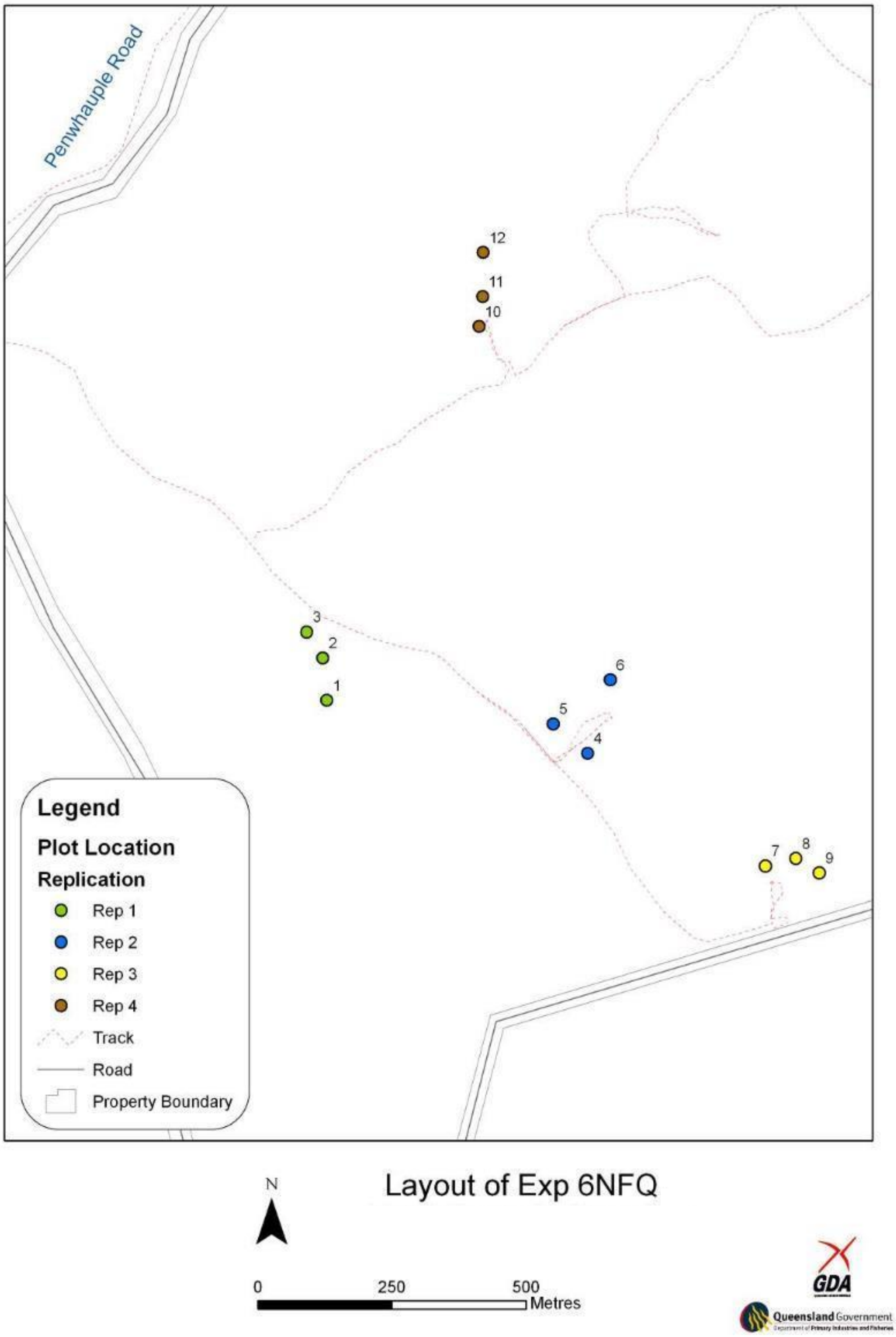
REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.6.1 – PLOT LAYOUT

Refer to Table 1 for the treatments applied to each plot.



Layout of Exp 6NFQ

APPENDIX 1.6.2 – PLOT PHOTOGRAPHS

Photographs taken June 2008.

Plot 1 (100 st/ha)

Plot 2 (100 st/ha)

Plot 3 (320 st/ha)

Plot 4 (100 st/ha)

Plot 5 (581 st/ha)

Plot 6 (100 st/ha)

Photographs taken June 2008.

Plot 7 (50 st/ha)

Plot 8 (50 st/ha)

Plot 9 (240 st/ha)

Plot 10 (50 st/ha)

Plot 11 (50 st/ha)

Plot 12 (300 st/ha)

Photographs taken October 2016

Plot 1(100 st/ha)

Plot 2 (100 st/ha)

Plot 3

Plot 4

Plot 5

Plot 6


Plot 7


Plot 8


Plot 9


Plot 10


Plot 11

COMMENCEMENT REPORT: Experiment 7 NFQ

OBJECTIVE
To establish a network of growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in remnant forest dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

The property was located 22 km south-east of Gayndah in the South Burnett region. The landscape consisted of undulating low hills with slopes up to 10 degrees.

The research sites have been classified under the Regional Ecosystem classification as 12.12.5 - *Corymbia citriodora*, *Eucalyptus crebra* open forest on mesozoic to proterozoic igneous rocks (Sattler & Williams 1999). The site was a spotted gum dominant, open forest.

Topography

Aspect - North and east
Slope - Variable but less than 10 degrees

Vegetation and land use

Land use - Grazing and timber production.
Surrounding vegetation type - Native forest (RE12.12.5, Sattler & Williams 1999) on the surrounding landscape. There were some ‘non-remnant’ areas in the lower landscape.

Soils and geology

Soil type - Bleached-Leptic Tenosol (Isbell 1996)
Geology - sandstone, shale (Aranbanga Volcanic Group Gayndah Formation)

Rainfall

Annual rainfall - 692 mm (Long Term MAR – Brian Pastures[8])

EXPERIMENTAL LAYOUT
Experiment 7 NFQ uses circular plots with variable plot sizes to ensure that there was a minimum of 10 measure trees per plot. Plot centres were marked with a steel fencing post and their location recorded using a GPS with an accuracy of 5–10 m. Plots were laid out as a randomised block design and Appendix 1.7.1 shows the layout of plots within the experiment.

Number of treatments - 3 (see Table 1 for listing of each treatment).
Number of replicates - 2
Number of plots - 6
Gross plot area
Control - 0.09 ha (17.6 m radius, 5 m isolation)
100 s/ha - 0.24 ha (27.8 m radius, 10 m isolation)
50 s/ha - 0.39 ha (35.2 m radius, 10 m isolation)
Nett plot area
Control - 0.05 ha (12.6 m radius)

[8] Source, Australian Government Bureau of Meteorology - site number 40428

100 s/ha	-	0.1 ha (17.8 m radius)
50 s/ha	-	0.2 ha (25.2 m radius)
Total nett experiment area	-	1.05 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The research area was located in remnant forest which was treated as part of a demonstration project funded by AgForests and Burnett Mary Regional Group (BMRG). The forest had a high basal area (BA) and was over-stocked, resulting in a high proportion of suppressed stems and trees with poor crowns. Total tree height was relatively low. Some difficulty was experienced in selecting 100 suitable trees/ha for retention in the experimental plots. Current management aims to integrate timber production with grazing in this area.

Trees that were removed were treated using a tomahawk and calibrated tree injection gun using the chemical *Tordon DS*®. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1 ml per cut. Each cut at waist height was no further than 2 cm apart.

The experimental thinning treatments were applied from the 10–13 June 2008 at the three stocking rates shown in Table 1. Following the thinning treatment, all trees ≥10 cm DBH[*] were measured (variables listed in Table 2). Retained trees were identified with a stainless steel tag with a unique number. Merchantable height (m) was measured, where merchantable height could be reasonably estimated (trees with a DBH >20cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Grimes crown scores (Appendix 5) were also measured in 2016, but only on trees with a DBH ≥10 cm. Photographs of each plot are provided in Appendix 1.7.2.

Table 1 –Treatment stocking at each plot.

Replicate	Plot Number[9]	Stocking (st/ha)
1	13	100
1	14	50
1	15	Control
2	16	Control
2	17	100
2	18	50

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging	- 13/05/2008
Initial measurement	- 14/05/2008
Application of stand treatments	- 13/06/2008

This experiment was re-measured in 2010, 2013 and 2016.

The variables measured are listed in Table 2. Only trees ≥10 cm DBH were measured, unless measurements were necessary to ensure the required stocking rates were achieved. All non-retained trees were treated.

[*] DBH – diameter at breast height (1.3 m)

[9] Experiment 6 NFQ was located on the same property. Plot numbers continue in sequence to ensure that there will be no confusion in future measures.

Table 2 – Variables assessed in treatment nett plots.

Stand Fraction	DBH	Species	Merch Height*	Total Height#	Merch Class	Unique I.D.
Retained Tree. ≥20cm DBH	✓	✓	✓	✓	✓	✓
Retained Tree. <20cm DBH	✓	✓	–	✓	✓	✓
Removed Tree ≥10cm DBH	✓	✓	–	–	✓	–

* Merchantable height only assessed on retained trees ≥20 cm DBH
\# Total height assessed on all retained trees.

MANAGEMENT
Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA
A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the 2008 and 2016 plot data shown in Table 3.

Table 3 – Plot summary data from the initial measure (2008) and the latest measure (2016).

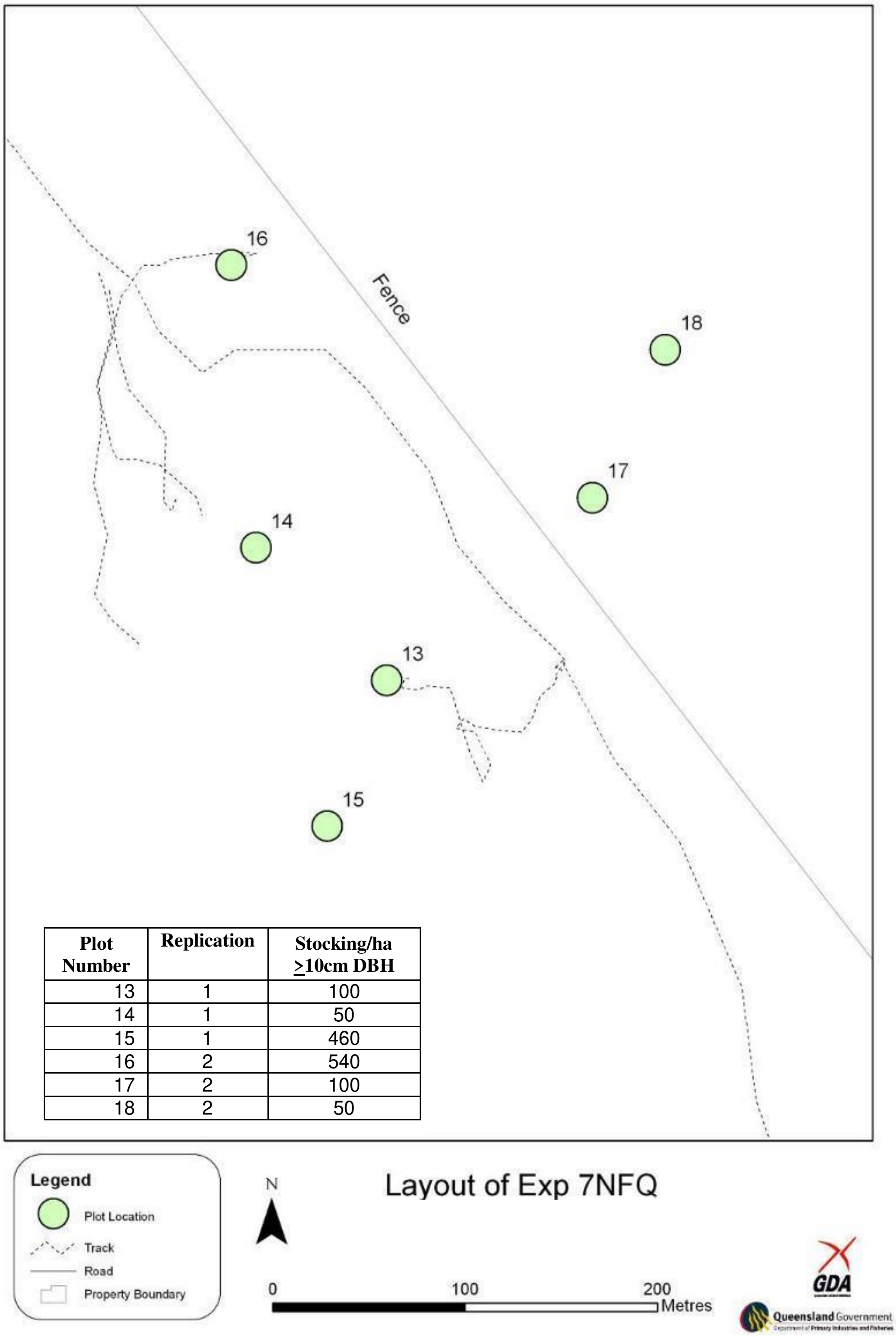
2008					**2016**		
Plot	**Replicate**	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**
13	1	100	25.7	5.4	100	25.7	5.4
14	1	50	22.9	2.1	50	28.9	3.4
15	1	460	17.7	12.5	461	19.1	14.5
16	2	540	16.4	12.2	481	18.1	13.2
17	2	100	21.1	3.6	100	25.8	5.3
18	2	50	22.0	1.9	50	27.5	3.0

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.7.1 – PLOT LAYOUT MAP



Plot Number	Replication	Stocking/ha ≥10cm DBH
13	1	100
14	1	50
15	1	460
16	2	540
17	2	100
18	2	50

APPENDIX 1.7.2 – PLOT PHOTOGRAPHS

Photographs taken June 2008 and October 2016

Plot 13 (100 st/ha) 2008

Plot 13 (100 st/ha) 2016

Plot 14 (50 st/ha) 2008

Plot 14 (50 st/ha) 2016

Plot 15 (460 st/ha) 2008

Plot 15 (461 st/ha) 2016

Photographs taken June 2008 and October 2016

Plot 16 (540 st/ha) 2008

Plot 16 (481 st/ha) 2016

Plot 17 (100 st/ha) 2008

Plot 17 (100 st/ha) 2016

Plot 18 (50 st/ha) 2008

Plot 18 (50 st/ha) 2016

COMMENCEMENT REPORT: Experiment 8 NFQ

OBJECTIVE

To establish a network of growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth vegetation dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

The property was located 34 km north-west of Kingaroy in the South Burnett region. The landscape consists of undulating low hills with slopes varying from 0 to 10 degrees.

The research sites have been classified under the Regional Ecosystem classification as 11.7.6 - *Corymbia variegata* or *Eucalyptus crebra* (narrow-leaved red ironbark) woodland on Cainozoic lateritic duricrust; with a vegetation management status of 'not of concern' (Sattler & Williams 1999). The site was a spotted gum dominant (almost monoculture), open forest with isolated occurrences of narrow- leaved red ironbark.

Topography:

Aspect - Easterly
Slope - Undulating between 3 and 6 degrees

Vegetation and land use

Land use - Grazing and timber production
Surrounding vegetation type - Native forest (RE11.7.6 - Sattler & Williams 1999) on the surrounding landscape. Large areas of previous cleared land with little to moderate densities of regeneration and regrowth in the greater landscape across the property.

Soils and geology

Soil type - Brown Chromosol (Isbell 1996) (reps 1 & 2) and Grey Sodosol (Isbell 1996) (rep 3).
Geology - Mudstone, slate, acid to basic metavolcanics (Maronghi Creek beds, sugarloaf metamorphics)

Rainfall

Annual rainfall - 720 mm (Long Term MAR – Mounefontein[10]).

EXPERIMENTAL LAYOUT

Experiment 8 NFQ uses circular plots with plot size altered to ensure that there were a minimum of 10 measure trees/plot (Table 1 shows plot details). Plot centres were marked with a steel fencing post and their location recorded using a GPS with an accuracy of 5–10 m. Plots were laid out as a randomised complete block and plot layout on the site is shown in Appendix 1.8.1.

Number of treatments - 3 (see Table 1 for listing of each treatment).
Number of replicates - 3

[10] Source, Australian Government Bureau of Meteorology - site number 40138

Number of plots	- 9	
Gross plot area		
Control	-	0.09 ha (17.6 m radius – 5 m isolation)
100 st/ha	-	0.24 ha (27.8 m radius – 10 m isolation)
200 st/ha	-	0.09 ha (17.6 m radius – 5 m isolation)
Nett plot area		
Control	-	0.05 ha (12.6 m radius)
100 st/ha	-	0.1 ha (17.8 m radius)
200 st/ha	-	0.05 ha (12.6 m radius)
Total nett experiment area		- 0.6 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The trial site was last logged during the late 1980's. Anecdotal evidence (stumps) suggests that the harvest was heavy with the smaller stand fraction also being targeted. This previous logging was possibly carried out in the 1950's or 60's. There was no evidence of previous silvicultural treatment in the plots.

Replicates 1 and 2 are located on what appears to be the better parts of the site. Replicate 3 was located on a rockier part of site where the stand tends to be of a more clumpy nature.

The forest has been burnt infrequently by the current owner (fire interval of 5 to 7 years), however evidence of previous hot fires was shown by the number of fire scars in plots 4 and 5.

Current management aims to integrate timber production with grazing in this area. The treatments (thinning) targeted all non-retained stems utilising a tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1 cc per cut. Each cut at waist height was no further than 2 cm apart.

The experimental treatments were applied on the 16/7/2008 (stocking rates are shown in Table 1). Variables of all retained trees ≥10 cm DBH* were assessed/measured (these variables are listed in Table 2). Retained trees were identified using a stainless steel tag with a unique number. New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. In 2016 merchantable height (m) was measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Grimes crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm. This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016.

Photographs of each plot are attached in Appendix 1.8.2.

* DBH – diameter at breast height (1.3 m)

Table 1 – Plot treatment design.

Replicate	Plot Number	Stocking st/ha
1	1	100
1	2	200
1	3	control
2	4	control
2	5	200
2	6	100
3	7	200
3	8	Control
3	9	100

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging - 16/06/2008
Initial measurement - 15/07/2008
Application of stand treatment / thinning - 16/07/2008
This experiment was re-measured in 2010, 2013 and 2016.

The measured variables and measure details are listed in Table 2. Unless required for retained stocking rates, only trees ≥10 cm DBH were assessed however all non-retained trees were treated.

Table 2 – Variables assessed in treatment nett plots.

Stand Component	DBH	Species	Merch Height*	Total Height#	Merch Class	Unique I.D.
Retained Tree. ≥20 cm DBH	✓	✓	✓	✓	✓	✓
Retained Tree. ≥10 cm DBH	✓	✓	–	✓	✓	✓
Removed Tree ≥10 cm DBH	✓	✓	–	–	✓	–

* - Merchantable height only assessed on retained trees ≥20 cm DBH
# - Total height assessed on all retained trees.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the 2008 plot data is shown in Table 3.

Table 3 – Summary of retained stand details following establishment.

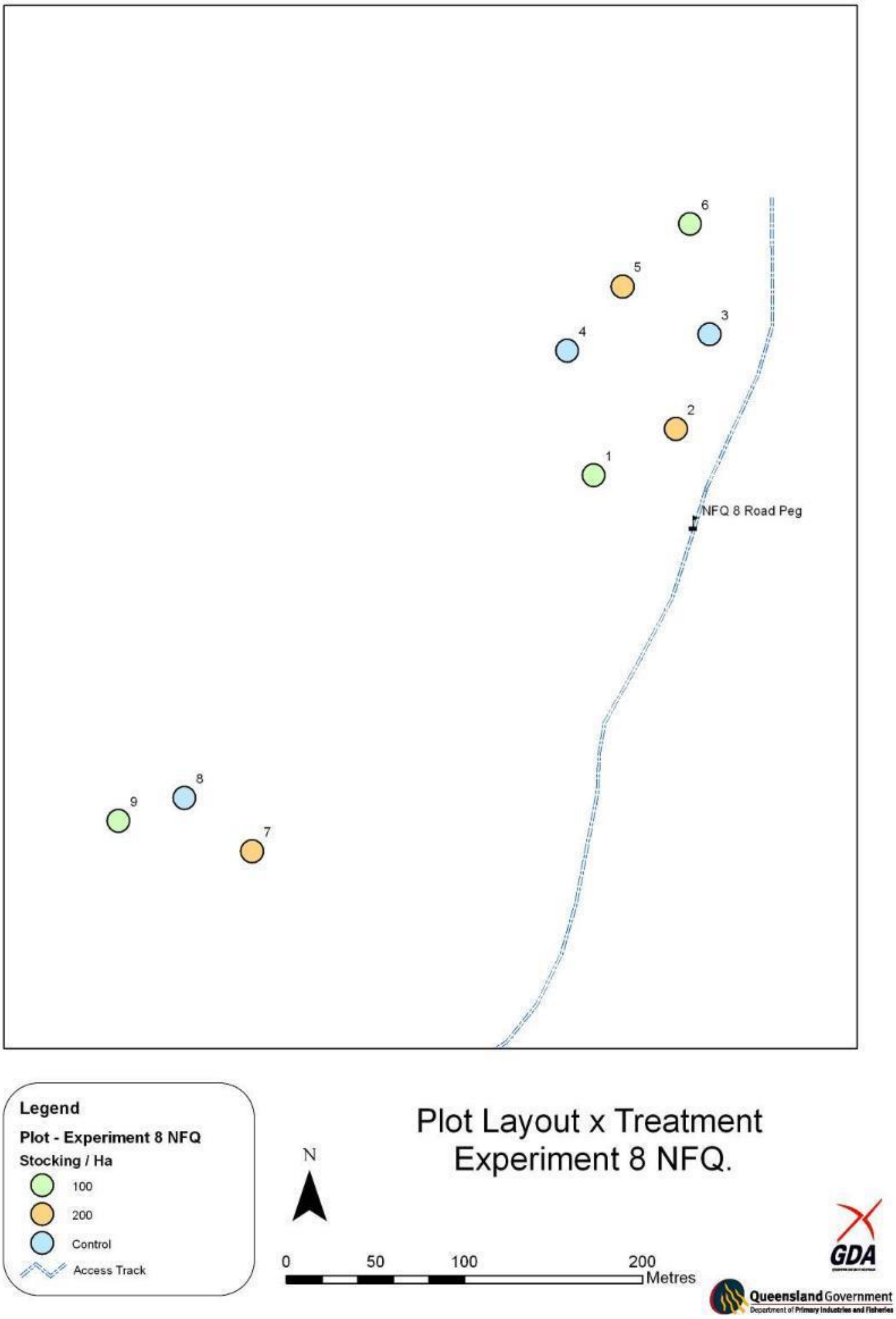
2008					**2016**		
Plot Number	**Replication**	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**
1	1	100	29.8	7.2	110	31.8	9.43
2	1	200	27.3	12.8	200	30.1	15.53
3	1	301	24.1	17.1	481	18.4	19.95
4	2	361	22.1	16.5	340	24.4	19.01
5	2	200	26.1	11.9	200	29.6	15.24
6	2	100	32.4	8.8	100	37.3	11.57
7	3	200	26.3	12.6	220	26.6	14.36
8	3	381	19.8	13.0	380	21.3	15.04
9	3	100	26.2	5.5	110	29.4	7.75

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.8.1 – PLOT LAYOUT MAP



APPENDIX 1.8.2 – PLOT PHOTOGRAPHS
Photographs taken 16/07/2008

Plot 1 (100 st/ha)

Plot 2 (200 st/ha)

Plot 3 (301 st/ha)

Plot 4 (361 st/ha)

Plot 5 (200 st/ha)

Plot 6 (100 st/ha)

Photographs taken 16/07/2008

Plot 7 (200 st/ha)

Plot 8 (381 st/ha)

Plot 9 (100 st/ha)

Photographs taken November 2016

Plot 1 (110 st/ha)

Plot 2 (200 st/ha)

Plot 3 (481 st/ha)

Plot 4 (340 st/ha)

Plot 5 (200 st/ha)

Plot 6 (100 st/ha)

Photographs taken November 2016

Plot 7 (220 st/ha)

Plot 8 (380 st/ha)

Plot 9 (110 st/ha)

COMMENCEMENT REPORT: Experiment 9 NFQ

OBJECTIVE
To establish a network of native forest growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth vegetation dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

The property is located 45 km north-west of Taroom in Central Queensland. The landscape consists of cleared brigalow and bottle tree scrub flats that are now cropped or grazed and undulating low hills with slopes up to 10 degrees.

The research sites have been classified under the Regional Ecosystem Classification as 11.5.9d: *Corymbia citriodora* and/or *Eucalyptus crebra* woodland on Cainozoic sand plains/remnant surfaces (Sattler & Williams 1999). The site was a spotted gum dominant open forest.

Topography

Aspect - North (rep 1) and South (rep 2)
Slope - Variable but less than 10 degrees

Vegetation and land use

Land use - Grazing/timber production
Surrounding vegetation type - Native forest (RE 11.9.4b – Brigalow vine thicket) on the lower slopes below the spotted gum forests (RE 11.5.9d, Sattler & Williams). Some areas of non-remnant in the lower landscape.

Soils and geology

Soil type - Grey Kurosols (Isbell 1996)
Geology - Sandstone, siltstone, mudstone, conglomerate (Injune Creek Group)

Rainfall

Annual rainfall - 640 mm (Long Term MAR – Broadmere[11])

EXPERIMENTAL LAYOUT
Experiment 9 NFQ used circular plots with plot size altered to ensure that there were a minimum of 9 measure trees/plot (10 trees in the standard treatments (control, 50 st/ha and 100 st/ha). Plot centres were pegged with a steel fencing post and their location recorded using a GPS with an accuracy of 5–10m. Plots were laid out as a randomised complete block design and Appendix 1.9.1 shows the layout of plots within the experiment.

Number of treatments - 4 (see Table 1 for listing of each treatment).
Number of replicates - 2
Number of plots - 8
Gross plot area
Control - 0.10 ha (17.6 m radius – includes 5 m isolation)
Owner (130 st/ha) - 0.13 ha (20 m radius – includes 5 m isolation)
100 st/ha - 0.24 ha (27.8 m radius – includes 10 m isolation)
50 st/ha - 0.39 ha (35.2 m radius – includes 10 m isolation)
Nett plot area

[11] Source, Australian Government Bureau of Meteorology - site number 35178

Control	- 0.05 ha (12.6 m radius)
Owner (130 st/ha)	- 0.07 ha (15.0 m radius)
100 st/ha	- 0.10 ha (17.8 m radius)
50 st/ha	- 0.20 ha (25.2 m radius)
Total nett experiment area	- 0.84 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The research area was located in remnant forest which has been previously logged over the past 100 years. The landholder commented that logging operations had been carried out in the 1920's and 1930's for bridge timber and then the area was logged again in the early 1950's and 1960's for mill timber. A pole sale was carried out in 1983 but no timber has been removed since.

The forest was typical of the drier spotted gum forests. The forest was situated in the mid to upper slopes which had a relatively broken landscape with many eroded but stable gullies. The lower slopes and valleys were brigalow/bottle tree scrub types and these have in the main been cleared for agriculture and grazing. The spotted gum was situated in the broken mid slope position and the numbers decline substantially the further up the slope and the lancewood (*Acacia shirleyi*) becomes the dominant species. Total tree height was relatively low compared to spotted gum forests in higher rainfall areas. Current management aims to integrate timber production with grazing (tends to be grazed in late winter and spring) in this area. Burning has been infrequent with the last burn in 1996. There were a few gum topped ironbark (*E. decorticans*) present in the plots but these were treated out.

Trees that were to be removed were treated using a tomahawk and calibrated tree injection gun using the chemical Tordon DS®. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1 cc per cut. Each cut at waist height was no further than 2 cm apart**.**

The experimental treatments (thinning) were applied 14–15 October 2008 at the stocking rates shown in Table 1. Following the thinning treatment, variables of all trees ≥10 cm DBH* were measured/assessed (variables listed in Table 2). Retained trees were identified using a stainless steel tag with a unique number. New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016. Photographs of each plot are provided in Appendix 1.9.2.

Table 1 – Plot and treatment allocations

Replicate	Plot Number	Stocking (st/ha)
1	1	50
1	2	Control
1	3	100
2	4	Control
2	5	50
2	6	100
1	7	127
2	8	127

* DBH – diameter at breast height (1.3 m)

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging	- 14–15/10/2008
Initial measurement	- 14–15/10/2008
Application of stand treatment / thinning	- 14–15/10/2008

This experiment was re-measured in 2010, 2013 and 2016.

The variables measured are listed in Table 2. Only trees ≥10 cm DBH were measured, unless needed to ensure the required stocking rate. All non-retained trees were treated. In 2016 merchantable height (m) was measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Grimes crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm.

Table 2 – Variables assessed in treatment nett plots.

Stand Component	DBH	Species	Merch Height*	Total Height#	Merch Class	Unique I.D.
Retained Tree. ≥20 cm DBH	✓	✓	✓	✓	✓	✓
Retained Tree. <20 cm DBH	✓	✓	–	✓	✓	✓
Removed Tree ≥10 cm DBH	✓	✓	–	–	✓	–

* - Merchantable height only assessed on retained trees ≥20 cm DBH

\# - Total height assessed on all retained trees.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the plot data is shown in Table 3.

Table 3 – Plot summary data from the initial measure (2008) and the latest measure (2016).

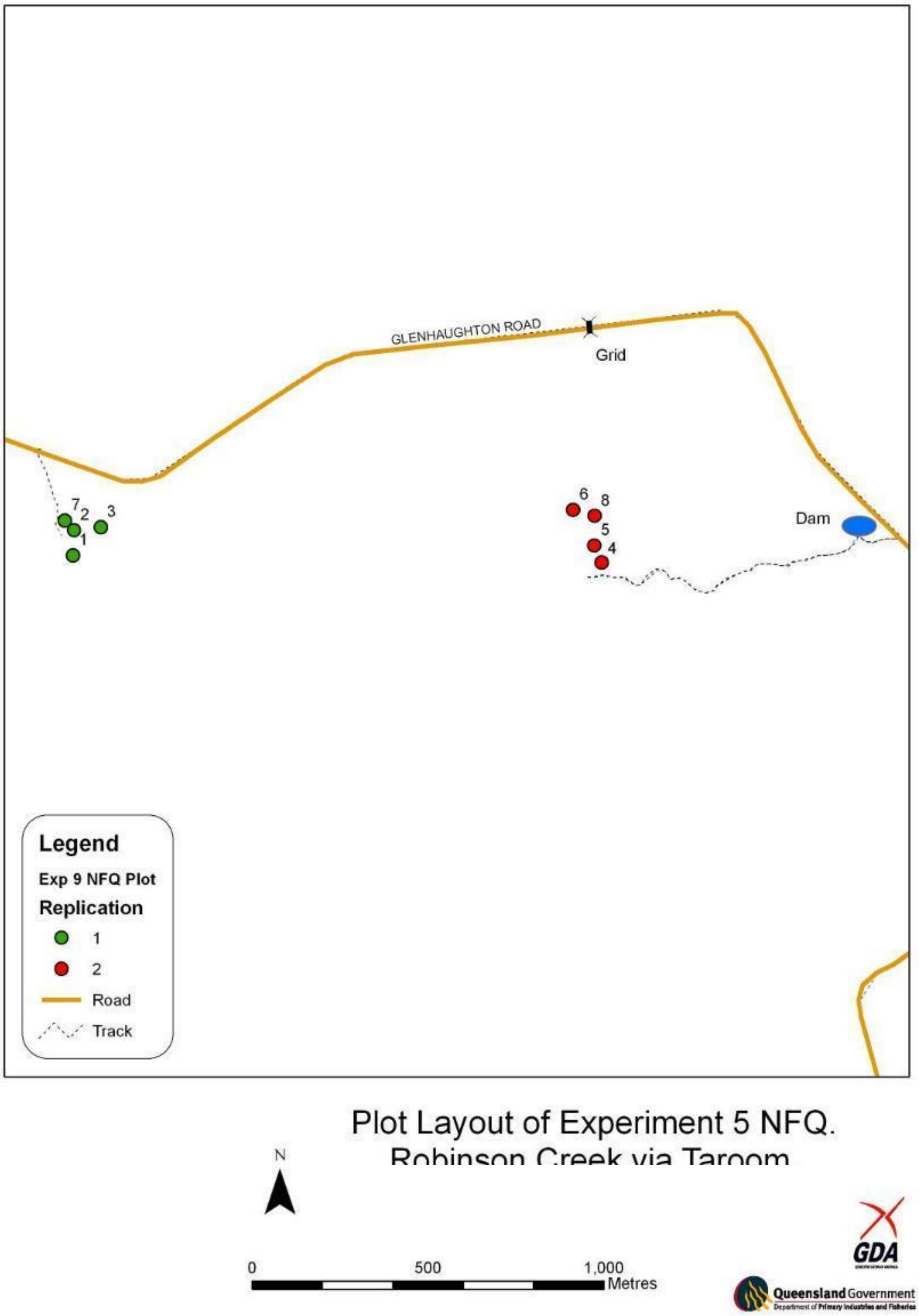
2008					2016		
Plot No.	Replication	Stocking (st/ha)	Mean DBH (cm)	BA (m^2/ ha)	Stocking (st/ha)	Mean DBH (cm)	BA (m^2/ha)
1	1	55	24.2	2.74	80	25.4	4.78
2	1	360	18.9	11.4	380	20.2	14.04
3	1	100	22.1	3.88	100	28.3	6.35
4	2	481	18.9	15.37	561	19.1	18.74
5	2	50	16.1	1.19	65	21.0	2.51
6	2	100	18.1	2.83	100	23.4	4.71
7	1	127	26.6	7.53	183	24.1	10.01
8	2	127	22.8	5.5	127	27.3	7.75

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.9.1 – PLOT LAYOUT MAP



APPENDIX 1.9.2 – PLOT PHOTOGRAPHS

Photographs taken October 2008

Plot 1 (55 st/ha)

Plot 2 (360 st/ha)

Plot 3 (100 st/ha)

Plot 4 (481 st/ha)

Plot 5 (50 st/ha)

Plot 6 (100 st/ha)

Plot 7 (127 st/ha)

Plot 8 (127 st/ha)

Photographs taken December 2016

Plot 1 (80 st/ha)

Plot 2 (380 st/ha)

Plot 3 (100 st/ha)

Plot 4 (561 st/ha)

Plot 5 (65 st/ha)

Plot 6 (100 st/ha)

Plot 7 (183 st/ha)

Plot 8 (127 st/ha)

COMMENCEMENT REPORT: Experiment 10 NFQ

OBJECTIVE

To establish a network of growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth forest dominated by spotted gum.

LOCATION / DESCRIPTION

General

The property was located 15 km south of Casino in northern NSW. The property was 1400 ha in size of which 1200 ha was forested. The landscape was low-lying with undulating low hills and slopes of up to 4 degrees.

The research sites have been classified under the 'CRAFTI Floristic Vegetation Mapping Layer' (DECC 1999) as either 'spotted gum dominant' or 'spotted gum complex – grey gum, grey ironbark, mahogany complex' and consist mostly of spotted gum dominant grassy dry sclerophyll forest with a mixture of other species including *Eucalyptus siderophloia* (grey ironbark), *E. moluccana* (grey box) and *Corymbia gummifera* (red bloodwood).

Topography

Aspect - Variable between north, south and flat
Slope - Mostly minimal, 0–2°, one plot (# 9) has 4° slope

Vegetation and land use

Land use - Timber production and grazing.
Surrounding vegetation type - Spotted gum occurs mostly on the slightly elevated rises but extends with varying associations across the lower/wetter soil types. Some low lying areas have been cleared for agricultural pursuits.

Soils and geology

Soil type - Grey Kurosol (Isbell 1996)
Geology - Sand, silt, clay, gravels (Quaternary alluvium) derived mostly from the sandstones of the Grafton Formation and the Kangaroo Creek Sandstone on the floodplain. The low hills and rises in the area have formed on the Grafton Formation (lithic sandstone, siltstone, conglomerate).

Rainfall

Annual rainfall - 1040 mm (Long Term MAR[12] – Upper Mongogarie)

EXPERIMENTAL LAYOUT

Experiment 10 NFQ has been re-established using older treated plots where available. These circular plots had their centres marked with a steel fencing post. Their location was recorded using a GPS with an accuracy of 5–10 m. The plots vary in stocking as a result of past management (Table 1 shows plot details).

Number of plots - 10 (see Table 1 for listing of each treatment).
Nett plot area - 0.1 ha (17.8 m radius)
Total nett experiment area - 1.0 ha

[12] Source, Australian Government Bureau of Meteorology - site 58192

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

The property has been managed for timber production with the establishment of an onsite mill to value add the timber selectively harvested from the site. Harvesting operations are typically light selective logging, targeting the removal of dying damaged and suppressed stems. Harvest operations only occur in some parts of the forest estate at any time. Details of past logging for each plot are listed in Table 1. Current management aims to integrate native forest timber production with grazing. Fire is applied at 10 year or greater intervals as a tool to manage pasture productivity and forest regeneration.

The landholder has established a series of over 40 inventory plots including basal area (BA) plots and fixed area plots. The purpose of these plots was to gain an understanding of productivity and resource availability of the property as well as a means of training students in forest mensuration and management.

This trial utilised some of these plot sites where they had been established in spotted gum dominant forest. Plots were re-established as fixed area plots. Trees previously measured and able to be identified have retained the unique identifiers assigned by the landholder. Where a tree measured for a basal area plot was external to and not included in the fixed area plot, the unique number was omitted from the sequence.

Variables of all trees ≥10 cm DBH* were measured/assessed (variables are listed in Table 2). Trees were identified with a stainless steel tag with a unique number. Photographs of each plot are attached in Appendix 1.10.1.

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* DBH – diameter at breast height (1.3 m)

Table 1 – Plot and treatment allocations.

NFQ Plot No	Logging History
1	Light selective logging
2	Late 70's Poles, Sawlog & Posts
3	Late 70's Poles, Sawlog & Posts
4	Logged 2000
5	Late 70's Poles, Sawlog & Posts
6	Late 70's Poles & Sawlog
7	Late 70's Poles & Sawlog
8	Thinned and treated 1992
9	Thinned and treated 1992
10	Late 70's Poles, Sawlog & Posts

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging - 24/09/2008
Initial measurement - Various (by landholder).
Second Assessment - 24/09/2008
Plots were re-measured in 2010 and 2016.

The measured variables and measure details are listed in Table 2. Only trees ≥10 cm DBH were measured however merchantable height was only assessed on trees ≥20 cm DBH. In 2016 merchantable height (m) was measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm. This experiment was measured by PFSQ in 2010, then subsequently measured by DAF in 2016.

Table 2 – Variables assessed/measured.

Stand Component	DBH	Species	Merch Height	Total Height#	Merch Class	Unique I.D.
Trees ≥20 cm DBH	✓	✓	✓	✓	✓	✓
Trees ≥10 cm DBH	✓	✓	–	✓	✓	✓
Trees <10 cm DBH	–	–	–	–	–	–

- Total height assessed on all trees.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the 2008 and 2016 plot data is shown in Table 3.

Table 3 – Plot summary data from the initial measure (2008) and the latest measure (2016).

2008				2016		
Plot Number	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**
1	250	29.4	19.22	260	30.6	22.03
2	420	24.7	24.78	480	25.2	30.43
3	180	32.3	17.09	210	32.1	20.67
4	260	23.7	14.06	350	23.8	20.31
5	100	36.8	11.79	140	32.5	14.62
6	420	18.6	14.14	500	18.7	17.11
7	150	25.9	10.39	240	21.9	13.10
8	100	20.9	4.01	230	17.5	6.63
9	210	30.8	18.5	210	32.8	20.89
10	160	23.0	8.89	280	20.6	12.66

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

DECC, (1999). A guide to using CRAFTI data, April 1999 draft – incomplete and unofficial. Internal publication. Coffs Harbour NSW.

FORECO, (1999). Forest ecosystem classification and mapping for the upper and lower north east CRA regions CRA unit, northern zone. NPWS, NSW. A project undertaken for the joint Commonwealth NSW regional forest agreement steering committee as part of the NSW comprehensive regional assessments project number NA35/EH.

APPENDIX 1.10.1 – PLOT PHOTOGRAPHS

Photographs taken September 2008

Plot 1 (250 st/ha)

Plot 2 (420 st/ha)

Plot 3 (180 st/ha)

Plot 4 (260 st/ha)

Plot 5 (100 st/ha)

Plot 6 (420 st/ha)

Photographs taken September 2008

Plot 7 (150 st/ha)

Plot 8 (100 st/ha)

Plot 9 (210 st/ha)

Plot 10 (160 st/ha)

Photographs taken August 2016

Plot 1 (260 st/ha)

Plot 2 (480 st/ha)

Plot 3 (210 st/ha)

Plot 4 (350 st/ha)

Plot 5 (140 st/ha)

Plot 6 (500 st/ha)

Photographs taken August 2016

Plot 7 (240 st/ha)

Plot 8 (230 st/ha)

Plot 9 (210 st/ha)

Plot 10 (280 st/ha)

COMMENCEMENT REPORT: Experiment 12 NFQ

OBJECTIVE
To establish a network of growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth vegetation dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

The property was located 12 km north east of Nanango in the South Burnett region. The landscape consists of undulating low hills with slopes of up to 10 degrees.

The research sites have been classified under the Regional Ecosystem Classification as 12.11.6 - *Corymbia variegata*, *Eucalyptus crebra* open forest on metamorphics ± interbedded volcanics with a vegetation management status of "Not of Concern' (Sattler & Williams 1999). The site is a spotted gum dominant open forest with isolated narrow-leaved red ironbarks.

Topography

Aspect - Plots 1–4 west, plot 5, North and plot 6, south

Slope - Undulating between 3 and 6 degrees

Vegetation and land use

Land use - Timber production and grazing

Surrounding vegetation type - Native forest (RE 12.11.6 & 12.11.14, Sattler & Williams 1999) on the surrounding landscape. Large areas of previous cleared land with little to moderate densities of regeneration and regrowth in the greater landscape from approximately 300 m to the north of the experiment site.

Soils and geology

Soil type - Kurosols (Isbell, 1996)

Geology - Mudstone, slate, greywacke, chert, jasper, acid to basic metavolcanics (Maronghi Creek beds, Sugarloaf Metamorphics)

Rainfall

Annual rainfall - 764 mm (Long Term MAR – Kia Ora Sandy Ridges[13])

EXPERIMENTAL LAYOUT
Experiment 12 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted posts and plots have their location recorded using a GPS with an accuracy of 5–10 m. The experiment is set up as a series of plots at different stockings to allow stocking rate comparisons.

Number of plots	- 6
Gross plot area	- 1 ha (100 × 100 m)
Nett plot area	- 0.25 ha (50 × 50 m)
Total nett experiment area	- 1.5 ha

[13] Source, Australian Government Bureau of Meteorology - site 40109

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The site is generally grazed all year round however cattle have been excluded since 2006 to allow regeneration to develop. The site has typically been burnt every 15 years to promote pasture development and regeneration.

Known harvest history includes a sawlog harvest approximately 20 years and 40 years ago (*circa* 1988 and 1968). The trial site was last logged in 2006, anecdotal evidence (stumps) suggests that the harvest was heavy with the smaller stand fraction also being targeted (poles / piles).The basis upon which trees were commercially removed in the this harvest was;
the tree had reached it's maximum value potential for a particular product,
the tree was declining and was not likely to improve in value or survive until the next harvest,
the tree needed to be removed for spacing or competition reasons.

Trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. The guidelines used for retention were:

1. the retained tree was healthy and capable of growth improvement, had reasonable form and had a good merchantable log length,
2. regeneration was retained based on health, good form and spacing requirements,
3. trees were retained if they had almost reached a merchantable size for a product such as a sawlog, pole or fencing material and were capable of reaching this size by the next harvest.

To comply with the code of practice, the harvesting operation retained 6 habitat trees plus 2 recruitment habitat trees per hectare (= 1.5/plot + 0.5 recruit/plot).

Current management aims to integrate timber production with grazing in this area. The treatments targeted all non-retained stems utilising a variety of techniques.
Plot 1 – Combination of methods
Plot 2 – Combination of methods
Plot 3 – Combination of methods
Plot 4 – Combination of methods
Plot 5 - Tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1 cc per cut. Each cut at waist height was no further than 2 cm apart.
Plot 6 – Cut stump – Trees cut off and stumps sprayed with *Tordon DS®* at a mixture of 1:20.

Table 1 – Plot stocking 2008 for all retained stems.

Plot Number	Stocking (st/ha)
1	108
2	120
3	212
4	140
5	76
6	100

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging - 26/07/2006
Initial measurement - 26/07/2006
Application of stand thinning / treatment - 27/07/2006
Second measurement - 24/11/2008
Plot survey and pegging - 01/04/2012
Plot survey and pegging - 08/11/2016

The measured variables are listed in Table 2. Trees required for stocking rates and resource purposes were retained and tagged, this included some trees as small as 2 cm DBH*. Trees ≥5 cm DBH which were not required were assessed prior to being treated (these trees are not reported in the attached data). New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. In 2016 merchantable height (m) was measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm).

Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm. In 2012 plot 7 was added to the site, following plots 8-9 in 2016. This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016.

Table 2 – Variables assessed in treatment nett plots.

Stand Component	**DBH**	**Species**	**Merch Height***	**Total Height#**	**Merch Class**	**Unique I.D.**
Retained Tree. ≥20 cm DBH	✓	✓	✓	✓	✓	✓
Retained Tree. ≥2–20 cm DBH	✓	✓	–	✓	✓	✓
Removed Tree ≥5 cm DBH	✓	✓	–	–	✓	–
Removed Tree ≤5 cm DBH	–	–	–	–	–	–

* - Merchantable height only assessed on retained trees ≥20 cm DBH
# - Total height assessed on all retained trees.

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the 2008 and 2016 plot data is shown in Table 3. Photographs of each plot are provided in Appendix 1.11.1.

* DBH – diameter at breast height (1.3 m)

Table 3 – Plot summary data from the second measure (2008) and the latest measure 2016.

2008				**2016**		
Plot Number	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**BA (m^2/ha)**
1	108	26.8	6.45	144	24.7	7.93
2	120	22.3	6.01	152	24.1	8.61
3	212	15.8	6.60	224	18.3	7.78
4	140	14.3	3.07	208	16.4	5.38
5	76	23.0	3.40	180	18.7	6.15
6	100	24.6	5.11	188	20.3	7.46
7				112	18.3	3.61
8				212	22.9	10.04
9				128	24.4	8.04

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.11.1 – PLOT PHOTOGRAPHS

Photographs taken November 2008

Plot 1 (108 st/ha)

Plot 2 (120 st/ha)

Plot 3 (212 st/ha)

Plot 4 (140 st/ha)

Plot 5 (76 st/ha)

Plot 6 (100 st/ha)

Photographs taken October 2016

Plot 2 (152 st/ha)

Plot 3 (224 st/ha)

Plot 4 (208 st/ha)

Plot 5 (180 st/ha)

Plot 6 (188 st/ha)

Plot 7 (112 st/ha)

Photographs taken October 2016

Plot 8 (212 st/ha)

Plot 9 (128 st/ha)

COMMENCEMENT REPORT: Experiment 13 NFQ

OBJECTIVE
To establish a network of growth and yield plots across the range of regrowth and remnant forest areas in the subtropics on private land.

The specific objective of this trial was to determine the effect of different tree stockings on tree growth in regrowth vegetation dominated by spotted gum, using a replicated experiment.

LOCATION / DESCRIPTION

General

Experiment 13 NFQ was located in southern Queensland in the Queensland and New South Wales border ranges. Previous owners extensively cleared the vegetation for grazing purposes resulting in a relatively young spotted gum (*Corymbia citriodora*) /ironbark (*Euclayptus crebra*) mixed regrowth forest. The site appears to have been logged within the last 5–10 years and some ironbark regeneration has been treated out within the past 2–3 years. For the purposes of the experiment, trees treated within the past 2–3 years were included in the original standing basal area. The site is mapped as cleared (Category X) by Sattler and Williams (1999).

Topography

Aspect - Northerly

Slope - Varies between plots but less than 15 degrees.

Vegetation and land use

Land use - Grazing and forestry
Surrounding vegetation type - Native forest on the upper slopes and hills with cleared areas for grazing and cultivation on the lower slopes and plains.

Soils and geology

Soil type - Red and Yellow Sodosols (Isbell 1996)
Geology - Sandstone siltstone and mudstone (Mulgildie Coal Measures,Walloon Subgroup)

Rainfall

Annual rainfall - 864 mm (Long Term MAR – Maroon[14])

EXPERIMENTAL LAYOUT
The uneven distribution (grazing country interspersed with clumps of forest) precluded the use of square plots (forest patches too small for the square plots due to concern that there would be too much edge effect). To overcome this, circular plots were used with plot centres arbitrarily located within the forested area to try and ensure that edge effect was minimal. Plot centres were identified with a steel picket and recorded using a GPS with 5–10 m accuracy.

Number of treatments - A range of stockings (see Table 1)
Number of plots - 9
Gross plot area - 0.97 ha (17.6 m radius, 5 m isolation)
Nett plot area - 0.05 ha (12.6 m radius)
Total nett experiment area - 1.57 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

[14] Source, Australian Government Bureau of Meteorology, site 40290

The site was extensively cleared by previous owners and currently carries isolated clumps of regrowth forest on the upper slopes while the lower slopes and flats are managed for grazing. The forest areas appear to have been logged within the last 5–10 years. The landowner has been managing the forest by treating out the ironbark regrowth to favour the spotted gum over the past 2–3 years. The additional treatment operation for this trial was undertaken on 21/05/2008.

Table 1 – Plot treatment layout.

Plot Number	Treatment (st/ha)
1	160
2	120
3	80
4	100
5	180
6	140
7	120
8	120
9	Control

Prior to thinning, stems to be retained were identified. All stems to be removed and ≥10 cm DBH* were measured (measure variables are listed in Table 2). All unmarked trees were removed (treated/thinned). The retained trees were identified with a stainless steel tag which has a unique number. New recruits into the plots at subsequent measures were tagged if the DBH was ≥10 cm. Trees were measured using the variables shown in Table 2. Retained trees <10 cm DBH were also assessed as per Table 2 but were not uniquely identified. There was a range of retained stockings in these plots (see Table 1).

DATES OF ESTABLISHMENT

Plot survey and pegging	- 26/05/2008
Initial measurement	- 27/08/2008
Application of stand treatment / thinning	- 29/08/2008

Table 2 describes which variables are to be measured, on which tree classes, the methods to be employed and the frequency which each will be done. In 2016 merchantable height (m) was measured, where merchantable height could be reasonably estimated (generally for trees with a DBH >15cm). Merchantable height is defined as the height from the ground to the highest merchantable point on the bole (e.g. this is based on straightness and defect, not the size of the bole). Crown scores were also measured in 2016, but only on trees with a DBH ≥10 cm. This experiment was measured by PFSQ in 2013, then subsequently measured by DAF in 2016. Photographs of each plot are shown in Appendix 1.12.1.

Table 2 – Variables measured in treatment plots.

* DBH – diameter at breast height (1.3 m)

Stand Component	Count	DBH	Species	Grimes Crown Assess *	Crown Break*	Total Height *	Merch Class	Unique I.D.
Retained Tree. ≥10 cm DBH (treatment plots)	–	✓	✓	✓	✓	✓	✓	✓
Retained Tree. <10 cm DBH (treatment plots)	–	✓	✓	–	–	✓	✓	–
Retained Tree. ≥5 cm DBH (control plots)	–	✓	✓	✓	✓	✓	✓	✓
Retained Tree. <5 cm DBH (control plots)	✓	–	✓	–	–	–	–	–
Removed Tree. ≥10 cm DBH	–	✓	✓	–	–	–	✓	–
Removed Tree. <10 cm DBH	✓	–	✓	–	–	–	–	–

* Variables only assessed on trees ≥10 cm DBH

MANAGEMENT

Future management of the site will be at the discretion of the landholder. Normal management is encouraged however it would be appreciated if management activities such as burning be documented and the relevant forestry extension organisation be advised. We request that that destructive activities such as thinning, only be carried out after consultation with the forestry extension organisation and the project leader.

DATA

A complete electronic copy of the data is stored on the DAF Forestry Science database. A summary of the 2008 and 2016 is shown in Table 3.

Table 3 – Plot summary data from the initial measure (2008) and the latest measure (2016).

2008				**2016**		
Plot Number	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**	**Stocking (st/ha)**	**Mean DBH (cm)**	**Retained BA (m^2/ha)**
1	160	23.9	7.6	160	33.4	14.87
2	120	18.1	3.1	120	29.9	8.59
3	80	23.0	3.4	80	33.8	7.38
4	100	19.0	2.9	100	27.4	6.03
5	180	22.3	7.3	180	29.9	13.15
6	140	20.8	5.4	140	28.2	9.32
7	120	23.5	5.3	120	32.2	9.98
8	120	20.4	4.2	100	29.9	7.35
9	1142	10.8	11.7	1102	13.3	17.49

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.12.1 – PLOT PHOTOGRAPHS (POST TREATMENT)

Plot 1 (160 st/ha)

Plot 2 (120 st/ha)

Plot 3 (80 st/ha)

Plot 4 (100 st/ha)

Plot 5 (180 st/ha)

Plot 6 (140 st/ha)

Plot 7 (120 st/ha)

Plot 8 (120 st/ha)

Plot 9 (1142 st/ha)

Photographs taken September 2016

Plot 1 (160 st/ha)

Plot 2 (120 st/ha)

Plot 3 (80 st/ha)

Plot 4 (100 st/ha)

Plot 5 (180 st/ha)

Plot 6 (140 st/ha)

Plot 7 (120 st/ha)

Plot 8 (100 st/ha)

Plot 9 (1102 st/ha)

COMMENCEMENT REPORT: Experiment 15 NFQ

OBJECTIVE

Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

Historically, thinning has involved hand tordoning (the traditional method over the last fifty years); however this method may not be considered viable in the private resource due to potentially large areas and high tree densities. This study will assess the mechanical silvicultural management option of a skidder drawn chopper roller to thin out young regrowth and mechanical harvesting of larger regrowth. To date limited trials have been untaken on mechanical thinning in subtropical eucalypt forest. Economic studies (to be conducted by the University of Queensland) on the effectiveness of the mechanical thinning treatments will supplement this experiment.

The specific objective of this study is to determine the effects of two different thinning treatments; routine tordon treatment and chopper roller treatment on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation, debris (e.g. leaf litter) and soil carbon stocks associated with the different treatments.

LOCATION / DESCRIPTION

General

This property is located approximately 25 km west of Gundiah. The landscape consists of undulating low hills with slopes of up to 10 degrees.

The research sites have been classified under the Regional Ecosystem classification (Sattler & Williams 1999) as predominantly 12.3.11/12.9-10.21 at the western replicate and 12.9-10.2/12.9-10.7 at the eastern replicate. The plot locations cover a mix of areas mapped as remnant and regrowth vegetation. The eastern replicate site is a spotted gum (*Corymbia citriodora* subsp. *variegata*) dominant open forest with isolated forest red gum (*Eucalyptus tereticornis*) and an understorey of wattles (mainly *Acacia leiocalyx*). The western replicate site is dominated by spotted gum, with broad-leaved red ironbark (*Eucalyptus fibrosa*) and scattered gum-top box (*Eucalyptus moluccana*) and an understorey of wattles (mainly *Acacia leiocalyx*). These sites were last harvested in February to October 2016.

Topography

Aspect: East replicate predominantly south easterly. West replicate predominantly northerly.

Slope: This varies between plots. The landscape is low hilly terrain mostly with undulating slopes. Slopes range between 0 and 10 degrees.

Vegetation and land use

Land use: Timber production and cattle grazing.

Surrounding Vegetation type: The dominant Regional Ecosystems at the site are 12.3.11/12.9-10.21 (*Eucalyptus tereticornis* +/- *Eucalyptus siderophloia*, *Corymbia intermedia* open forest on alluvial plains usually near coast. *Eucalyptus acmenoides* or *E. portuensis* woodland usually with *Corymbia trachyphloia* subsp. *trachyphloia* on Cainozoic to Proterozoic sediments) at the western replicate. At the eastern replicate 12.9-10.2/12.9-10.7 (*Corymbia citriodora* subsp. *variegata* +/- *Eucalyptus crebra* open forest on sedimentary rocks. *Eucalyptus crebra* +/- *E. tereticornis*, *Corymbia tessellaris*, *Angophora* spp., *E. melanophloia* woodland on sedimentary rocks).

Soils and geology

Soil type: Most likely a Sodosol based on GIS layers.

Geology: Tiaro Coal Measures which consists of Lithofeldspathic labile and sublabile to quartzose sandstone, siltstone, shale, coal ferruginous oolite marker.

Rainfall

Mean annual rainfall of 950 mm (Home Park TM QLD, 11.4 km away, site 040833).

EXPERIMENTAL LAYOUT

Experiment 15 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The experiment has two replicates (eastern and western) each with treatments of tordoning, chopper rolling and no treatment. Appendix 1.13.1 shows the layout of plots within the experiment.

Number of treatments:	3
Number of plots:	6
Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Total experiment area:	0.96 ha

PAST HISTORY, TREATMENT AND MEASUREMENT METHODOLOGY

The trial site was last logged with a reset harvest in 2016. Up to October 2016 approximately 1000 m^3 was logged from the property, consisting of mainly suppressed and or defected stems. Pre-treatment measurements were carried out in March and April 2016; all logging in the immediate vicinity of the plots had been completed by this date. Chopper rolling treatments were carried out in April-May 2016. Tordon treatments were carried out in April 2016.

Trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Chopper roller treatments involved driving a skidder drawn chopper roller through the tree marked area, avoiding the marked trees. The log skidder used was a 15 tonne, 180 hp machine pulling a 5 tonne 3 m wide chopper roller (Figure 1). Chopper roller treatment effectively removed stems <10 cm in diameter. Stems larger than this were manually cut with a chainsaw by PFSQ staff.

Figure 1. The chopper roller used in this trial.

Tordon treatments involved using a tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart.

Table 1 – Plot treatment design experiment 15 NFQ. Stocking figures (stems per hectare) based only on all retained (tagged) stems ≥10 cm DBH.

Replicate	Plot	Treatment	Pre-treatment stocking (st/ha)	Pre-treatment BA (m^2/ha)	Post-treatment stocking (st/ha)	Post-treatment BA (m^2/ha)
1 (Eastern)	1	Tordon	150	6.2	119	4.5
1 (Eastern)	2	Chopper roller	181	3.7	56	1.8
1 (Eastern)	3	Control	144	4.4	169	4.6
2 (Western)	4	Control	188	3.1	188	3.4
2 (Western)	5	Tordon	138	4.7	75	2.3
2 (Western)	6	Chopper roller	125	4.3	70	3.0

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging:	9/3/2016 and 6/4/2016
Initial measurement:	9/3/2016 and 7/4/2016
Application of stand treatment / thinning:	1/4/2016
Post-treatment measurement:	7/3/2017

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

Tree measurements

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 10 cm DBH were assessed however all non-retained trees were treated.

Table 2 – Tree variables assessed in treatment nett plots in the pre-treatment measured and the post-treatment measures. Re-tagging, where necessary was done in the post-treatment measure.

Stand Fraction	Unique I.D.	DBH	Species	Grimes crown score	Merch Height *	Total Height#	Merch Class
Retained Tree. ≥ 20cm DBH	✓	✓	✓	✓	✓	✓	✓
Retained Tree. ≥ 2 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓
Removed Tree ≥ 5 cm DBH		✓	✓				

* - Merchantable height only assessed on retained trees ≥ 20.0 cm DBH
# - Total height assessed on all retained trees ≥ 10 cm DBH.

Data management

A complete electronic copy of the data associated with this project accompanies this document and is stored on the DAF database. Photographs of selected plots are provided in Appendix 1.13.2.

Soil and litter sampling

Each plot was divided into 40 sub-plots of 10 × 10 m and ten sub-plots were randomly selected for sampling. Plots and sub-plots were established using tape measures, optical squares and sighting posts to ensure right-angles. Each sub-plot contained 100 1 × 1 m squares, of which one was randomly selected for sampling. Each selected sub-plot and square was marked with line-marking paint to delineate the sampling positions. Pre-treatment sampling took place on the 10th March and 7th April 2016.

A steel quadrat (0.5 × 0.5 m square) was placed in the centre of each 1 × 1 m sample square, and all dead and detached vegetation (litter) was collected down to the soil surface, being careful to exclude mineral soil. All litter material ≤25 mm diameter was defined as litter. All litter was collected and oven dried (70°C) to constant weight to allow determination of biomass. Litter carbon stocks will be estimated by multiplying biomass by C concentration (based on published literature).

Following litter collection, at each randomly selected sampling location soil samples were collected to a depth of 30 cm using 70 cm long hardened steel cores with a 42 mm cutting head and an internal tube diameter of 45 mm. The cores were driven into the ground using a Bosch GSH16 jack-hammer powered by a portable generator (Honda EU20i 240V). A specially designed soil-core lifter was used to remove the core from the ground.

The soil samples were pushed out of the core onto hemi-cylindrical tubes, then divided into two sampling depths: 0–10 cm and 10–30 cm and transferred into labelled, sealable plastic bags. Soil samples collected within each of the ten 10 × 10 m sub-plots were kept separate for each depth. Once collected, soils were kept in a cool dark location until the samples were air dried, processed and sent to the laboratory.

In addition to the above samples for analysis, samples for 'soil core mass' (oven-dried mass per unit core volume for bulk density) determinations were collected from two randomly selected, previously sampled squares in each plot. Each of these samples was collected using the same core sampler as that used for soil C samples. Soil core mass samples were collected for the same sampling depths as for the standard soil samples, and were placed in individually labelled plastic bags for each depth. These samples were later dried in an oven at 40°C to constant weight, to determine air-dry weights, and then dried at 110°C to constant weight, to determine the oven-dry weight for calculation of core mass and the moisture correction factor between air-dry and oven-dry soil for a plot.

All soil samples, except the core mass samples, were weighed after air drying and carefully processed by hand through a 2 mm sieve. Total C and nitrogen (N) concentrations were determined by dry-combustion with a LECO CNS-2000 analyser (LECO Corporation, MI, USA).

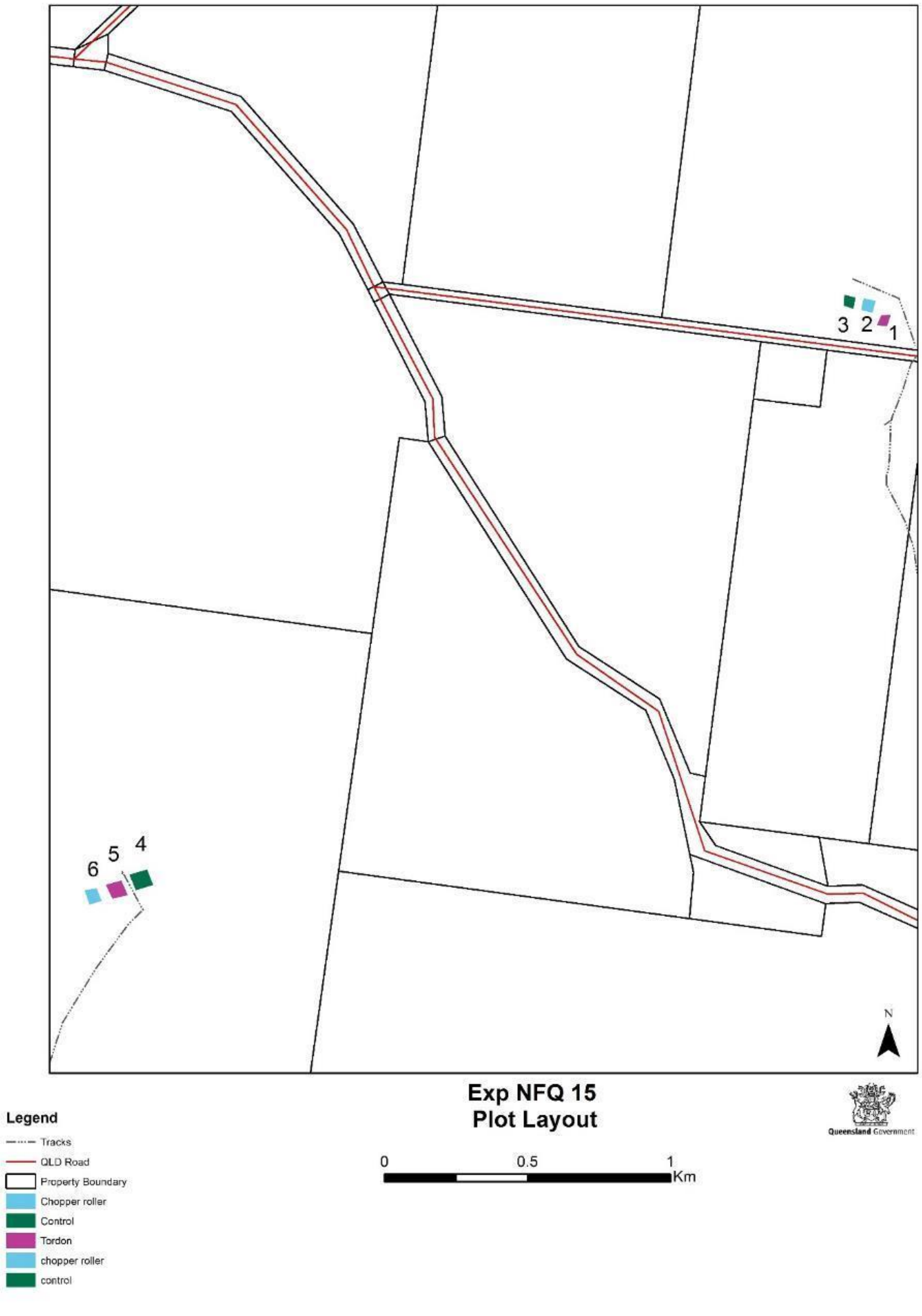
REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.13.1 –PLOT LAYOUT MAP



APPENDIX 1.13.2 – PLOT PHOTOGRAPHS

Photographs were taken in March 2017, post-treatment.

Plot 2

Plot 3

Plot 4

Plot 6

COMMENCEMENT REPORT: Experiment 18 NFQ

OBJECTIVE
Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this study is to determine the effects of silvicultural harvesting/thinning treatments on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION/DESCRIPTION

General

The property is located approximately 42 km north-west of Gympie. This property is owned by Ergon Energy and PFSQ are responsible for managing the property.

The research sites have been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as predominantly12.9-10.3 (*Eucalyptus moluccana* open forest on sedimentary rocksand) / 12.9-10.2 (*Corymbia citriodora subsp. variegata +/- Eucalyptus crebra* open forest on sedimentary rocks) / 12.9-10.21 (*Eucalyptus acmenoides or E. portuensis* woodland usually with *Corymbia trachyphloia subsp. trachyphloia* on Cainozoic to Proterozoic sediments) and 12.3.11 (*Eucalyptus tereticornis +/- Eucalyptus siderophloia, Corymbia intermedia* open forest on alluvial plains usually near coast). The plot locations cover a mix of areas mapped as regulated and non-remnant vegetation. The landscape consists of flat and undulating low hills with slopes of up to 5 degrees.

Topography

Aspect: Varies greatly between plots.
Slope: This varies between plots, but most plots had a slope of <5 degrees. The landscape is mostly flat with undulating slopes. Slopes range between 1 and 8 degrees.

Vegetation and land use

Land use: Timber production. The site is managed to encourage growth of poles to supply Ergon Energy. The site is not grazed by livestock.

Surrounding Vegetation type: The dominant Regional Ecosystems at the monitoring plots is 12.9-10.2 (*Corymbia citriodora subsp. variegata +/- Eucalyptus crebra* open forest on sedimentary rocks).

Soils and geology

Soil type: soil profile descriptions are not available at this site. Soil types are most likely Dermosols based on GIS layers.

Geology: Sedimentary (Tiaro Coal Measures)

Rainfall

Mean annual rainfall of 989 mm (Theebine QLD (7.3 km away, site 040200))

EXPERIMENTAL LAYOUT
Experiment 18 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The experiment has treatments of harvesting or thinning, and no treatment.

Number of treatments:	2
Number of plots:	6
Treatment plots	
Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control plots 4 and 5	
Gross plot area:	0.25 ha (50 × 50 m)
Net plot area:	0.04 ha (20 × 20 m)
Isolation plot area:	0.21 ha (15 m)

Control plot 6	
Gross plot area:	0.25 ha (50 × 50 m)
Net plot area:	0.0625 ha (25 × 25 m)
Isolation plot area:	0.1875 ha (12.5 m)
Total experiment area:	2.22 ha

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

The property was periodically high graded, but details on the timing of the last harvest were unavailable at the time of writing. The property has never been treated and has been burnt regularly.

Plots 1 and 3 were selectively logged just prior to establishment. Tordon DS® was applied to the stumps of harvested trees at a ratio of 1 part Tordon to 20 parts water. Coppice was also treated, where necessary.

Plot 2 was silviculturally thinned with a tomahawk and calibrated tree injection gun using Tordon. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart.

As part of this trial, trees in 'treated' plots that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Plots 4, 5 and 6 were not harvested or treated, and represent the stand structure typical of forest that has a history of high-grading.

Table 1 – Plot treatment design for experiment 18 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based only on stems with a DBH ≥ 5 cm in the initial 2012 measure (September 2012, post treatment) and the last measure (December 2016).

Plot	Treatment	Initial stocking (st/ha)	Initial BA (m^2/ha)	Stocking at last measure (st/ha)	BA at last measure (m^2/ha)
1	Tordon/thinning	118.8	5.8	100	4.4
2	Tordon/thinning	162.5	9.5	168.8	10.2
3	Tordon/thinning	156.2	2.1	131.2	2.6
4	Control	1050	12.5	1000	11.7
5	Control	850	32.4	700	29.2
6	Control	1136	10.0	960	9.7

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging:	September 2012
Initial measurement:	20/09/2012
Application of stand treatment / thinning:	September 2012
Plots were remeasured:	6/12/2016

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 5 cm DBH were assessed however all non-retained trees were treated.

Table 2 – Tree variables assessed in treatment nett plots. Grimes crown scores were only assessed consistently in the 2016 measure, but should be assessed in future measurements at these plots.

Stand Fraction	DBH	Species	Unique I.D.	Grimes crown score	Merch Height *	Total Height#	Merch Class
Retained Tree. ≥ 20cm DBH	✓	✓	✓	**✓ (2016)**	✓	✓	✓
Retained Tree. ≥ 5 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓
Removed Tree ≥ 5 cm DBH	✓	✓					

Data management

A complete electronic copy of the data associated with this project is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.14.1.

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.14.1 – PLOT PHOTOGRAPHS
Photographs were taken in December 2016

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

COMMENCEMENT REPORT: Experiment 20 NFQ

OBJECTIVE

Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this study is to determine the effects of thinning treatments on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION/DESCRIPTION

General

This property is located in Gympie.

The research sites have been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as predominantly 12.11.5 (*Corymbia citriodora* subsp. *variegata* woodland to open forest +/- *Eucalyptus siderophloia*/*E. crebra*, *E. carnea*, *E. acmenoides*, *E. propinqua* on metamorphics +/- interbedded volcanics) and 12.3.11 (*Eucalyptus tereticornis* +/- *Eucalyptus siderophloia*, *Corymbia intermedia* open forest on alluvial plains usually near coast). The landscape consists of undulating low hills with slopes of up to 8 degrees. The predominant commercial species throughout the property is *Corymbia citriodora* var *variegata* (Spotted Gum). The other three major species occurring across the property are: *Eucalyptus acmenoides* (White Mahogany), *Eucalyptus major* (Grey Gum) and *Eucalyptus moluccana* (Grey Box). There are minor occurrences of *E. fibrosa* (Broad Leaved Red Ironbark) and *E. excreta* (Queensland Peppermint).

Topography

Aspect: Plots 3, 4, 5 and 6 have a south-easterly aspect. Plots 1 and 2 have a north-westerly aspect.
Slope: This varies between plots. The landscape is low hilly terrain mostly with undulating slopes. Slopes range between 2 and 8 degrees.

Vegetation and land use

Land use: Timber production and local trail network for passive recreation (walking, mountain biking, horse riding). The site is currently used as a recreation area.
Surrounding Vegetation type: The dominant Regional Ecosystem at the site is 12.11.5 (*Corymbia citriodora* subsp. *variegata* woodland to open forest +/- *Eucalyptus siderophloia*/*E. crebra*, *E. carnea*, *E. acmenoides*, *E. propinqua* on metamorphics +/- interbedded volcanics).

Soils and geology

Soil type: Soil profile descriptions are not available at this site. Soil types are most likely Chromosol based on the digital version of The Atlas of Australian Soil mapping layer 1991.
Geology: Gympie Group (Shale, mudstone, siltstone, basic volcanics, greywacke, limestone)

Rainfall

Mean annual rainfall of 1125 mm (Gympie QLD (2.9 km away, site 040093)).

EXPERIMENTAL LAYOUT

Experiment 20 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The experiment has two replicates each with treatments of chemical thinning and no treatment. Appendix 1.15.1 shows the layout of plots within the experiment.

Number of treatments:	2
Number of replicates:	2
Number of plots:	6

Treatment Plots

Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control Plots

Gross plot area:	0.25 ha (50 × 50 m)
Net plot area:	0.0625 ha (25 × 25 m)
Isolation plot area:	0.1875 ha (12.5 m)
Total experiment area:	2.46 ha

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

The trial site is owned by the Gympie Regional Council and has had a long history as a reserve for a rifle shooters practice range. The main practice had been closed for many years and a new range is now located on the western side of the property. Timber harvesting has been carried out periodically and Apiarist use the site for honey production. Prior to 2003 there was ample evidence of past harvest operations within the stand (e.g. logging debris, logging smash, stumps, old ramps sites, etc.) but no treatment (non-commercial thinning) has been performed in the past. The property exhibited a high proportion of defective and suppressed stems as a consequence of the past management. In 2003-4 a reset harvest was carried out, organised by PFSQ and completed 2004. The area was marked by PFSQ to retain the best stems at a spacing to encourage regeneration where required and promote optimum tree growth. In 2004 chemical treatment of undesired stems to encourage stand productivity and forest health was organised by PFSQ. A treatment gang using Glyphosate herbicide applied into tomahawk cuts at waist height was completed in 2004. Results were patchy due to inexperienced operators and some re-treatment was carried out. In 2006 a post-harvest top-disposal burn (burning of felled tree heads and other logging debris) was organised and carried out by CRC in the hot spring month of October. This fire did considerable damage to mature trees in the form of wood and bark scarring as well as loss of foliage. Young regeneration in places was either killed or badly damaged. A further salvage harvest was carried out to remove the more seriously damaged trees. In 2010 chemical treatments were carried out between 19/01/2010 and 16/02/2010. In 2010 legal trail building began for the Victory heights mountain bike tracks, disturbing plots 1 to 3 through removal of some trees and changes to the land by the form of bike tracks and jumps. The degree of influence of the trail bike tracks and the future value of plots 1 to 3 will be re-assessed at the next measure.

Thinning involved chemical treatments using a tomahawk and calibrated tree injection gun with Roundup (Glyphosate) 450 mix. Roundup 450 mix was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart. The top-disposal burn in 2006 affected all plots. Chemical treatments for small regeneration involved using a brush cutter cut stump method using Roundup 450 mix. Roundup 450 mix was diluted in water at a ratio of 1:20 and applied to the cut stump by pressure sprayer.

In the thinned plots, an attempt was made to thin to stockings of 100 and 200 stems per hectare in each replicate (Table 1). As part of the thinning treatments, trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Table 1 – Plot treatment design experiment 20 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based on stems with a DBH ≥2 cm, assessed initially in February 2010 (after treatment) and then in December 2016.

Replicate	Plot	Treatment	2010 stocking (st/ha)	2010 BA (m^2/ha)	2016 stocking (st/ha)	2016 BA (m^2/ha)
1	1	200s/ha	200	7.29	175	8.01
1	2	100s/ha	93	3.0	100	3.82
1	3	Control	224	7.06	544	9.88
2	4	200s/ha	181	8.45	137	9.90
2	5	100s/ha	106	5.14	106	7.06
2	6	Control	432	13.21	640	17.13

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging:	19/01/2010
Initial measurement:	17/02/2010
Application of stand treatment / thinning:	19/01/2010 and 16/02/2010
Post-treatment measurement:	9/10/2012 and 7/12/2016

MANAGEMENT

Future management of the site will be at the discretion of the landholder and CTCA. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning regimes. It has been requested that any management activities such as burning, thinning or treatment be documented.

MEASUREMENT

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 2 cm DBH were assessed however all non-retained trees were treated.

Table 2 – Tree variables assessed in treatment nett plots in the pre-treatment measured and the post-treatment measures. Re-tagging, where necessary was done in the post-treatment measure.

Stand Fraction	DBH	Species	Unique I.D.	Grimes crown score	Merch Height *	Total Height#	Merch Class
Retained Tree. ≥ 20cm DBH	✓	✓	✓	✓	✓	✓	✓
Retained Tree. ≥ 2 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓
Removed Tree ≥ 2 cm DBH	✓	✓					

Data management

A complete electronic copy of the data associated with this project is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.15.2.

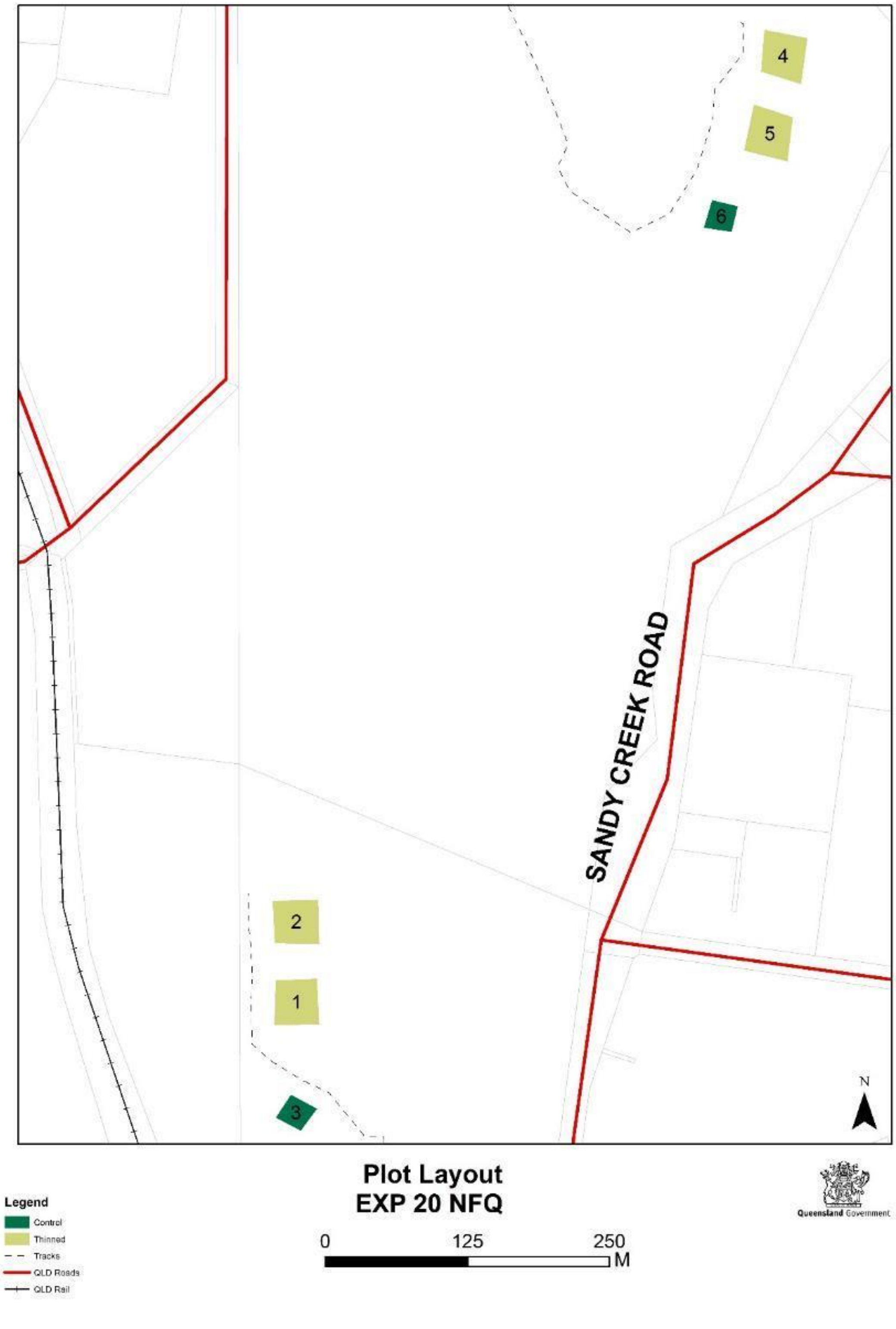
REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.15.1 – LAYOUT MAP for EXPERIMENT 20 NFQ



APPENDIX 1.15.2 – PLOT PHOTOGRAPHS

Photographs were taken in December 2016

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

Plot 1 changes to the land by the form of bike tracks

COMMENCEMENT REPORT: Experiment 21 NFQ

OBJECTIVE
Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this study is to determine the effects of thinning treatment on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION/DESCRIPTION

General

The property is located approximately 13 km north of Miriam Vale.

The research sites have been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as 12.3.3 (*Eucalyptus tereticornis* woodland on Quaternary alluvium). The plot locations are mapped as regulated (remnant) vegetation. The landscape consists of flat to undulating low hills with slopes of up to 2 degrees.

Topography

Aspect: Mostly north-easterly.
Slope: Up to 2 degrees. The landscape is mostly flat with undulating slopes.

Vegetation and land use

Land use: Timber production and cattle grazing.
Surrounding vegetation type: The dominant Regional Ecosystems at the site is 12.3.3 (*Eucalyptus tereticornis* woodland on Quaternary alluvium). However, spotted gum (*Corymbia citriodora* subsp. *variegata*) was the dominant species in the monitoring plots.

Soils and geology

Soil type: Soil profile descriptions are not available at this site. Soil types are most likely Rudosols based on The Atlas of Australian Soil mapping layer 1991.
Geology: Metamorphosed sediments.

Rainfall

Mean annual rainfall of 1009 mm (Springs QLD (11.5 km away, site 039255))

EXPERIMENTAL LAYOUT
Series 21 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The site has treatments of chemical thinning treatment (i.e. tordon) and no treatment.

Number of treatments:	2 (treated and untreated)
Number of plots:	3

Treatment plots

Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control plot

Gross plot area:	0.25 ha (50 × 50 m)

Net plot area: 0.04 ha (20 × 20 m)
Total area: 0.74 ha

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

The trial site has been owned by the Bates family for a long period of time. The site has been selectively harvested based on a minimum diameter of 48 cm and never had any follow up treatment.

In the 'treated' plots, trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Tordon treatments involved using a tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart.

Table 1 – Plot treatment design experiment 21 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based on stems with a DBH ≥5 cm in March 2010 (post treatment) and November 2016.

Plot	Treatment	2010 stocking (st/ha)	2010 BA (m^2/ha)	2016 stocking (st/ha)	2016 BA (m^2/ha)
1	Tordon	143.8	10.2	143.8	12.6
2	Tordon	81.2	7.1	81.2	8.4
3	Control	775	15.1	575	16.6

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging: March 2010
Initial measurement: 29/03/2010
Application of stand treatment / thinning: 29/03/2010
Plots were remeasured in November 2016.

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 5 cm DBH were assessed however all non-retained trees were treated. No information (DBH and species) was available for trees that were treated.

Table 2 – Tree variables assessed in treatment nett plots in the pre-treatment measure. Grimes crown scores and merchantable heights were only assessed in the 2016-17 measures, but should be assessed in future measurements at these plots.

Stand Fraction	**DBH**	**Species**	**Unique I.D.**	**Grimes crown score**	**Merch Height ***	**Total Height#**	**Merch Class**
Retained Tree. ≥ 20cm DBH	✓	✓	✓	✓	✓	✓	✓
Retained Tree. ≥ 5 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓

Data management

A complete electronic copy of the data associated with this site is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.16.1.

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.16.1 – PLOT PHOTOGRAPHS
Photographs were taken in April 2010

Plot 1

Plot 2

Plot 3

COMMENCEMENT REPORT: Experiment 22 NFQ

OBJECTIVE

Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this trial site is to determine the effects of thinning treatments (routine tordon treatment and brush cutting treatments) on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION/DESCRIPTION

General

The property is located approximately 26 km south west of Gin Gin. The research site has been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as 12.12.5 (*Corymbia citriodora* subsp. *variegata, Eucalyptus crebra* woodland on Mesozoic to Proterozoic igneous rocks). The plot locations are mapped as unregulated (non-remnant) vegetation, and are thus considered re-growth forest. The landscape consists of undulating low hills with slopes of up to 10 degrees.

Topography

Aspect: Varies between plots, but predominantly easterly aspects.
Slope: The landscape is low hilly terrain mostly with undulating slopes. Plots are located on slopes that range between 2 and 14 degrees.

Vegetation and land use

Land use: Timber production and cattle grazing. The site is currently grazed by cattle.
Surrounding vegetation type: The dominant Regional Ecosystems at the site is 12.12.5 (*Corymbia citriodora* subsp. *variegata*, *Eucalyptus crebra* woodland on Mesozoic to Proterozoic igneous rocks). Areas of *Eucalyptus tereticornis* (Blue gum flats) also exist on the property.

Soils and geology

Soil type: Soils were classified as Podosols (Isbell 1996).
Geology: Igneous origin. Granite, granodiorite, diorite and gabbro.

Rainfall

Mean annual rainfall of 958 mm (Moolboolaman QLD, 13.5 km away, Bureau of Meteorology station 039218)

EXPERIMENTAL LAYOUT

Experiment 22 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The experiment has treatments of tordoning, chainsaw cutting and no treatment (control). Plots 1 to 6 were in relatively young regrowth forest and plots 7 and 8 were in mature regrowth. Plots 1-3 were grouped as one replicate and plots 4-6 were grouped as a separate replicate. Plots 7 and 8 should be analysed separately given their different level of maturity.

Number of treatments:	2 (treated and untreated)
Number of plots:	8
Number of Replicates:	2

Treatment Plots

Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control Plots

Gross plot area:	0.25 ha (50 × 50 m)
Net plot area:	0.04 ha (20 × 20 m)
Isolation plot area	0.21 ha (15 m)
Total area:	3.44 ha

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

In 1963, the property was purchased by an owner with connections to the local timber industry. The potential value of timber was recognised and the owner commenced a long-running timber treatment program. Tree density was reduced to promote grass to run more cattle, and young trees were retained with the potential to grow into sawlogs. Between 1963 and the late 1980s, approximately 650 ha had been treated. Over the period 1970 to 2009, a total of approximately 3000 m^3 was periodically selectively harvested with follow-up silvicultural treatment. The property was sold in 2009, and then again in 2011 to the current owners, Ergon Energy.

In 2011, Private Forestry Service Queensland (PFSQ) developed a forest management plan for the property to assist Ergon Energy effectively manage the forest for timber production. PFSQ are responsible for the ongoing management of the property and are continuing to carry out silvicultural treatments. Revenues from the harvest of approximately 3000 m^3 between 2013 and 2017 have paid for the ongoing management of the property. This has involved silvicultural treatment of the forest to around 100 to 200 stems per hectare, using tordon stem injection, brushcutting and chopper rolling.

Plots that were thinned in the current trial were thinned with a mix of tordon stem injection (for larger trees) and brushcutting. In the 'treated' plots, trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Tordon treatments involved using a tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart. Chemical treatments for small regeneration involved using a brush cutter cut stump method using Roundup

450 mix. Roundup 450 mix was diluted in water at a ratio of 1:20 and applied to the cut stump by pressure sprayer.

Table 1 – Plot treatment at experiment 22 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based on stems with a DBH ≥5 cm (in some cases in treated plots, trees 2.5–5 cm DBH were included to obtain the required stocking) in January 2013 and November 2016.

Replicate	Plot	Treatment	2013 stocking (st/ha)	2013 BA (m^2/ha)	2016 stocking (st/ha)	2016 BA (m^2/ha)
1	1	Tordon / brushcutter	175	2.9	162	3.9
1	2	Tordon / brushcutter	143	2.6	156	3.7
1	3	Control	112	2.8	112	3.2
2	4	Tordon / brushcutter	150	5.1	156	6.6
2	5	Tordon / brushcutter	80	1.9	100	3.0
2	6	Control	950	3.9	950	7.7
NA	7	Harvest / Tordon	144	17.8	150	18.9
NA	8	Harvest / Tordon	94	17.6	94	18.5

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging:	January 2013
Initial measurement:	21/01/2013
Application of stand treatment / thinning:	31/01/2013
Latest measurement:	16/11/2016

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 5 cm DBH were assessed. No information was available on the trees that were thinned (i.e. DBH or species) from the stand at the time of treatments.

Table 2 – Tree variables assessed in nett plots in the post-treatment measures.

Stand Fraction	**DBH**	**Species**	**Unique I.D.**	**Grimes crown score**	**Merch Height**	**Total Height[#]**	**Merch Class**
Retained Tree. ≥ 20cm DBH	✓	✓	✓	✓	✓	✓	✓
Retained Tree. ≥ 2 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓

- Total height assessed on all retained trees ≥ 10 cm DBH.

Data management

A complete electronic copy of the data associated with this site is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.17.1.

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.17.1 – PLOT PHOTOGRAPHS
Photographs, taken in February 2013

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

Photographs, taken in February 2013

Plot 7

Plot 8

COMMENCEMENT REPORT: Experiment 23 NFQ

OBJECTIVE
Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this study is to determine the effects of thinning treatments on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION/DESCRIPTION

General

The property is located approximately 7.8 km west of Monto. The research sites have been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as predominantly 11.9.9/11.3.4 (*Eucalyptus crebra* woodland on fine-grained sedimentary rocks / *Eucalyptus tereticornis* and/or *Eucalyptus* spp. woodland on alluvial plains). However, the plots were established in spotted gum (*Corymbia citriodora* subsp. *variegata*) dominant forest. The most likely Regional Ecosystem, based on the species composition at the plots is 11.10.1 (*Corymbia citriodora* woodland on coarse-grained sedimentary rocks). The landscape consists of undulating low hills with slopes of up to 10 degrees.

Topography

Aspect: Plots 1-3 have a mostly south-easterly aspect. Plots 4-6 have a north-easterly aspect.
Slope: The landscape is low hilly terrain mostly with undulating slopes. Plots 1-3 had a slope of approximately 10 degrees, while plots 4-6 had slopes of around 4 degrees.

Vegetation and land use

Land use: Timber production and cattle grazing. The site is currently grazed by cattle and horses.
Surrounding Vegetation type: The most likely Regional Ecosystems at the monitoring plots is 11.10.1 (*Corymbia citriodora* woodland on coarse-grained sedimentary rocks).

Soils and geology

Soil type: Soil profile descriptions have not been completed at this site. Soil types are most likely Sodosol based on The Atlas of Australia Soil mapping layer 1991.
Geology: Sedimentary (Arenite-mudrock). Dominated by Burnett Formation.

Rainfall

Mean annual rainfall of 767 mm (Malakoff QLD, 17.3 km away, Bureau of Meteorology site 039129)

EXPERIMENTAL LAYOUT
Experiment 23 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The experiment has treatments of tordoning and no treatment. Appendix 1.18.1 shows the layout of plots within the experiment.

Number of treatments: 2
Number of plots: 6
Number of replicates: 2

Treatment Plots

Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control plots

Gross plot area:	0.25 ha (50 × 50 m)
Nett plot area:	0.04 ha (20 × 20 m)
Isolation plot area:	0.21 ha (15 m)
Total area:	2.46 ha

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

The plots were established in a spotted gum (*Corymbia citriodora* subsp. *variegata*) dominant forest with an understorey of wattles. Plots 1–3 were established in an advanced regeneration and plots 4–6 were established in younger regeneration.

In treated plots, trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Tordon treatments involved using a tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart. Chemical treatments for small regeneration involved using a brush cutter cut stump method using Roundup 450 mix. Roundup 450 mix was diluted in water at a ratio of 1:20 and applied to the cut stump by pressure sprayer.

Table 1 – Plot treatment design at experiment 23 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based on stems with a DBH ≥5 cm in May 2014 (post treatment) and February 2017.

Replicate	Plot	Treatment	2014 stocking (st/ha)	2014 BA (m^2/ha)	2017 stocking (st/ha)	2017 BA (m^2/ha)
1	1	Thinned	75	5.9	81	6.5
1	2	Thinned	81	6.1	75	5.7
1	3	Control	375	20.5	325	20.2
2	4	Thinned	106	2.6	106	3.4
2	5	Thinned	125	2.1	131	3.1
2	6	Control	1150	21.2	850	20.9

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging:	24/05/2014
Initial measurement:	24/05/2014
Application of stand treatment / thinning:	May 2014
Last measurement:	07/02/2017

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 5 cm DBH were assessed however all non-retained trees were treated.

Table 2 – Tree variables assessed in treatment nett plots in the pre-treatment measure.

Stand Fraction	DBH	Species	Unique I.D.	Grimes crown score	Merch Height	Total Height	Merch Class
Retained Tree. ≥ 20cm DBH	✓	✓	✓	✓	✓	✓	✓
Retained Tree. ≥ 5 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓
Removed Tree ≥ 5 cm DBH	✓	✓					

Data management

A complete electronic copy of the data associated with this site is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.18.2.

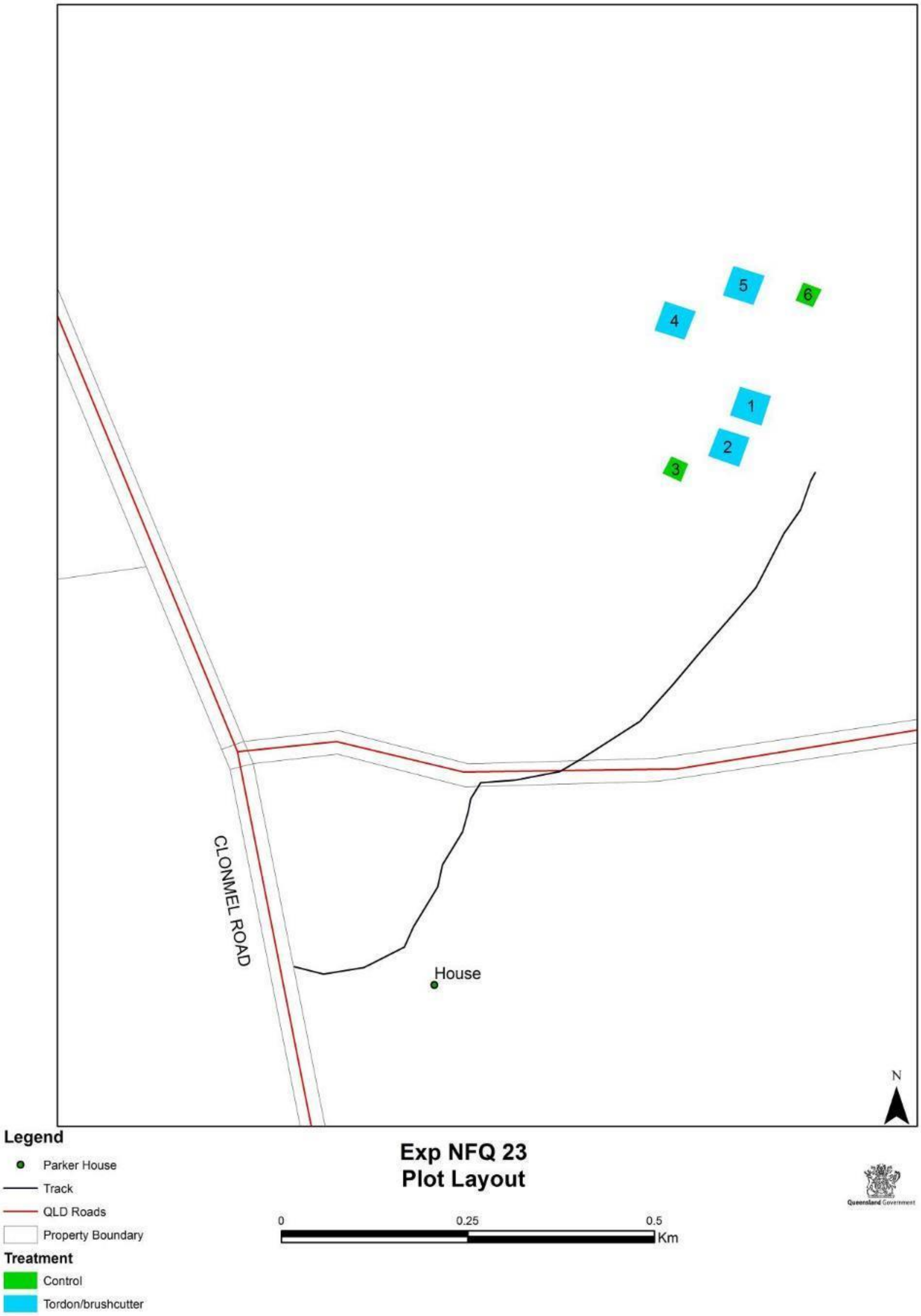
REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.18.1 –PLOT LAYOUT MAP for EXPERIMENT 23 NFQ



APPENDIX 1.18.2 – PLOT PHOTOGRAPHS
Photographs, taken in February 2017

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

COMMENCEMENT REPORT: Experiment 24 NFQ

OBJECTIVE

Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this series of plots is to determine the effects of different thinning treatments (routine tordon treatment), mechanical harvester and chainsaw cutting treatment on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION / DESCRIPTION

General

The property is located approximately 42 km south west of Esk. The research sites have been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as predominantly 12.5.6 (*Eucalyptus siderophloia, E. propinqua, E. microcorys* and/or *E. pilularis* open forest in remnant Tertiary surfaces, usually deep red soils). The plot locations cover a mix of areas mapped as remnant and non-remnant vegetation. The landscape consists of undulating low hills with slopes generally less than 10 degrees.

The eastern series of plots (1-3) are located in non-remnant vegetation on northerly and north-westerly aspects and slopes of 2-6 degrees. Plots 4 and 5 are located in remnant vegetation on north-easterly and south-easterly aspects and slopes of 11 degrees and 2 degrees, respectively. The two western plots (6 and 7) are located in non-remnant vegetation on south-easterly and southerly aspects and slopes of 3-6 degrees. All plots were in open forest dominated by blackbutt (*Eucalyptus pilularis*) with tallowwood (*Eucalyptus microcory*) and an understory of blady grass (*Imperata cylindrica*), *Angophora woodsiana*, *Lophostemon confertus* and *Allocasuarina*.

Topography

Aspect: Varies between plots.
Slope: Varies between plots (ranging from 3-11 degrees). The landscape is low hilly terrain mostly with undulating slopes.

Vegetation and land use

Land use: Timber production. The site is managed to encourage growth of poles to supply Ergon Energy. The site is not grazed by livestock.
Surrounding Vegetation type: The dominant Regional Ecosystem at the site is 12.5.6 (*Eucalyptus siderophloia, E. propinqua, E. microcorys* and/or *E. pilularis* open forest in remnant Tertiary surfaces, usually deep red soils). *Eucalyptus pilularis* is a dominant species over most of the site.

Soils and geology

Soil type: Soil profile descriptions have not been completed at this site. Soils are most likely Kandosols or Tenosols based on GIS layers.
Geology: Dominated by Helidon Sandstone (sandstone, siltstone, shale, conglomerate).

Rainfall

Mean annual rainfall of 1187 mm (Ravensbourne, QLD, 5 km away, Bureau of Meteorology site 40270)

MONITORING PLOT LAYOUT

Square monitoring plots have been established. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. This site is not a replicated experiment, but has a series of scattered plots with differing levels of tree density and differing methods of silvicultural treatment, including use of tordoning, chainsaw cutting, mechanical harvested and no treatment (control).

Number of treatments:	4
Number of plots:	7

Treatment Plots

Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control Plot

Gross plot area:	0.25 ha (50 × 50m)
Net plot area:	0.0625 ha (25 × 25m)
Isolation plot area:	0.21 ha (15 m)
Total area:	1 ha

PAST HISTORY, TREATMENT AND MEASUREMENT

These growth monitoring plots were established in 2011 and 2012; plots 1-3 were established in early 2011 and plots 4-7 were established in early 2012. Plots were established approximately three years after silvicultural treatments. Trees selected for retention were required to be of sufficient standard for growth into a future pole or mill log with emphasis on form vigour and spacing. Favoured species were blackbutt and tallowwood, but where possible other commercially acceptable species were also included. Retained trees were identified with a stainless steel tag with a unique number.

Prior to plot establishment, plots 2 and 3 were marked for retention for pole and sawlog production prior to pulpwood removal by mechanical harvesting for hardboard production (Australian Hardboards – Ipswich). Plot 2 was harvested on the 04/08/2009 (Blackbutt Timbers) and plot 3 was harvested on the 12/12/2008 (Ashers). All unwanted regrowth including coppice and regeneration was foliar sprayed with a Glyphosate / Amonium sulphate / Wetter / Water mix. Rates applied were: Glyphosate 450 (7 litres/600 litres water), Amonium sulphate (12 k/600 litres) plus Agril wetting agent 100 mls/600 litres. The average height of sprayed regrowth was approximately 1-2 metres. Plots were sprayed in May and December 2009 (plots 3 and 2, respectively). The control plot was not sprayed.

Trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and

- the retained tree had almost reached a merchantable size for a product, such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Chainsaw cutting treatments involved felling trees and applying *Tordon DS®* to the stump. Tordon was diluted in water at a ratio of 1:20. Any trees that were chainsaw cut were measured on site by PFSQ staff to determine the likely merchantable products available.

Tordon treatments involved using a tomahawk and calibrated tree injection gun using *Tordon DS®.* Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart.

A wildfire burnt through some of the site in spring 2016. Plots 5 and 7 were affected by this wildfire. This fire resulted in significant scorch of sapling trees, but assessments in 2017 showed that most of the retained trees survived the fire. Prescribed burning is likely to be important in the management of this property to help reduce the risk of wildfire.

Table 1 – Plot treatments at experiment 24 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based only on stems with a DBH ≥1.5 cm. Plots were initially measured in 2011 or 2012 (post treatments) and measured again in 2016-2017.

Plot	Treatment	Initial stocking (st/ha)	Initial BA (m^2/ha)	Stocking at last measure (st/ha)	BA at last measure (m^2/ha)
1	Control	1184	39.5	1040	34.9
2	Mechanical Harvested	156	9.6	150	13.4
3	Mechanical Harvested	206	9.9	187	13.4
4	Mechanical Harvested	206	14.3	206	17.1
5	Tordon	225	2.6	200	5.3
6	Chainsaw	287	3.1	262	7.3
7	Tordon	256	7.1	250	10.5

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging:		01/02/2011 - 01/04/2012
Initial measurement:	Plot 1-3:	03/03/2011
	Plot 4-7:	01/04/2012
Application of stand treatment / thinning:		12/12/2008 - 15/12/2009

Plots were remeasured in December 2016 (plots 6 and 7) and March 2017 (plots 1-5).

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

The measured variables are listed in Table 2. Unless required for retained stocking rates, only trees ≥ 5 cm DBH were assessed (i.e. only stems ≥ 5 cm were assessed in the control plot).

Table 2 – Tree variables assessed in treatment nett plots. Grimes crown scores and merchantable heights were only assessed in the 2016-17 measures, but should be assessed in future measurements at these plots. Some trees <5 cm DBH were measured in treated plots.

Stand Fraction	**DBH**	**Species**	**Grimes crown score**	**Merch Height**	**Total Height**	**Merch Class**
Trees ≥ 5 cm DBH	✓	✓	Only on ≥ 10 cm DBH	Only on ≥ 20 cm DBH	Only on ≥ 10 cm DBH	✓

Data management

A complete electronic copy of the data associated with this site is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.19.1.

REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.19.1 – PLOT PHOTOGRAPHS
Photographs taken March 2017

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

Plot 7

COMMENCEMENT REPORT: Experiment 25 NFQ

OBJECTIVE

Our overall objective is to establish a network of growth and yield plots across the range of regrowth and remnant forest areas on privately owned land in the subtropics.

The specific objective of this experimental site is to determine the effects of two different thinning treatments (routine tordon treatment) and chainsaw cutting treatment on: (1) growth of trees for future commercial harvest; and (2) changes in standing vegetation.

LOCATION/DESCRIPTION

General

The property is located approximately 30 km south of Mundubbera. The research site has been classified under the Regional Ecosystem Classification (Sattler & Williams 1999) as 11.7.6 (*Corymbia citriodora* or *Eucalyptus crebra* woodland on Cainozoic lateritic duricrust). The plot locations cover a mix of areas mapped as remnant and non-remnant vegetation. The landscape consists of undulating low hills with slopes of up to 15 degrees.

The northern replicate plots (1-3) are located in remnant vegetation on an upper slope position, while the southern replicate plots (4-6) are regrowth forest that is located on lower slopes. Both replicates were open forest dominated by spotted gum (*Corymbia citriodora* subsp. *variegata*) with narrow-leaved red ironbark (*Eucalyptus crebra*) and an understorey of wattles (mainly *Acacia leiocalyx*). The species composition of the plots suggests that both Regional Ecosystem 11.7.6 and 11.11.3 (*Corymbia citriodora, Eucalyptus crebra*, *E. acmenoides* open forest on old sedimentary rocks with varying degrees of metamorphism) are appropriate for these plots.

Topography

Aspect: Northern replicate is predominantly north-westerly. Southern replicate is predominantly west-south-west.

Slope: This varies between plots. The landscape is low hilly terrain mostly with undulating slopes. Slopes range between 5 and 15 degrees.

Vegetation and land use

Land use: Timber production and cattle grazing. The site is currently grazed by cattle.

Surrounding vegetation type: The dominant Regional Ecosystems at the site is 11.7.6 (*Corymbia citriodora* or *Eucalyptus crebra* woodland on Cainozoic lateritic duricrust).

Soils and geology

Soil type: soil profile descriptions have not been completed at this site. Soil types are most likely Sodosol (Isbell 1996) based on The Atlas of Australian Soil mapping layer 1991.

Geology: Dominated by Rockhampton Group (dark grey mudstone, siltstone, felsic volcaniclastic sandstone, polymictic conglomerate with mudstone rip-up clasts; oolitic and pisolitic limestone and minor skeletal limestone; rare rhyolitic igimbrite) and Evergreen Formation Group (weathered, flagged, fine to medium- grained, micaceous, labile to sublabel sandstone; pale green or khaki mudstone, carbonaceous mudstone; minor white siltstone and coal).

Rainfall

Mean annual rainfall of 703 mm (Mundubbera QLD, 34.2 km away, Bureau of Meteorology site 039073).

EXPERIMENTAL LAYOUT

Experiment 25 NFQ uses square plots. Plot corners are marked with 50 × 50 mm painted hardwood posts and plots have their location recorded using a GPS with an accuracy of approximately 5 m. The experiment has treatments of tordoning, chainsaw cutting and no treatment (control). Appendix 1.20.1 shows the layout of plots within the experiment.

Number of treatments:	3
Number of plots:	6
Number of replicates	2

Treatment plots

Gross plot area:	0.49 ha (70 × 70 m)
Nett plot area:	0.16 ha (40 × 40 m)
Isolation plot area:	0.33 ha (15 m)

Control plots

Gross plot area:	0.49 ha (70 × 70m)
Net plot area:	0.16 ha (40 × 40m)
Isolation plot area	0.33 ha (15 m)
Total experiment area:	2.94 ha

PAST HISTORY, TREATMENT and MEASUREMENT METHODOLOGY

The trial site has been treated previously (with a Tordon axe) and the site has been logged at least a couple of times (evidence of old stumps >20 years, and scattered younger stumps <10 years old). The site was burnt within 6 months at the time of the initial measures. Plots 1-3 were mapped as remnant forest. Plots 4-6 were regrowth forest in a more productive part of the landscape (lower slope position). Chainsaw cutting and tordon treatments were carried out in July 2017. Post-treatment stocking varied from 87 to 175 stems per hectare (Table 1).

Trees that were surplus to stocking requirements and not suitable for commercial harvest were silviculturally treated. All trees to be retained were paint marked prior to treatments by PFSQ. The guidelines used for retention were:

- the retained tree was healthy and capable of growth improvement and had reasonable form;
- regeneration (<10 cm DBH) was retained based on health, good form and spacing requirements; and
- the retained tree had almost reached a merchantable size for a product such as a sawlog, pole or fencing material (i.e. it was capable of reaching this size by the next harvest).

Chainsaw cutting treatments involved felling trees and applying *Tordon DS®* to the cut stump. Tordon was diluted in water at a ratio of 1:20. Any trees that were chainsaw cut were measured on site by PFSQ staff to determine the likely merchantable products available.

Tordon treatments involved using a tomahawk and calibrated tree injection gun using *Tordon DS®*. Tordon was diluted in water at a ratio of 1:4 and applied at a rate of 1cc per cut. Each cut at waist height was no further than 2 cm apart.

Table 1 – Plot treatments at experiment 25 NFQ. Stocking figures (stems per hectare) and basal area (BA, m^2/ha) based only on stems with a DBH ≥10 cm.

Replicate	Plot	Treatment	Pre-treatment stocking (st/ha)	Pre-treatment BA (m^2/ha)	Post-treatment stocking (st/ha)	Post-treatment BA (m^2/ha)
1	1	Chainsaw	306	12.3	87	6.2
1	2	Control	512	15.6	512	15.6
1	3	Tordon	356	10.5	100	3.7
2	4	Control	268	7.8	268	7.8
2	5	Tordon	337	7.6	175	4.7
2	6	Chainsaw	206	7.4	100	4.6

DATES OF ESTABLISHMENT / MEASUREMENT

Plot survey and pegging: 24/7/2017 - 26/7/2017
Initial measurement: 24/7/2017 - 26/7/2017
Application of stand treatment / thinning: 26/7/2017 and 27/7/2017

MANAGEMENT

Future management of the site will be at the discretion of the landholder and PFSQ. Normal management with the exception of interfering with the measure plots/trees is encouraged. This includes burning and grazing regimes. It has been requested that any management activities such as burning, thinning or treatment be documented and that the landholder's primary contact (PFSQ) be advised.

MEASUREMENT

The measured variables and details of which trees the variables are measured are listed in Table 2. Unless required for retained stocking rates, only trees ≥10 cm DBH were assessed. Future measurements are recommended within 5 years.

Table 2 – Tree variables assessed in treatment nett plots.

Stand Fraction	Unique I.D.	DBH	Species	Grimes crown score	Merch Height	Total Height	Merch Class
Retained Tree. ≥ 20cm DBH	✓	✓	✓	✓	✓	✓	✓
Retained Tree. ≥ 5 cm DBH	✓	✓	✓	Only on ≥ 10 cm DBH		Only on ≥ 10 cm DBH	✓
Removed Tree ≥ 5 cm DBH		✓	✓				

Data management

A complete electronic copy of the data associated with this site is stored on the DAF Forestry Science database. Photographs of each plot are provided in Appendix 1.20.2.

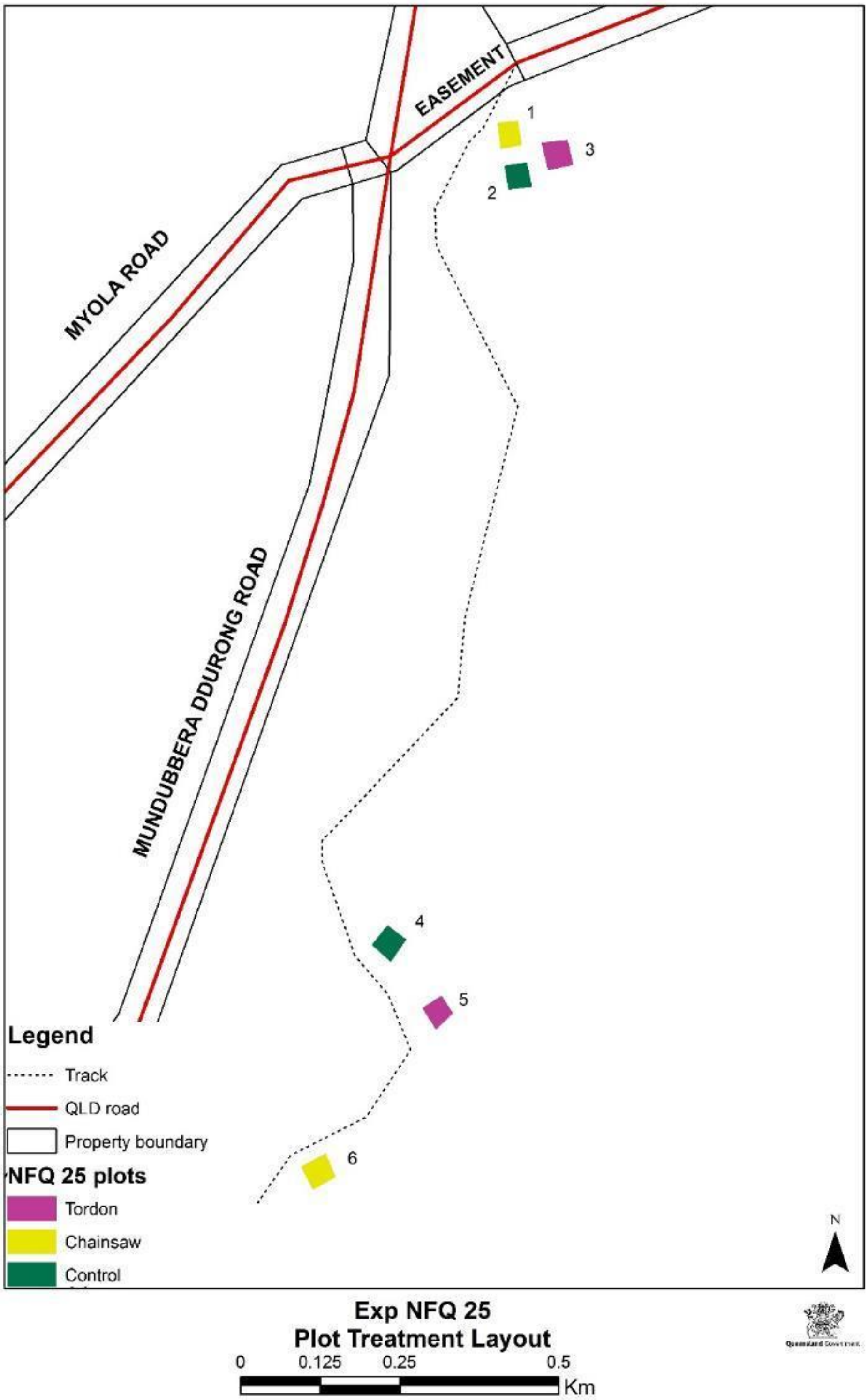
REFERENCES

Isbell, R.F. (1996). *The Australian soil classification*. CSIRO, Melbourne.

Lewis, T., Osborne, D., Hogg, B., Swift, S., Ryan, S., Taylor, D., Macgregor-Skinner, J. (2010). Tree growth relationships and silvicultural tools to assist stand management in private native spotted gum dominant forests in Queensland and northern New South Wales. Final Report for Forest and Wood Products Australia (PN 07.4033).

Sattler, P. & Williams, R. (1999). The Conservation Status of Queensland's Bioregional Ecosystems. Environmental Protection Agency, Brisbane.

APPENDIX 1.20.1 – LAYOUT MAP for EXPERIMENT 25 NFQ



APPENDIX 1.20.2 – PLOT PHOTOGRAPHS
Photographs, pre-treatment, taken in July 2017


Plot 1


Plot 2


Plot 3


Plot 4


Plot 5


Plot 6

Photographs, post-treatment (chainsaw treatment), taken in July 2017.

Plot 1

Plot 1

Appendix 2: Species codes for common tree species in existing private native forest plots.

Species Code	Common Name	Species	Qld Spp No
CP-	White Cypress Pine	*Callitris glaucophylla*	1120
BBT	Blackbutt	*Eucalyptus pilularis*	934
BBW	Brown Bloodwood	*Corymbia trachyphloia subsp. trachyphloia*	937
BBX	Brush Box	*Lophostemon confertus*	156
BGL	Brigalow	*Acacia harpophylla*	974
BKS	Forest Oak / Black Sheoak	*Allocasuarina littoralis*	1159
BOK	Bulloak	*Allocasuarina luehmannii*	1091
BRI	Broad-leaved Red Ironbark	*Eucalyptus fibrosa*	1042
BSP	Spotted Gum	*Corymbia henryi*	1351
BWT	Curracabah / Black Wattle	*Acacia concurrens*	995
OAK	Casuarina	*Casuarina sp*	3172
EPL	Grey Gum	*Eucalyptus longirostrata*	2083
FRG	Forest Red Gum	*Eucalyptus tereticornis*	395
GBX	Grey Box	*Eucalyptus moluccana*	957
GGM	Grey Gum	*Eucalyptus biturbinata*	1012
GIB	Grey Ironbark	*Eucalyptus drepanophylla*	1038
GMS	Gympie Messmate	*Eucalyptus cloeziana*	1081
GRG	Grey Gum	*Eucalyptus propinqua*	1011
GRI	Grey Iron Bark	*Eucalyptus siderophloia*	1037
GTI	Gum Topped Ironbark	*Eucalyptus decorticans*	1039
MBA	Moreton Bay Ash	*Corymbia tessellaris*	536
NRI	Narrow-leaved Red Ironbark	*Eucalyptus crebra*	1043
QPM	Queensland Peppermint	*Eucalyptus exserta*	1111
RBA	Rough Barked Apple	*Angophora floribunda*	910
RBW	Red Bloodwood	*Corymbia intermedia*	396
RDA	Red Ash	*Alphitonia excelsa*	480

Species Code	Common Name	Species	Qld Spp No
ROS	Rose Sheoak	*Allocasuarina torulosa*	393
RMY	Red Mahogany	*Eucalyptus resinifera*	400
SBA	Smooth Barked Apple	*Angophora leiocarpa*	911
SBX	Swamp Box	*Lophostemon suaveolens*	893
SGU	Spotted Gum	*Corymbia citriodora* subsp. *citriodora*	1014
SLI	Silver-leaved Ironbark	*Eucalyptus melanophloia*	1044
SPG	Spotted Gum	*Corymbia citriodora* subsp. *variegata*	1027
SRG	Slaty Red Gum / Narrow-leaved Red Gum	*Eucalyptus seeana*	1018
STY	Satinay	*Syncarpia hillii*	1154
TRP	Turpentine	*Syncarpia glomulifera*	397
TWD	Tallowood	*Eucalyptus microcorys*	1177
WAT	Wattle	*Acacia spp.*	1906
WMY	White Mahogany	*Eucalyptus acmenoides*	1063

Appendix 3: Site quality mapping for private native forestry in southeast Queensland

Executive summary

An algorithm for combining environment and soil attributes is used to generate a map of site quality (SQ) for the southeast Queensland region. SQ is an indicator of the potential productivity and yield from native forest growing on the land.

The map covers all tenures, at a resolution of about 90 x 90m (0.8ha) per pixel.

This report explains how the map was created by combining 100 GIS layers.

The SQ map can assist forest managers achieve more productive outcomes from native forest. Silvicultural management can be more specifically tailored to suit the potential productivity of the site.

The map is provided as a file for use with GIS systems. The data is also provided in a spreadsheet table, with a function to enable look-up of SQ for any list of Lat/Long co-ordinates.

Acknowledgement

This project was undertaken with funding from Department of Agriculture and Fisheries Queensland and University of the Sunshine Coast. The assistance of Dr. Tom Lewis is gratefully acknowledged.

Site Quality mapping for Private Native Forestry in southeast Queensland

Table of Contents

1. Introduction

Improving the management and productivity of native forest requires a good understanding of silviculture, and how it can be tailored to suit the land quality, species mix and current forest condition. Landowners can be more confident to invest in better growth and product quality in their forests when the future productivity of the site can be forecast based on some objective and consistent measures. Soil and climate factors are among the key drivers of tree growth productivity.

Site Quality (SQ) is a term which encapsulates all the various factors which determine the productivity of the site. For example the amount of sunshine, minimum and maximum temperature, distribution and amount of rainfall, evaporation rates, and soil fertility, depth and moisture availability may all have an impact on tree growth. Site productivity measures may be based directly on such biophysical variables, or on indirect expressions such as tree height, presence/absence of indicator species, or physiognomy such as leaf size and inclination (Vanclay et al 1997).

For even-aged monocultures a common yardstick for site quality is predominant height at a given age. This is also termed "site index". However age is unknown in many native forests, so an objective measure must be sought that is independent of time. It is important that the measure be as objective as possible, since any bias will systematically distort the outputs from a growth and yield model. Vanclay (1992) suggested four criteria should be satisfied by any measure of productivity; it should be reproducible and consistent, provide a fair indication of the site without being unduly influenced by stand condition and silvicultural history, correlated with the site's productive potential, and at least as good as any other productivity measure available.

Recent forest growth modeling has attempted to integrate biophysical factors directly in process-based models, of which 3PG is perhaps the best known (eg Tickle et al 2001, Richards and Brack 2004). However process models are data intensive, require calibration to known species, and are subject to scaling problems when moving from leaf to landscape. Coops et al 1998 and Kesteven et al 2004 merged the thinking behind process models with a landscape mapping approach. Kesteven et. al's National Forest Productivity (NFP) model is widely known and is the basis for carbon accounting from native vegetation in Australia. SQ as conceived originally by the author in ~2004 (Jay 2013) for native forest sites in upper northeast NSW (uneNSW), and now for in this project in southeast Queensland (seQ), follows a broadly similar approach to NFP. SQ inputs are monthly time steps for climate, multiplied by a modifier based on landscape attributes. One distinct difference is that NFP estimates growth, whereas SQ is an estimate of yield, ie accumulated growth over the longer term. In practice one would expect good correlation between the two. However Jay 2013 compared his SQ mapping with NFP mapping for uneNSW, and found some distinct differences, including that NFP had a bi-modal distribution of productivity rating in the area, whereas SQ had a right skewed bell-shaped distribution which is more in keeping with what is found from regional scale NVDI and Leaf Area Index analyses (LAI and NVDI are methods for estimating productivity).
No investigation of spatial correlation between NFP and SQ was made at the time, but will be pursued further. They appear to be loosely correlated but examining reasons for differences could be instructive.

Another reason to use SQ for forest management modelling and recommendations in this seQ project is that SQ is created at finer scale resolution than NFP. The NFP grid is scaled at 9 seconds Lat/Long (0.0025 deg) per pixel side, which, near the centre of the project area, is about 270m x 270m or ~7.3ha per unit. SQ is scaled at 3 seconds per pixels side, or about 90m x 90m or ~0.8 ha per unit. SQ is thus more useful for farm-scale management decisions.

SQ was originally devised by Jay for use with the EUCAMIX forest growth model. (Jay and Dillon 2016, Jay 2013, Jay 2009). The EUCAMIX model adopts an approach which draws on observations that forest stands with sufficient stocking to fully occupy the site tend towards a limiting Stand Basal Area SBA which is constant for that site. SBA is the cross-sectional area of wood of all the tree trunks at breast height (1.3m above ground), in a given area of land. SBA is expressed in units of m2/ha, with typical numbers in native eucalypt forest being between 10 and 50. It can be noted that a small number of very large diameter trees in a given unit area, may have the same SBA as a large number of small diameter trees in the same area. For example each of these stands has SBA 40m2/ha…..

Stocking N trees per ha	5093	566	80
Average Diameter DBH cm	10	30	80

Site Quality **SQ** is defined as the **maximum accumulated stand basal area which may occur at a given location with a healthy mature native forest in good silvicultural condition.**

$$\mathbf{SQ = SBA}_{\boldsymbol{max}}$$

As a simple, theoretically measurable single number, SQ integrates (sums) all factors of the physical environment that impact on tree growth, including the interactions between those component factors, and reasonably fulfils Vanclays (op.cit.) four criteria. Conceptually, SQ is the site's "carrying capacity" for trees. At near-full carrying capacity when SBA is approaching SQ, the growth of individual trees becomes very slow because of competition and full usage of the available water, soil and sunlight resources

However, some qualifying statements are needed. Mature SBA may be influenced by the relative proportion of crown-shy intolerant and tolerant species in a mixed species native stand; eg early successional stage stands with a high proportion of light demanding species may not attain the same maximum basal area as later successional stages. Similarly poor silvicultural condition may arrest stand development below its potential. Finally, basal area is a measure which includes heartwood, which is non-respiring tissue and therefore not a sink for site resources, and large old trees often contain central hollows which is a hidden "negative basal area". Hence the EUCAMIX model incorporates some factors which mean that in practice SQ is not a rigid upper limit. In the model, SQ acts initially as an asymptote, but it may be exceeded under some conditions with enough time.

Stand Basal Area SBA is chosen as the indicator variable for Site Quality because SBA at any given time is correlated with any measure of relative occupancy of the site, and is also an indicator of the degree of competition between trees which in turn affects growth rates. Reducing SBA by removing the weaker non-commercial trees creates space for stronger growth in the more valuable retained trees. Moreover SBA is faster and easier to measure than other stand descriptors such as average diameter and stocking rate. Tree height is difficult to measure accurately enough for discriminating differences between sites, but can be readily estimated in the field with fair accuracy by an experienced observer. If tree height and/or average log (bole) length are known or can be estimated, then also knowing SBA enables a quick and simple estimate for total and/or commercial stand volumes, and thus standing biomass. Stand age as used for Site Index is not needed.

2. Project area and data sources

The analysis region 'seQ' is the southeast Queensland area within the bounding box Latitudes -24.65 to -29.2 and Longitudes 151.3 to 153.65. This is a rectangle approximately 500 km x 235km. The western extent was selected to encompass the >700mm/ann rainfall zone, and area with moderate or greater NFP values.

Figure 1

The analysis region, seQ (excluding NSW section)

Data was obtained from

1. CSIRO Soil and Landscape Grid for Australia
   http://www.clw.csiro.au/aclep/soilandlandscapegrid/GetData-GIS.html
2. BOM Australian Bureau of Meteorology
   http://www.bom.gov.au/jsp/ncc/climate_averages/solar-exposure/index.jsp?period=jan#maps
3. WCLIM Temperature and rainfall
   http://www.worldclim.org/current

A total of 100 GIS layers shown in Table 3 were used to construct the SQ index.
The data layers were uploaded into QGIS using the methods described on the respective website pages, and thence exported as GeoTIFF files to Manifold 8 for the GIS processing work.
https://qgis.org/en/site/ , http://www.manifold.net/

Each layer at 3 seconds (3") resolution contains 2820 x 5460 pixels, 15.4M approx, and each GeoTIFF being about 60MB.

Table 1. 100x GIS layers used to construct the SQ index

	Variable	Abbrev	Name	Source	N
	RainSol	RainF	average monthly Precipitation mm	WCLIM	12
		SOLbom	annual flat land solar radiation; MJ/m2/mth	BOM	13
		Sol1	SRAD Total Shortwave Sloping Surface January	CSIRO	1
		Sol7	SRAD Total Shortwave Sloping Surf July	CSIRO	1
		SolN	constructed for months other than 1,7		10
	DayNight Temp	MinT	average monthly minimum temperature °C (x10)	WCLIM	12
		MaxT	average monthly maximum temperature °C (x10)	WCLIM	12
	Moisture	PMI	Prescott Index	CSIRO	1
	Rooting	DES	Depth of Soil (m), A& B horizons	CSIRO	1
Fertility	Physical	BDW	Bulk Density (whole earth) g/cm3	CSIRO	6
		CLY	Clay %	CSIRO	6
		PHC	pH (CaCl2)	CSIRO	6
	Nutrients	CEC	Effective Cation Exchange Capacity meq/100g	CSIRO	6
		PTO	Total Phosphorus %	CSIRO	6
		SOC	Organic Carbon %	CSIRO	6
	Position	TWI	Topographic Wetness Index	CSIRO	1

The six components of the 'Fertility' variable were three dimensional, ie. GIS data was obtained for six different depths in the soil as shown in this table. The values in each depth layer were weighted (%) as shown.

GIS File_nn	Layer Depth (cm)	Layer Weighting% Nutrient	Physical
1	0 - 5	5	15
4	5 - 15	10	30
7	15 - 30	40	30
10	30 - 60	30	10
13	60 - 100	10	10
16	100 - 200	5	5

More explanation of how each of the GIS layers was used is in the next section on Methods.

3. Methods

Construction of the SQ index from biophysical attributes is now described. An empirical modelling and validation of the component factors has not been undertaken. The choice of variables to include in the index was to some extent dictated by the available data. To avoid undue complexity, process variables such as evapotranspiration, vapour pressure deficit, soil moisture content have been included by using landscape scale proxies such as Prescotts index and topographic wetness index and soil properties including depth and texture. The algorithm was originally devised from ecophysical relationships as described in Specht and Specht (1999), available data on stand productivity in the region, and experienced judgment. Vanclay (1992 p269 ff) discusses some similar mechanistic productivity prediction models and the rationale for including particular variables. In many years of practice as a forestry consultant undertaking inventory in private native forests, the author has found that SQ mapping in uneNSW was a reasonably accurate depiction of relative site productivity at the localized landscape and farm scale.

This project includes some enhancement of the original method, and uses better quality data. Some relatively minor differences in outcome from the current and old NSW mapping became apparent using the overlap area of the seQ and uneNSW regions around the Border Ranges as a benchmark. Comments on the differences are made later in this report. The original mapping for NSW is now being revised by the author to ensure it is compatible with seQ. The new data sources cover the whole continent, and SQ can conceivably now be more widely mapped. However the method was originally developed for use with native eucalypt forests in the subtropics, and the algorithm may need extra variables before being applied in areas with very different climates (eg heavy frost) or soils (eg alkaline or saline).

The SQ algorithm combines physical site attributes to produce an index value which was designed to fall only within a range from 0 to about 80, (the likely extremes of potential range for SBA).

The SQ algorithm is

$$SQ = \left[\sum_{month=1}^{12} \left(\frac{RainSol_{month}}{12} \times \sqrt{DayNightTemp_{month}} \right) \right] \times \sqrt{Moisture \times Rooting \times Fertility \times Position}$$

This equation describes a sum of monthly climate values multiplied by soil and topography factors. Moisture and sunlight are the primary drivers of plant growth. Hence in this algorithm, the main variable is the interaction between monthly rainfall and sunlight (RainSol), and this is then modified by temperature, soil and topography factors which each vary between ~0.5 and 1.

a. RainSol

Since the net effect of all the multipliers, if at their maximum, could conceivably be equal to 1.0, the primary RainSol variable needed to be constructed so as to fall into the range 0-80.

This started from the simple concept in Table 2, where a site with "medium" rainfall and sunshine was expected to reach about 40 m2/ha mature forest SBA if temperature and soil factors were not unduly limiting. Then the highest productivity/yield (SBA ~80) was assumed to occur at the "very high" combination of rainfall and sunlight (and no temp/soil constraints). Varying the rainfall and sunlight was envisaged to create a ~smooth surface around these two points, with an interaction between the two variables that included a decline at their extremes.

Initially the table just had a categorical scale… low , medium, high …etc; later the categories became a 1-5 low-high scale, and actual rainfall and sunlight values were connected to the scale based on their occurrence in the region as found from GIS layers.

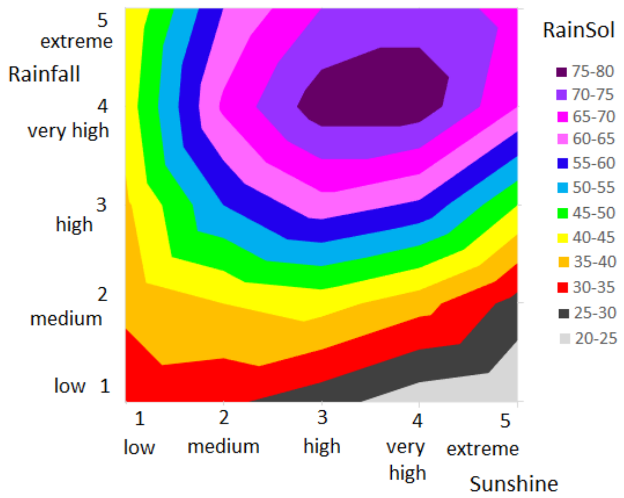
The table is visualized in Figure 2 as a contour chart. The same rainbow colour scale ROYGBIV low to high is used later in the actual maps of SQ.

Table 2
RainSol values

Rainfall					
extreme	40	60	70	73	68
very high	42	66	78	78	65
high	39	55	63	59	45
medium	36	**40**	42	37	28
low	32	31	27	22	15
	low	medium	high	very high	extreme
					Sunlight

Figure 2

This shows a 2D surface version of the above table



b. DayNightTemp

With a similar simple conceptual start, the temperature multiplier was constructed to match the following Table 3. The table assumes an optimum temperature range for most eucalypts to be in the order of 25-30 °C in the day and 5-10 °C at night. (Multiplier =1) The highlighted areas are where NightTemp>= DayTemp… unlikely to occur in the real world.

Table 3

DayTemp \ NightTemp	0	5	10	15	20
30	0.8	0.95	1	0.9	0.75
25	0.875	1	1	0.95	0.85
20	0.9	0.975	0.95	0.9	na
15	0.85	0.85	0.8	na	na
10	0.75	0.7	na	na	na

The underlying rationales for the optimum point and shape of the surface are as follows; large tall eucalypts occur in many areas across Australia where there is a warm summer. In the hottest or coldest areas, the trees are smaller. Therefore eucalypts are likely to be well adapted to the range and average of day time temperatures which occur most commonly in the (original) study area of uneNSW. The largest biomass and carbon storage ecosystems are those in cool wet temperate climates, not the lowland tropics, not the subtropics, and not the cold alps. Hence a cool to moderate night temperature is likely to be more favourable than warm nights. High night temperatures increase the respiration losses of photosynthates, and very low night temperatures can reduce the length of time during the day in which the optimum temperature is in effect.

This therefore leads to a contoured 'surface' where the optimal point is a shallow hill descending slowly at first in any direction away from optimum but becoming increasingly steep towards the extremes. A square root of the table values was used to reduce the steepness of the modelling surface moving away from optimum.

c. Quantifying RainSol

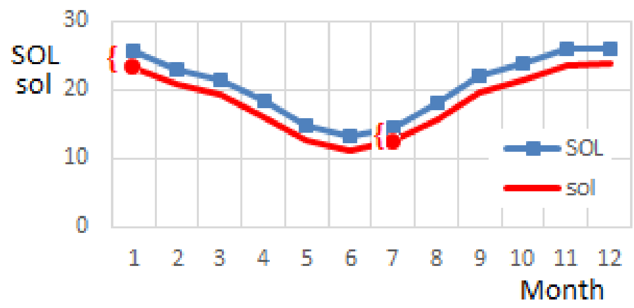
First some missing solar radiation data had to be calculated (see SRAD, Table 1).

Note two sets of radiation data were obtained. The CSIRO data (SRAD, referenced herein using lower case 'Sol') is at higher resolution (3" pixels) and gives net radiation adjusted for slope, aspect and cloudiness. The BOM data (referenced with upper case 'SOL') is for flat land with 3' pixels, ie 60 times less resolution on a linear scale. The CSIRO data was only available for months January and July, ie Sol1 and Sol7. BOM data was available for all months, plus an annual total. It was reasoned that the BOM flat land radiation data would provide a reasonable estimate of the basic variation over the course of a year for all the higher resolution CSIRO points within the larger BOM pixel. Since the slope and aspect of the land would not change, the data sources could be used together to construct the missing 10 months of higher resolution sloping land data. This was done by taking the average difference between BOM and CSIRO for months 1 and 7, and subtracting that from BOM for month *n* to give the sloping land value for month *n* .

The formula used was Sol*n* = SOL*n* – [(SOL1-sol1) + (SOL7-sol7)] / 2

Figure 3 Using BOM data to calculate SRAD for missing months in CSIRO data.

BOM data (SOL blue squares) was available for every month.
CSIRO data (Sol red circles) was only available for months 1 and 7.
The average difference between the values for those two months {
was subtracted from all other BOM months to create the data which forms the red line.



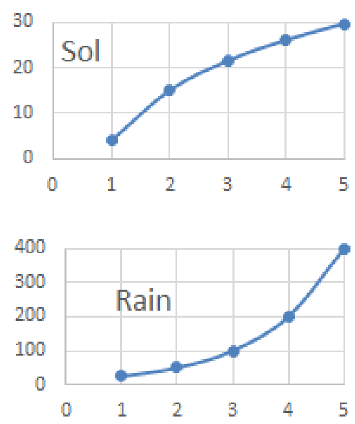
The procedure was tested for several real locations with steep slopes on different aspects. It gave reasonable results in all cases, and Fig 3 is a typical example. Therefore the method was applied for the whole project area.

With all months SRAD now available, calclulating RainSol began by assigning the numbers 1-5 as a scale for low to extreme, for rainfall and solar radiation. The actual value to use were obtained from observing the distribution of data, ie histograms, in the GIS datasets.

For 'extreme' Sol, the value of 30 in the table below (Fig 4) is the highest found in Australia in the SOLbom data. This occurs in northwest WA in December/January. The lowest value of ~4 is in southern Tasmania in June/July. For sol1 (January) in seQ, ~90% of the values were in the range ~20-27 with a median of ~24, and for sol7 the 90% range was ~9-15 and median ~12.

Using scale low to extremely high as 1-5, a logarithmic curve fit to the data range was used to reflect the shape of the surface in Figure 2 when varying along the Sunshine axis. Similarly, values for monthly rainfall low to extremely high as 1-5 were designated to be from 25 to 400mm/month, and these were fitted fitted as an exponential curve to conform to the shape of the surface in Figure 2 when varying on the Rainfall axis .

	low				extreme	
scale	**1**	**2**	**3**	**4**	**5**	
Sol	4	15	22	26	30	MJ/m2/mth
Rain	25	50	100	200	400	mm/month



<u>Figure 4 Scaling RainSol</u>

Where S is the scale 1-5 for Sol, and
R is the scale 1-5 for Rain, then

Sol = 16* LN (S) - 4 S = exp (Sol-4)/16
Rain = 25/2 *exp (0.6931 * R) R = 1.4427* LN(Rain) - 3.6439

Then the RainSol surface in Figure 2 was then obtained by two stage regression of S and R which generated the following formula. S and R are the values from 1-5 obtained as above. The table of co-efficients corresponds to a1, a2 a3… etc in the formula.

$$\begin{aligned} &RainSol = \\ &(a_1S^2 + a_2S + a_3).R^4 + \\ &(b_1S^2 + b_2S + b_3).R^3 + \\ &(c_1S^2 + c_2S + c_3).R^2 + \\ &(d_1S^2 + d_2S + d_3).R + \\ &(e_1S^2 + e_2S + e_3) \end{aligned}$$

-0.07738	0.322619	-0.48333
1.297619	-6.43571	7.633333
-6.52976	35.17024	-37.9167
10.2381	-54.3286	61.56667
-5.85714	26.54286	1.00000

For every map pixel, each month's RainSol was calculated with the formula and multiplied by the month's DayNightTemp variable.

d. Quantifying DayNIghtTemp

To calculate the DayNightTemp variable to match the surface of Table 2, a two stage regression of D and N using quadratics was used to find the following formula.

$$\begin{aligned} &DayNightTemp = \\ &(f_1D^2 + f_2D + f_3).N^2 + \\ &(g_1D^2 + g_2D + g_3).N + \\ &(h_1D^2 + h_2D + h_3) \end{aligned}$$

-3.91837E-06	8.64490E-05	-1.19143E-03
2.93878E-06	2.30016E-03	-3.20314E-02
-1.23878E-03	5.21367E-02	3.54429E-01

where D = average maximum monthly temperature (Day) from GIS cell attribute / 10
N = average minimum monthly temperature (Night) from GIS cell attribute /10
co-efficients f1,f2,f3…etc as shown in corresponding matrix table

This gives values of between 0.5 and 1.0, as intended.

The outcomes were checked to be sure they produced a reasonable value within a more extended range of possible values from 0 to 40 °C. The multiplier was satisfactorily above 0.5 for all Day/Night combinations, except with day temps above 35 and night temps 25 and above. The hottest parts of the seQ project area had D averages in the low 30s, and N averages in the very low 20s, so no values occurred <0.5 in this project area. However higher average temps exist further inland and northward, and generally those areas will have low SQ forests. The east coastal areas of Qld, right up to Cape York, have somewhat higher average temps, both D and N, but still for Dec/Jan, D <35, N<25. However to accommodate wider use of the SQ algorithm, a "floor" value for DayNightTemp can be set at 0.5. After taking the square root, this means even the warmest sites would have a Temperature derived multiplier of ~0.7 for their most unfavourable month.

e. completion of step 1 of SQ index : AnnRainSolTemp

Referring back to the first line of the SQ algorithm…

$$\sum_{month=1}^{12}\left(\frac{RainSol_{month}}{12}\times\sqrt{DayNightTemp_{month}}\right)$$

… the formula is completed by calculating each month's RainSol, multiplying that by square root of each month DayNightTemp factor, summing all the monthly products and dividing by 12.

This gives the raw figure for a variable now referred to as 'AnnRainSolTemp' to be modified now by soil and landscape factors.

f. step 2 of SQ index : the soil and landscape mutipliers

The second line of the algorithm is a multiplier with four components.

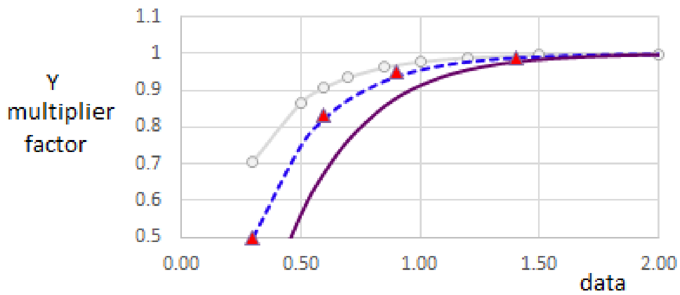
$$Moisture\times Rooting\times Fertility\times Position$$

The reasoning again is to estimate an optimum value for each of these components and scale the component so it will produce an outcome of between 0.5 and 1.0.

The functional form chosen to represent these 4 components was a logistic equation of the form $y = A * (1-e^{aX})^b$. In this formulation, y is the dependent variable, X is the data, A is an asymptote, and a and b are coefficients which control the shape and can be found by least squares curve-fitting. Since we want the curve to start at ~0.5 and reach a maximum of ~1, the asymptote was taken to be ~0.5 and a constant of 0.5 was added to the equation…. $y = \sim0.5 * (1-e^{at})^b + 0.5$. The logistic equation was chosen because its shape is such that it increases very quickly from a low value then remains ~constant over a long range of upper values. The exaggerated response at the low end of the range means that one limiting factor (eg low soil fertility, very shallow soil) may substantially reduce SQ even if all other parameters suggest otherwise. At the upper end, the variable might be saturated, eg growth on fertile soil cannot be increased greatly by adding fertilizer. The sensitivity, ie degree of response to lower values, can be easily altered by changing the exponent b, for example squaring or taking square root.

A hypothetical example is used to illustrate the method. Suppose we had some data on a range low to extreme, for which we wished to create an outcome Y (ie the multiplier we are seeking) between 0.5 and 1.0 as shown in the table.

	data	Y
low	0.3	0.5
med	0.6	0.83
high	0.9	0.95
v.hi	1.4	0.99
extreme	5	1



The table data is illustrated by the red triangles. A regression for the logistic equation can be fitted to find the blue dashed line that will give us a multiplier Y for any data input value. If it was later decided that a more or less sensitive multiplier was preferred, then without redoing the red triangles and re-fitting a regression, it is possible to simply take the square root (grey line with circle markers) or square (brown line no markers) of the initial value.

The selection of just these four additional variables to create a modifier value was a balance between making the SQ algorithm sufficiently general without adding extra complexity (Occam's razor).

For example another variable available in CSIRO data was depth of regolith (DER), ie depth to solid rock. For deep rooting trees, it may be thought this would be more important than just depth of A and B horizons (CSIRO variable DES). However on examining the data, some areas had DER >>10m, which is generally much greater than the depth where root biomass for even large trees is found.

Similarly, there were additional variables which could have been included in the Fertility component. As it was, the Fertility component required a large amount of data and processing. It has six sub-components, three described "physical chemistry" and three described as "nutrient chemistry" (see Table 1). Each of those six had a value for six depth layers from surface to 200cm. Other variables could have been included, for example total N in addition to total P, sand % in addition to clay%. However a decision was made to limit the construction of this component to include only the most crucial variables. Total P was chosen because of the frequent low P in Australian soils. Even though Eucalypts have a great ability to tolerate low P soils, they will nevertheless respond to extra P. Total N was thought to be more ephemeral, waxing and waning with legume components, soil moisture throughflow, and fire history.

Clay % was included in the fertility component because high clay soils are problematic for many plants including trees. High clay content can reduce water infiltration and its availability to plants, and very high clay can create a hardpan barrier to root penetration. However clay chemistry is a complicating factor, some high kaolinite clay soils (red kraznosems) may have very good water holding and drainage character, on the other hand soils with high content of montmorillinite clays (black vertisols) will swell with moisture and shrink in the dry, causing deep soil cracks which can physically tear tree root apart.

Finally a simple topographic variable was also available, categorizing sites on an integer scale 1 to 5 from flat or bottom land to high spots such as ridgetops. On inspection, it was found that this variable showed the localized high spots on a flood plain ti have the same score as high ridgetops, so this was deemed to be not as relevant for forest productivity as the variable TWI (see Table 1). Topographic Wetness Index is a measure of how the soil moisture at a localized position may be influenced by its landscape context. Shallow rises on a flood plain will still be wet, a saddle between two high points on a ridge line will still be quite dry. Therefore TWI was chosen to represent the effect of topographic position on forest productivity.

Comment on the variables is included below. The range and median values for all variables in the seQ project area, and the coefficients of their logistic equations are in the text.

g. Moisture

Prescotts Soil Moisture Index (PSMI) is an index of available moisture based on rainfall R and Evaporation E such that PSMI = 0.445*R / E $^{0.75}$

where E = S * (6.226 + 0.2670T - 0.002130T^2)

for average monthly Temperature T and Solar radiation S

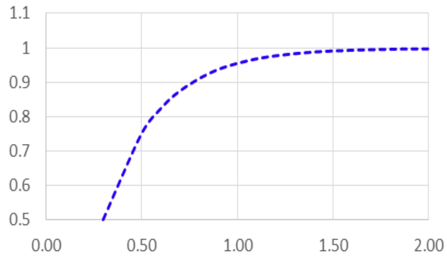
https://data.csiro.au/dap/landingpage?pid=csiro%3A9636

The quadratic expression for E produces maximum E when T=63, so in practice E increases for all normal values of T.

Sites with low PSMI will have less forest productivity. Sites with average and above PSMI will have good moisture availability through the year.

The range in the PSMI data was from 0.3 to 7.5 approx, with narrow modal peak about 0.7-0.8 and 90% of pixels < ~1.3.
The logistic equation for the Moisture multiplier is

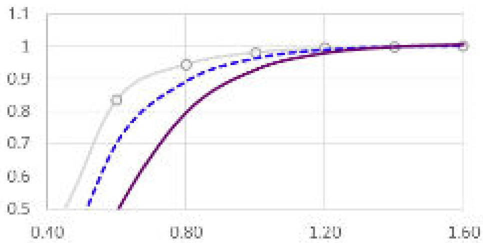
Moist= 1/2*(1-EXP(-0.25*([PSMI]*100-30)/7.2))+0.5



No square or root transform was applied to the multiplier.

h. Rooting

Rooting depth DES is the combined depth of A and B horizons in the soil; units are metres.
The range in the DES data was from 0.4 to 1.6 approx, with bell-shaped modal peak about 0.9-1.1 and 90% of pixels < ~1.3.



The logistic equation for the Rooting multiplier is
Rooting =(1.01/2*(1-EXP(-0.05*([DES]*1000-500)/10))+0.5))^2

A square transform was applied (brown line), using the reasoning that shallow soils impose a severe constraint on forest productivity.

i. Fertility

As already noted this is a composite variable; six components and six depths per component.
The components and depths, and relative weighting of values for each depth are shown in Table 1.

To construct this component each of the six component values was first converted to a scale ‘Fscore’ 1-5 low to high fertility, by lookup table rather than as a function with continuous variable

The look-up values are here; variable values are for upper bound of class

Physical Chemistry						**Nutrient Chemistry**			
Bulk Density **BDW**	**Fscore**	Clay% in soil **CLY**	**Fscore**	pH in CaCl2 solution **PHC**	**Fscore**	Effective Cation Exchange Capacity **CEC**	Total P% in soil **PTO**	Soil organic carbon% **SOC**	**Fscore**
1	**3**	10	**5**	4	**1**	4	0.02	1	**1**
1.2	**5**	15	**4**	5	**2**	8	0.04	3	**2**
1.3	**4**	20	**3**	6	**3**	10	0.08	4	**3**
1.4	**2**	40	**2**	6.5	**4**	12	0.12	6	**4**
>>	**1**	>>	**1**	7	**5**	>>	>>	>>	**5**
				7.5	**4**				
				8	**2**				
				>>	**1**				

The lookup classes are based on the histograms of data and/or expected effects of different variables using experienced judgment… An example of the latter is for soil pH ratings, ideal pH Fscore=5 is estimated to be when pH at a given depth is between 6.5 and 7. Note that the physical chemistry ratings are not uniformly increasing with an increase in the variable. The Nutrient chemistry ratings are increasing in one direction (viz more fertile is better), however the class boundaries are not necessarily linear.

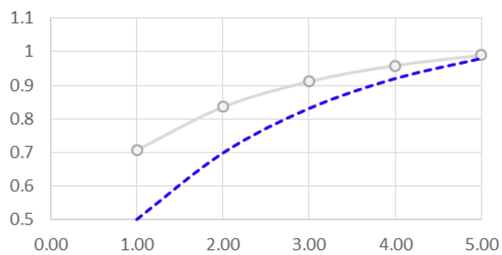
So, each variable for each depth is given an Fscore 1-5. The Fscores are then multiplied by the depth weightings% given in Table 1, making the sum for the component fall into the range 1-5 . Note that depth weightings are different for each of the two subcomponent groups. The greatest weighting (40% of total) was given to nutrient components in the 15-30cm depth layer. This was subjectively judged to be where nutrient factors were most crucial. The physical factors were given more even weightings with emphasis on the upper soil… it was assumed that if clay and bulk density were high at depth, it would likely already show up in the DES (depth of A&B horizons) as a low value.

Now the six components scores were summed and divided by 6 to give an evenly weighted average of the components across the board, and a final 'SFert5' score nominally between 1 and 5 low to high. There was no a priori reason for weighting the six fertility components differently in the final mix. Note the word 'nominally' … in theory there could have been soils with scores of 1 or 5 but in practice no soil was perfect or imperfect. The combined results actually showed raw scores in the range 1.46 to 3.3. Hence the raw layer was re-normalised to show a range 1-5+, using the formula

Sfert5= 2.1661*[SFert_raw] -2.1588

The range in the constructed SFert5 data was from 1 to 5 approx, with a broad modal peak from 1 to 3 and 90% of pixels < ~3.5.

The logistic equation for the Fertility multiplier is
Fertility = SQRT (1.2/2*(1-EXP(-2*([SFert5]-1)/5))+0.5)



A square root transform (grey line) was applied, so that low fertility soils were only lightly and gradually penalized in the overall SQ index. The asymptote is increased by using 1.2/2 not ½ as the initial constant, and this creates the general upward slope with fertility even at the upper level of 5. This allows for example, the possibility of a Fertility multiplier >1 if the raw score in other areas is >3.3, or if the soil is improved by fertiliser, lime or deep ripping working to reduce bulk density.

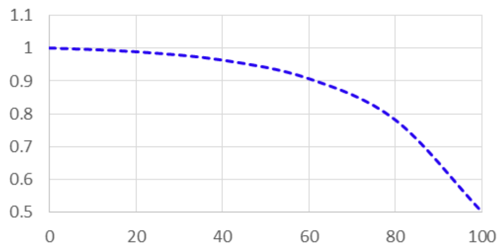
j. Position

The topographic wetness index TWI was used to indicate the relative position in the localised landscape. The values in the original data ranged from 3.3 to 20, with large values indicating more wetness (eg typically gullies or flood plains). To make the scale easier to compare with previous work, I first converted the score to a scale 'T' of 0-100 running in the inverse direction, so that 100 is a high part of the landscape and 0 is a low part.   T= -6*TWI+120

Broadly descriptive terms	TWI	T
floodplain	20.00	0
gully	16.67	20
lower slope or concave	13.33	40
midslope, saddle, high plateau	10.00	60
upperslope or convex	6.67	80
steep ridgetop	3.33	100

The range in the TWI data was from 3.3 to 20 approx, with a bell-shaped modal peak from 7 to 9 and 90% of pixels < ~11.

The logistic equation for the Position multiplier is 1.02/2*(1-EXP(1*((-6*[TWI1]+120)-100)/25))+0.5



No square or root transform was applied to the multiplier.

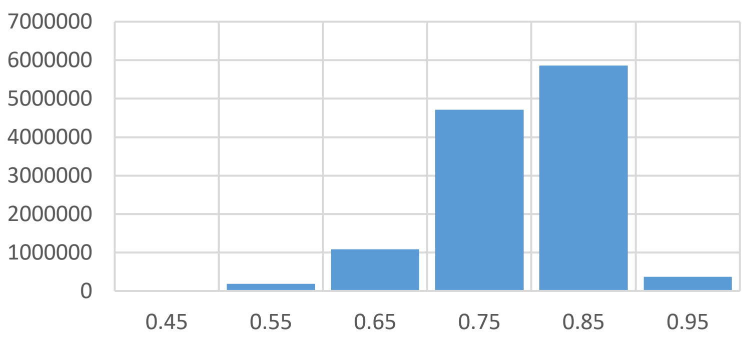
k. completing step 2 of SQ index : combining the soil and landscape multipliers

$$\sqrt{Moisture \times Rooting \times Fertility \times Position}$$

The four multipliers, three with potential range between 0.5 and 1.0 and one (Fertility) between 0.7 and 1.0, were multiplied together and then the square root was taken.

This variable, the second part of the SQ algortithm, is now referred to a 'Modif4SQRT'

The pixel count frequency histogram for Modif4SQRT is as shown.
The most frequent modifier values are in the bin 0.8 to 0.9.

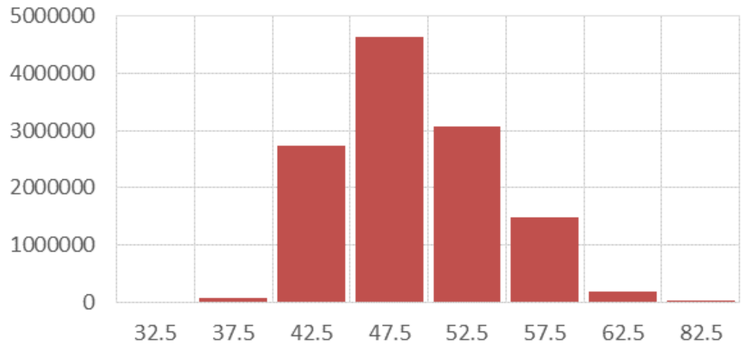


l. completing the SQ index

The final step is to put together parts 1 and 2 of the algorithm.

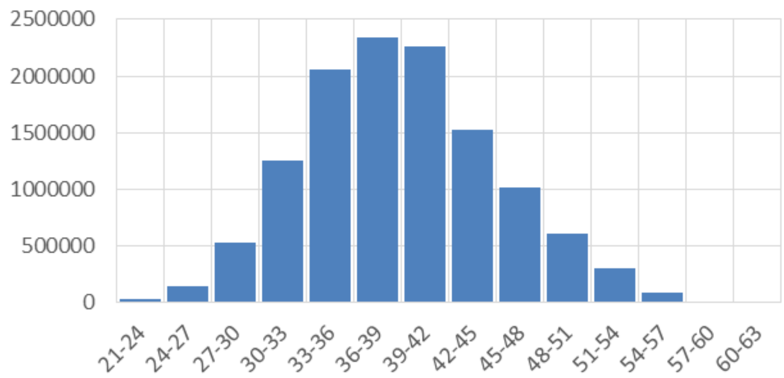
The pixel count frequency of AnnRainSolTemp values, the step 1 outcome as described in section 3e above, is as shown below.

The most frequent values are in the bin 45-50.



Now multiplying AnnRainSolTemp x Modif4SQRT for every pixel in the landscape, we get the SQ-seq map.

The pixel frequency distribution of the gross SQ-seq mapped area is as shown below.
The most common SQ is in the bin 36-39
Some very high and very low values exist.
Note the unimodal distribution of values, with a slight skew towards the right.

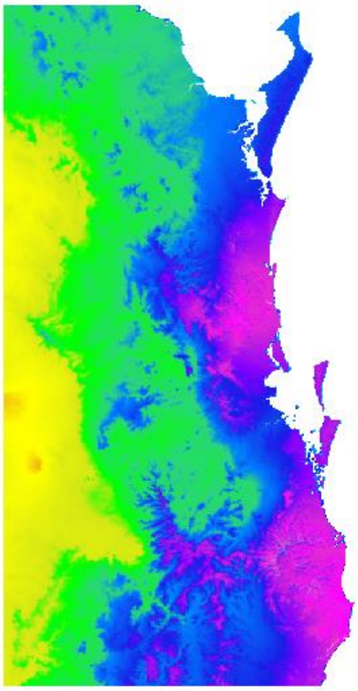


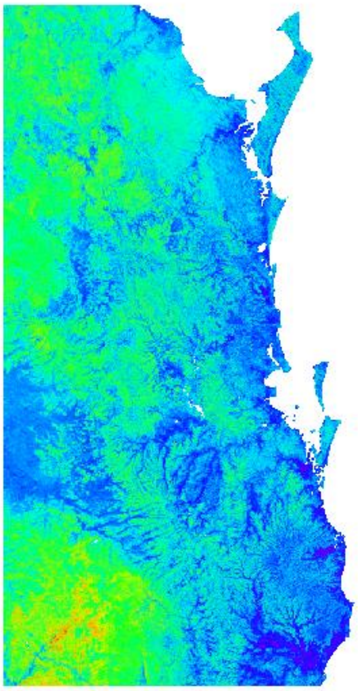
For the uneNSW area, the highest SQ value was 61.

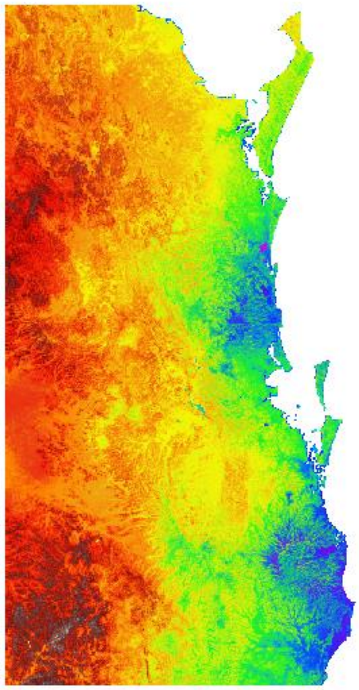
SQ less than 30 is considered to be a site with low yields per unit area, low growth rates for timber production, and low return on silvicultural effort.

4. Results

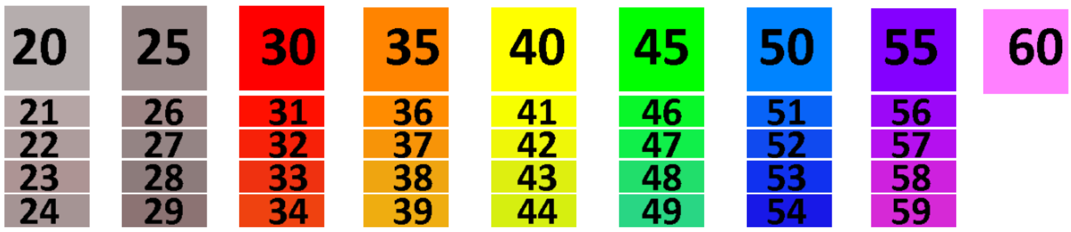
AnnRainSolTemp x Modif4SQRT = SQ







Each map is coloured on a rainbow scale ROYGBIV low to high.
AnnRainSolTemp and SQ colour scale is



These are a low resolution overview only.
The fully detailed maps are provided for use in a GIS system.

Some anomalies appear in the SQ mapping around the coastal fringes. This appears to be an outcome from the different scale of pixels used in the different map layers.

5. Discussion

SQ is a general productivity index, and does not distinguish individual species relative responses to variation in rainfall or fertility. The mix of species in native forest currently growing on the site are assumed to be those which can capture the site resources in the most efficient way.

The map has not been ground-checked, but exhibits generally sensible interpretations of site productivity potential in relation to climate and topographic factors and the author's general knowledge of the forest types in the region. Some anomalies and limits of the previous application of the algorithm for mapping in uneNSW were identified and corrected during this project, for example, the former exaggerations of local variation due to topography (eg ridge tops being overly penalized), improved rating for soil fertility which was previously based only on broad geological mapping. Some caution is still needed for interpreting the map in different landscapes, for example, low lying areas with high water tables may have high potential basal area potential productivity with Melaleuca and Casuarina forest, but not eucalypt.

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(B.Sc[For] Dip.Ag.Econ)

BlueChip forest services

6. References

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http://www.fullcam.com/FullCAMServer/Help/reps/TR23%20Developing%20a%20National%20Forest%20Productivity%20Model.pdf

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https://www.cabdirect.org/cabdirect/abstract/20000707327

7. Appendix; comparing NFP and SQ

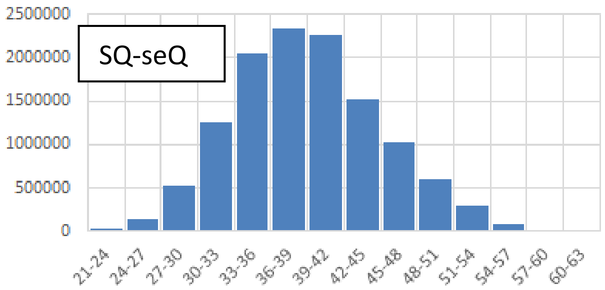
A brief comparison of Kesteven et al 2004 NFP mapping with current SQ mapping is on the following page. The information is presented without detailed comment or analysis, but simply as an observation and a cue for potential further examination.

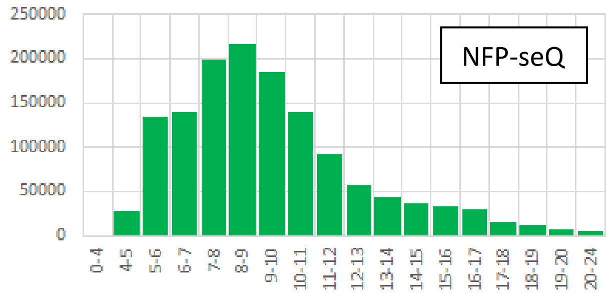
The colour scales between SQ and NFP maps are not an exact match because the index values differ, but both follow the scale ROYGBIV low to high. There appears to be some visual correspondence between the two indices for seQ, but this is less apparent when looking at uneNSW. Note there is some overlap with the southern part of the seQ area with uneNSW, eg Mt Warning to Lismore region.

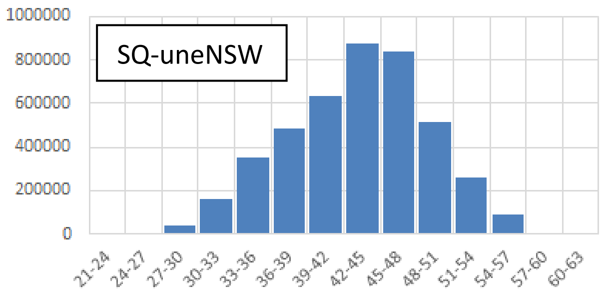
The distribution histograms show that uneNSW has a somewhat higher proportion of high SQ land. This may be expected because seQ includes a larger area of low rainfall country.

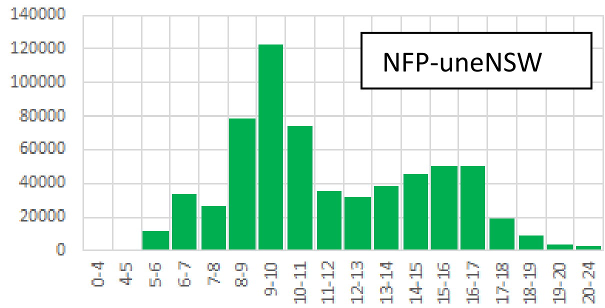
SQ has a bell-shaped distribution in both regions, with some difference in direction of skew. The bi-modal distribution of NFP in uneNSW does not occur in seQ. This may in part be because a distribution approaching normal is more likely to be found in a larger analysis area.

Histograms of pixel values



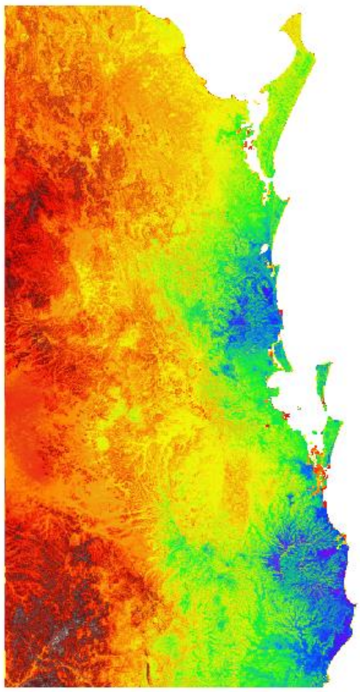




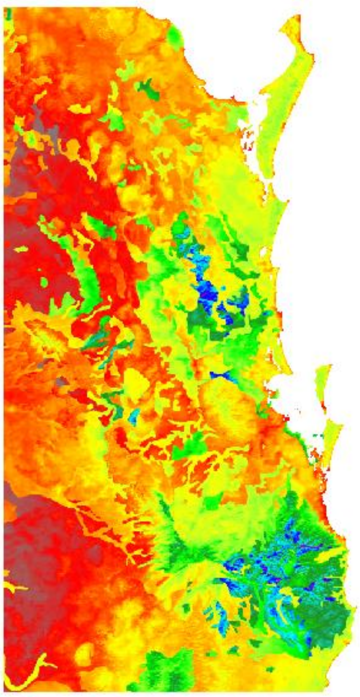


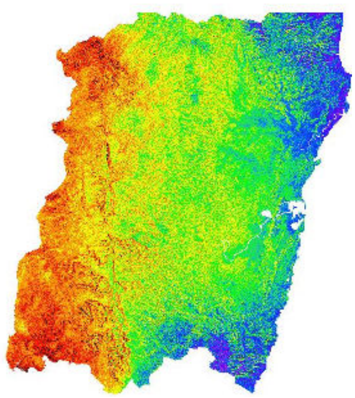
Mapping

SQ-seQ

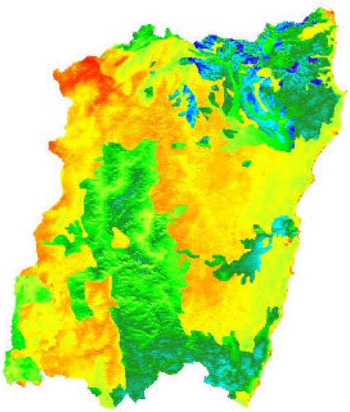


NFP_seQ





SQ_uneNSW



NFP_uneNSW

Appendix 4: Commercial forest types and commercial species in sub-tropical Queensland

Relationship between the six commercial forest types defined in this study for sub-tropical Queensland, the PFSQ (c2015) forest types, regional ecosystems (REs), and broad vegetation groups (BVGs) (Neldner et al. 2017a).

PFSQ forest type	REs in PFSQ forest type	BVGs	Commercial forest types adopted for this study
Flooded gum tall open forest	11.10.2, 12.3.2, 12.8.8, 12.11.2, 12.12.20, 12.12.15a, 12.5.6a (major). 12.9-10.14a, 12.12.2b (minor)	8a	1. Moist tall
Blackbutt tall open forest	12.9-10.14, 12.12.2, 12.11.23, 12.12.6, 12.8.1, 12.9-10.20, 13.12.1	8b	
Gympie messmate tall open forest	12.11.16 , 12.5.1b	8b, 12a	
Stringybark wet forest	12.12.4, 12.9-10.1, 12.8.12	8b	
Spotted gum on granite	12.12.5, 11.12.6 (major). 12.12.3 (minor)	10b	2. Spotted gum
Spotted gum on sandstone	12.9-10.2, 12.9-10.17b, 12.9-10.5a, 11.10.1 (major). 12.9-10.19a, 12.9-10.5 (minor)	10b, 9h, 10a,	
Spotted gum on metamorphics and mixed volcanics	12.11.6, 12.11.5, 11.11.3, 11.11.4, 11.7.6 (major). 12.8.24 (minor)	10b, 10a, 13c,	
Spotted gum on snuffy red soils	12.5.1, 12.5.7 (major). 12.9.7a, 11.5.9d (minor)	10b, 10a	
Grey ironbark and grey gum open forest	12.9-10.17, 12.11.3, 12.12.15, 12.5.6, 12.9-10.17d (major). 12.11.3a, 12.12.15b, 11.10.13	13c, 9a (mostly), 8a	3. Mixed hardwood
Stringybark mixed woodland	11.5.7, 12.5.11, 12.8.14, 12.9-10.21, 12.12.11, 12.9-10.17 (major). 12.8.25, 12.11.17, 12.9-10.17c (minor)	11a, 9h, 9a, 9g,	
Blue Gum Flats	12.3.3, 11.3.4, (major). 12.3.7, 11.3.23, 11.3.25, 13.3.7, 12.3.6 (minor).	16c, 15b, 16a	4. Queensland blue gum
Blue Gum and Grey Ironbark lower slopes and hollows	12.3.11, 12.9-10.7, 12.11.14, 11.12.3, 13.3.5 (major)	16c, 13c	
Blue gum open forest	12.12.12, 12.12.23, 12.5.2, 11.8.2a (major). 12.11.9, 12.11.15, 11.11.4a, 13.3.5, 12.9-10.12, 13.12.4 (minor).	9g, 11a, 9h, 10a	

PFSQ forest type	REs in PFSQ forest type	BVGs	Commercial forest types adopted for this study
Gum-topped box open forest	11.5.20, 12.9-10.3, 12.11.18, 12.12.28, 11.3.26, 11.9.13, (major). 12.8.14a, 11.11.4c, 11.12.2b, 12.12.28X1, 11.11.3c, 13.11.8 (minor)	13d	5. Gum-topped box
Broad-leaved red ironbark woodland	12.9-10.19, 11.7.7 (major). 12.11.19, 12.12.25, 12.7.1, 11.11.7, 13.11.5 (minor)	12a, 9h (50-50)	6. Ironbark
Gum-topped ironbark woodland	12.12.9, 12.8.20, 11.10.4, 11.7.4 (major). 12.9-10.5b, 12.5.1a (minor)	12a (all but 1), 9h	
Narrow-leaved ironbark open forest	12.11.7, 12.12.7, 11.9.9, 11.9.9a, 11.11.1 (major). 11.3.36, 11.5.2, 13.11.3, 12.11.22 (minor)	13c, 15a, 18b	
Narrow-leaved ironbark shrubby forest	11.10.7, 11.11.15, 11.12.1, 11.5.1, 11.5.4 (major). 11.10.7a, 11.11.15a, 11.12.1a, 11.3.29, 11.5.9, 11.5.9b (minor)	12a, 13c, 18b (mostly)	
Narrow-leaved ironbark on basalt	12.8.16, 12.8.17	11a	
Mixed cypress and eucalypt woodland *	11.5.21, 11.3.14, 11.3.18		

Note: * This is a new forest type not described in PFSQ (c2015).
Sources: PFSQ forest types and the regional ecosystems (REs) that define them are from PFSQ {, c2015 #45} and expert opinion from Private Forestry Services Queensland for REs outside their published study area. Broad vegetation groups (BVGs) at the 1:1 M mapping scale from the online regional ecosystem description database (https://environment.ehp.qld.gov.au/regional-ecosystems/).

Dominant and commonly associated commercial species by forest type in Queensland.

Forest Type	Dominant commercial species	Commonly associated commercial species
Moist tall forest	*Eucalyptus pilularis* (blackbutt), *E. grandis* (flooded gum), *E. saligna* (Sydney blue gum), *E. acmenoides* (white mahogany), *E. cloeziana* (Gympie messmate), *Syncarpia glomulifera* (turpentine)	*Lophostemon confertus* (brush box), *E. microcorys* (tallowwood), *E. resinifera* (red mahogany), *E. propinqua* (grey gum)
Mixed hardwood forest and woodland	*E. propinqua* (grey gum), *E. siderophloia* (grey ironbark), *E. acmenoides* (white mahogany)	*E. microcorys* (tallowwood), *C. citriodora* subsp. *variegata* (spotted gum), *E. moluccana* (gum-topped box), *E. tereticornis* (Queensland blue gum), yellow box. *Lophostemon confertus* (brush box), *E. major* (grey gum), *E. biturbinata* (grey gum), *E. longirostrata* (grey gum), *E. cloeziana* (Gympie messmate), *E. crebra* (narrow-leaved red ironbark), *E. fibrosa* (broad-leaved red ironbark), *C. intermedia* (pink bloodwood), *C. trachyphloia* (brown bloodwood), *C. henryi* (spotted gum), *Syncarpia glomulifera* (turpentine)
Spotted gum forest and woodland	*Corymbia citriodora* subsp. *variegata* and *citriodora* (spotted gum), *E. crebra* (narrow-leaved red ironbark).	*E. acmenoides* (white mahogany), *E. siderophloia* (grey ironbark), *E. tereticornis* (Queensland blue gum / forest red gum), *E. crebra* (narrow-leaved red ironbark), *E. major* (grey gum), *E. biturbinata* (grey gum), *E. longirostrata* (grey gum), *E. moluccana* (gum-topped box), *E. fibrosa* (broad-leaved red ironbark), *C. intermedia* (pink bloodwood), *C. trachyphloia* (brown bloodwood)
Blue gum woodlands and open forest	*E. tereticornis* (Queensland blue gum / forest red gum), *E. crebra* (narrow-leaved red ironbark) *E. siderophloia* (grey ironbark)	*E. moluccana* (gum-topped box), *Corymbia citriodora* subsp. *variegata* and *citriodora* (spotted gum), *E. acmenoides* (white mahogany), *C. intermedia* (pink bloodwood)
Gum-topped box woodland	*E. moluccana* (gum-topped box)	*Corymbia citriodora* subsp. *citriodora* (spotted gum), *E. crebra* (narrow-leaved red ironbark), *E. fibrosa* (broad-leaved red ironbark), *E. siderophloia* (grey ironbark), *E. tereticornis* (Queensland blue gum / forest red gum), *C. intermedia* (pink bloodwood)

Forest Type	Dominant commercial species	Commonly associated commercial species
Ironbark woodland	*E. fibrosa* (broad-leaved red ironbark), *E. crebra* (narrow-leaved red ironbark), *E. decorticans* (gum-topped ironbark)	*E. moluccana* (gum-topped box), *Corymbia citriodora* subsp. *variegata* and *citriodora* (spotted gum), *E. acmenoides* (white mahogany), red bloodwood, *E. tereticornis* (Queensland blue gum / forest red gum)

Notes: At any given locality, typically one or two species from the dominant commercial species column i will comprise a large proportion of the merchantable volume of the stand, and about two to six associated commercial species will also be important at the site. Listed dominant commercial species for a forest type can be an associated commercial species when another species is dominant. For example, flooded gum can be an associated commercial species in blackbutt dominant forests.

Appendix 5: Queensland timber processor employment and economic survey (DAF Sawmill Survey 2017)

BACKGROUND

The Queensland forest and timber industry makes a significant contribution to Queensland's economy, with a strong presence in rural and regional areas. Some state wide and regional level information on the industry is available from existing sources, such as the Australian Bureau of Statistics and the five yearly census. However, often this information is not sufficiently detailed to provide a detailed picture of the industry's contribution.

This survey is seeking to develop an understanding of the employment and economic value of Queensland's timber processing sector. This information will be used by the Department of Agriculture and Fisheries (DAF) and the broader industry to help document and demonstrate the importance of the forest and timber industry to Queensland's economy.

The survey results will also be used by both DAF and the University of Queensland in a Forest and Wood Products Australia research project that is focusing on private native forests.

THE SURVEY

Company details

Company name	
Contact name	
Contact phone number	
Contact email	
Mill location	
Mill first constructed	
Other useful company information	

Note: The term 'mill' in this survey refers to a sawmill, panel board manufacturing factory, plywood or veneer plant, pole treatment plant, or other log timber processing plant. *A separate survey should be completed for each mill owned by a company*

EMPLOYMENT

Mill employment

Employment by the primary processor is a key measure of the contribution that the industry makes to the economy.

Direct mill employees

	Number of employees (male/female)		
	Male	Female	Total employees
Full time employees			
Part time (Full time equivalents)			
Total number of individual employees			

Employees in your business that work elsewhere (e.g., sales and marketing staff)

	Number of employees (male/female)		
	Male	Female	Total employees
Full time employees			
Part time (Full time equivalents)			
Total number of individual employees			

Employee town of residence

The processing sector can make an important contribution to particular regions and individual communities in Queensland.

	Town name	Number of employees living in / near the town
Town 1		
Town 2		
Town 3		

Town 4		
Town 5		

Note: Nominate nearest town where employees do not live in a particular town

Contractor employment (harvest and haulage)

Forestry harvesting and haulage contractors are an important element of the forest and timber industry. Although these workers are not directly employed by your business, we would like to get an understanding of the harvesting and haulage contractors used by your business.

	Contractor 1	Contractor 2	Contractor 3
Contractor name			
Key activity (harvest, haulage, other)			
What % of your business is with that contractor?			
What % of the contractors business is with your operations?			

Number of employees Estimate their full time employees			
Base town for contractor business			
Main towns where contractor employees live			
Other useful information			

MILL INPUTS

Resource information

The origin and type of resource used by a mill / processing plant is important to understanding the nature of the processor, and a link to supply considerations.

Native forest logs

Forest type – circle type	Cypress	Hardwood

	Current situation - 2015/16 total	Situation 5 years previously
Crown %		
Private %		
Total volume (cubic metres)		
Total volume (lineal metres)		

Plantation logs

Plantation type – circle type	Exotic Pine	Hoop pine

	Current situation - 2015/16 total	Situation from 5 years previously
Total (cubic metres)		
Total volume (lineal metres)		

Other inputs (e.g., sawn timber, woodchips)

Species type- circle type	Cypress	Hardwood	Hoop pine	Exotic pine

	Current situation - 2015/16 total	Situation from 5 years previously
Total quantity of input (cubic metres)		
Total quantity of input (lineal metres)		
Source of wood supply (which mill?)		

Other useful information	

Note: Please fill out the tables relevant to your business. If there has been a change from the 5 year average, estimate by how much.

Cost breakdown

Your operations provide wider benefits to the local economy through the goods and services you purchase. We would like an understanding of the breakdown of your main expenses and what proportion is spent in the local economy.

Approximate total expenditure in 2015/16	$

Main expenses	Amount or percentage	Identify which town expenses are made
Wages Superannuation Workers compensation Payroll tax		N/A
Harvest and haulage contractors		N/A
Repairs and maintenance		
Log supply		
Supplies – fuel/electricity		
Supplies – other goods		
Freight		
Other – please list		

Define 'Local'	

MILL OUTPUTS

Main products produced

The products produced from your mill are valuable to the industry and the community. Please estimate in cubic meters what products you produce.

Describe main products produced	

	Current situation - 2015/16	Situation 5 years previously
Green		
Green structural (m^3)		
Green other (specify) (m^3)		
Green landscaping and/or fencing (m^3)		
Dry		
Dry structural (m^3)		
Dry other (specify) (m^3)		
Poles		
Poles/Posts/Girders (m^3 or lineal metres)		
Panels		
Panels (m^3)		
Total annual output (m^3)		
Other products		
Chip (tonnes)		
Other products		
Other useful information		

Note: If there has been a change in the last 5 years, estimate by how much.

Sales

Please provide an estimate of the value of sales at the mill door and proportion into each market

	Value of sales at mill door ($)	Markets %		
		Queensland	Interstate	Export
Total value				
Green				
Dry				
Poles				
Panels				
Other				
Other useful information				

MILL INVESTMENT

Capital expenditure

What major investments have been made in the past 10 years, and what, if any, investments will be made in the next 5 years?

	Year	Description	Approximate value
Past 10 years			
Planned major upgrades over next 5 years			

Other questions

Have there been any significant changes to your business over the last 5 years?	
What factors would influence your future investment decisions?	
Please identify other businesses that are heavily reliant on your business?	
Please identify other businesses that are heavily reliant on you purchasing their products?	
What do you think is the optimal level of throughput for your mill (m^3/yr)?	
What are the most important constraints that prevent your mill from operating at its optimal level? (e.g., capital, log resource, policies and regulations)	
What are the key features you are looking for in your future log timber supply?	
What product lines would you like to supply in the future?	

Supplementary questions for private native forest RDE project

DAF is working with the University of the Sunshine Coast and other partners on a Forest and Wood Products Australia-funded project to better understand the importance of private native forests for the Queensland timber industry and regional economies. The project has multiple objectives, including assessing the extent of private native forests, appraising the existing and potential future productive condition of the resource, and evaluating the financial performance for landowners of investments in alternative silvicultural treatments aimed at improving productivity of private native forests. Your responses to the following questions will be greatly beneficial to this research.

How would you compare the productivity and state of private native forest with the crown native forest resource?	
Do you perceive there to be a difference in the distribution of log size, desired species and wood quality of private native forest compared with crown native forest resource?	
Do you think there will be adequate supply of private native forest resource to meet future timber industry needs?	
Do you think the productivity of the private native forest resource can be increased? How?	
Has the availability of logs from private native forests changed over the past 10 years? If yes, why? Is this due to a change in the number of landholders harvesting their forest, or a change in the condition of the forest?	
Has the quality of logs and the products obtained from private native forests changed over the past 10 years?	

What is the average distance would you travel to source private native forest logs, and do you have a maximum distance you would travel?	

Privacy statement

We respect your privacy by:

- keeping your information secure and confidential and in accordance with the *Information Privacy Act 2009* and the Queensland Government Code of Conduct;
- complying with the University of Queensland's ethics protocol and confidentiality relating to storing and using the survey information;
- ensuring our staff are aware of their obligations in protecting your confidential information
- we will not publish any data that you provide in any way that would identify you, your business or your organisation without your consent.

We will treat you with respect and courtesy by:

- explaining to you why we are conducting the survey (as outlined in the Background section of this form)
- wherever possible, notifying you in advance of the survey that you are being asked to participate in
- introducing and identifying ourselves when we contact you
- informing you how and why you have been selected to participate in the survey explaining the purpose of the survey and how your information will be used.

Appendix 6: Development of a decision support tool to demonstrate the effects of silvicultural management

Overview

Private native forests are recognised as an important source of timber to the hardwood processing industry, across Queensland and NSW. The current project on "Improving productivity of the sub-tropical private native forest resource" aims to determine whether the productive condition of the private native forest resource can be improved with management. Data from silvicultural trials across the private native forest resource was analysed to determine the impacts of silvicultural treatments on stem diameter growth. The resulting growth model, which is influenced by the total basal area of the stand, forms the basis of future growth in the decision support tool. The decision support tool was developed primarily as an extension tool, for groups such as the Private Forestry Service Queensland (PFSQ) to demonstrate the influence of stand management. It is reliant on inventory input, following the template provided. As such, some experience with forest inventory is needed, and it is envisaged that such inventory be carried out by extension groups like PFSQ.

This report provides a description of the decision support tool that has been developed. An example of the outputs is presented for demonstration purposes. The tool allows users to select different options (e.g. to thin or harvest the stand at varying intervals) to compare the outputs ($/ha) that might be expected. There are options to predict both timber values and the values associated with the pasture that grows under the forest. At the time of this report, the tool was still in the testing phase, and it is likely that future modifications will take place. Further, the R code used to create the tool will be made available to others to allow further improvements over time.

Contents

Introduction

Private native forests are recognised as an important source of timber to the hardwood processing industry, across both QLD and NSW. In Queensland and northern New South Wales, the private native forest (PNF) resource contributes approximately 50-70% of the annual log volume, and mapping carried out during the current project shows that the resource covers approximately 2.5 million hectares of potentially harvestable, sub-tropical forest. The demand for privately grown hardwood timber is likely to increase in the next decade as long-term wood supply agreements from State land conclude and supply from plantations is not expected to deliver the volume required to support the hardwood industry. Despite the broad extent of privately owned native forests, the productive condition of these forests is often poor (Ryan and Taylor 2006; Jay 2017; https://publications.qld.gov.au/dataset/private-native-forest-resource-extent-and-condition). This is often due to a history of poor harvest management (e.g. high-grading) and a lack of silvicultural treatments, and over time can lead to a stand with a high proportion of unmerchantable trees, and often a high density of small, competing stems. Silvicultural treatment, or thinning the forest, can be done to reduce the number of small and unmerchantable trees, which encourages growth of the remaining, higher value stems and merchantable volume. Thinning is also used to remove non-commercial species, stems that are too close together, stems with poor form (i.e. not straight) and stems with defects, such as large fire scars.

Forestry extension groups, such as the Private Forestry Service Queensland (PFSQ) have been working with private landholders to help them realise the potential of their native forest stands. However, useful extension tools to help demonstrate the effects of native forest management are lacking. Previous studies in private native forest (e.g. Lewis et al. 2010, PFSQ unpublished data) have established a number of permanent plots for monitoring tree growth. The current project has analysed this permanent plot data from silvicultural trials in southern Queensland. This analysis has revealed the important influence of silvicultural treatment of individual tree growth. On average, silviculturally treated plots had DBH growth increments that were approximately four times more than those on trees in plots that had not been treated. Understanding the impacts of this on future total merchantable volumes and products harvested is critical when trying to demonstrate the long-term benefits associated with stand management. Further, there can be additional benefits of silvicultural treatments on grazing production that also need to be considered. Hence, there was a need to develop a decision support tool that can be used to predict the likely consequences of stand management and a lack of management.

The aim of this report is to document the development of a decision support tool to assist in assessing the effectiveness of stand management (logging and thinning treatments). The decision support tool that has been developed here is still subject to changes following testing of the tool by project stakeholders.

Methods

The decision support tool was developed using R (R Core Team, 2013). The purposes of this report is not to document the detailed R script, rather, it is intended to describe process that was used to develop the application to convert native forest inventory data into information for land owners.

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R Core Team (2013). R: A language and environment for statistical
computing. R Foundation for Statistical Computing, Vienna, Austria.
URL http://www.R-project.org/.
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Users of the tool will need a computer with R (version 3.5.1) and RStudio installed to read the scripts developed by DAF. R and R studio are freely available: https://cran.r-project.org/bin/windows/base/

The underlying tree growth model was derived from permanent plot data collected as part of this project, and utilised previous measurements made under an earlier FWPA project (Lewis et al., 2010), and by PFSQ. This data set included a total of 203 plots. Most of these were located on private land (158 plots) across 19 sites (Appendix 1). Forty-five plots were located in Queensland State Forest. These State Forest plots were selected to help boost the number of plots in the data set that had not been recently treated (or logged). The average period of growth data (between the first available measure and the latest measure) was 7.6 years. A detailed description of this data will be provided in the final project report.

Statistical analysis showed the significant effect of tree basal area on individual tree DBH growth, which differed by thinning treatment (thinned vs non-thinned) and forest condition (Regrowth vs Remnant). The growth model underlying the model is based upon DBH periodic annual increments, which differ by treatment and condition. Mean (± standard error) annual DBH increment was 0.18 cm yr^{-1} (± 0.003) in the unthinned plots and 0.76 cm yr^{-1} (± 0.010) in the thinned plots. Mean annual DBH increment was 0.24 cm yr^{-1} (± 0.004) in the remnant forest plots and 0.78cm yr^{-1} (± 0.013) in the regrowth forest plots. Other factors such as climatic variables (maximum temperature) and soil type also had some influence of DBH growth and were not included in the resultant growth model, to minimise complexity and the number of input values required in the decision support tool. Nevertheless, changes in productivity caused by environmental effects can be simulated with options to increase DBH periodic annual increment and an upper limit to productivity may be simulated by defining the maximum basal area of the site (an input by the user). Figure 1 demonstrates the change in individual stem annual diameter increment as stand basal increases for each treatment and stand condition. Sufficient data was available to approximate these relationships where basal area was lower and a second degree polynomial was used to model this. The minima of the polynomial provided a point from which increment decreases linearly to the maximum basal area provided by the user (Figure 2, e.g. 50 m^2/ha). These relationships were derived from the data collected from this project and expert opinion may be used to alter these relationships in a file provided with the software.

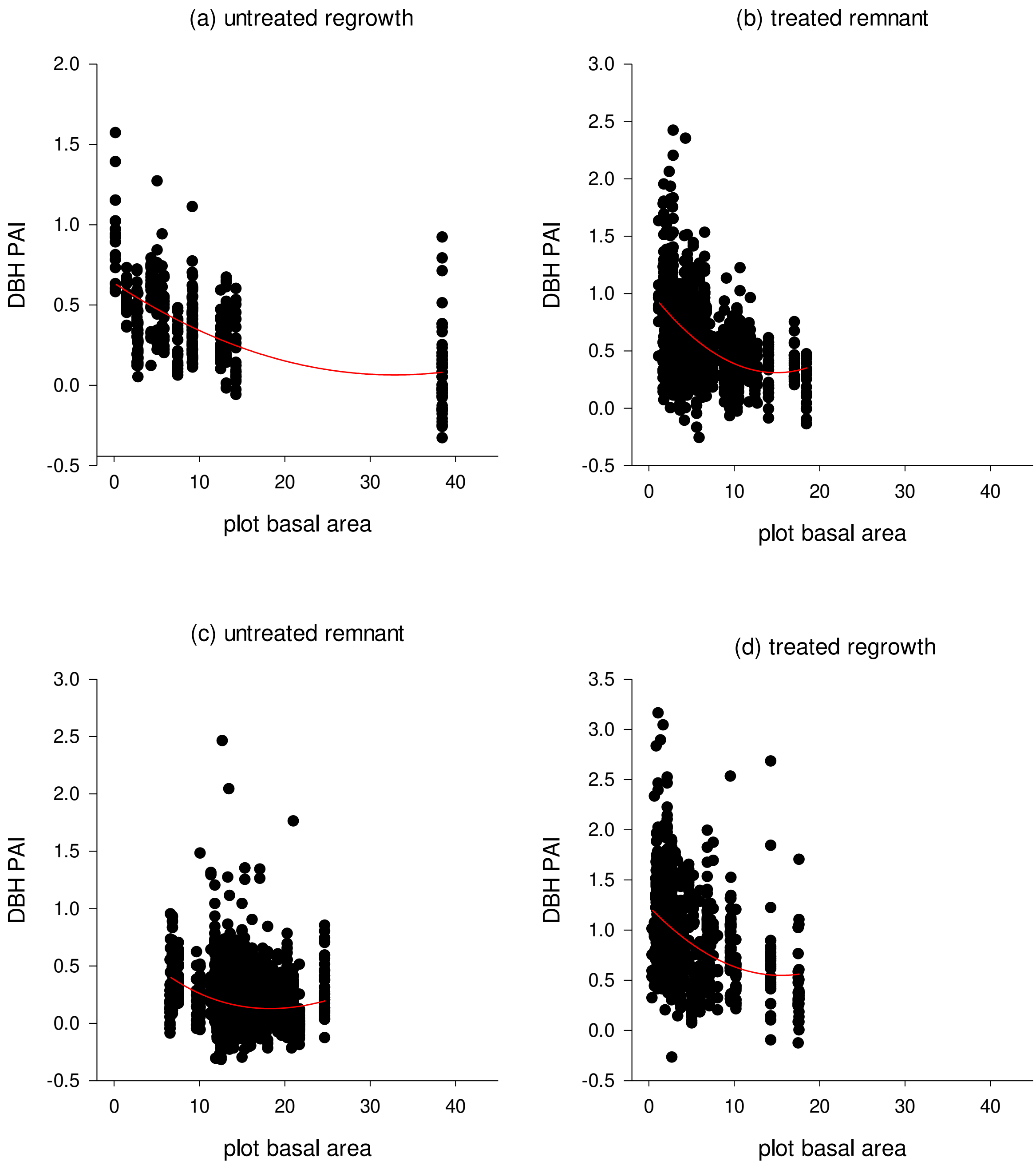


Figure 1. The relationships between DBH PAI (cm yr^{-1}) and plot basal area (m^2/ha) for (a) untreated regrowth; (b) treated remnant; (c) untreated remnant; and (d) treated regrowth.

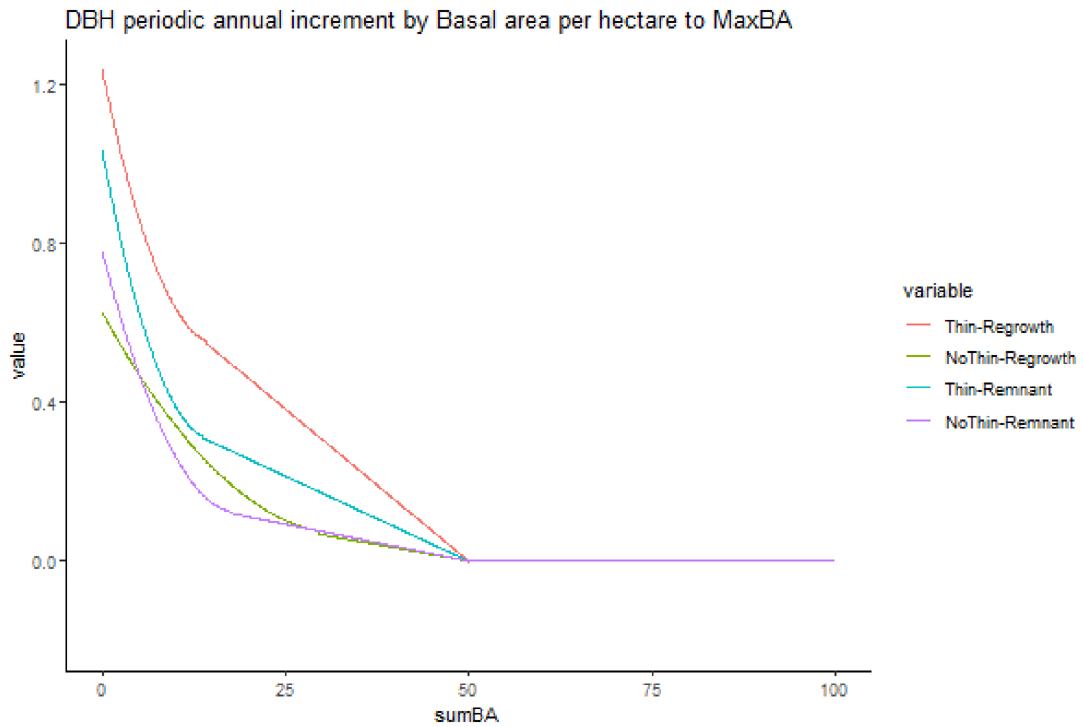


Figure 2. The relationship between DBH growth (annual increment, cm per year, on the y axis) and total tree basal area (m^2/ha, on the x axis) used in the decision support tool, for thinned and unthinned plots in areas of remnant and regrowth vegetation. DBH growth remains constant when the maximum basal area for the site is reached.

Some of the key assumptions used in this model are: (1) Recruitment of seedlings is consistent across years and the stems per hectare will double over 20 years. (2) No mortality function is included given the uncertainty of tree death and it is assumed that unhealthy trees will be marked for thinning or logging. (3) Merchantable height and the product type identified for each stem at the time of the inventory does not vary over time as the forest is grown.

The pasture growth information was based on the GRASP model (Littleboy and McKeon, 1997). We utilised existing relationships between tree basal area and grass biomass growth to determine the utilisable pasture available (i.e. the proportion of average annual pasture growth that can be grazed without leading to a loss of land condition) for a given basal area. These relationships were available for a 135 land types in Queensland. To allow prediction of livestock value, the model assumes an average daily intake throughout the year of 10 kg (this is a standard value for an adult equivalent, AE). Different annual live-weight gain (kg/AE/year) are associated with each land type.

Collection of the inventory data for running the model

The tool was developed specifically to align with inventory data collected by the Private Forest Service Queensland. As such, it requires inventory data before any outputs can be predicted. Individual landholders who wish to use the decision support tool should consult with the PFSQ or a forestry extension officer for assistance with collection of the inventory data.

An excel template for the inventory data (Figure 3) and example data will be provided upon request. It is important that this template is not altered, so that the program reads the data correctly. It will be up to the individual users to ensure the inventory data is collected appropriately and is representative of the forest of interest. Providing accurate inventory data is critical to ensure valid predictions of forestry value. While collecting inventory data is time consuming, this is a critical step to ensure accurate assessment of current and future products available from the stand.

For extension purposes, to help demonstrate the effects of management, mock inventory data has been created for common forest types. This will allow use of the decision support tool for demonstration without the need for inventory collection.

Inventory measurements include:

1. Tree number, diameter at breast height (cm), and species;
2. Whether each stem should be retained, logged or treated (at the time of the assessment, recorded in the inventory file as a 'r' for retained, 'l' for logged' or a number '1' in the 'trt' column);
3. Product type (pole, sawlog, salvage log, fencing, pile, habitat, required for Code); and
4. Product length (likely merchantable height, m).

When carrying out the inventory it is important to determine which trees should be retained for future logging, or as a requirement under relevant legislation (e.g. 'Managing a native forest practice: A self-assessable vegetation clearing code' in Queensland). The trees that could be logged at the time of the inventory should also be recorded (along with likely products) along with trees which should be thinned to improve productivity of the stand. Thinning involves removing trees that are: unlikely to make a commercial product, competing with crop trees, an undesirable species, trees with poor form, trees with defect, trees that are too close together.

PFSQ has run field days and workshops to assist landholders interested in carrying out thinning operations.

After collecting the inventory data, the inventory data file is saved in the 'Data' folder that is within the files provided. The area of inventory (m^2) should be added to the appropriate cell of the inventory file (summary tab). Prices for the different products are also included in the inventory files (prices tab) and may be changed to suit the current market for forest products. Default values (i.e. stumpage prices, based on some current industry values) are included here, but these can be modified if an agreed stumpage price for the different products is known. These prices might also be altered if a landholder plans to carry out some of the harvest operation (e.g. cutting, or snigging).

Inventory data has been collected as part of resource assessments by PFSQ since 2005. This data covers a large area of south-eastern QLD and northern NSW, and has been collected over more than 30 properties. Generally the resource assessments involve gathering forest resource data across approximately 1% of the productive forest area on a property. In advance of the field work, a desk top evaluation of the vegetation cover on the property is completed utilising the latest available imagery, slope gradient and Regional Ecosystem overlays. Strip lines are located to cover the forecast forest types. In the field all trees 5 m either side of the strip line are measured. This inventory data provides a useful dataset for testing the decision support tool.

Figure 3. Example of the inventory template spreadsheet. For each merchantable tree a product is specified. Trees that should be silviculturally treated, trees that should be retained for habitat purposes and other trees that should be retained for legislative requirements (e.g. the Code). A ‘l’ is placed in the cell if the stem should be logged or removed at the time of the inventory, and a ‘r’ is placed in the cell if the stem should be retained for the future. Stems with a DBH < 10 cm should be recorded and a tally of such stems can be added to the columns LT 10 cm thinned (stems to be thinned) and LT 10 cm retained (stems to be retained). Each tree (row in the file below) should have a DBH and product type (either ‘l’ or ‘r’) recorded or a ‘1’ in the ‘trt’ (to be treated) column.

Landholder/Property:
Coupe/Unit/Strip No.: Unit Description:

Tree	Species	Dbhob	Lgth	swl	slv	pole	pile	fng	trt	hbt	eco	SUM OF LT10 cm thinned	SUM OF LT10 cm retained
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													

Data Entry | Summary Page | Prices

Running the model

A series of R files and the inventory template will be provided in a folder. It is important that these files are not deleted or modified for the model to run. To run the model, the following steps are followed:

1. Open the R file labelled **'app'**.

2. Click on 'Run App' to start the tool (Figure 4). This will be located near the top right-hand-side of the screen. This runs the application known as 'Shiny' (website: https://shiny.rstudio.com/). The necessary packages are automatically downloaded. A separate window will then open (Figure 5).

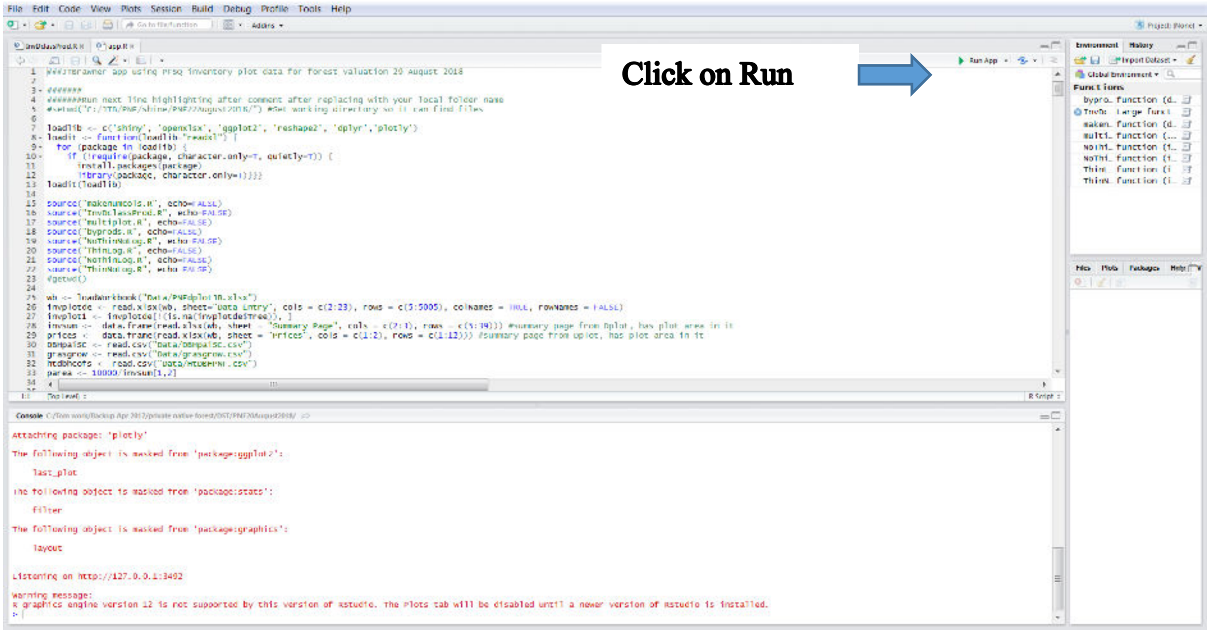


Figure 4. After opening the 'app' file, the 'Run App' is clicked to start running the decision support tool.

3. After ensuring the inventory data has been added to the template provided, and this file is saved on the computer being used (e.g. file saved on the C drive where the 'Data' folder has been placed), click 'Browse' to select the file location (Figure 5).

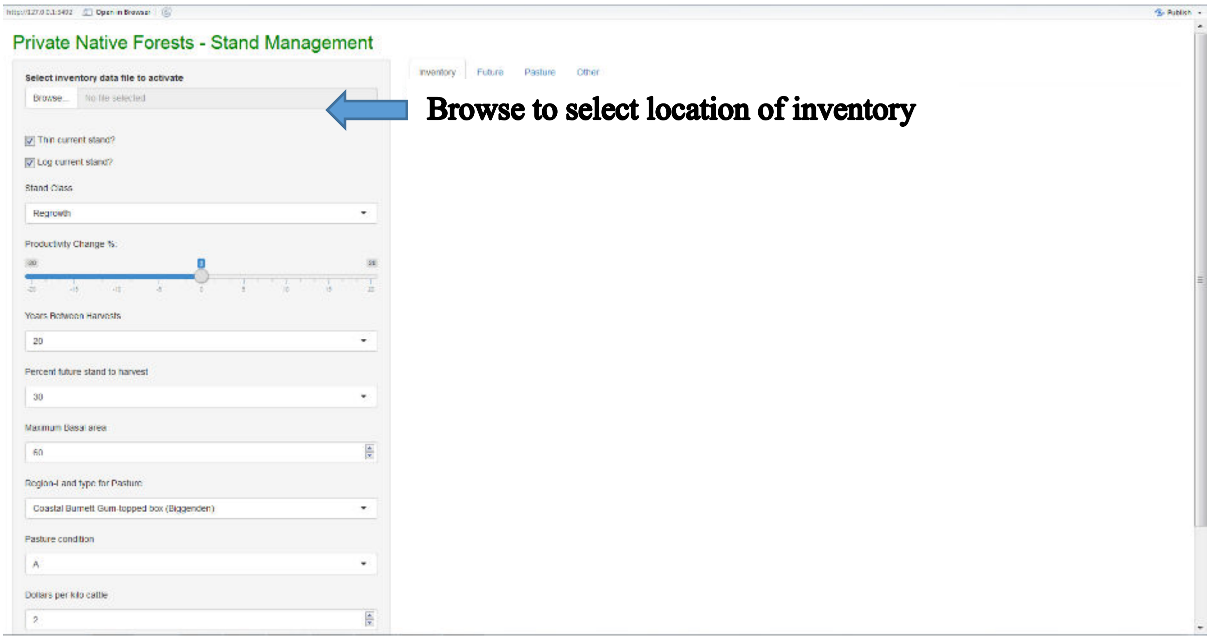


Figure 5. Window that opens when the App is run. Locate the inventory data file using the 'Browse' function. Note that there is an option to open this box in a web browser ('Open in Browser' near the top left-hand-side of the screen).

When the upload is completed, a summary of the current inventory data is provided in a table (per hectare value of each product within each 10 cm diameter class and totals) and graphically (volumes in different diameter classes).

4. The next step is to grow the stand. Before doing this there are a number of options to consider (Figure 6). This tool allows the user to run different options, and through a comparison of the outputs allows the user to consider the best management option for the stand. To assess the impacts of thinning or logging (or both), use the check boxes to indicate whether thinning or logging of the stand is desired. Specify whether the stand is regrowth forest or remnant forest. While expert opinion is typically used, this can be determined in Queensland by using Regional Ecosystem mapping. A Vegetation Management Property Plan (based on Lot and Plan details for the property), produced by the Department of Natural Resources, Mines and Energy can be used. Visit: https://www.dnrm.qld.gov.au/qld/environment/land/vegetation/vegetation-map-request-form for confirmation. In the Vegetation Management Property Plan, regrowth is on vegetation categories C, R and X and remnant forest is category B.

It is recommended that the % productivity change bar is left at zero. This modifier allows the user to investigate outputs if the forest is growing at a faster or slower rate than that based on the current dataset used to develop the growth model. The data used to model growth was based primarily on data collected over time in forests dominated by spotted gum. Some forests (e.g. wet sclerophyll forests) might grow at a faster rate, so there is an opportunity to increase productivity (DBH periodic annual increment) here. This should be discussed with a local forestry extension officer.

The number of years between harvests can also be modified. This allows the user to see the effect of harvesting more frequently or less frequently than the default value (20 years). The proportion of the future stand that is harvested can also be modified. Thirty percent is used as a default value, as this reflects a common proportion of the stems removed in a harvest in a dry sclerophyll forest. This percentage could be higher in a wet sclerophyll forest (e.g. *Eucalyptus pilularis* forest) where a higher proportion of basal area may be sustainably removed. The model assumes stems will only be harvested when they reach a minimum DBH of 30 cm. The maximum basal area (m^2 /ha) can be modified, where this is known for a site. The maximum basal area is set at a default of 60 m^2/ha as it is very unlikely that basal areas will exceed this within the region that this tool should be used. This value provides an upper limit to stand productivity, where DBH increment becomes zero, and alters the rate at which DBH increment decreases to the maximum basal area.

The following three options relate to predictions for pasture growth and values. These options do not need to be considered if the user is only interested in timber production values. The first option allows the user to select the most appropriate 'Land type' for the site. Land types (https://futurebeef.com.au/land-types-of-queensland/) determine the amount of pasture that will likely grow on the site. Land type (and region) can be selected from the drop-down menu. The next option is to select the condition of the pasture. The ABCD scale for pasture condition is explained at:

www.healthycountry.com.au/_literature_129384/Grazing_Land_Condition

Condition varies from A (best condition) to D (worst condition), based on factors such as the density of perennial grasses, soil exposure (bare ground), weed infestations, etc. The final option involves providing a current market value ($ per kilogram) for the livestock that are run on the site.

After choosing the appropriate options, select the 'Grow' button. This generates output in the 'Future' and 'Pasture' tabs that is detailed below.

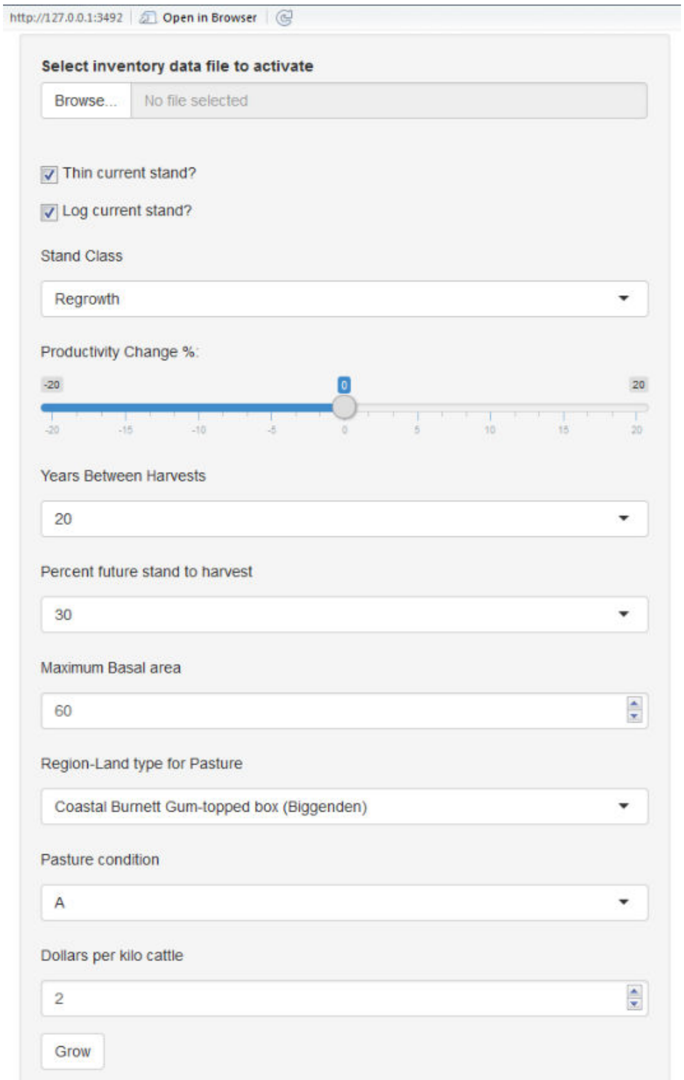


Figure 6. Options to consider before growing the stand. In particular the effects of checking and unchecking the 'Thin current stand' can be compared to determine the likely benefits from thinning the forest. Determining whether the stand is 'remnant' forest or 'regrowth' forest is also important.

Outputs

The tool provides a summary of the existing stand and predicts the production of different forest products over time. As well, the expected gross financial returns from both timber production and livestock production are provided. The current stand is described in the inventory tab and future timber outcomes are reported under the 'Future' tab. This includes a table that reports dollar per hectare values for different timber products in different diameter (DBH) classes, as well as a total value across all diameter classes. Two figures are also reported in the ‘Future’ tab that summarise standing volumes (trees with DBH >20 cm). The first figure shows products for stems that are grown forward for the selected period of time that were assessed to be ‘retained’ at the time of the inventory. A total volume of the stems assessed as available for logging (at the time of the inventory) is also provided when ‘logging’ is not selected in the options before growing the stand. The second figure shows products (grown forward) for those assessed as ‘to be logged’ at the time of the inventory. When ‘logging’ is selected as an option before growing the stand, these products will not be included in the second figure (as they are logged, and show up in the values based on the current inventory). The second figure also shows a total volume of all stems that are retained in the stand. Hovering the mouse over the relevant bar in each graph allows the user to read the volume of each product produced in each diameter class.

The ‘Pasture’ tabs shows outputs associated with livestock grazing. A graph is presented to show the change in utilisable pasture available as tree basal area increases over time (as the stand grows). A table is also provided which lists for each year of the simulation the utilisable pasture (dry matter kg/ha), standing basal area of trees (m^2/ha), animal stocking rate (animal equivalents /ha), and the gross dollar value per hectare for livestock grazing.

An example of the outputs from one property is provided here for demonstration purposes. This output covers two scenarios: (1) no logging or thinning of the stand; and (2) logging and thinning of the stand. For this demonstration we have assumed that: (1) the stand is regrowth forest, rather than remnant forest; (2) the productivity scale bar is not modified; (3) a 20 year interval been harvests; (4) 30% of the stand is harvested at the time of the future harvest; and (5) maximum basal area for the stand is 40 m^2/ha. For pasture growth we have assumed (1) the “Moreton Mixed open forests on duplex and loams (Kilcoy)” land type; (2) the pasture is in “A condition”; and (3) that the price per kilo for cattle is $2.

Scenario 1: no logging or thinning of the stand.

DBHclass	Sawlog	Salvage	Pole	Pile	Fence	Habitat	Code	Total
DLT10	0	0	0	0	0	0	0	0
D1020	0	0	0	0	0	0	0	0
D2030	0	0	0	0	0	0	0	0
D3040	129.46	0	106.18	0	4.76	0	0	240.4
D4050	183.66	3.24	35.99	0	3.68	0	0	226.57
D5060	170.74	5.71	0	0	15.72	0	0	192.17
D6070	31.24	0	0	0	0	0	0	31.24
DGT70	0	12.57	0	0	0	0	0	12.57
Total	515.1	21.52	142.17	0	24.16	0	0	702.95

Output table in the 'Future' tab showing the future value of the stand ($/ha) in 20 years (i.e. $703/ha), based on the assumptions listed above, with no thinning or logging of the stand.

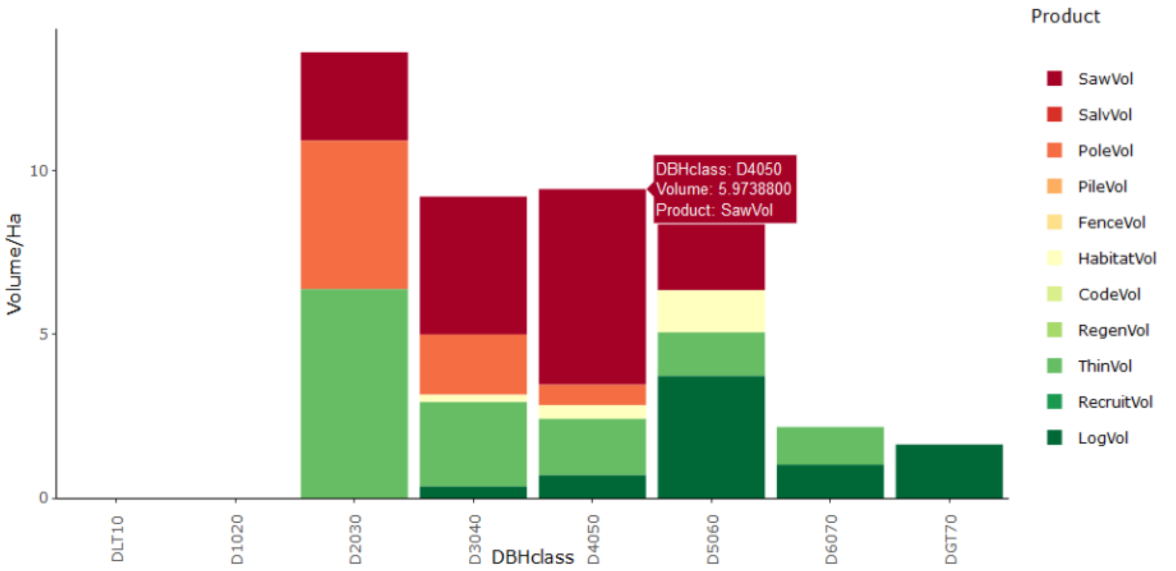
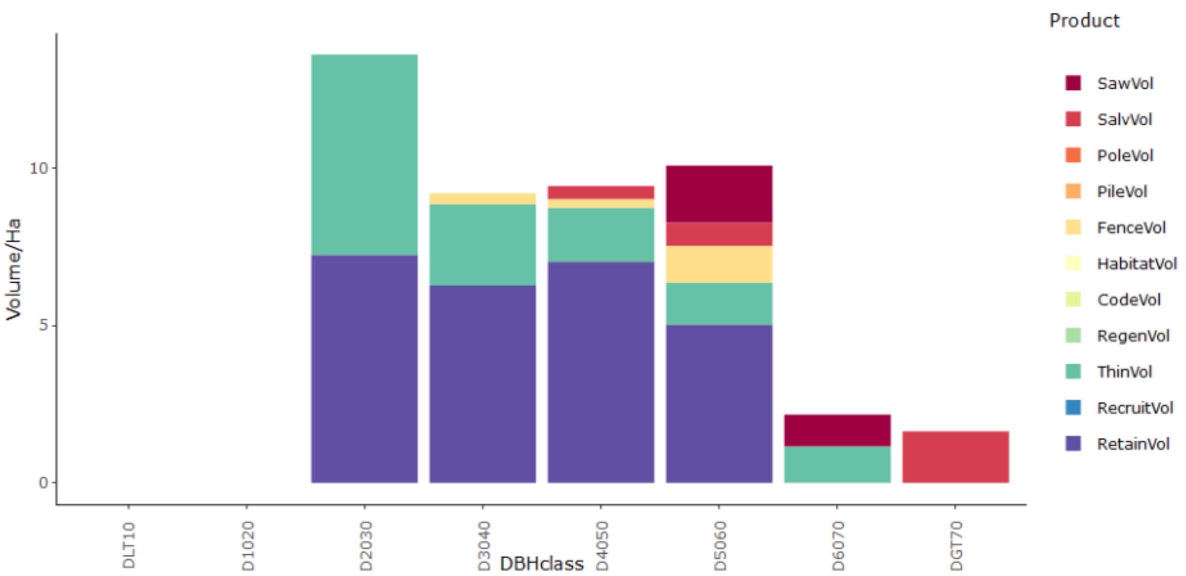


Figure in the 'Future' tab showing the volume (m^3/ha) of future products in the stand in different diameter classes, based on inventory assessments (products only for those stems assessed for retention at the time of the inventory). LogVol refers to the total volume of products that could have been logged at the time of the inventory. The graph below shows the products that could have been logged from this component of the stand. Only diameter classes >20 cm are considered here, as stems smaller than this are do not contribute to the $/ha value of the stand. Hovering the mouse over each colour of a bar graph provides the values used in each of the figures presented in the decision support tool.



The second figure in the ‘Future’ tab showing the volume (m^3/ha) of future products that were marked for logging at the time of the inventory assessment in different diameter classes. RetainVol refers to the total volume of products that were marked to be retained at the time of the assessment (graph above shows the products in this component of the stand). ThinVol refers to the total volume of stems assessed as those that could be thinned at the time of the inventory.

Year	Pasture	BA	AnimalEquivPerHa	DollarsPerHa
1	173.56	6.67	0.05	12.36
2	162.31	7.08	0.04	11.56
3	148.97	7.51	0.04	10.61
4	138.87	7.93	0.04	9.89
5	129.28	8.36	0.04	9.21
6	120.21	8.79	0.03	8.56
7	109.59	9.23	0.03	7.81
8	101.67	9.66	0.03	7.24
9	92.49	10.1	0.03	6.59
10	85.72	10.54	0.02	6.11
11	79.47	10.99	0.02	5.66
12	72.37	11.43	0.02	5.16
13	67.27	11.89	0.02	4.79
14	61.62	12.34	0.02	4.39
15	56.77	12.8	0.02	4.04
16	53.46	13.27	0.01	3.81
17	50.05	13.75	0.01	3.57
18	47.45	14.23	0.01	3.38
19	45.64	14.73	0.01	3.25
20	44.63	15.24	0.01	3.18

The table of outputs in the ‘Pasture’ tab. This table provides the utilisable pasture (kg of dry matter/ha) for each year of growth, the resulting basal area of trees (m^2/ha), the stocking rate (animal equivalents/ha) and the likely dollar value of livestock per hectare. The total value over the 20 year period can be determined through summing all values in the ‘DollarsPerHa’ column.

Scenario 2: logging and thinning of the stand.

DBHclass	Sawlog	Salvage	Pole	Pile	Fence	Habitat	Code	Total
DLT10	0	0	0	0	0	0	0	0
D1020	0	0	0	0	0	0	0	0
D2030	0	0	0	0	0	0	0	0
D3040	203.8	0	485.96	0	0	0	0	689.76
D4050	184.09	0	148.65	0	0	0	0	332.74
D5060	331.54	0	54.55	0	0	0	0	386.09
D6070	73.54	0	0	0	0	0	0	73.54
DGT70	0	0	0	0	0	0	0	0
Total	792.97	0	689.16	0	0	0	0	1482.13

Table in the 'Future' tab showing the future value of the stand ($/ha) in 20 years (i.e. $1482/ha), based on the assumptions listed above, with thinning and logging. The total value here can be compared to that under scenario 1 above to see the benefits of stand management. In this case there are clear benefits (total $ value) associated with logging and thinning the stand.

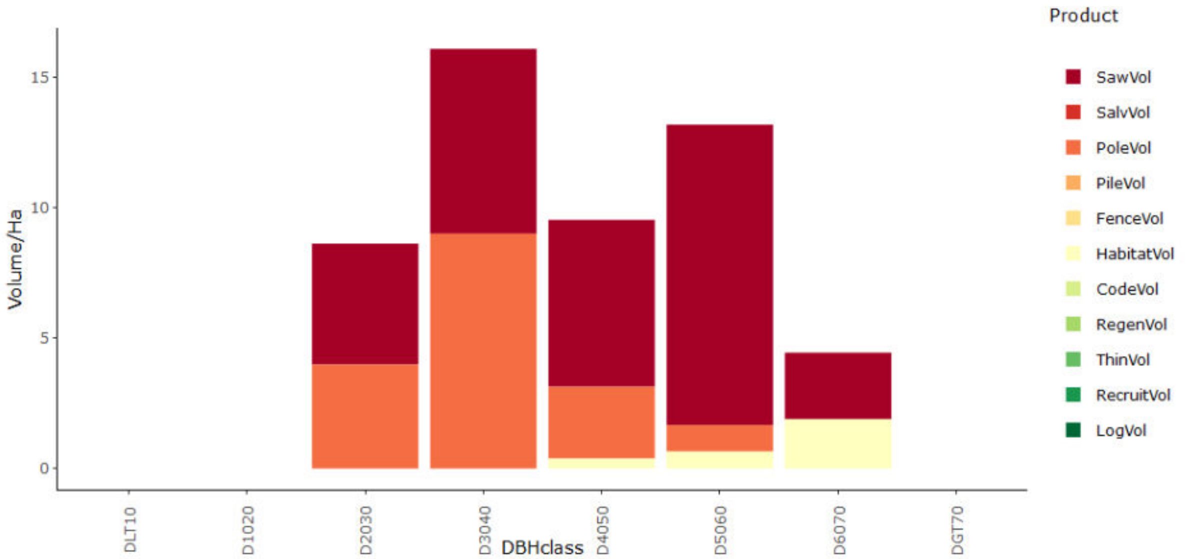


Figure in the 'Future' tab showing the volume (m^3/ha) of future products in the stand in different diameter classes, based on inventory assessments. In this case there is no 'LogVol' as this component was assumed to be logged at the time of the inventory. Only diameter classes >20 cm are considered here, as stems smaller than this are do not contribute to the $/ha value of the stand.

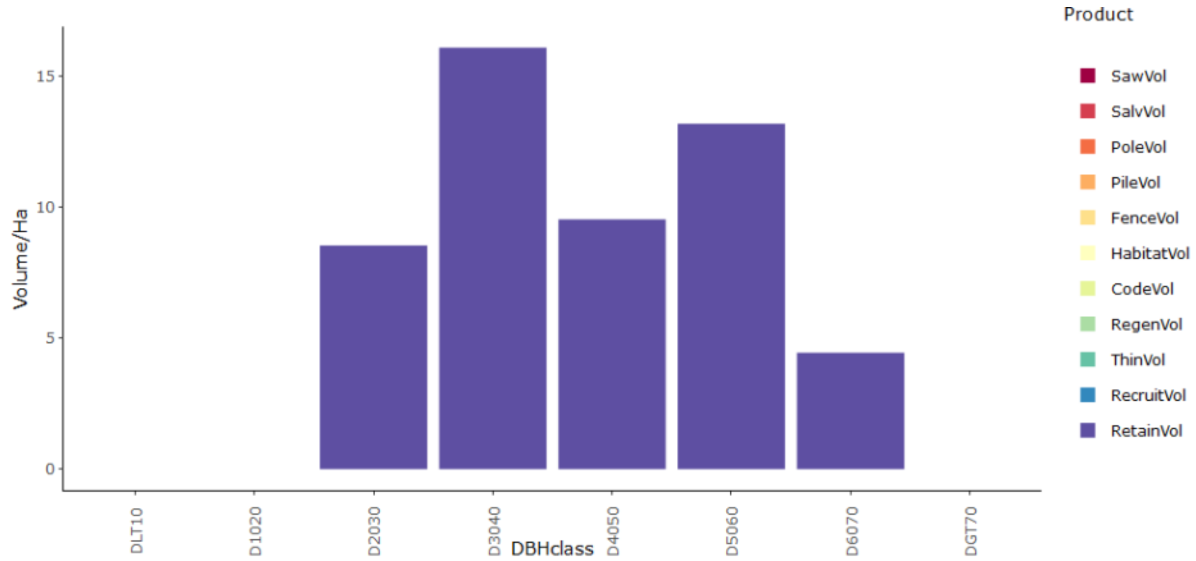


Figure in the ‘Future’ tab showing the total volume (m^3/ha) in different diameter classes that was recorded as ‘retain for the future’ in the inventory assessment. The graph above shows the specific products in this component of the stand.

Year	Pasture	BA	AnimalEquivPerHa	DollarsPerHa
1	289.91	3.24	0.08	20.65
2	278.16	3.51	0.08	19.81
3	270.48	3.8	0.07	19.27
4	259.2	4.09	0.07	18.46
5	248.22	4.4	0.07	17.68
6	234.02	4.71	0.06	16.67
7	223.7	5.03	0.06	15.93
8	213.68	5.36	0.06	15.22
9	203.94	5.7	0.06	14.53
10	191.4	6.05	0.05	13.63
11	179.38	6.4	0.05	12.78
12	170.7	6.77	0.05	12.16
13	159.58	7.14	0.04	11.37
14	148.97	7.51	0.04	10.61
15	141.34	7.9	0.04	10.07
16	131.63	8.29	0.04	9.38
17	122.43	8.69	0.03	8.72
18	111.65	9.1	0.03	7.95
19	103.6	9.51	0.03	7.38
20	96.06	9.93	0.03	6.84

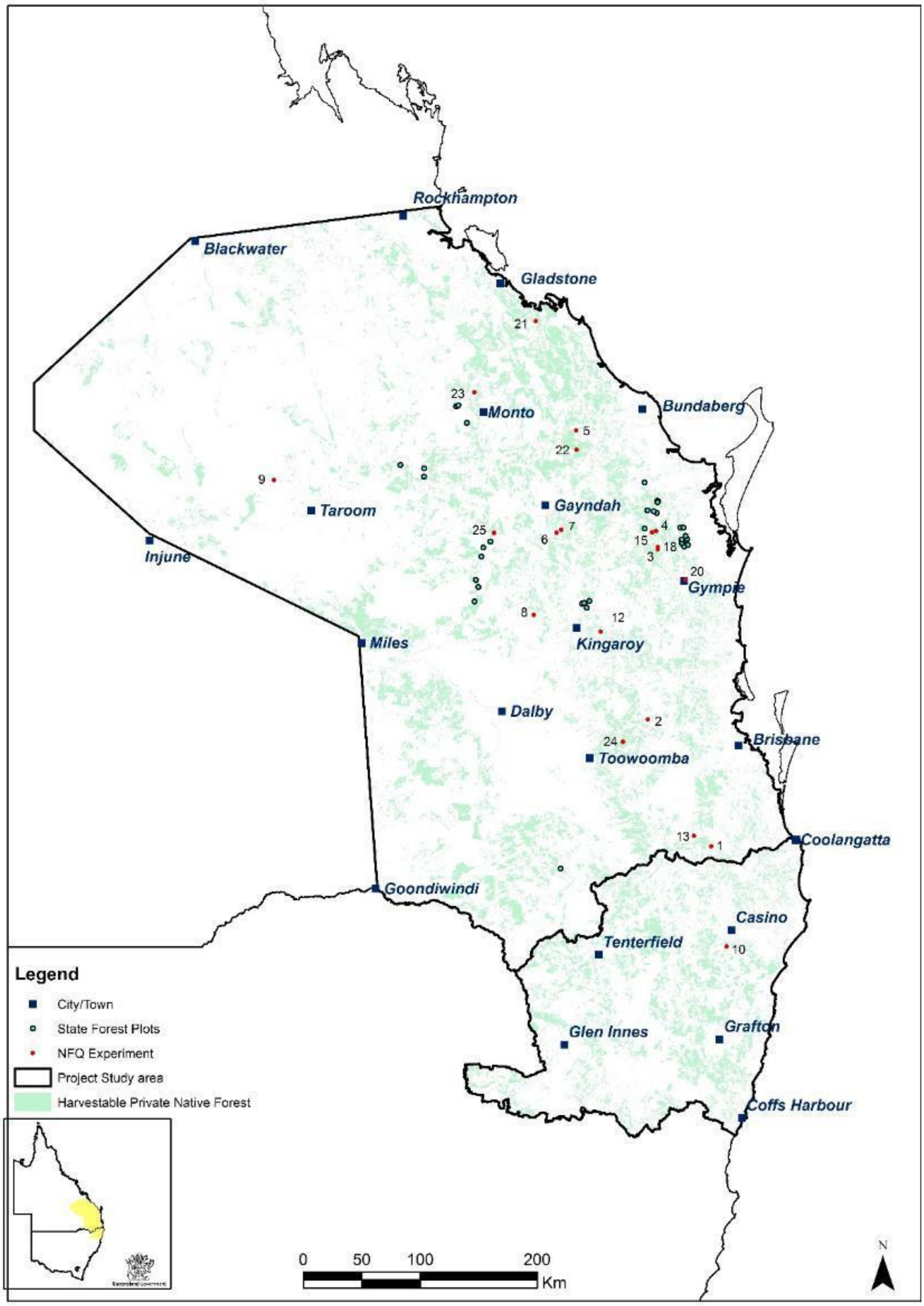
The table of outputs in the ‘Pasture’ tab. This table provides the utilisable pasture (kg of dry matter/ha) for each year of growth, the resulting basal area of trees (m^2/ha), the stocking rate (animal equivalents/ha) and the likely dollar value of livestock per hectare. This table can be compared to the same table under scenario 1 (no logging or thinning) to see the effects of forest management on livestock production.

Note that in the ‘Pasture’ outputs tab a graph is also presented to show the change in utilisable pasture available as tree basal area increases over time.

Future work and limitations

There are limitations with the data used to generate the DBH growth model. Most of the growth data utilised is based on dry eucalypt forest, usually with spotted gum (*Corymbia citriodora* subsp. *variegata*) as one of the dominant species. Further thinning trials should be established across other forest types and in parts of the study area where such trials are lacking (western Queensland and northern NSW). The growth data utilised here also covers only a relatively short period of time. As further growth data is collected the growth model should be updated to improve the prediction of future outputs from the stand. There are also many other variables that could be refined (for example, using volume equations for individual species, varying productivity by DBH) in future versions of this decision support tool. Linking the tool to spatially explicit productivity layers to directly impact productivity modifiers and identify land-type for pasture predictions would also be desirable. The decision support tool developed here could be made readily available to users on the internet. Making the source code available online could also encourage further improvements and development of this product.

Appendix 6.1. Locations of the sites (private forest sites, red dots with site numbers; state forest plots, aqua dots) where the effects of thinning or differing tree stocking levels have been investigated within the project study area.



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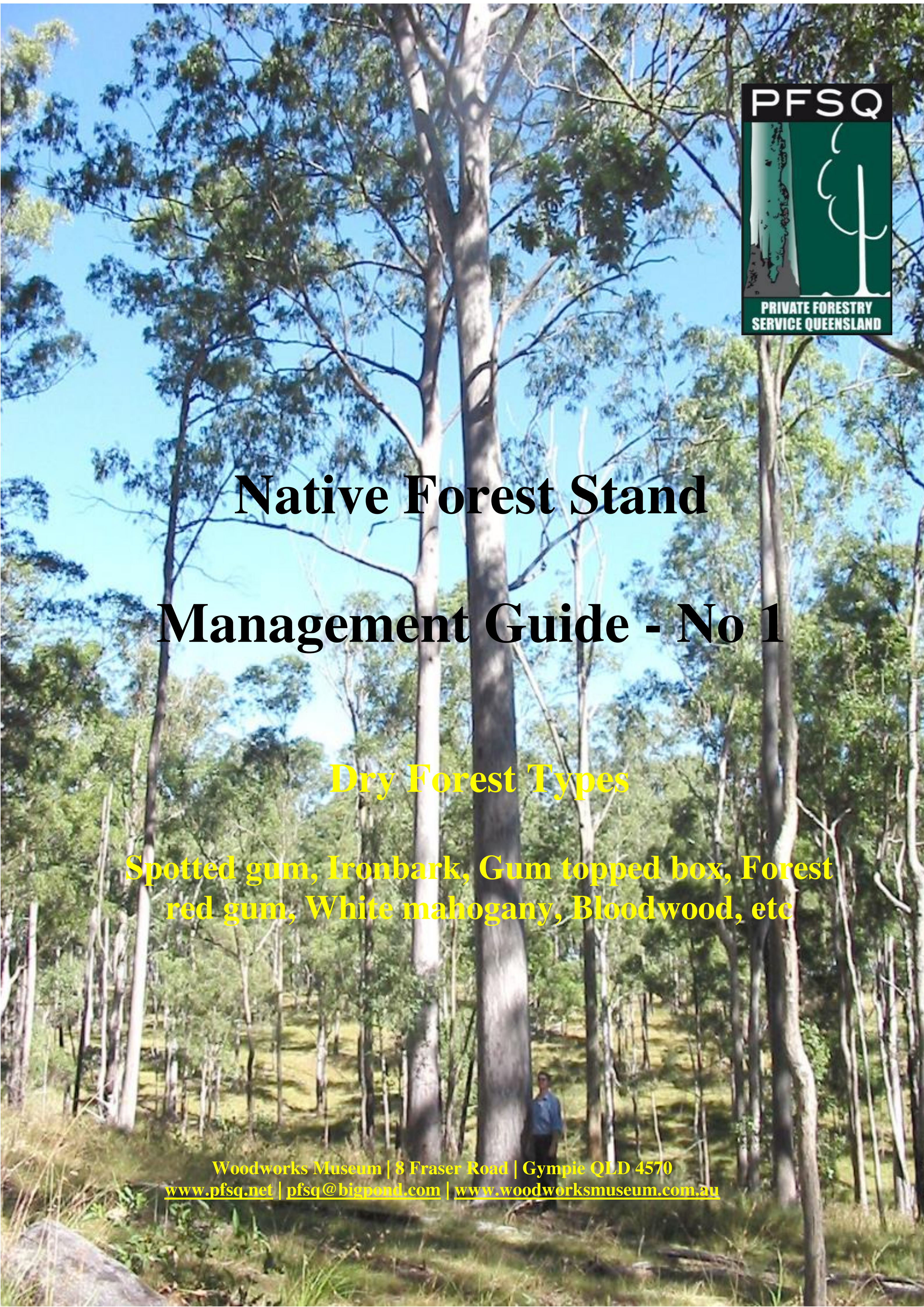
Appendix 7: Silvicultural guidelines for dry forest types: spotted gum, ironbark, gum topped box, etc



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PRIVATE FORESTRY SERVICE QUEENSLAND

Native Forest Stand

Management Guide - No 1

Dry Forest Types

Spotted gum, Ironbark, Gum topped box, Forest red gum, White mahogany, Bloodwood, etc

Woodworks Museum | 8 Fraser Road | Gympie QLD 4570
www.pfsq.net | pfsq@bigpond.com | www.woodworksmuseum.com.au

Native Forest Management Guidelines – No 1

Dry Forest Types: Spotted Gum, Ironbark, Gum Topped Box, etc

Contents

Revision History and Version Control				
Version #	**Author**	**Changes**	**Approved By**	**Approval Date**
3	**Matthews/Ryan**	**Final version**	**S Ryan**	**2006**
4	**Ryan**	**Rewrite**	**S Ryan/DAF**	**2017**

TERMINOLOGY

BA / ha	Basal area is a measurement of tree density/ha expressed as the cross section area (m^2) of all trees at 1.3 m from ground level
DBHOB	Diameter at breast height over bark
Doze	A breakdown in the wood fibre due to fungus attack
Drought Index	Measurement of moisture into and out of soil and fuel, a good tool for predicting when to burn in conjunction with the Fire Danger Index calculator
Fencing material	Logs of durability 1 classification that meet minimum fencing requirements (this preference is often area specific eg: yellow stringy bark (Gympie region), Narrow leaved red ironbark (everywhere), Tallowwood (NSW/Qld border region)
Fire Danger Index	Calculates fire intensity, flame height, rate of spread and expected spotting distance
Fuel Loading	This generally refers only to grass fuels and light forest residues <6mmØ
Habitat trees (Original sph)	Habitat trees/ha before management intervention (the definition of a habitat tree is a tree with a 100mm+ hollow)
Forest Inventory	In field and desk top analysis of forest attributes
Logged m3/ha	Estimated volume of commercial trees available/ready for harvest
Logged sph	Estimated number of commercial trees removed in a harvest/ha
MAI – Mean Annual Increment	A measurement of tree growth by either 1. Diameter at breast height (cm); 2. Volume (M^3/ha/year); 3. Basal Area (m^2/ha/yr)
Original m3/ha	Total volume of all trees/ha many of which may be non-commercial
Original sph	Number of trees /ha before management intervention
Pipe	Euphemism for pipelike rotted out centre of the log
Pole	Log that meets the Australian Standard (AS 2209 -1994) for timber electrical transmission line pole specifications
Residual m3/ha	Total commercial volume of trees retained after harvest and treatment
Residual sph	Number of trees /ha retained after management intervention (harvest or treatment)
Sawlog	Log with a minimum 2.4 m section with a ≥ 30cm small end diameter under bark that meets sawlog specifications for species, straightness and defect
Salvage log	Log that fails sawlog specification but of good enough quality to extract a commercially viable product considering extraction costs
Stand Assessment	In field measurement of a representative sample of the forest by management unit (volume, sph, products etc)
Treated sph	The number of trees (non-commercial) chemically treated or otherwise removed due to being useless or in excess of optimal tree stocking levels

1 Productive Native Forest Management

1.1 General Forest Condition

Queensland’s dry native forests usually support a mix of one or more of the following species, Spotted gum, Ironbark, Gum topped box, Forest red gum, White mahogany, Bloodwood etc. These forests generally react to disturbance (clearing, heavy harvesting, severe wild fires) by producing large numbers of regeneration, consequently the majority of Queensland’s productive native forests are overstocked, often supporting more than 600 + stems/ha. Long term stocking trials has shown 120-150 stems /ha (8.5 x 8.5m spacing) provides sufficient spacing to maximise individual tree growth, ensure native grass cover to minimise soil loss and optimise ground and arboreal habitat values.

The first element of sustainable native forest management is achieved by optimising individual tree growing space. Tree stocking levels i.e. trees/stems per hectare, is dependent upon the average tree diameter (size) and the quality of the site (soil type and depth, rainfall, etc). As a general rule, as trees get larger, more space is required for them to maintain health and vigour. As trees grow and mature their crowns and roots begin to interact and there is increased competition for available sunlight, nutrients and moisture. In simple terms too many trees and they all go hungry. Reduced crown or root development directly impacts on growth rates.

Photo 1-3 . Thinning, an essential element of sustainable forestry to ensure optimal crown and root development

Another measurement of tree density is basal area. It is usually measured using a basal area wedge. This is a sum of the area of a cross section of all trees per hectare measured at 1.3m from the ground. All forests have a threshold basal area, that is when the basal area reaches a maximum density that cannot be exceeded, trees start to die. In a dry forest this will be in the vicinity of 25m². Table 1 is a basal area reckoner and it shows 25m², the point at which trees start to die in dry forest as 700 x 20cm trees (average); 350 x 30cm; or 150 x 45cm dbh trees. It also means that from about 18m² individual tree growth drops off markedly.

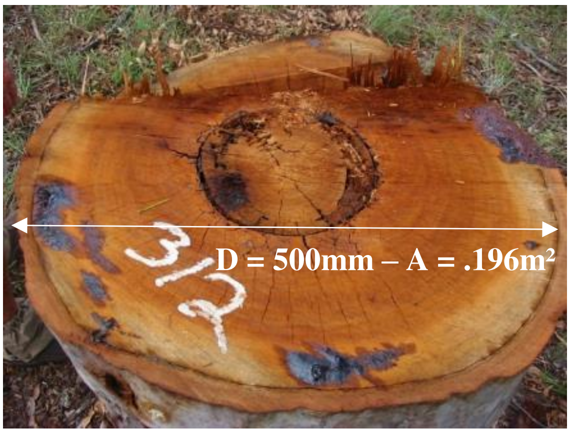

Photo 4. Example of a cross section of tree calculation for basal area

DBH (Diameter @ Breast Height)	TBA (Total Basal Area)																	
50	1.0	2.0	3.9	5.9	7.9	9.8	11.8	13.7	15.7	17.7	19.6	29.5	39.3	49.1	58.9	68.7	78.5	88.4
45	0.8	1.6	3.2	4.8	6.4	8.0	9.5	11.1	12.7	14.3	15.9	**23.9**	31.8	39.8	47.7	55.7	63.6	71.6
40	0.6	1.3	2.5	3.8	5.0	6.3	7.5	8.8	10.1	11.3	12.6	18.8	25.1	31.4	37.7	44.0	50.3	56.5
35	0.5	1.0	1.9	2.9	3.8	4.8	5.8	6.7	7.7	8.7	9.6	14.4	19.2	24.1	28.9	33.7	38.5	43.3
30	0.4	0.7	1.4	2.1	2.8	3.5	4.2	4.9	5.7	6.4	7.1	10.6	14.1	17.7	21.2	**24.7**	28.3	31.8
25	0.2	0.5	1.0	1.5	2.0	2.5	2.9	3.4	3.9	4.4	4.9	7.4	9.8	12.3	14.7	17.2	19.6	22.1
20	0.2	0.3	0.6	0.9	1.3	1.6	1.9	2.2	2.5	2.8	3.1	4.7	6.3	7.9	9.4	11.0	12.6	14.1
15	0.1	0.2	0.4	0.5	0.7	0.9	1.1	1.2	1.4	1.6	1.8	2.7	3.5	4.4	5.3	6.2	7.1	8.0
10	0.0	0.1	0.2	0.2	0.3	0.4	0.5	0.5	0.6	0.7	0.8	1.2	1.6	2.0	2.4	2.7	3.1	3.5
5	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	5	10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	450
	SPH (Stems per Hectare)																	

Table 1. Basal Area reckoner using average diameter at breast height x the number of trees/ha

The best opportunity to bring an overstocked forest back into a healthy condition is at harvest; this is known as reset silviculture. One methodology to achieve this is to paint mark the best trees to be retained (minimum of 100 stems/ha, down to 10cm dbh), based on good crown health, good form and little stem defect as well as retaining 6 habitat trees/ha in remnant mapped forest. All other trees with a merchantable product in them are then harvested, all remaining un-merchantable trees are either:

- Chemically injected,
- Chopper rolled, or
- Harvested for bio-fuels (under development)

Best practice forest management aims to retain the best quality trees each time a harvest occurs. Removing the bent, twisted or forking trees results in the stand's genetics being improved, as opposed to past practices of removing the best trees and leaving the worst trees to parent the next generation.

1.2 Tree Selection for Retention

Traditionally selecting which tree was to be harvested was undertaken by the cutter, as was the tree to be chemically injected for thinning (Tordon® gang). This does not necessarily achieve the best result for the long term productivity of the forest. Paint marking for retention is focused on choosing the best possible trees for the future of the forest, not which trees are going to earn the cutter the most money.

How do we determine what trees to keep? The obvious attributes are preferred species, straight stem, little defect and a reasonable diameter. However a tree's crown is the single most important factor in determining the future of the tree. Generally, regardless of how straight the trunk is, if the crown is defective or in poor health, tree growth will be slow or declining and defects such as pipe or doze are likely to be increasing.

The crown of a tree is the power house for tree growth. A small defective crown invariably results in poor tree growth (see Photos 5-8). A healthy crown is demonstrated by:

1. **Crown Position –** Dominant or co-dominant with clear growing space
   a. Crown position is the relationship of the tree crown to the trees that are directly next to it. If a tree has its crown above all adjacent trees, it is regarded as "dominant". If it is equal in position to all adjacent trees, it is regarded as co-dominant. If the tree has a crown that is below all adjacent trees and is being adversely effected by them, it is regarded as "suppressed". Ideally, retain only dominant or a maximum of 2 co-dominant trees in a cluster as your future forest.

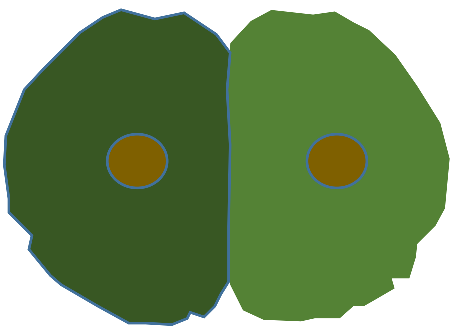

Figure 1. Typical plan view co-dominant crown development

2. **Crown Shape - Conical** with 360º crown cover,

   a. If a tree is codominant it may have only 200° +, if the rest of the crown is healthy, then that is adequate
3. **Crown Foliage Density** - This is the measure of the trees photosynthetic area and is seen in the crown depth, density and distribution of the foliar clumps as in Photo 5.
4. **Degree of Dead Branches -** Few dead branches greater than 25mm in diameter inside the leaf zone
   a. There are often dead branches at the bottom of the crown, that is crown lift and not associated with crown health
5. **Crown Epicormic Growth –** Few small vertical branches along major branches,
   a. Epicormic growth is a sign the tree is under or has come under stress (competition, drought, fire or severe insect attack)

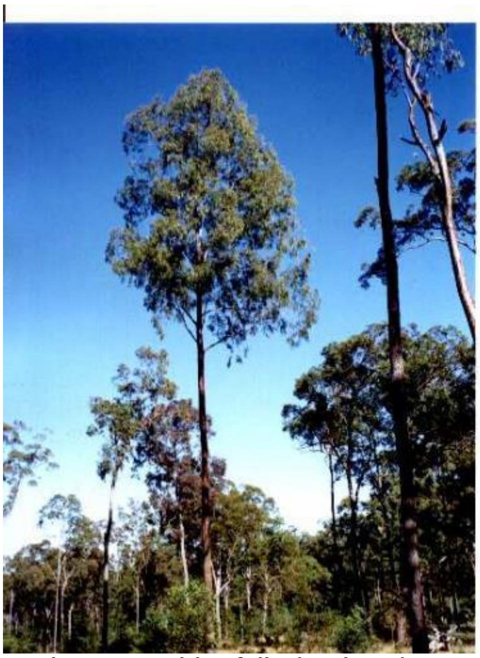

Photo 5. Healthy, fully developed crown with dense foliage in a dominant position

Photo 6. Suppressed offset crown with poor shape development on only 1/3 of the crown area

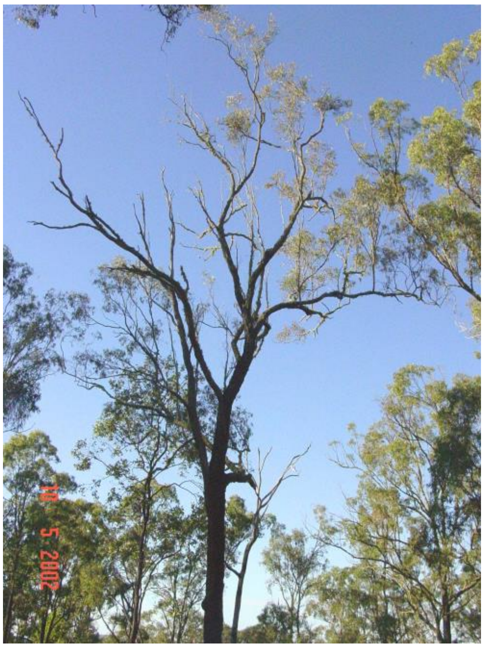

Photo 7. Crown in severe decline with predominance of dead branches, epicormic shoots and sparse foliage

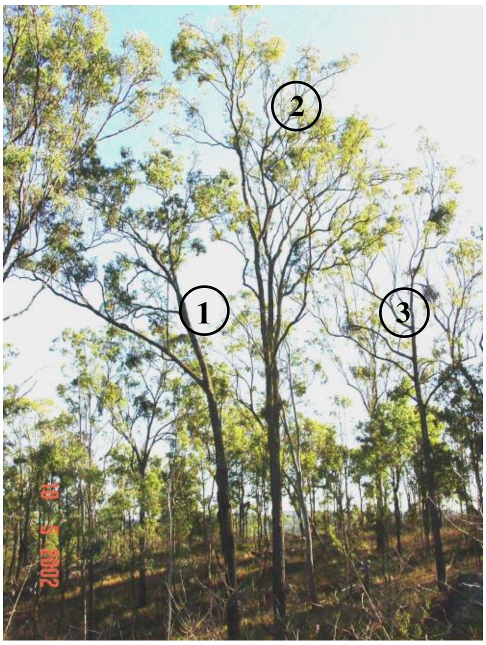

Photo 8.Tree crown No 1. is offset in a suppressed position, No 2. is in a dominant position and No 3. has sparse foliage and dead branches

Summary of selection Criteria

Thin or space trees to average 8-8.5 m apart based on:

1. Preferred Species
2. Good quality - straight log length (>6m), limited fire or other scars, defect bumps or insect damage
3. Healthy, uniform dense tree crown and limited dead branches, mistletoe and/or epicormic shoots.
4. Dominant or at least a co-dominant tree crown placement in the canopy.
5. In 'remnant' vegetation retain the required numbers of 'habitat' trees prescribed in the 'Forests Practices Code'

Thinning/spacing method

- Based on the selection criteria above, mark trees to keep with paint
- If commercial amounts of 'product' trees are present, organise a harvest prior to chemical thinning/treatment of the forest.
- Chemically thin/treat any unmarked, un-merchantable stems.

Summary of Stem Fault to look for:

Vertical Dead Branches – sizable dead branch will persist on the tree and allow decay to develop

Fire Scar – usually at butt level, may allow decay to develop or restrict nutrient transfer and hinder growth

Stem Damage – broken off large branch or damage resulting from an impact from machine or treefall

Lumps or Bumps – generally an indication of an internal fault or termite attack,

Bracket Fungi - indication of internal decay

Photo 9-11 Lumps, Bumps and dead branch stubs

1. Understanding Your Forest Type and Its Condition

There is not a single system of management that is broad enough to cover all forest types and their condition. The basics are the same based around optimal stocking and good quality trees, however forest condition can vary widely as do the management intervention processes to be employed.

Below are just three examples that describe the conditions you may find your forest in and how management needs to be adaptive to these conditions before and after a harvest operation. There are many variations to these conditions, but for simplicity three are considered.

Forest Condition 1. - A Regenerating Forest with few Mature Trees Present

2.1.1 Description

A regeneration forest is one that has regenerated from being cleared or heavily harvested.

The regeneration (suckers, saplings, etc) have a fairly uniform diameter, commonly 10-20cm DBH (Diameter at breast height – 1.3m from the ground), and are generally a uniform age. In this situation the forest has mostly one layer of tree crowns in the canopy. There is little understorey, there are a few dominant trees that have emerged, but overall the forest can be regarded as being "locked up" or "choked". In other words the growth of the trees has stalled as they have come under increasing competition for light, nutrients, moisture and growing space. The number of trees per hectare in this type of forests condition can be as high as 1000+.

Photo 12-13. Overstocked / locked up forest with too many small trees

2.1.2 Improving the Productivity of this Type of Forest

2.1.3 Stage One Management

A forest stand in this condition is in dire need of thinning to enable the better trees to be released from competition, to regain their growth and vigour and to put on greater diameter. The important point to remember is that the optimal number of trees/ha to retain is determined by the site quality and the diameter of the trees. A dry forest such as a spotted gum and/or ironbark forest should have a maximum of 120 - 150 trees per Ha (which equates to an average spacing of 8 – 8.5 metres between trees). Remember, most of the trees in this stand are between 10 and 20cm diameter. Trees will not always be where we want them to be and so there will be times when trees are 8 metres apart or 5 metres. The point isn't to try and achieve an exact spacing, just an overall average.

2.1.4 Tree Marking for Treatment

In preparation for thinning, this stand ideally should be marked for retention. Trees to be retained (8 - 8.5m apart) are marked with spray paint or alternatively spend time with the Tordon® gang and train them to select the trees that should be removed according to your criteria. Marking trees will usually produce a better result, but is more costly and/or time consuming. When training a Tordon® gang, mark out an area of 2-5Ha with spray-paint, point out the desirable characteristics you require for the retained stems (crown health, straightness, position, spacing, species etc) so that they will understand what you require. You'll need to monitor them, and possibly mark out more areas, particularly when a forest type or condition changes to ensure they are doing the job you want.

Photo 14. Retained trees clearly showing paint marking

Photo 15. Chopped pocket adequate to take the 2ml of chemical

Most landowners or contractors use either Glyphosate or Tordon® via an axe and stem injection. The axe should pass through the bark and then into the sapwood creating a pocket to hold the chemical without run-off. The required quantity of chemical is then injected into the pocket.

An alternative to chemical injection is the use of a chopper roller. A chopper roller is a 9 tonne roller with 200mm vertical blades attached in a chevron pattern. It is towed with a skidder or similar machine and weaves through the trees knocking over and chopping up any unmarked trees. The stand must be paint marked as the driver cannot see which trees are the best trees to retain. There is often a fair degree of coppicing, this is either controlled by fire within 2 years or sprayed out.

Photo 16-17. Chopper roller working between paint marked trees, note the delineation line between thinned and unthinned

2.1.4 Management - Stage Two

As the forest grows to the point that the retained trees (spaced at 8 - 8.5m apart) have reached an average diameter greater than 40cm dbh another thinning operation will probably be required to maintain the forest health and productivity. At this stage there should be a range of product types that are able to be harvested as part of the thinning process. If the trees have sufficient log length there should be the opportunity to harvest smaller poles. Major pole species include Iron bark, Grey gum, and Grey box (durability 1 species) and Spotted gum, durability 2 species. Shorter length trees with a 30cm small end diameter (SED) under bark could make A class sawlogs and down to 25cm for salvage class log. Durability class 1 species such as, Ironbark, White mahogany, Red bloodwood, Grey gum, etc may be suitable for fencing timbers, (strainers, split posts, rails and stays).. Further discussion on products can be found in the "Forest Products and Marketing Guide – No 4".

Even though this thinning operation has a product component able to be realised, the same principles of selection for trees to be retained should be applied to ensure ongoing forest health and productivity advances. The principles of retaining trees based on their form, vigour and spacing is something that should be maintained throughout the management cycle. Again depending upon site quality, the number of trees per hectare to be retained in the 40cm+ category should be around 100 trees per hectare, that equate to a 9-10m average spacing. On top of this there will be a layer of around 50 stems /ha regeneration. This smaller regeneration is extremely important to protect and manage as it is your future crop. As the forest is managed, this regeneration will also need to be thinned.

The timing and intensity of that thinning will change as the forest matures (changes in structure) however thinning every 10 to 15 years is recommended. The forest condition described in **3.3 - An 'optimal managed' forest** is what to aim for.

2.2 Forest Condition 2. – Over Harvested Forest with a Non Productive Overstory.

2.2.1 Description

Photo 17. Forest dominated by poor form trees and residues from previous harvest

It is probable that a forest in this condition has had most trees with a sawlog grade product or pole removed. There are usually two layers to the forest canopy, namely:

1. An upper layer of bent, defective or damaged trees
2. A subdominant layer of overstocked regrowth often with good potential that is being suppressed by the overstory.

A forest in this condition can also have a high proportion of non-commercial species such as Swamp mahogany, Acacia, Supple jack, (*sub species of Lophostemon confertus*) etc. The non-productive trees have a dramatic impact upon the forest, competing heavily with the young regenerating commercial species.

In this type of forest the size class distribution shows high numbers in the small diameter classes and few stems within the harvestable range.

2.2.2 Improving the productivity of this type of forest

2.2.3 Stage One Management

There are two outcomes to be achieved by thinning this forest, namely:

1. Provide good quality trees clear space to grow
2. Trigger a regeneration event to ensure the future stand is brought back to 100% productivity.

Photo 18. Forest dominated by poor form trees but with sufficient good trees to warrant thinning

Well managed regeneration growing into clear space will achieve a much higher rate of growth than the retained tree as these trees will still be partially affected by their earlier suppression.

The difference with this forest compared to a regrowth forest (as in 2.1) is that the harvesting stage of this operation should generate income to offset the costs of the thinning. The number of trees per hectare in a stand such as this can be highly variable depending upon the frequency and intensity of past harvest practices, but invariably there are a range of products, such as some sawlog, salvage grade logs and fencing material.

Generally the larger trees are defective or they would have been removed in previous harvests. Unless required for habitat, these trees should be removed. The below table gives the spacing guide recommended for each tree diameter size class.

Management Recommendations

Trees 30cm + diameter class. (few of these will be retained due to fault)	**Trees within the 20 – 30 cm diameter class**	**Smaller trees in the 10 – 20cm diameter class (advanced growth)**	**The combined retained stand should not exceed 150 trees/ha, on the condition that every tree has space to freely grow into**.
Spaced at an average of 10m from other trees in this size class.	Spaced at an average of 7 – 8m from other trees in this size class or larger.	Spaced at an average of 5 – 7m from any other tree.	

Selection Criteria for Retained Trees

1. Preferred Species
2. Good quality - straight log length (>6m), limited fire or other scars, defect, bumps or insect damage
3. Healthy, apical dominance crown with limited dead branches, mistletoe and/or epicormic shoots.
4. Dominant or ability/space to become dominant (not too impacted by suppression).
   In 'remnant' vegetation retain the required numbers of 'habitat' trees required in the ***Managing a native forest practice -*** *A self-assessable vegetation clearing code.*

Thinning/spacing method

- Based on the selection criteria above, (mark trees to keep with paint, recommended)
- If commercial amounts of 'product' trees are present, organise a harvest prior to chemical thinning of the forest.
- Chemically thin any unmarked (if painting trees), un-merchantable stems

2.2.4 Stage Two Management

As the forest stand matures and trees increase in diameter taking up available nutrients and moisture, competition again starts to impede growth rates. At this time a commercial thinning (harvest), for poles or fencing timbers may be possible. If this is the case, carry out a harvest but leave the better trees to grow on as per Table 1. There may be a need to follow the commercial thinning with a chemical treatment to reduce competition from regeneration that has now moved in to the advanced growth stage.

There are a range of product types that may be harvested as a 'thinning harvest'. Smaller diameter Durability class 1 species such as, Ironbark, White mahogany, Red bloodwood and Grey gum may be suitable for strainer posts, rails and stays. If the trees have sufficient log length there may be the option of harvesting poles. Major pole species include Grey gum, Forest red gum, Grey box, Spotted gum and Ironbark, which are all Durability class 1 or 2 species. Alternatively, for trees which have limited log length but sufficient diameter i.e. 30 cm small end diameter, compulsory grade sawlogs may be harvested. Further discussion on products can be found in the "Forest Products and Marketing Guide" No 4 of this series.

In some cases no commercial thinning harvest options may be possible. If this is so, proceed straight to having a chemical thinning operation to remove non-commercial trees and competition, allowing the better trees to grow on and reach to maximum product potential, as fast as possible.

For further information on native forest management go to: www.pfsq.net

2.3 Forest Condition No 3. A Well Managed Forest

2.3.1 Description

A forest that has been selectively harvested with follow up management to promote growth.

In this forest condition, retained trees are well spaced, have a healthy crown and a straight stem free of fault. A tree is only removed when it has reached its full economic potential, are declining in health or is approaching its threshold basal area. There has been adequate regeneration over the years and timely management that has maintained forest growth and health. The management has maintained an optimal number (130-150) of quality trees per hectare by applying timely 'thinning harvesting' and 'chemical treatment'.

Photo 19. Spotted gum spaced to suite the large diameter

Fire management has been undertaken by the landowner to reduce competition and fuel load, while protecting the retained trees.

2.3.2 Maintaining or improving the productivity of this type of forest

Management of a forest that is in good condition is less complicated than the processes required to restore a forest. Maintaining high productivity involves timely harvesting and the follow-up processes of tree head disposal, regeneration establishment, thinning and fire management. This management regime is based on an approximate 60 year cycle with a harvest occurring at approximately 10-15 year intervals and an 'ideal' stand structure carrying 20% of the stand in the <20cm dbh, 20% 20-40 cm dbh and 60% >40cm stem size classes.

This structure allows a number of selection opportunities (during treatment) along the growth cycle, particularly in the <20cm dbh range, to select the superior trees to grow into the harvestable range at the high end of the product value spectrum. This treatment process would take place around 5 years after each harvest cycle once the regeneration has reached a sufficient height to select on form and vigour.

2.3.3 Harvesting

A typical harvest for this management regime would aim at the removal of one quarter to one third of the standing volume. A harvest at a higher volume is likely to include a significant proportion of immature smaller diameter trees that are significantly under their potential value and is compromising the stands future productivity and returns.

Criteria for tree removal is directed towards harvesting trees that have reached their maximum economic value, or showing signs of defect or poor health, or will decline prior to the next harvest or are suppressed and unlikely to develop to potential. In this way harvesting is used as a tool for stand improvement.

2.3.4 A Recommended Management Timeline for This Regime:

Year 1 – harvest trees that have reached their maximum value or are showing signs of deterioration and merchandise into the highest value product considering the quality of the log (girder, poles, sawlog, fencing timbers, etc). Ensure the retention of the best 100 sph over 20 cm dbh, including the required habitat trees if in 'remnant' vegetation under the Forests Practices Code.

Post-harvest - top disposal burning and the maintenance of snig tracks, haul roads and log dumps by the installation of suitable drainage and if appropriate the removal of temporary gully crossings.

Year 3 to 5 - once subsequent regeneration has grown enough to indicate form and growth habit, chemically treat any unwanted **regeneration** to approximately 50 sph, ensuring each retained tree is growing into an adequate space in the canopy.

Year 10-15 –the forest should be ready for another harvest, following the same principles as the harvest in year 1.

Post-harvest – as per **Year 1**

Year 18-20 - 3 to 5 years after harvest, once subsequent regeneration has grown enough to indicate form and growth habit, chemically treat any unwanted **regeneration** to approximately 50 sph, ensuring each retained tree is growing into an adequate space in the canopy.

The twenty year old regeneration from the year 1 harvest (now advanced growth 20cm+) is again selected to remove any faulty or damaged stems to ensure all retained stems are of the highest quality. A maximum stocking rate of 150 stems/ha is maintained.

Year 40 – 15 years after the last harvest, the forest should be ready for another harvest, following the same principles as the harvest in year 1. Some of the harvested stems are likely to be from the selected regeneration from year 1 now 40cm+ that may have developed some fault (insect or pathogen attack, physical damage from storms etc) and need to be removed.

Post-harvest – as per **Year 1**

Year 43 or 3 to 5 years after harvest, once subsequent regeneration has grown enough to indicate form and growth habit, chemically treat any unwanted regeneration to approximately 50 sph, ensuring each retained tree is growing into an adequate space in the canopy. The twenty year old regeneration from Year 18-20 harvest (now advanced growth 20cm+) is again selected to remove any faulty or damaged stems to ensure all retained stems are of the highest quality

Year 60 or 15 to 20 years after the last harvest. This harvest represents the completion of a full growing cycle with the removal of selected stems from the regeneration that occurred after the year 1 harvest.

Post-harvest – as per **Year 1**

Criteria for Selecting Trees for Removal (Harvest or thinning) Includes:

- **Optimum product size**
- **Declining tree health, usually assessed by crown condition**
- **Defect such as large vertical dead limbs or suspected decay from old wounds**
- **Bad mistletoe infestation**

Tree Injection Methodology

Using either a Tordon® axe or long handled tomahawk, make cuts through the bark and into the wood at 13 cm centres around the stem. The herbicide mix is then immediately applied into each pocket using a calibrated sheep drench gun and backpack (1 ml of mixture for trees with a base diameter under 25cm and 2 ml for any larger trees).

Photo 20. Axe cuts at 13 cm centres suitable for herbicide application

Herbicide Mixes

- ❖ Glyphosate (Round-up 450), Using a 1: 3 Glyphosate : water mix
- ❖ Tordon® TM (Regrowth master), Using a 1: 4 Tordon® water mix (DOW Woody Weed Control Guide)

Table 2 – Number of cuts/diameter class

Tree Ø cm	**No cuts**	**Tree Ø cm**	**No cuts**
10 cm	3 cuts	40 cm	10 cuts
20 cm	5 cuts	50 cm	12 cuts
30 cm	7 cuts	60 cm	14 cuts

RATE: Mix one part Tordon® RegrowthMaster with four parts water
Application rate - 1 ml/cut <25cm Ø **;** 2ml/cut>25cm Ø at base of tree.

3.0 Forest Regeneration

Dry Eucalypt forests in Queensland generally regenerate via the lignotuber pool (older seedlings that have developed a thickened root that allows the seedling to persist on the forest floor for decades until an opportunity to grow on occurs).

Seed based regeneration however does occur (some into the lignotuber pool and some progressing straight into advanced growth) Due to the seed of Eucalypts being very small, successful germination requires areas of bare earth. Some bare earth will be evident from the snigging operation, but broader scale bare earth will be achieved as a result of tree head disposal burning after harvesting is completed.

Photo 21. Lignotuberous growth on an advanced seedling

Dry forest species follow similar habits of other seedling-regenerating eucalypts in retaining seed in the canopy for up to 18 months or until some event (e.g. fire) triggers shedding. This has been dramatically demonstrated in research sites where, after a fire, the majority of the seed within the burnt area is shed within three days of the fire and the adjoining un-burnt areas have no seed capsules that have opened. This illustrates the importance of burning - a delayed seed fall risks weed and other pioneer species becoming established before the eucalypt seed fall even occurs which can severely restrict the regeneration process.

Photo 22. Seedlings regenerating along an ash bed

The resulting regeneration needs to be protected from fire for at least three years. Care should be taken with the first fire or burn after regeneration establishment to ensure the fire does not destroy it. In areas where there is a poor regeneration history, it is recommended that timing of harvest operations coincides with a mature seed crop in the preferred species. In most eucalypts mature seed is present in the canopy 6 months after flowering.

The advantage of many eucalypts is their ability to coppice (re-shoot from stump). Many stumps from a harvest will coppice immediately. This will only be a minor addition to the regeneration pool but requires stump heights of <30cm to ensure the coppice is well grounded and not lost to 'wind-throw' or rot associated with the old stump. Coppice regeneration can be thinned to one shoot, preferably originating from ground level, when a height of 6 meters is reached.

Photo 23. The presence of mature seed in the forest canopy at the time of a harvest will greatly enhance regeneration prospects

4.0 Fire Management

Damage to a forest from wildfires can be severe, particularly if it occurs in the hotter, drier parts of the year accompanied by strong winds. The value of a forest can be reduced dramatically, depending on the severity of a fire. Tree losses, downgrading due to fire scarring, loss of growth due to defoliation, combined with increased germination of non-commercial species such as wattle can all impact on the productivity of a forest after wildfire.

Periodic fuel reduction burning (2-5 years) should be undertaken during mild conditions (during winter or following rain) to reduce the build-up of forest fuel. Targeted burning can also have a number of important management functions such as the control of excessive regeneration, invasive species, particularly Supple Jack (*sub species of Lophostemon confertus*) and weeds such as lantana.

When planning a harvest it is highly advantageous to undertake a burn in the 12 months prior to the harvesting operation. This improves visibility and access for tree marking, cutting and snigging. Damage to products such as poles, during the cut and snig operation from hidden tree stumps or rocks can result in downgrading at the ramp. Harvesting can also produce a large quantity of fuel and reducing any build-up of fuel before the harvest ensures the head disposal burn after the harvest is not too hot causing damage to the retained stems.

5.0 Complying with Legislation and Planning Laws

5.1 Queensland Vegetation Management Act (VMA) 1999

Under the Queensland Vegetation Management Act (VMA) 1999 trees or vegetation on freehold land are either 'remnant' (green, orange or pink on a Vegetation Management Map - DNRM) or 'non-remnant' (white on the map). If you have trees or vegetation that are in 'non-remnant' areas (white), you do not need to comply with Vegetation Management Act 1999, or Forest Practices Code. It is only in areas mapped as 'remnant' (coloured on the regional ecosystem map) that you must comply with the VMA 1999, and the Self-assessable Vegetation Clearing Code.
The following sets out your rights and responsibilities for 'remnant' vegetation (coloured on the regional ecosystem map). However, this does not relate to vegetation on 'white' mapped areas. It is strongly advised to 'lock in' the white areas by submitting a Property Mapping of Assessable Vegetation (PMAV) application. https://www.dnrm.qld.gov.au/__data/...file/.../**pmav-application**-form.pdf

5.1.1 Landowners Rights for 'remnant' mapped trees or vegetation

- Can I still harvest my freehold native forest or have it harvested?

  Yes, as an ongoing forest practice and existing lawful use and if timber harvesting has happened previously. If a forest area is to be harvested or thinned, etc for the first time it may be a 'new use', and require a development approval from local government (see your local government if this is the case).

- Is there a restriction on the regional ecosystem (RE) types that can be managed (harvested, thinned, etc)?

  *Yes these are outlined in Tables 1A, 1B and 1C - **Managing a native forest practice** A self-assessable vegetation clearing code.*
  https://publications.qld.gov.au/storage/f/2014-08-04T23%3A17%3A15.199Z/managing-native-forest-practice-code.pdf

- Do I need to have a forest management plan?

  No, it may be required under the proposed code but it is advisable to develop one to assist you in protecting your harvest right and to aid in successful enterprise management.

5.1.2 Landowners Responsibilities for 'remnant' mapped vegetation

- Do I have to notify DNRM if I am harvesting my freehold native forest or having it harvested?

  Yes, notification is required and can be completed on the DNRM website, or by filling out the form and lodging it with DNRM.

  Landowners conducting a forest practice must be able to demonstrate that it is "ongoing". In other words it needs to be planned to provide recurring income over time and part of a properties' business. Landowners are advised to maintain records of timber removals and other forest management activities that they perform such as thinning, fire, etc. to justify this.

  - Is there a forest practice code I have to comply with for 'remnant' mapped areas?
    *Yes - **Managing a native forest practice** - A self-assessable vegetation clearing code.*

Summary of Code Requirement - Dry Native Forest

Landholders must lodge a notification of a Forest Practice with DNRM (can be done online)
A native forest practice must: • only occur for the purpose of producing value added forest products • maintain documentary evidence of the sale of products.
No more than 5% of the area, in which a native forest practice is conducted, may be disturbed by roads, tracks, snig tracks and log landings.
Selective harvesting and thinning: only occur in the regional ecosystems listed in Table 1A, 1B and 1C as per ***Managing a native forest practice -** A self-assessable vegetation clearing **Code**).* • retain the number of habitat and recruitment habitat trees listed in Table 5 in the **Code** • in a hardwood forest, must retain the number of timber trees listed in Table 2 in the range of sizes and spacing's outlined in Table 3 in the **Code** • retain representatives of all species in a range of sizes in each hectare • wherever possible retained trees are evenly spaced • not create a park like appearance by removing the majority of understorey species. • not involve felling trees into or against trees required as future crop or habitat trees
Except for roads, tracks, snig tracks and landings, a native forest practice will maintain at least 50% of the ground surface in any 50 by 50 metre area either: • undisturbed; or • with a vegetative ground cover (dead or alive).
A native forest practice must not occur: • on an area with a majority slope greater than 45 percent or 25 degrees • within 20 metres of an unstable area or area vulnerable to mass movement. • within a buffer zone of a wetland or designated stream line except for the establishment of a crossing – Table 4 in the **Code**
A native forest practice must retain • the number of habitat and recruitment habitat trees listed in Table 5 in the **Code** • retain all active feed, nest and shelter trees
Roads and tracks • not be used when soils are saturated

• be drained and water diverted onto undisturbed areas before the water is able to traverse the maximum permitted distances listed in Table 6 in the **Code** • that a creek crossing in a creek bed is to be set at bed level
• Snig tracks are not to be located within a filter or buffer zone except at a creek crossing • Log dumps are to be a maximum 50x50m

5.2 Local government planning schemes and local laws

The majority of forests have been harvested at some time in the past and have ample evidence of an on-going forest practice. Tree stumps, snig tracks, logging debris, local knowledge of timber removals, fire management, past thinning, regeneration from stumps, tree diameter distribution, etc are all indications of past forest management. Forestry is a long term business that may be many years between events, as such section 681 and 682 of the Sustainable Planning Act protects the existing legal use from any requirements of council for a development application or material change of use. (See sections below)

681 Lawful uses of premises on commencement
(1) To the extent an existing use of premises was lawful immediately before the commencement of this Act, the use is taken to be a lawful use under this Act on the commencement.

(2) To remove any doubt, it is declared that subsection (1) does not, and has never, affected or otherwise limited a requirement under another Act to obtain an approval for the existing use.
Example of an approval—
an environmental authority under the Environmental Protection Act

682 Lawful uses of premises protected
(1) Subsection (2) applies if—

(a) immediately before the commencement of a planning instrument or an amendment of a planning instrument, the use of premises was a lawful use of the premises; or
(b) immediately before an existing planning instrument starts applying to land, the use of premises was a lawful use of the premises.

Neither the instrument nor the amendment can—
(a) stop the use from continuing; or
(b) further regulate the use; or
(c) require the use to be changed.

A new native forest use is one where no evidence of an on-going forest use exists or the use has been abandoned, changed in scale or intensity. A <u>new</u> forest <u>use</u> may be regarded as a "*material change of use*" by some Local Government planning schemes and may require the submission of a development application.

Disclaimer: