SOUTH + CENTRAL QUEENSLAND REGIONAL
FORESTRY HUB

REPORT: SPATIAL MODELLING OF FINANCIALLY SUITABLE AFFORESTATION UNDER DIFFERENT SCENARIOS FOR TIMBER PRODUCTION AND CARBON STORAGE WITH KEY PROSPECTIVE WOOD SPECIES

PF OLSEN

30 May 2024 | Forest Resource Security

This report was commissioned by the South & Central Queensland Regional Forestry Hub with funding from the Australian Government, Department of Agriculture, Fisheries and Forestry.

PLANTATION LAND SPATIAL SUITABILITY ASSESSMENT

Spatial modelling of financially suitable afforestation under different investment scenarios for timber production and carbon storage with key prospective wood species

This report was commissioned by the South & Central Queensland Regional Forestry Hub with funding from the Australian Government - Department of Agriculture, Fisheries and Forestry

May 2024

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Suitable areas

The areas most suitable for future commercial plantations are located in the east of the Hub region.

These area totals represent the most suitable land for plantation establishment and exclude the poor growth, forested areas and prohibited land.

- Spotted gum 2,496,073 ha
- Gympie messmate 198,767 ha
- Southern Pine 197,997 ha
- Hoop pine 189,080 ha

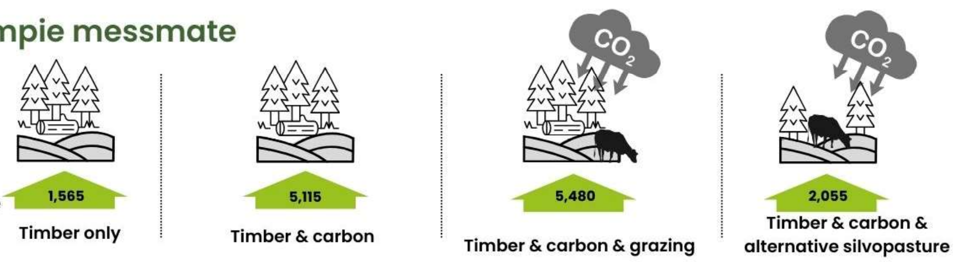
Economic analysis

The following graphics provide the Net Present Value (NPV) for each species and the four land-use scenarios. The NPV is inclusive of the currently available Australian government grant of $2,000 per hectare.

The timber only, timber and carbon, and timber, carbon and grazing land-use scenarios use a standard commercial plantation regime with grazing underneath the established trees. The alternative silvopastoral land-use scenario consists of strip tree plantings with wide pasture alleys and grazing throughout.

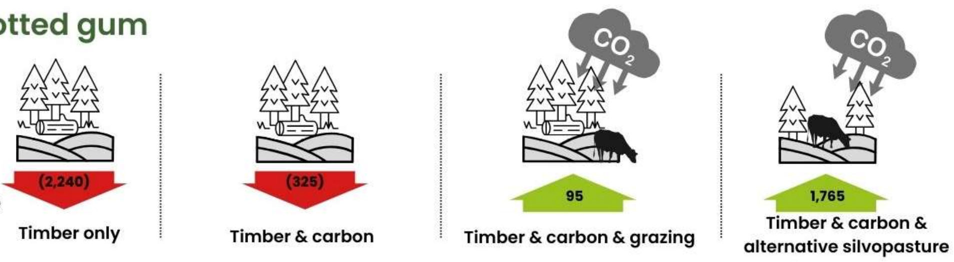
Gympie messmate

NPV $ per ha
5% discount rate



Spotted gum

NPV $ per ha
5% discount rate



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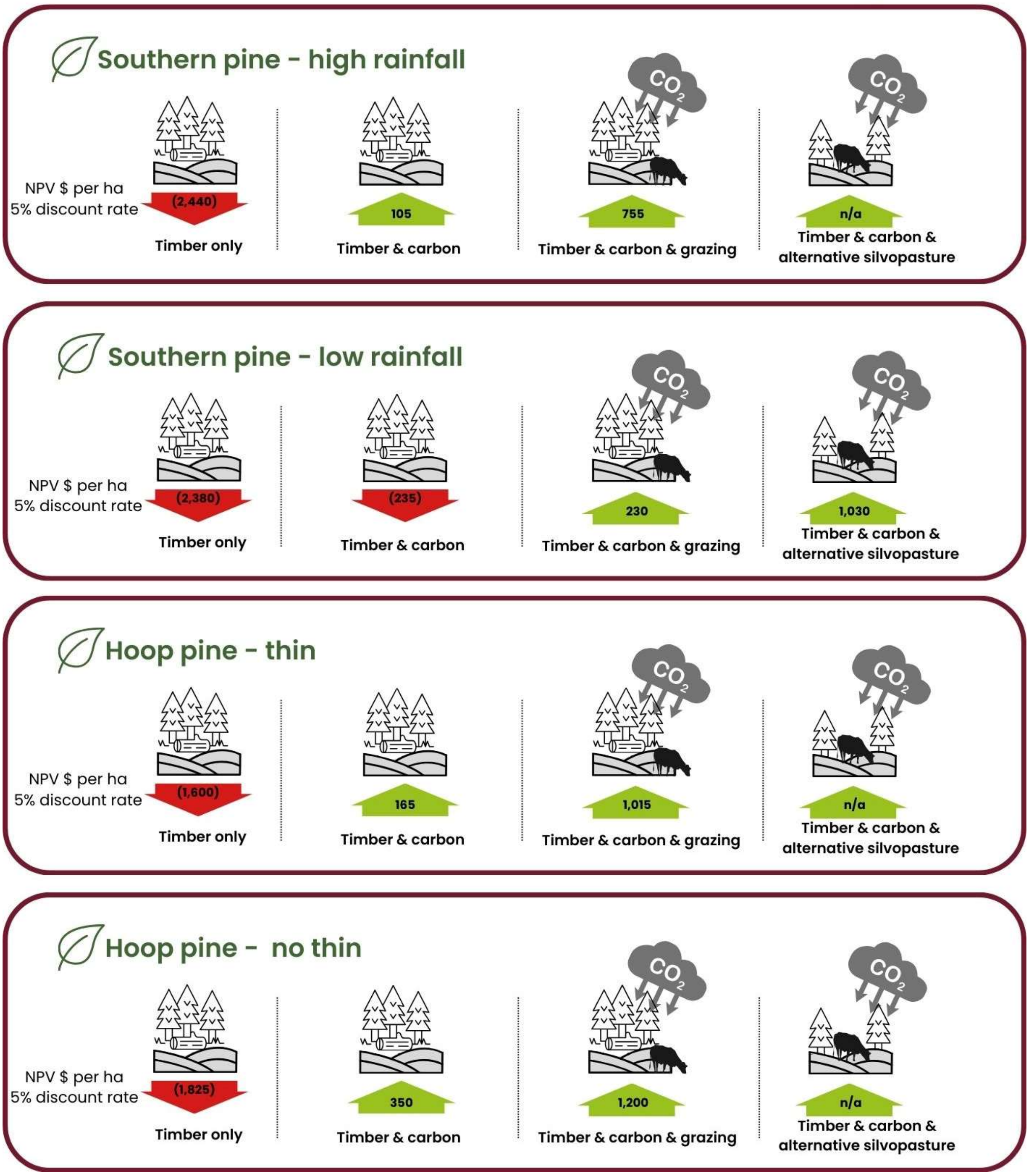

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Executive summary

The South & Central Queensland Regional Forestry Hub (the Hub) seeks to grow the forestry sector to deliver strong financial outcomes and design and test new models of investment for plantation forests. This report presents the findings of a project that had four main elements:

1. Literature review
2. Land suitability assessment for future plantations
3. Economic analysis of 'traditional' plantations that include the production of timber, carbon and cattle, as well as an economic analysis of a silvopasture alternative model.
4. Exploration of current government policy that influence the development of new plantations, and the development of models for stakeholder engagement.

Literature review

The literature review provides insights into plantation expansion and the drivers behind it in southeast Queensland. It covers the history of softwood and hardwood plantation development, including government initiatives and private sector involvement. The review also discusses the evaluation of land suitability for plantations and the methodology used in the 1990s Comprehensive Regional Assessment.

Key findings include:

- Queensland has significant forested land, with 233,000 hectares of plantations, mostly owned by HQPlantations Pty Ltd.
- The softwood plantation area has remained fairly static since the 1990s, while hardwood plantation areas have fluctuated due to significant private investment and subsequent plantation failures.
- Plantation species like Hoop pine, Spotted gum, Gympie messmate, and Southern pine are commercially important in southeast Queensland, with varying growth rates and uses.
- Market demand for forest products, particularly timber, is expected to increase, driven by population growth and housing demand.
- Silvopasture, the integration of trees and livestock, is gaining attention for its environmental and economic benefits, including carbon sequestration and land rehabilitation.

Overall, the literature review highlights the complexities of plantation expansion in southeast Queensland, emphasizing the need for sustainable practices and innovative investment models to meet future demand while balancing economic and environmental objectives.

Land suitability

We explored and identified the biophysical characteristics that are most important to plantation development in the Hub region. We used this information to classify each characteristic into levels of suitability for each of the four species in the project. These levels of suitability were combined to create a classification of plantation suitability of five classes from 'ideal' to 'unsuitable'. In parallel, we identified land within the Hub region that would be excluded from future plantations due to current land use (such as national park, existing forest, zoning limitations, existing plantations). We then produced maps that presented areas of plantation suitability by class within the Hub region. These maps also showed the areas that were excluded.

We found that the areas that are most suitable for future commercial plantations are in the eastern part of the Hub, which is where the highest rainfall is. In terms of species differences, Spotted gum has the greatest area of suitability, and the other three species are reasonably similar in their extent.

Area most suitable for future plantations by species

Species	Hectares
Hoop pine	189,080
Southern pine	198,767
Gympie messmate	197,990
Spotted gum	2,496,073

Economic analysis

Economic analysis was conducted across the four species and included two separate silvicultural regimes for Hoop pine (thin and no thin) and Southern pine (low rainfall and high rainfall). In the process of building up the dataset for the economic analysis, we used FullCAM to estimate the carbon sequestration potential across the Hub region, for the six regimes. The outcome of this was the production of carbon 'heat maps' that display the total ACCU's per hectare estimated across the Hub area. These maps will allow landowners to get an estimate of the ACCUs for their land by the different species.

The economic analysis was used to analyse the four species regimes in three different landscape management scenarios (timber only, timber & carbon, and timber & carbon & grazing). The outcomes from the economic analysis found that the only species with a positive net present value (NPV) from timber alone is Gympie messmate. The addition of the government grant, carbon revenue and grazing have a significant positive impact on cashflow. The scenarios which include all three land management options of timber & carbon & grazing return the greatest NPV.

Net present value ($/ha) of each modelled scenario, with and without government grant*

	Scenarios	Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
With govt. grant	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(235)	105	165	350	(325)	5,115
	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
Without govt. grant	Timber only	(4,340)	(4,395)	(3,560)	(3,785)	(4,195)	(390)
	Timber & carbon	(2,195)	(1,855)	(1,795)	(1,605)	(2,285)	3,155
	Timber, carbon & grazing	(1,730)	(1,200)	(945)	(755)	(1,865)	3,525

*Discount rate 5%

It should be noted that the economic modelling includes a 'notional land rental' which can also be described as an opportunity cost when compared to other land uses. The NPV impact of including this notional land rental is an average of around $2,600/ha. If the reader wants to compare forestry NPVs against other land uses that don't include the cost of land, the NPVs presented should be increased by $2,600.

Alternative silvopasture

An alternative silvopasture system was also explored in which alleys of pasture are planted on either side by two or three rows of trees for commercial production of timber. This system enables a greater amount of feed available for livestock over the life of the project. Economic modelling of this scenario resulted in highly favourable NPV outcomes, even without the Government Grant. The volume outputs from FullCAM are very likely to be underestimating the true growth potential of this system and a sensitivity analysis demonstrated that greater returns could be achieved with a 25% increase in volume.

Net present value ($/ha) for the alternative silvopasture model (timber, carbon and grazing) with and without government grant*

	Southern pine	Spotted gum	Gympie messmate
With grant	1,030	1,765	2,055
Without grant	178	1,112	1,403

*Discount rate 5%

Policy

Forest management in Australia involves balancing economic, social, and environmental interests across different levels of government. Plantation forest policies aim to meet timber demand, conserve biodiversity, and mitigate climate change.

Federal policies prioritise increasing plantation timber resources and transitioning to a bioeconomy. State governments have legislation covering forestry, land use, and conservation.

Despite increasing timber demand, log availability is projected to decline. Strategies to encourage plantation expansion include agroforestry, carbon farming, and addressing funding and land competition issues.

To enable expansion, recommendations include integrating plantations into agricultural systems, including timber production in carbon farming benefits, ensuring a 'right to harvest,' and developing aggregated carbon farming projects. Stakeholder engagement should focus on providing clear and consistent information to landholders.

Overall, policies aim to support sustainable forestry, meet timber demand, and ensure economic and environmental benefits for Australia.

1. Introduction

1.1 Background

The South & Central Queensland Regional Forestry Hub (the Hub) seeks to grow the forestry sector to deliver strong financial outcomes and design and test new models of investment for plantation forests. The Hub has engaged PF Olsen to explore and analyse the amount of land that is suitable for future commercial plantations and agroforestry plantings.

The total land area of the Hub region is 325,517 square kilometres.

1.2 Scope

The Hub wishes to better inform landowners, industry, and policy makers on the scope of, and opportunity for, new plantation investment in the region by:

1. Reviewing and analysing existing relevant published literature and other sources of information of South & Central Queensland. This information will be integrated into the North Queensland Foundational GIS platform.
2. Defining the biophysical characteristics affecting land suitability and investment and gain insights into available plantation land identified in point 1.
3. Spatially analysing the available and financially suitable land for afforestation for the most prospective wood species across the region for:
    - Timber production
    - Timber and carbon storage
    - Integrated timber production, carbon storage and agroforestry
4. Determining policy factors impacting new tree plantations. Then, establishing a methodology to support successful relationships with key stakeholders between the industry, farmers, Indigenous communities, and other landholders investing in, or participating in plantations and agroforestry.

1.3 Species

The following four species were selected in consultation with the Hub as being the most suitable and commercial for the region:

- Hoop pine - *Araucaria cunninghamii*
- Southern pine - *Pinus elliottii var. elliottii* (PEE) x *Pinus caribaea var. hondurensis* (PCH)
- Gympie messmate – *Eucalyptus cloeziana*
- Spotted gum – *Corymbia citriodora subsp. variegata*

1.4 Deliverables

The deliverables for this project are:

Activity 1
Literature review, data analysis and consolidate into a Foundational GIS platform

- Review academic (peer reviewed) and relevant published literature/studies as well as any other (grey) literature and data covering relevant spatial and remote-sensing imagery for South & Central Queensland forestry regions and integrate it in the North Queensland Hub Foundational GIS platform.
- Describe main biophysical factors and characteristics affecting land suitability and investment for tree plantation; provide insights describing the identified available land for plantations.

Activity 2
Spatial modelling of the amount of land that is available and financially suitable for afforestation (macro level) for the 3-4 most prospective wood species across the region under different scenarios:

- for timber production
- for timber production and carbon storage
- for integrated timber production, carbon storage and agricultural productivity (i.e. agroforestry system).

Summarise and aggregate this spatial information and desired outputs at a regional scale to better inform landowners, industry and policy makers on the scope for new plantation investment in the region.

Activity 3
Determine policy factors slowing and/or supporting tree plantations. Establish a methodology to support successful relationships among industry and farmers, farmers groups, indigenous communities, and other landowners for investing and/or enter in partnerships to establish forestry plantings.

2. Literature review

It is important to understand the current plantation estate and the drivers for its development in the context of the aims of this project. This section briefly describes plantation expansion in southeast Queensland and the drivers of plantation establishment through timber supply and demand. Plantation suitability evaluation for the comprehensive regional assessment (CRA) in the 1990s is described, as well as a current methodology for assessing agricultural land.

The characteristics of the most suitable plantation species are presented, along with a discussion on plantation investment models. A background into carbon sequestration from plantations in the Australian regulatory context is provided. Alternative forms of plantation development that incorporate a balance between trees, carbon and livestock, is known as 'silvopasture'.

2.1 Plantation expansion

Queensland is home to 41% of Australia's forests. The state has the largest area of forested land in the country, with 52.5 million hectares of native forests and 233,000 hectares of plantations. Most of Queensland's timber comes from mature softwood plantations dominated by exotic pine and complemented by native hoop pine (*Araucaria cunninghamii*). In Queensland, 96% of the plantation resource is owned by HQPlantations Pty Ltd. The other 4% of plantations are owned by several other private growers, mostly in the Southeast Queensland region.

The softwood plantation estate was principally developed by the Queensland government, with a steady increase in area since the 1950s and reaching over 170,000 hectares by the 1990s (Figure 1). Since the 1990s, the softwood plantation area has remained fairly static with a modest increase to 184,500 as at 2022 (ABARES, 2023).

In 2009, the entire government owned softwood and hardwood plantation estate was sold to HQPlantations.

This estate in southeast Queensland provides sustainable log volume that supports well-established processors who make timber for the building and landscape markets, as well as particleboard and medium density fibreboard (MDF) for domestic use. Research into genetics and silviculture have resulted in gains in tree form, branching habit, and growth, as well as a thorough knowledge of growth potential across a range of sites.

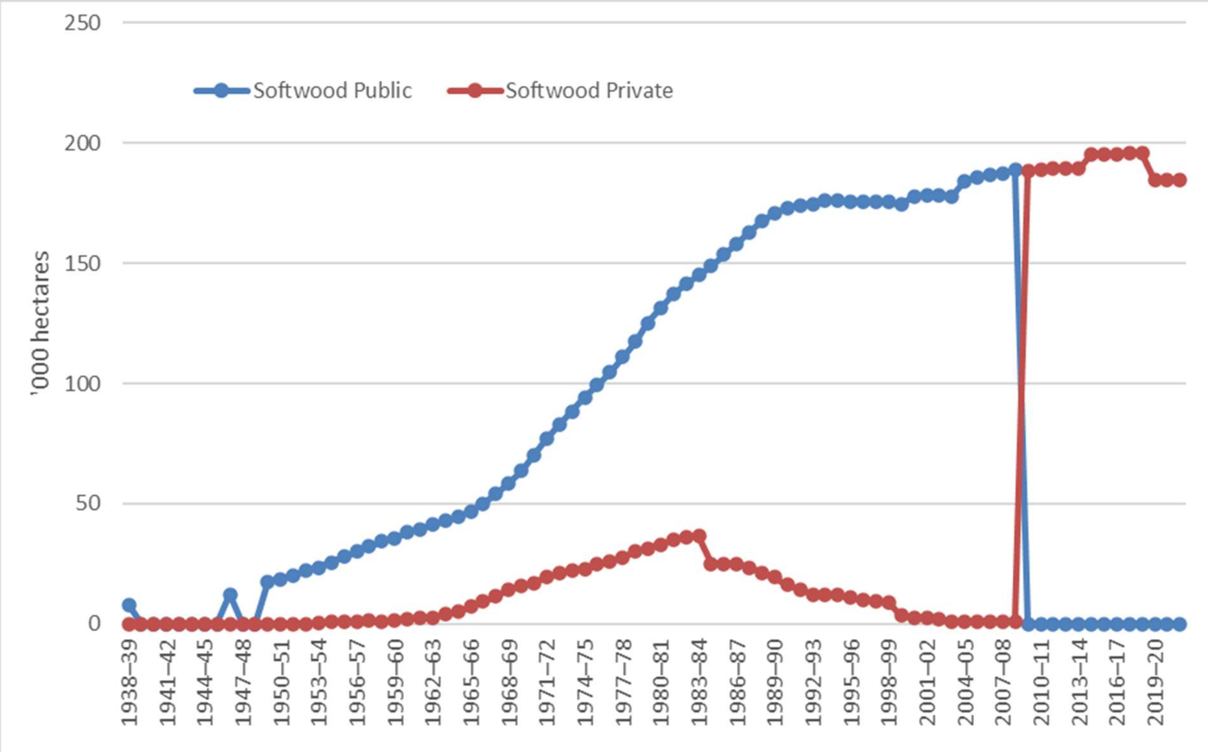

Figure 1 - Queensland softwood plantation area over time (ABARES, 2023)

In the early 1999, the Queensland government embarked on a hardwood plantation development program with the aim of supplementing the sawlogs from native forests. The program invested in research and purchased land for plantations. At the time planting commenced, large-scale native hardwood plantations were untested in Queensland. By the time of the sale of this estate to HQPlantations in 2009, 9,300 hectares had been planted (Queensland Department of Agriculture and Fisheries, 2020).

In addition to the government hardwood plantations, significant areas were being planted by a range of private companies who were primarily funded through Managed Investment Schemes (MIS) (Figure 2). These hardwood plantations were intended to be for short rotation woodchip and species were selected for their paper-making qualities, rather than for solid wood products.

From a peak hardwood plantation area of over 53,000 hectares in 2009, some significant plantation failures led to a reduction in area over the next decade (Figure 2).

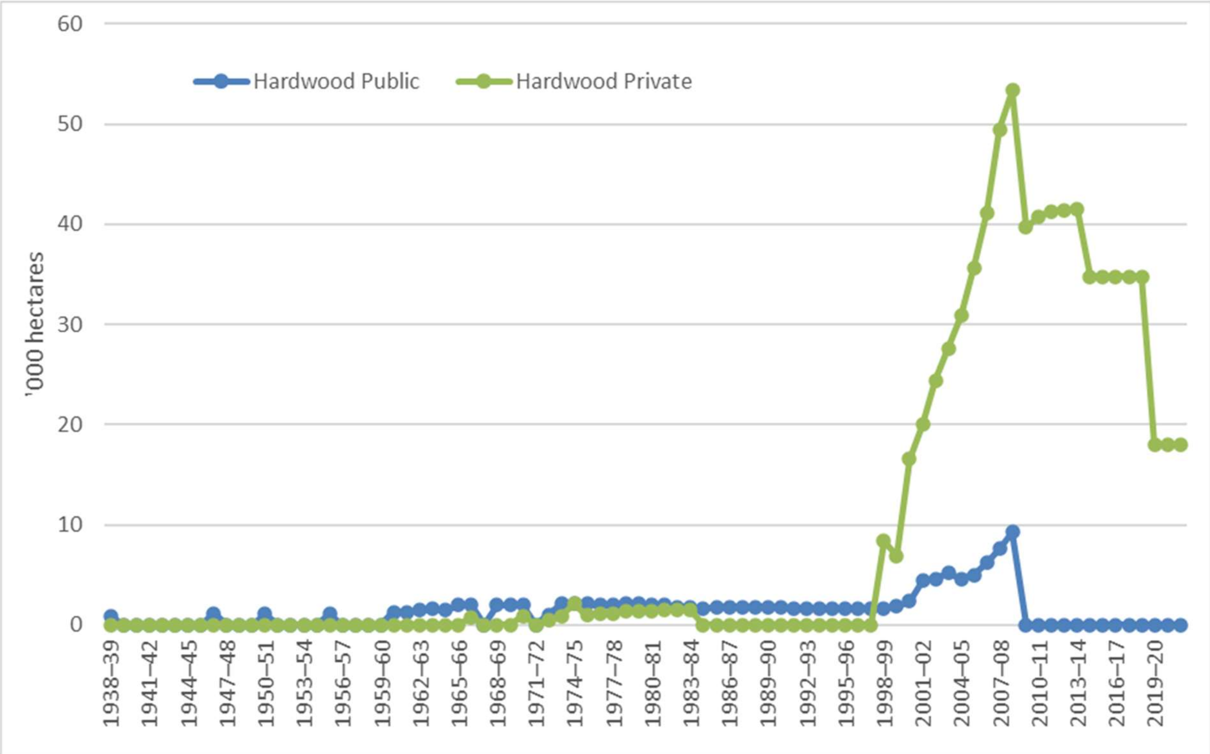

Figure 2 - Queensland hardwood plantation area over time

HQPlantations continued with expanding the hardwood plantation estate and had reached around 15,000 hectares by 2015 (Queensland Department of Agriculture and Fisheries, 2020). In 2015, an independent review of the hardwood plantation program was conducted, and it was evident that the hardwood plantation estate was not performing as expected, due to a combination of issues:

- Site selection was limited by available land at a suitable price.
- Sites typically had marginal soil quality and variable climatic conditions.
- Matching the right species to the right site proved challenging, with research benefits from improved plant genetics, including for insect and pest resilience, yet to be realised.

The combination of these issues resulted in poor growth rates, and it was clear that these plantations "would not deliver the alternative hardwood resource as intended" (Queensland Department of Agriculture and Fisheries, 2020).

2.2 Agricultural land evaluation

The most comprehensive study on land classification mapping and analysis of forestry plantations was conducted in the 1990's as part of the comprehensive regional assessment (CRA) of the southeast Queensland CRA Region. This region is a much smaller area than the Hub region and mostly matches the Southeast Queensland National Plantation Inventory Region (refer to Section 2.6.3).

The purpose of the study was to investigate the capability of land in southeast Queensland for the development of native and exotic plantations to supply a range of wood products (Queensland CRA/RFA Steering Committee, 1998).

The CRA project evaluated five plantation types:

- Hoop pine (a native softwood)
- Exotic Softwood (specifically the F1 hybrid of Caribbean and Slash pines)
- Spotted gum
- Queensland Western white gum
- a group of three native hardwoods (comprised of Blackbutt, Gympie messmate and Rose gum).

Soil suitability and rainfall were the key variables for determining plantation capability in the region. Soil suitability was determined through a workshop of experts as information for each species was limited at the time of the project. This information was overlaid spatially with an analysis of available land (this being cleared land greater than 10 ha with a slope of less than 25 degrees). The area estimate was divided between low value and high value land, high value land being that which was identified as being a cropping or pasture land use.

A key outcome from this project was the estimation of areas of plantation capability in southeast Queensland (Table 1).

Table 1- Estimation of areas of plantation capability in SE Queensland (Queensland CRA/RFA Steering Committee, 1998)

	Area in each Capability Class (ha)			
	High	Medium	Low	Unsuitable
Exotic softwood- specifically the F1 hybrid of Caribbean and Slash Ppines				
Low value cleared land	13,856	575,377	956,415	940,666
High value cleared land	873	74,707	72,141	88,855
Total	14,729	650,084	1,028,556	1,029,521
Hoop pine - Native softwoods				
Low value cleared land	43,475	523,737	726,540	1,192,562
High value cleared land	5,268	58,253	50,370	122,685
Total	48,743	581,990	776,910	1,315,247
Queensland Western white gum				
Low value cleared land	422,212	824,528	669,210	570,364
High value cleared land	42,522	85,067	38,691	70,296
Total	464,734	909,595	707,901	640,660
Spotted gum				
Low value cleared land	294,888	1,494,456	627,785	69,185
High value cleared land	26,173	147,393	54,117	8,893
Total	321,061	1,641,849	681,902	78,078
Blackbutt, Gympie messmate and Rose gum/Flooded gum				
Low value cleared land	535,201	59,910	750,701	1,140,502
High value cleared land	47,588	18,914	50,838	119,236
Total	582,789	78,824	801,539	1,259,738
All hardwoods (highest potential)				
Low value cleared land	871,427	1,233,155	329,535	52,197
High value cleared land	85,688	108,194	35,844	6,850
Total	957,115	1,341,349	365,379	59,047

In 2015, the Queensland government developed guidelines for undertaking agricultural land evaluation, including forestry plantations (DSITI & DNRM, 2015).

The guidelines describe land use limitations and five land suitability classes, with land suitability decreasing progressively from class 1 to class 5. Class 1 land is highly productive, requiring only simple management practices to maintain economic production, with minimal degradation to the land resource. Class 5 land has extreme limitations that preclude the possibility of successful sustained use of the land in the proposed manner.

Coupled with the guidelines, Queensland Globe[1] provides an online interactive ESRI-based tool to view Queensland's geographic information. This information includes fundamental natural resource datasets for soils, geology, slope drainage, as well as infrastructure and regulatory datasets (e.g. regulated vegetation) that is easily downloaded. This data helps to inform the limitations used for the land evaluation.

The Queensland Globe also includes an Agricultural Land Audit data layer (2012) which describes both current and future agricultural land uses. The layer identifies several agricultural classes including land suitable for forestry plantations. It is understood that the general criteria for potential plantation selection includes cleared land on slopes less than 25 degrees and excludes vertisol soils.

2.3 Market demand

The key driver for future investment in plantations lies in the demand for forest, timber, fibre, and environmental services. The total demand for forest products is comprised of regional, national, and international market segments and includes structural sawn timber, landscaping components, poles and roundwood, durable high-strength decorative timbers, engineered wood products, fibre for pulp and paper, feedstock for energy and oil for pharmaceutical and ceremonial products.

2.3.1 Domestic housing market

By 2050, Forest & Wood Products Australia (Woods & Houghton , 2022) predicts that Australia's population will reach between 34 to 40 million people with a new housing demand of around 259,000 dwellings annually. Softwood timber demand will rise to 6.5 million m^3 annually which is almost 2.0 million m^3 per annum higher than in 2021. However, softwood timber production will remain static at between 3.6 and 3.8 million m^3 annually as we reach Australia's current plantation estate yield limits.

[1] https://qldglobe.information.qld.gov.au

Forest & Wood Products Australia anticipates that the implied gap of 2.6 million m^3 per annum could be met by establishing 468,000 hectares of new plantations and by increasing Australia's timber import program. Whittle *et al* (2019), however suggests that under current market conditions, new plantation development is not economically viable. To develop new plantations, we will therefore need to develop new investment models that exploit a broader range of value opportunities. These investment models could include additional income through ecosystem service markets, or better utilisation of land through a broader awareness of the benefits of silvopasture.

2.3.2 Regional housing market

The Queensland Government released its draft Southeast Queensland Regional Plan in August 2023. This includes a plan for almost 900,000 new homes by 2046 to accommodate 2.2 million new residents across 12 regional councils (approximately 40,000 new homes each year).

Forest & Wood Products Australia (FWPA) in its 'Timber Usage in Residential Construction' project analysed around 4,500 building plans in the financial year 2018 and estimated that the use of timber in a home averaged 14.58 m^3 (FWPA, 2018). This implies that southeast Queensland will need to source 13,122,000 m^3 over the next 22 years for the planned 900,000 new homes, or an average 596,454 m^3 of sawn framing products per year.

The FWPA also provides statistics in relation to national demand for various timber products and states that the ratio of structural timber to landscaping timber is approximately 2.7 to 1.0, or 37%. Therefore, total framing consumption for new homes in southeast Queensland would approximate 817,140 m^3. This does not account for regions outside of southeast Queensland.

Table 2 presents an estimate of timber production outputs from southeast Queensland mills. Total production is estimated at ~ 395,000 m^3 which is clearly short of projected demands.

This is supported by ABARES data that suggests a total log supply in Queensland of ~ 2,000,000 m^3. At a recovery rate of 40%, this provides for 800,000 m^3, which potentially satisfies demand for southeast Queensland only. Given the mill's desire to increase their output, it is fair to state that demand will continue to outweigh supply.

Table 2- Southeast Queensland production estimations (internal sources)

Southeast Mill Type (Main product)	Timber Species	Approx. Sawlog Input (m^3/yr.)	Finished Product Recovery		MGP10+ recovery	
Framing	Southern pine	1,200,000	49%	588,000	60%	352,800
Industrial/Landscape	Southern pine	150,000	44%	66,000	20%	13,200
		1,350,000		654,000		366,000

2.4 Plantation species selection

Commercial species in southeast Queensland are well known. All four proposed tree species in this project are commercially important and feed a well-established market, mostly with both national and international demand. Figure 3 below displays the occurrence records for each of the species used in this report.

2.4.1 Hoop pine

Araucaria cunninghamii is a native conifer that is well-established in commercial plantations across southeast Queensland. This is due to its ecological flexibility and high-quality general-purpose softwood. The species' known distribution extends from far northern NSW all the way up to Cape York (Figure 3), (comprising primarily rainforest and rainforest edge habitat (Australian National Botanic Gardens , 2017). *A. cunninghamii* plantations in Queensland currently span around 44,000 ha, representing roughly 95% of global production of the species (Department of Agriculture, 2013a). *A. cunninghamii* achieves optimal performance under subtropical climates, where rainfall is > 750 mm per annum (ibid.). Mean Annual Increment (MAI) has the potential to reach 15 - 20 m^3/ha/year. The species is sensitive to fire (ibid.).

The timber of *A. cunninghamii* serves as structural plywood and particleboard in construction, furniture, joinery, and sawn wood and woodchip for export (Bootle, 2005). In Australia, the rotation age spans a minimum of 45 years (Crown & Kimberley, 2007). Branches shed naturally in closed stands but pruning of the butt log is considered essential for producing high-quality timber (ibid.).

2.4.2 Spotted gum

The group of (sub-)species jointly referred to as Spotted gum comprise *Corymbia citriodora subsp. variegata/citriodora* and hybrids. They represent the highest volume of native hardwood produced in Queensland (Department of Agriculture, FIsheries and Forestry, 2013b). They occupy primarily open forest habitats and are geographically distributed between southeast Queensland and southern NSW, including areas further inland (Figure 3). In Queensland, more than 10,000 ha of Spotted gum plantations have been established in the past 30 years (Department of Agriculture, FIsheries and Forestry, 2013b). The species is generally suitable for a range of soil types and rainfall regimes, but optimal conditions are reflected by deeper, moist, and well-drained soils (Private Forestry Service Queensland, 2011). *Corymbia spp.* tend to have low tolerance to frost (ibid.).

Corymbia spp. are associated with high-quality and high-durability timber employed in construction, landscaping, and pulpwood products. Under cultivation, timber properties have been shown to resemble those of wood from native forests (Department of Agriculture, FIsheries and Forestry, 2013b). The MAI of plantations in Southeast Queensland have been shown to average 4 m^3/ha/year, with up to 10 m^3/ha/year in the best provenances (ibid.). Plantations managed for timber production typically exhibit stocking rates of less than 200 trees/ha, and a rotation age of 20 - 40 years (Lewis, et al., 2010).

2.4.3 Gympie messmate

Eucalyptus cloeziana is a native hardwood species with excellent stem form and growth, particularly in the Gympie region (Department of Agriculture, FIsheries and Forestry , 2013c). It is scattered in distribution, primarily between Gympie and Cooktown (Figure 3), and currently comprises roughly 2,500 ha of plantation in Queensland (ibid). *E. cloeziana* is optimally suited for regions with higher rainfall (on average >700mm/year) and free-draining soils of moderate to high fertility. In its early establishment stage, it is relatively sensitive to drought (Department of Agriculture, FIsheries and Forestry , 2013c).

E. cloeziana timber has a well-established national market, with similar uses to Spotted gum. The rotation age ranges from 15 to >30 years, with younger wood typically useful for panels and veneers, and wood of 30+ years generally dedicated towards construction and appearance products. While productivity data for southeast Queensland could not be identified, the MAI derived for the Wide Bay and Burnett region ranges from 7 (average) to 10 (best provenances) m^3/ha/year (Department of Agriculture, FIsheries and Forestry , 2013c). Estimates of the projected plantation resource of *E. cloeziana* furthermore predicts a near-doubling of MAI between inland/northern plantations (~7.9 m^3/ha year) and southern, coastal plantations (~ 15m^3/ha/year) (Department of Agriculture, Fisheries and Forestry, 2015).

2.4.4 Southern pine

The Southern pine comprises a group of exotics, including Caribbean pine (*Pinus caribaea var. hondurensis*), Slash pine (*Pinus elliottii var. elliottii*) and a hybrid of the two. At present, around 148,000 ha of Southern pines are managed for timber production in Queensland (Figure 3). The species show optimal performance in sites where average rainfall exceeds 800 mm / year, while being tolerant of a broad range of soil conditions (Department of Agriculture, Fisheries and Forestry, 2013d). Young trees are relatively sensitive to fire, and Southern pine plantations more generally have shown low resilience to cyclonic winds (ibid.).

Southern pine wood is processed to sawn timber for building, joinery, furniture, plywood, other high value uses, posts and poles; residues used for paper, particleboard, and other panels. Typical growth of 10 - 20m^3/ha/year are seen on sites with better growth conditions (Department of Agriculture, Fisheries and Forestry, 2013d). In southeast Queensland, MAIs for Slash pine, Caribbean pine and their hybrids were even found to range between 17.6 and 23.7 m^3/ha/year (Dieters & Brawner, 2008). Rotation ages between 15 and 30 years have been suggested, and this spectrum involves a trade-off between reduced wind damage risk in shorter rotations and timber quality in longer ones (Keenan, Doley, & Lamb, 2005)

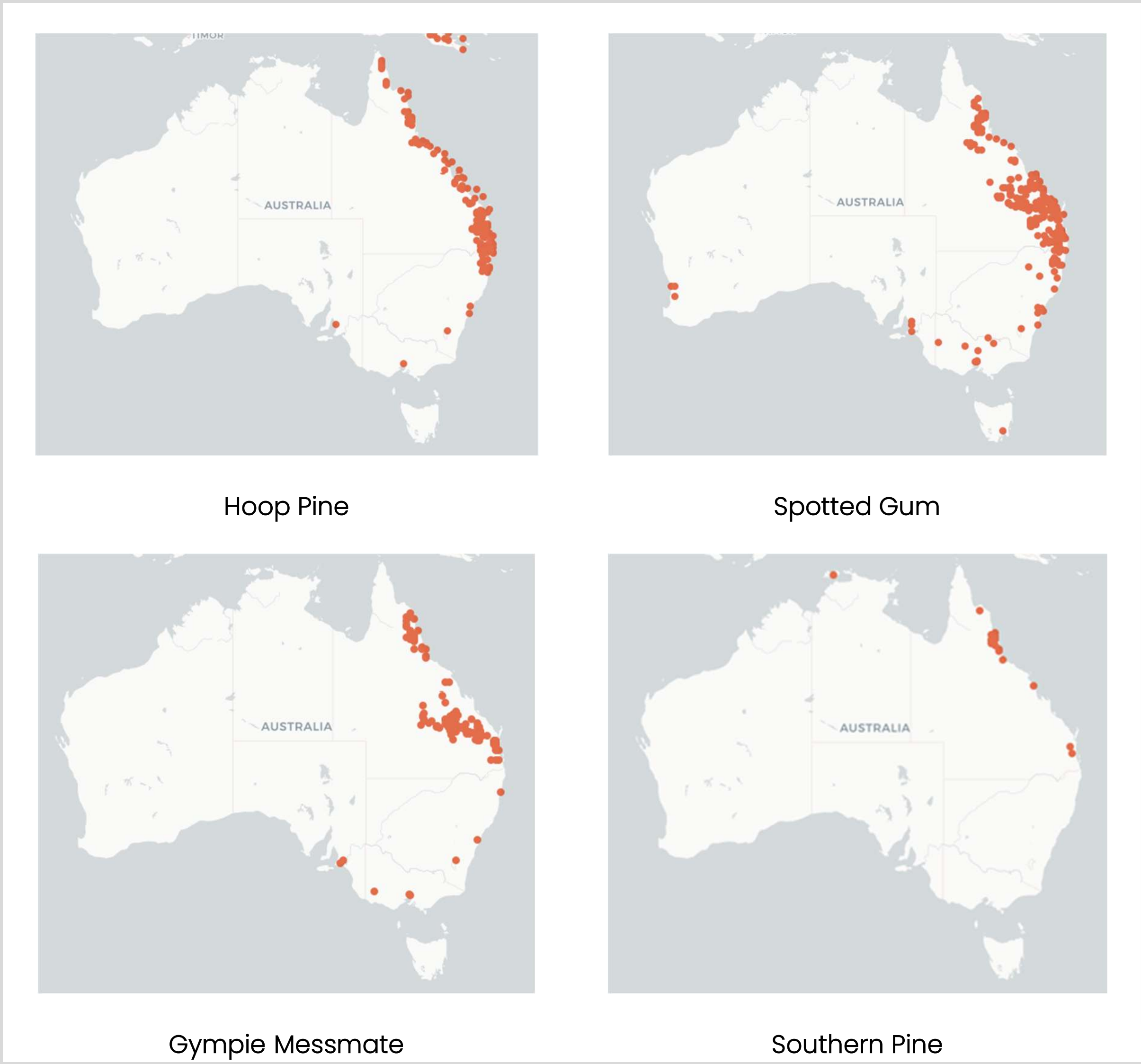

Figure 3- Occurrence records within Australia for the four species in this project (Atlas of Living Australia and Leaflet, 2023)

2.5 Investor models for plantation expansion

Bull & Keenan (2020) pointed out that:

- Australia's economy needs more wood.
- The environment needs more trees.
- Farmers are increasingly seeking income options that are integrated with their agricultural operations.
- investors are searching for reliable and sustainable sources of return on capital. Investors are searching for reliable and sustainable sources of return on capital.

This alignment in objectives seems to be highly favourable for plantation development.

2.5.1 Processor investment models

Processors seek long-term supply security at an economically viable scale and at market prices for strategic growth planning purposes. There are several advantages, including:

- Value addition
- Local economic impact
- Quality control
- Long-term sustainability
- Market demand
- Logistics and transportation optimisation

2.5.2 Carbon investment models

Carbon sequestration initiatives have the capacity to play a significant role in delivering a resilient and low-carbon future. New tree plantings can be established in agricultural landscapes to sequester carbon dioxide and help offset greenhouse gas emissions. There are several commercial offset companies who are operating in the regulated and voluntary carbon markets and selling credits. New tree plantings offer one of the most robust ways for the land use sector to offset greenhouse gas emissions because amounts of carbon sequestered are readily measurable and verifiable. The Clean Energy Regulator reported that the spot price for an Australian Carbon Credit Units ranged from $20, reaching a peak of $57 on 24 January 2022.

The Queensland Government supports carbon farming land management activities[2].

> *'Carbon farming land management activities seek to reduce anthropogenic carbon emissions or increase carbon sequestration in carbon sinks. Carbon farming can also provide landholders with a range of benefits such as increased natural capital and an alternate source of income.*
>
> *The Queensland Government has also committed to reducing emissions by at least 30 per cent on 2005 levels by 2030 and reaching zero net emissions by 2050.*
>
> *Due to its size and diverse natural ecology, Queensland is well positioned to generate carbon credits through carbon farming. There are already over 250 carbon farming projects in the state operating under the Federal Government's Emissions Reduction Fund (ERF).'*

2.5.3 Role of the Land Restoration Fund

The Land Restoration Fund (LRF) is growing the carbon farming industry in Queensland by supporting 'premium' land sector carbon farming projects that deliver Australian Carbon Credit Units (ACCUs) plus priority environmental, socio-economic and First Nations co-benefits[3]

> *'The LRF will support 'premium' land-sector carbon farming projects that deliver Australian Carbon Credit Units (ACCU's) plus priority environmental, social, economic and First Nations co-benefits.*
>
> *The LRF also makes investments in research, innovation, and development to grow environmental markets in Queensland, including the carbon farming market.'*

It is important for prospective investors in forestry plantations to undertake due diligence as to how their project might deliver carbon ACCU returns. The policy environment in this space has been very dynamic and quite complex over the last 10-20 years and partnering with or contracting a carbon specialist is highly recommended for those who do not have the time or capacity to make themselves fully informed of the requirements of both Federal and State government bodies who provide oversight and policy definition for these schemes.

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[2] *Carbon farming in Australia | Environment, land and water | Queensland Government (www.qld.gov.au)*

[3] *Carbon farming in Australia | Environment, land and water | Queensland Government (https://www.qld.gov.au/environment/climate/climate-change/land-restoration-fund/carbon-farming/australia).)*

2.6 Carbon

Carbon farming can enhance the economics of forestry plantations in several ways:

- Carbon credit income: carbon farming involves practices that sequester carbon dioxide from the atmosphere, such as afforestation (planting trees) and sustainable forest management. These activities can generate carbon credits, which can be sold on carbon markets or used to meet carbon reduction targets. Income from carbon credits can provide a significant revenue stream for new forestry plantations.
- Diversification of revenue: relying solely on timber sales can make forestry plantations vulnerable to fluctuations in timber prices and market demand. Carbon farming provides an additional source of income, diversifying revenue streams and reducing financial risk.
- Long-term revenue: many carbon farming projects involve long-term commitments, such as 25-year contracts. This long-term income stability can provide financial security and predictability for forestry plantation owners.
- Enhanced land value: carbon farming activities often improve soil health and ecosystem services, which can enhance the overall land value. This can be advantageous when selling or leasing the land.
- Access to grants and incentives: government programs and incentives may provide financial support for carbon farming projects in forestry plantations. These incentives can offset costs and increase profitability.
- Improved forest management: carbon farming often requires sustainable forest management practices, which can lead to healthier and more productive forests. Healthy forests are more resilient to pests, diseases, and natural disasters, reducing the risk of financial losses.
- Co-benefits for biodiversity: many carbon farming practices, such as maintaining forest buffers or conserving native vegetation, can have positive impacts on biodiversity. This can lead to opportunities for further payments and economic returns.
- Market access and reputation: carbon-conscious consumers and businesses may prefer products from forestry plantations engaged in carbon farming, providing market access, and enhancing the reputation of plantations within the Hub region.
- Job creation: expanding forestry operations to include carbon farming can create jobs in activities like tree planting, maintenance, and monitoring, benefiting local communities.
- Risk mitigation: climate change poses risks to forestry plantations, including increased susceptibility to bushfires, droughts, and pests. Carbon farming, in the long-term, can help mitigate these risks.

Although risk mitigation is a long-term potential outcome from carbon farming, there are also risks involved in establishing and growing a plantation. Such risks include losses from fire, drought, diseases and pests.

To effectively leverage carbon farming for economic benefit in forestry plantations, it's essential to understand the local regulatory framework, access technical expertise, and carefully plan and implement carbon farming practices while considering their long-term implications for the plantation.

2.6.1 Framework

The primary market mechanism for trading carbon in Australia is through the ACCU Scheme. Participation in the scheme may occur by individuals, sole traders, companies, local, state, and territory government entities. Project registration requires a high level of due diligence.

The Clean Energy Regulator administers the ACCU Scheme that includes the development of methodologies (Methods). Methods adhere to integrity standards that requires abatement to be additional, measurable, and verifiable. The methods set the rules for estimating emissions reductions from different activities. Understanding these rules is important in the context of this project and modelling the carbon potential from plantations.

Two ACCU vegetation methodologies enable timber production:

- Plantation Forestry (4 schedules)
    - Schedule 1 – Establishing a new plantation.
    - Schedule 2 – Converting an existing plantation from a short to long rotation.
    - Schedule 3 – Continuing plantation forestry activities.
    - Schedule 4 – Transition to a permanent (not-for-harvest) forest.
- Farm Forestry Plantations

Further information on the carbon farming framework is provided in Section 6.1.1.

The focus of modelling within this project is Plantation Forestry - Schedule 1. Carbon estimation under the Plantation Forestry method is conducted using the software modelling tool FullCAM 2016 (or Full Carbon Accounting Model). FullCAM provides a fully integrated estimate of carbon pools and emissions in forest and agricultural systems for Australia's land sector. Although there is a 2020 version of FullCAM, Plantation Forestry method carbon estimates must be done using FullCAM 2016. A new version of FullCAM is due for release with updated calibrations for plantation species outside NPI regions. Further detail on FullCAM is provided in the sections below.

2.6.2 ACCU calculations

The FullCAM model estimates the average amount of carbon the planting would sequester over a 100-year period. This average is used to determine the maximum number of ACCUs a project can accrue; projects cannot claim more than the 100- year average in ACCUs.

All vegetation carbon projects are subject to permanence obligations and these obligations run with the land. The project originator decides whether they wish to maintain permanence obligations for either 100 or 25 years when they register the project. The regulator does not allow changes to permanence choices once the project has been registered. The longer permanence timeframe enables a greater amount of ACCUs to be claimed, but also commits the land to this land use for 100 years.

The end of the permanence period is the end of the carbon project. Following this, the landowner has no further obligation to maintain trees on their land.

A series of discounts are applied to the planting to account for the project having a shorter permanence period of 25 years (-20%) and the risk of reversal that applies to all projects (- 5%).

Disturbances such as fire, drought, disease or damage by pests may reduce carbon stocks. If these occur, the project manager is obliged to notify the CER and report on the area impacted. If ACCUs have been issued, and the estimated carbon stock following the event is below the amount issued, no further ACCUs can be issued until the carbon stocks in the plantation reach the level prior to the disturbance.

For this project, all carbon mapping estimates are based on a 100-year permanence period and the economic modelling is based on a 25-year permanence.

2.6.3 National Plantation Inventory Regions

There are 15 National Plantation Inventory regions in Australia (NPI regions) based on species, management, and wood flow characteristics (Figure 4). Three NPI regions occur within the Hub:

- Southeast Queensland
- Northern Queensland (only the most southern end)
- Northern Tablelands (only the most northern end).

These NPI regions do not cover the whole Hub region. The Department of Agriculture, Fisheries and Forestry (ABARES) collects data and reports on plantations established primarily for timber production within these NPI regions, where most plantations occur. This data has been collected since 1993 and is included in FullCAM. This means the information required to inform the carbon farming modelling exists within NPI regions but is limited elsewhere.

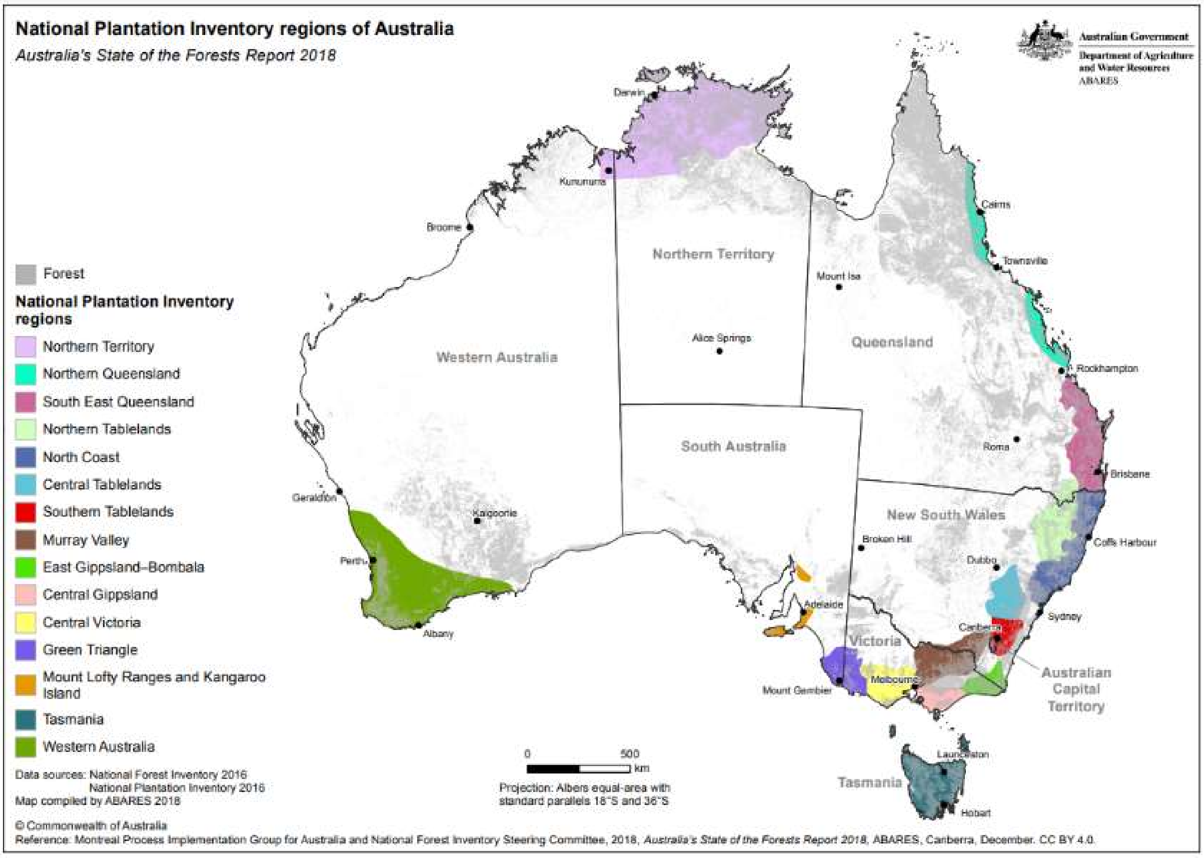

Figure 4- National Plantation Inventory Areas

The applied version of FullCAM (released in 2016) embeds several parameters for predicting the growth of a wide range of commercial plantation species within the NPI regions, with specific settings to recognise the regional differences in growth rates and management systems.

Under the carbon farming plantation methodology, Schedule 1 projects can occur inside and outside the NPI regions. However, when outside the NPI, data for species modelling requires the use of specific settings under the Environmental Planting Method. The result of this is that there is a conservative estimate of carbon sequestration in areas outside the NPI regions.

2.7 Silvopasture

Silvopasture refers to the integration of trees and livestock on pasture for the provision of various benefits including environmental services, animal wellbeing, as well as promoting diversification and resilience of the farm economy. It is a land use strategy that can provide pronounced value to Australian agriculture given the pressure on this sector to reduce its contribution to greenhouse gas emissions (IPCC, 2000), and a decline of >10% in forest plantation area across the country since 2012 (Legg, Frakes, & Gavran, 2021). Furthermore, with the timber available from public native forests set out to continuously decline in future years, silvopastoral systems (hereafter SPS) on private land may be critical in securing domestic timber supply.

Overall, numerous environmental and socio-economic advantages have been documented in the Australian and international scientific literature. SPS have been shown to enhance soil and water quality, promote biodiversity conservation and play a vital role in boosting carbon sequestration of the land (Smith, 2022) (Shrestha & Alavalapati, 2004). Considering that many areas in eastern Queensland exhibit some decline in pasture condition (e.g., loss of topsoil) and would naturally exhibit some tree growth, SPS appears an obvious solution for land rehabilitation (Lewis, et al., 2010).

While silvopastures do require lower stocking of both grazers and trees compared with pure systems of either type, SPS have repeatedly demonstrated to be financially attractive in the Southeast Queensland context (Francis B. , Venn, Lewis, & Browner, 2022), (Maraseni, Cockfield, & Maroulis, 2009). In fact, Francis et al. (2022) showed SPS with silvicultural treatments (thinning) to outperform other scenarios, with forest clearing for grazing associated with the worst economic performance over a 20-year period. In addition to timber sales, even modest carbon prices can prove financially worthwhile for graziers in Australia (Donaghy, et al., 2010). Nonetheless, high upfront costs and long payback periods must be addressed in incentivising greater adoption of SPS among graziers.

From a livestock performance perspective, SPS have been linked with reduced heat stress of livestock, and more even utilization and longer grazing hours on pastures with mature trees of the *Pinus* genus in the eastern US (Karki, 2008). Indeed, this has been a key motivation for graziers in the United States to adopt SPS (Orefice, Carroll, & Ketner, 2017).

3. Plantation suitability analysis

Plantation suitability analysis involved the identification of aspects to land availability for plantation establishment across the Hub region. This review came up with three key focal groups that helped define and limit suitable land for plantation establishment. These are:

- Biophysical parameters for suitable plantation growth
- Physical constraints that restrict plantation location
- Land exclusions, landuse and other considerations.

These three broad focal groups are explored in the following sections.

A full data list and available online open data resources are provided in Appendix A.

3.1 Biophysical parameters

3.1.1 Land suitability assessment - approach

For Queensland there is an established suitability framework for multiple primary production systems. The Regional Land Suitability Frameworks for Queensland (Department of NRM QLD, 2013) sets out, for various regions across Queensland, biophysical parameters, their limitations and ranges, and how to establish various classes for particular primary production systems of concern.

Biophysical parameters are principally concerned with climatic variables, landscape factors and soil or geological types. The approach adopted includes a suitability analysis for the establishment of commercial forestry plantations. Suitability analysis is defined as the process of determining the fitness, or the appropriateness, of a given area of land for a specified use. It provides a rational basis for the most favourable utilisation of land resources and land use planning.

Under the Regional Land Suitability Framework there are multiple components considered for plantation species. These are outlined in Table 3.

Table 3- Biophysical components for suitability analysis as outlined by the Queensland Regional Land Suitability Framework

Landuse requirements	Limitations	Soil and landuse attributes used to assess each limitation
Frost-free	Frost	Frequency of damaging frosts, landform, landscape position.
Adequate rainfall (non-irrigated crops only)	Precipitation	Amount and distribution of rainfall, evaporation, crop modelling.
Minimise soil loss from subsoil (from water erosion)	Subsoil erosion	Soil classification, depth to B horizon, B horizon dispersion, Exchangeable sodium percentage of B horizon, electrical conductivity, CEC and Ca/Mg ratio of B horizon
Avoid environmental harm from acid drainage water from actual acidity	Acid drainage water hazard actual	Depth to actual existing acidity (pH<4.0), soil texture.
Avoid environmental harm from acid drainage water from potential acidity	Acid drainage water hazard potential	Depth to potential acidity, depth to oxidisable sulphur above %S threshold, soil texture.
Minimise soil loss from erosion	Water erosion	Soil susceptibility to erosion, slope, soil stability group, erodibility factor (K factor).
Absence of damaging floods	Flooding	Frequency of flooding (recurrence interval – ARI).
Adequate water supply	Soil water availability	Plant Availability Water Capacity
Adequate nutrients	Nutrient deficiency	Level of Phosphorous (P) in top 0.3m of soils.
Low levels of toxic elements	Element toxicity	pH at the soil surface (<0.3m) and pH at 0.6m depth.
Adequate soil depth for physical support	Soil depth	Depth to C horizon, hard rock or other impermeable layer.
Ease of seedbed preparation and plant establishment	Soil surface condition	Surface (<0.3m) physical condition, texture, structure.
Rock-free	Rockiness	Size and content (%) of coarse fragments, % rock outcrop.
Favourable levels of soluble salts	Soil salinity	Saturated extract conductivity (dS/m ECse) of the top 0-0.1m of soil.
Level land surface	Microrelief	Height of microrelief vertical interval.
Land surface of acceptable slope	Topography	Slope (%)
Adequate soil aeration	Wetness	Soil drainage and permeability, height of underground water table.
Adequate land area available for efficient production	Landscape complexity	Minimum area of contiguous suitable soil available for crop production.

These components can be divided into three broad categories that are relevant for plantation establishment.

- Climate
- Soil type and geological structure
- Landscape

Initial scoping by the Project Team determined which biophysical parameters were most important to plantation establishment, as well as defining the bands or zones within each parameter to identify ideal and less than ideal suitability for plantations.

From this full list as outlined in the Framework, the project team assessed each for its relevancy in the Hub and also against spatial data availability. Four components were not included in the subsequent analysis:

- Minimise soil loss from subsoil (from water erosion) - This was excluded due to a lack of consistent and available spatial data for the Hub.
- Ease of seedbed preparation and plant establishment - This was excluded due to expert review deeming this unnecessary for this run of the suitability framework.
- Favourable levels of soluble salts - This was excluded due to a lack of consistent and available spatial data for the South & Central Queensland Forestry Hub.
- Level land surface - This was excluded due to expert review deeming this unnecessary for this run of the suitability framework.

The remaining components were inputted into a most limiting factor overlay model that defined grades of areas (e.g., low to high) where plantations can grow. The Regional Land Suitability Framework (Department of NRM QLD, 2013) establishes five key categories to define suitability in Queensland.

For use in this framework application, the original five classes were used but with a slightly differing naming convention. This system was applied once all factors were combined in a final suitability calculation. This aligns more so with plantation establishment, growth and management interventions at critical stages. When looking at management interventions in these classifications, these are referring to active management of the land, not the tree, to ensure adequate suitability for establishment and growth.

- Class 1 – Ideal – Suitable land with negligible limitations to plantation establishment and productivity.
- Class 2 – Good – Suitable land with minor limitations to plantation establishment and productivity.
- Class 3 – Moderate – Suitable land with moderate limitations to plantation establishment and productivity.
- Class 4 – Poor – Marginal land, which can be considered unsuitable due to limitations to plantation growth and establishment.

- Class 5 – Unsuitable – Unsuitable land with extreme limitations that preclude its use in its current form for plantation growth and establishment.

Within the Framework, each biophysical component is scored against these five classes. The input spatial data is classified by various methods which are outlined in the following sections.

3.1.2 Climate

Of the climatic inputs, the following were determined as the most influential on plantation suitability:

- Adequate rainfall
- Frost-free

Current baseline climate

Data from the Bureau of Meteorology was used for these variables. For rainfall, the average annual rainfall map[4] was used. The dataset is average total annual rainfall for the years between 1991 and 2020. It presents climatic variables as a continuous surface at a $5km^2$ spatial resolution.

For frost days, the annual potential frost day map[5] was used. This is an average of total annual frost days, for certain degree thresholds, for the years between 1976 and 2005. It presents climatic variables as a continuous surface at a $5km^2$ spatial resolution.

Categorisation

These two parameters for the 2010 to 2019 period were collated and averaged to form a single gridded ($5km^2$ resolution) output. These outputs were then classified into (at most) the five-class system from very poor to ideal. For example, the 850mm total annual rainfall was considered a key threshold. Anything below this level was less suitable for commercial plantations, whereas above this, in increasing bands, was increasingly more ideal. The categories for these are presented in Table 4 and Table 5.

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[4] *Average annual, seasonal and monthly rainfall maps* - http://www.bom.gov.au/climate/maps/averages/rainfall/

[5] *Annual and monthly potential frost days* - http://www.bom.gov.au/climate/maps/averages/frost/

Table 4- Total annual rainfall categories by class for each species

Mean annual rainfall	Hoop pine	Gympie messmate	Spotted gum	Southern pine
> 1500mm	1	1	1	1
> 1200 to 1500mm	2	2	1	2
> 1000 to 1200mm	3	3	1	3
> 850 to 1000mm	4	4	2	4
<850mm	5	5	3	5

Table 5- Number of days below frost temperature by class for each species

Frost	Hoop pine	Gympie messmate	Spotted gum	Southern pine
Frost free or occasional light frost >-1°C (<3 events per year)	1	1	1	1
Regular light frosts (>/= 3 events per year) over winter months only (>-1°C)	1	3	4	1
Regular light frosts over late autumn and early spring (>-1°C)	1	3	4	3
Regular moderate frosts (>/= 3 events per year) over winter months only (-1°C to -4°C)	1	4	5	4
Regular severe frosts (>/= 3 events per year) over winter months only (<-4°C)	2	5	5	5

3.1.3 Soil type and geological structure

For classification of soils in the Hub, various data sources were used. This included the use of the Australian Soil and Landscape soils grids, and available data within the Queensland Government open data platform. These are outlined in Appendix A and under each relevant section.

The following sections provide details about each soil component as listed in Table 3..

Acid drainage water hazard actual and potential

As outlined in the Regional Suitability Framework, acid drainage water hazard (actual and potential) are used to avoid environmental harm from acid drainage water from actual acidity. Toxic quantities of heavy metals may contaminate land and adjacent waterways when acid sulphate soils are disturbed or drained.

This is of particular concern in these actual and potential acid soil areas where flooding can 'activate' sulphates in the soil profile. Acid sulphate soils create a leachate risk exposure when soil cultivation/excavation exposes iron pyrites to atmospheric oxygen. Acid sulphate soils are limited to coastal and ancient marine landscapes.

In the Hub region, there are several studies for particular regions prone to flooding, but this is not consistent across the Hub and is dispersed through multiple studies and spatial datasets. For the application of the suitability framework, we used elevational profiles as an indicator of potential acid sulphate soils; very low elevation equates to high acid soils which are not suitable for commercial plantations. The elevation data has been sourced from the Queensland Government open data platform, QSpatial.

Soils are classified for acid drainage water hazard (actual and potential) suitability in Table 6.

Table 6- Soils classification for acid drainage water hazard (actual and potential) suitability

Elevation	Hoop pine	Gympie messmate	Spotted gum	Southern pine
>= 5m	1	1	1	1
1 - 5m	3	3	3	3
<1m	5	5	5	5

Water erosion

Water erosion relates to soil susceptibility to erosion, slope, soil stability group and a defined erodibility factor. Soil erosion can lead to land degradation and productivity declines on unprotected arable land.

In the suitability framework, four soil stability categories are defined:

1. Very stable soils
2. Stable soils
3. Unstable soils
4. Very unstable soils

These have been classified for water erosion and soil stability suitability in Table 7. Spatial data to support this classification has been sourced from the Queensland Government open data platform, QSpatial, for the soil stability, K factors and slope ranges.

Table 7- Soils classification for stability and slope

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
Very stable soils; K factor <0.05 & slope range <2%	1	1	1	1
Very stable soils; K factor <0.05 & slope range 2-5%	1	1	1	1
Very stable soils; K factor <0.05 & slope range 5– 8%	2	1	2	1
Very stable soils; K factor <0.05 & slope range 8-12%	2	1	2	1

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
Very stable soils; K factor <0.05 & slope range 12-15%	3	1	3	2
Very stable soils; K factor <0.05 & slope range 15-20%	3	2	3	3
Very stable soils; K factor <0.05 & slope range 20-25%	5	3	5	4
Very stable soils; K factor <0.05 & slope range >25%	5	5	5	5
Stable soils; K factor <0.05 & slope range <2%	1	1	1	1
Stable soils; K factor <0.05 & slope range >2-5 %	1	1	1	1
Stable soils; K factor <0.05 & slope range 5–8%	2	1	2	1
Stable soils; K factor <0.05 & slope range 8-12%	3	1	3	1
Stable soils; K factor <0.05 & slope range 1215%slope	3	1	3	2
Stable soils; K factor <0.05 & slope range 15-20%	4	2	4	3
Stable soils; K factor <0.05 & slope range >20-25%	5	3	5	3
Stable soils; K factor <0.05 & slope range >25%	5	4	5	4
Unstable soils; K factor 0.05 – 0.07 & slope range <2%	1	1	1	1
Unstable soils; K factor 0.05 – 0.07 & slope range >2-5%	2	1	2	1
Unstable soils; K factor 0.05 – 0.07 & slope range 5–8%	2	1	2	1
Unstable soils; K factor 0.05 – 0.07 & slope range 812%	3	1	3	1
Unstable soils; K factor 0.05 – 0.07 & slope range 12-15%	4	1	4	2
Unstable soils; K factor 0.05 – 0.07 & slope range 15-20%	4	2	4	3
Unstable soils; K factor 0.05 – 0.07 & slope range 20-25%	5	4	5	4
Unstable soils; K factor 0.05 – 0.07 & slope range >25%	5	4	5	4
Very unstable soils; K factor > 0.07 & slope range <2%	1	4	1	4
Very unstable soils; K factor > 0.07 & slope range 2 – 5%	2	1	2	1

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
Very unstable soils; K factor > 0.07 & slope range 5 – 8%	3	1	3	1
Very unstable soils; K factor > 0.07 & slope range 8 – 12%	3	1	3	1
Very unstable soils; K factor > 0.07 & slope range 12 – 15%	4	1	4	2
Very unstable soils; K factor > 0.07 & slope range 15 – 20%	5	2	5	3
Very unstable soils; K factor > 0.07 & slope range 20 - 25%	5	3	5	4
Very unstable soils; K factor > 0.07 & slope range >25%	5	4	5	5

Flooding

This suitability component details the presence or absence of damaging floods in the Hub region. As detailed in the suitability framework, effects of flooding include:

- yield reduction or plant death
- physical removal or damage of the trees
- floodplain erosion
- damage to infrastructure.

There is a paucity of spatial data in the Hub region for this variable. For full application in the framework, varying frequency of flooding or Annual Recurrence Interval (ARI) datasets (i.e., 1 in 5 year or 1 in 20 year) is required.

The only availability of flooding data at a consistent scale across the region are 1 in 100-year ARI extents. This has been sourced from the Queensland Government open data platform, QSpatial.

For application in this framework, a binary presence or absence scale is used for all species, as outlined in Table 8.

Table 8- Soils classification for flooding suitability (1 in 100 year ARI)

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
No Flooding	1	1	1	1
Flooding	3	3	3	3

Soil water availability

The measurement of adequate water supply for plantation establishment and growth is detailed through soil Plant Availability Water Capacity (PAWC). This is mainly of concern for rain-fed systems where limited water can stress the plant and inhibit growth, particularly during critical growth periods. The spatial data to determine PAWC was supplied through the Soil and Landscape Grid of Australia[6] (2023) and the Available Water Capacity percentage for varying depth increments.

For use in this application of the suitability framework soils have been classified for PAWC suitability as outlined in Table 9.

Table 9- Soils classification for plant availability water capacity (PAWC) suitability

PAWC	Hoop pine	Gympie messmate	Spotted gum	Southern pine
>150mm	1	1	1	1
125-150mm	1	1	1	1
100-125mm	1	1	1	1
75-100mm	1	2	1	1
50-75mm	2	3	2	2
<50mm	3	4	3	3

Nutrient deficiency

In the Regional Suitability Framework for Queensland, a main limiting factor in terms of nutrient supply for primary production was levels of phosphorous (P) in the soil profile. Fertiliser management can mitigate this deficiency in agricultural systems. For example, Queensland exotic and native softwood greenfield plantation establishment has been historically managed for nitrogen and phosphorus through the application of 200-250kg/ha MAP. Recently the major commercial grower has abandoned P application in 2R & 3R arguing that there is sufficient P in the profile from original applications.

The spatial data to determine levels of P was supplied through the Soil and Landscape Grid of Australia[7] (2023) and the percentage mass fraction of total P in the soil by weight for varying depth increments. For use in this application, soils have been classified for levels of P in the top 0.3m of the soil profile as outlined in Table 10.

[6] *Soil and Landscape Grid of Australia - https://esoil.io/TERNLandscapes/Public/Pages/SLGA/ProductDetails-SoilAttributes.html*

[7] *Soil and Landscape Grid of Australia - https://esoil.io/TERNLandscapes/Public/Pages/SLGA/ProductDetails-SoilAttributes.html*

Table 10- Soils classification for nutrient deficiency suitability

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
P >20ppm	1	1	1	1
P 10-20ppm	2	2	2	2
P 5-10ppm	2	2	2	2
P <5ppm	3	3	3	3

Element toxicity

For application in the framework, element toxicity relates to the oversupply or excessive level of some mineral nutrients, mainly where soil pH is very low. This can be throughout the soil profile but can be divided into surface soil and subsoil toxicity. To measure this, pH levels are used at varying depth increments, as supplied by the Soil and Landscape Grid of Australia[8] (2023) utilising the pH level product.

For use in this application of the suitability framework, soils have been classified for pH levels of in the top 0.3m of the soil profile and at 0.6m, as outlined in Table 11.

Table 11- Soils classification for element toxicity suitability

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
Surface soil (0-0.3m) pH >5.0.	1	1	1	1
Soil pH at 0.6m >5.0.	1	1	1	1
Surface soil (0-0.3m) pH <5.0.	3	3	3	3
Soil pH at 0.6m <5.0.	3	3	3	3

Soil depth

In the establishment and growth of plantations there is a requirement for adequate soil depth (1,000-1,200mm) for physical support of the plant. Shallow soils can prevent suitable root anchorage leading to poor growth and physical damage, i.e., uprooting during strong winds.

[8] *Soil and Landscape Grid of Australia* - https://esoil.io/TERNLandscapes/Public/Pages/SLGA/ProductDetails-SoilAttributes.html

The spatial data to determine soil depth was supplied through the Soil and Landscape Grid of Australia[9] (2023) utilising the depth of soil profile product.

For use in this application of the suitability framework, soils have been classified for soil depth suitability as outlined in Table 12.

Table 12- Soils classification for soil depth suitability

Soil depth (m)	Hoop pine	Gympie messmate	Spotted gum	Southern pine
> 1.0	1	1	1	1
0.5 - 1.0	2	2	2	2
0.3 - 0.5	3	3	3	3
< 0.3	4	4	4	4

Rockiness

Large coarse fragments, such as rocks, pebbles, gravel and other fragments, in the soil profile can cause a range of problems. In typical agricultural systems, this can be in relation to infrastructure and equipment hazards. But in plantations, coarse fragments can cause root zone disruptions, on top of interference with machinery if the soil profile is disturbed.

In the suitability framework the size and content (%) of coarse fragments and percentage of rock outcrops is measured and classified. The spatial data to determine coarse fragments was supplied through the Soil and Landscape Grid of Australia[10] (2023) utilising the proportion of coarse fragments size class.

For use in this application of the suitability framework, soils have been classified for rockiness suitability as outlined in Table 13.

Table 13- Soils classification for plant availability water capacity suitability

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
No rock.	1	1	1	1
2-6mm (fine gravel) 2-10%.	1	1	1	1
2-6mm (fine gravel) 10-20%.	1	1	1	1
2-6mm (fine gravel) 20-50%.	1	2	2	1
2-6mm (fine gravel) >50%.	2	3	3	2
6-20mm (medium gravel) 2-10%.	1	1	1	1

[9] *Soil and Landscape Grid of Australia - https://esoil.io/TERNLandscapes/Public/Pages/SLGA/ProductDetails-SoilAttributes.html*

[10] *Soil and Landscape Grid of Australia - https://esoil.io/TERNLandscapes/Public/Pages/SLGA/ProductDetails-SoilAttributes.html*

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
6-20mm (medium gravel) 10-20%.	1	1	1	1
6-20mm (medium gravel) 20-50%.	1	2	2	1
6-20mm (medium gravel) >50%.	2	2	2	1
20-60mm (coarse gravel) <2%.	1	1	1	1
20-60mm (coarse gravel) 2-10%.	1	1	1	1
20-60mm (coarse gravel) 10-20%.	1	2	2	1
20-60mm (coarse gravel) 20-50%.	2	2	2	2
20-60mm (coarse gravel) >50%.	3	3	3	3
60-200mm (cobbles) <2%.	1	1	1	1
60-200mm (cobbles) 2-10%.	1	1	1	2
60-200mm (cobbles) 10-20%.	2	2	2	3
60-200mm (cobbles) 20-50%.	2	2	2	4
60-200mm (cobbles) >50%.	3	3	3	5
200-600mm (stones) <2%.	1	1	1	2
200-600mm (stones) 2-10%.	2	2	2	3
200-600mm (stones) 10-20%.	3	3	3	4
200-600mm (stones) 20-50%.	4	4	4	5
200-600mm (stones) >50%.	4	4	4	5
>600mm or rock outcrop (boulders) <2%.	2	2	2	3
>600mm or rock outcrop (boulders) 2-10%.	3	3	3	4
>600mm or rock outcrop (boulders) 10-20%.	4	4	4	5
>600mm or rock outcrop (boulders) 20-50%.	5	5	5	5
>600mm or rock outcrop (boulders) >50%.	5	5	5	5

Wetness

The wetness of the soil profile relates to soil drainage, permeability, and potential depth of underground water table. As it relates to soil suitability for primary production, waterlogged soils restrict soil aeration and, for certain species, can restrict plant growth. In general terms soil wetness can limit access to the site and use of equipment.

For use in this application of the suitability framework, wetness or permeability of the soil profile was unable to be sourced as a spatial dataset. However, from expert review and discussion it was decided to use the Vertosol soil classification category from the Australian Soil Classification. These soil types generally relate to heavy clay or cracking soils that can become waterlogged in certain areas. Additionally, due to the swelling and shrinking properties of Vertosols, there is potential for 'root shear' which severely hampers tree development.

For use in this application of the suitability framework, soils have been classified for wetness suitability as outlined in Table 14.

Table 14- Soils classification for wetness suitability

Category	Hoop pine	Gympie messmate	Spotted gum	Southern pine
Non Vertosol	1	1	1	1
Vertosol	4	4	4	4

3.1.4 Landscape

In the Regional Suitability Framework for Queensland, for plantations, there are two key landscape components that are used and mapped. These include:

- Topography
- Landscape complexity

Topography

The use of this component in the framework refers to the percentage slope of the land surface and how it is classified into divisions of acceptable slope. Percentage slope relates to the gradient of the landscape as a ratio of its rise over run. When referring to a 100% slope, this is a slope that has a 45-degree angle from being flat.

Steeper slopes can limit access to site for establishment, maintenance, and harvesting. Additionally, slope is an indicator of greater erodibility.

For use in the framework, a Digital Elevation Model (DEM) has been used to calculate slope with a GIS platform. The DEM layer has been sourced from the Queensland Government open data platform for use in this project.

It should be noted that slope is applied directly here through the DEM, but this layer has been leveraged in other suitability components.

In this application of the suitability framework, slope has been classified for topography suitability as outlined in Table 15.

Table 15- Landscape classification for topography suitability

Slope	Hoop pine	Gympie messmate	Spotted gumgum	Southern pine
<5%	1	1	1	1
5 - 8%	1	1	1	1
8 - 12%	1	1	1	1
12 - 15%	2	1	1	1
15 - 20%	2	1	1	2
20 - 30%	3	2	2	3
>30%	3	3	3	5

Minimum production area

The minimum production area relates to the smallest practical land area for specific land uses within a parcel. In the context of this framework, it represents the measurement of the smallest contiguous piece of suitable land available for production. This factor also considers the economic feasibility of utilising a given land unit.

A parcel cadastre layer is used to help define boundaries for a minimum production area. From the Queensland Government open data platform, a Lot/Plan layer has been sourced and areas are calculated for each unit.

In this application of the suitability framework land parcels have been classified for landscape complexity suitability as outlined in Table 16. For the purpose of this project, each land parcel was considered to have a unique owner, i.e., there was no assumption that adjoining land parcels may be owned by the same party. Further discussion on property size and economies of scale is provided in Section 3.2.6.

Table 16- Area classification for landscape complexity

Minimum practical production area	Hoop pine	Gympie messmate	Spotted gum	Southern pine
>10ha	1	1	1	1
5-10ha	3	3	3	3
1.5-5ha	4	4	4	4
<1.5ha	5	5	5	5

3.2 Land exclusions

The next phase of land suitability assessment consisted of defining land exclusions; barriers within the Hub region that block or limit where plantations can be established. This section is limited to factors that fully prohibit plantation establishment. There are other factors that may or may not exclude plantations depending on specific permit requirements.

A comprehensive list of important barriers to plantation establishment in southeast Queensland was reviewed by the Project Team, including:

- Regulated vegetation management overlays
- Current landuse and tenure
- Existing plantations
- Existing forested areas

3.2.2 Regulated vegetation management overlays

In Queensland, the Vegetation Management Act 1999 in conjunction with the *Planning Act 2016,* regulates the clearing of vegetation. To map and define where and to what scale clearing can occur, a series of Codes have been applied statewide and spatially represented.

The Codes outline requirements for clearing vegetation for particular purposes and to achieve desired environmental outcomes. Each accepted development vegetation clearing Code describes the scope of the activities covered by that code and prescribes the clearing requirements, as well as other various stipulations.

Regulated vegetation management maps and the associated spatial data show the different vegetation categories that are present in Queensland. This information helps determine the type of approval needed for vegetation clearing.

- Category A area - vegetation that is subject to compliance notices, offsets and voluntary declarations.
- Category B area - remnant vegetation shown on a regional ecosystem or remnant map as an endangered regional ecosystem, an of concern regional ecosystem or a least concern regional ecosystem.
- Category C area - high-value regrowth vegetation
- Category R area - regrowth watercourse area
- Category X area - vegetation that is generally exempt from requirements under vegetation management laws.

As used in this analysis, Category X is the most relevant for application. All other areas outside this category are excluded from any area summation and further consideration.

The spatial representation has been sourced from the QSpatial open data platform.

3.2.3 Landuse - tenure and existing uses

The 'Tenure and Existing Uses' spatial layer was sourced from the QSpatial open spatial data platform, under the Australian Landuse and Management layer (ALUM). Within the ALUM spatial layer, 'landuse' means the purpose to which the land cover is committed for the property type. For each property within the Hub region, a landuse is defined.

Landuse is classified into a six-class system under a three-tier hierarchy. The six classes include:

- Conservation and natural environments
- Production from relatively natural environments
- Production from dryland agriculture and plantations

- Production from irrigated agriculture and plantations
- Intensive uses
- Water

For the purposes of exclusions relating to plantation establishment, Table 17 demonstrates that most landuses are barriers to plantation establishment. However, ALUM category 2 and 5 can be broken up further where certain classes then become permitted.

Table 17- Landuse exclusions in the Hub region and relevant plantation exclusions

ALUM Code	Name	Exclusion
1	Conservation and Natural Environments	Yes
2	Production for Relatively Natural Environments	--
2.1.0	Grazing Native Vegetation	No
2.2.0	Production Native Forests	Yes
2.2.1	Wood Production Forestry	Yes
2.2.2	Other Forest Production	Yes
3	Production from Dryland Agriculture and Plantations	No
4	Production from Irrigated Agriculture and Plantations	No
5	Intensive Uses	--
5.1	Intensive horticulture	Yes
5.2	Intensive animal production	No
5.3	Manufacturing and industrial	Yes
5.4	Residential and farm infrastructure	Yes
5.5	Services	Yes
5.6	Utilities	Yes
5.7	Transport and communication	Yes
5.8	Mining	Yes

3.2.4 Existing plantations

Knowing where existing plantations are, can help identify suitable future plantation areas with known plantation productivity.

Several data sources were used to define where plantations have been established. The two major ones include the ALUM layer and the National Forest Inventory (NFI) Australian Plantations 2016 layer.

3.2.5 Existing forested areas

As with the existing plantation exclusion, areas that are identified as having existing forest can be an exclusion. Existing vegetation that meets the definition of forest is excluded. The reason for this exclusion is that the clearing of existing forest for plantations is not allowed under the ACCU Scheme (refer to Section 4.3 for further details).

The key data source for this exclusion is the Statewide Landcover and Trees Study (SLATS). This is a Sentinel Satellite derived product, created by the Queensland Department of Environment and Science's Remote Sensing Centre. It measures and monitors woody vegetation extent and change in an annual basis. Used in this project is the SLATS product for 2021, as accessed in the QSpatial open data platform.

This product uses a common definition of forest which is:

- a mature or potentially mature stand height exceeding 2 metres.
- stands dominated by trees usually having a single stem.
- the mature or potentially mature stand component comprises 20% canopy coverage using a Crown Projective Cover (CPC) measure.

3.2.6 Property size

The economic suitability of plantation is significantly impacted by scale. A 20 ha plantation area has been used in the economic modelling for this report. The government grant outlined in Section 6.5.1 also has a minimum project of 20 ha. However, when looking at establishing a carbon project, a property greater than approximately 100 ha will provide economies of scale because many of the administration costs for carbon projects are fixed costs.

There was no land parcel minimum area exclusion on the spatial suitability analysis. However areas less than 10 ha were attributed a class from 3 to 5 to show that such areas are less suitable from an economic viewpoint. Refer to Section 3.1.4 for more detail.

3.3 Analysis and results

The inputs described in the previous sections were visualised and then modelled within a biophysical suitability model. This was conducted in the ESRI ArcMap suite of products and automated where possible using Python code.

Initial processing of the models split it into two parts: biophysical suitability based on input parameters, and land availability. This stage focussed on adjusting the modelling framework to ensure that spatial outputs are consistent in terms of parameterisation rules. These two output layers were then combined into a unified layer to detail potential plantation suitability.

This section will outline the approach and results for both the land exclusions and then the biophysical suitability. Final analysis on landuse types is outlined below once all land exclusions are taken into consideration.

3.3.1 Land exclusions and key considerations

The key variables in landuse exclusions, as described in Section 3.2 include:

- Regulated vegetation management overlays
- Current landuse and tenure
- Existing plantations
- Existing forested areas.

The exclusions are filtered out of input layers and presented in a separate new layer. This combined exclusion layer can then be used in mapping and analysis. This is presented in Figure 5 alongside existing plantations across the Hub region.

As noted previously, the majority of exclusions relate to Regulated Vegetation Management areas. However, around townships there are a number of areas excluded due to landuse categories that exclude plantation development.

The total area excluded is 173,335.47km^2, which is approximately 56% of the Hub region.

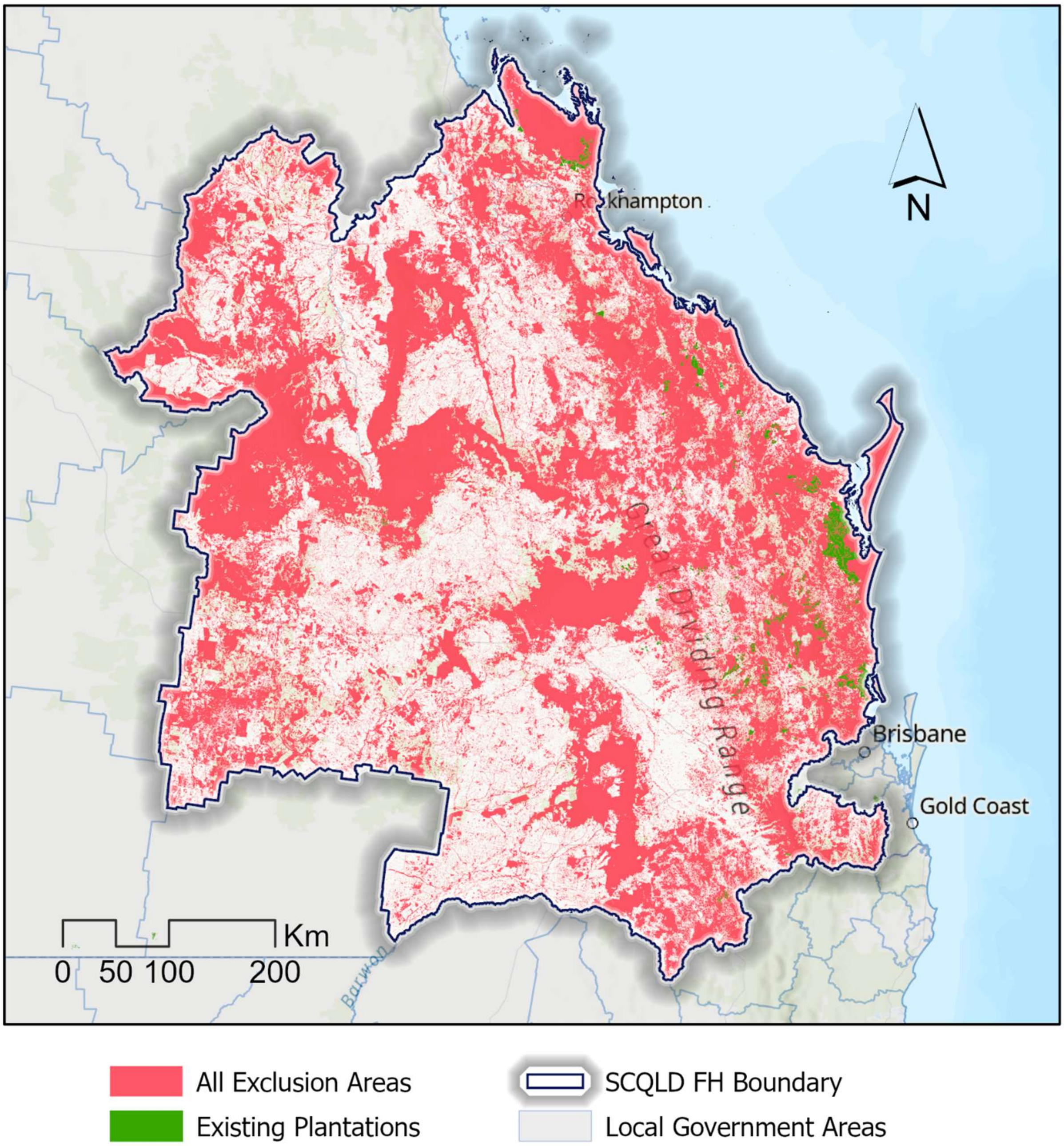

Figure 5- Land exclusions, including existing plantation locations.

3.3.3 Biophysical suitability – approach and outputs

Each of the biophysical parameters defined in Section 3.1 are combined into a suitability analysis model. A suitability analysis is defined as the process of determining the fitness, or appropriateness, of a given area of land for a specified use. It can provide a rational basis for the most favourable utilisation of land resources and landuse planning.

It is important to understand that this approach does not consider other constraints related to management, operational or economic limitations. Plantation suitability is solely determined based on the biophysical parameters themselves.

Process workflow

For each of the 13 components, and each of the 4 species, the spatial data layers are all converted to a raster grid surface of 100m resolution (i.e., 1 hectare). For each component gridded surface, a reclassification of data range values per the suitability tables presented in the previous section is run. This recalculates the gridded surface to a 1 to 5 scale range as per the suitability class ranges.

The combination of each component layer to determine a final suitability is run through a Most Limiting Factor (MLF) overlay analysis; between each of the 13 components, the cell with the greatest value (i.e., the lowest suitability class range), was used as the final suitability class. For example, if all soils and landscape factors were between 1 and 3, but rainfall had a value of 5, the final combined layer for that grid cell is Class 5.

As per the description in Section 3.1 land units with limiting factors may inhibit plantation establishment or growth. The final analysis layer retains the value for each of the 13 input components to enable identification of what is the MLF.

Once applied to each component for each species, the resultant layers are combined.

As mentioned earlier, the five-class system is designed to highlight those areas that are the most suitable for new plantation establishment and identify areas that have limited or no suitability. The definition for each class is provided in Table 18.

Table 18- Plantation suitability classifications

Class	Suitability	Definition
1	Ideal	Highly suitable land with no limitations for new plantations
2	Good	Highly suitable land with few limitations for new plantations
3	Moderate	Suitable land that may have some limitations for plantation productivity
4	Poor	Identified limitations will impact plantation productivity
5	Unsuitable	Not suitable for new plantations

Non-excluded area by biophysical classification

Following our analysis, we found that no species in any area within the Hub had a suitability classification of 1. This means that, across all the 13 biophysical components for a specific grid cell, at least one of these had a classification of 2 or greater, which meant that the overall classification for that cell was 2 or greater. This explains why the following tables and maps do not have any area for Class 1.

The following sections present the spatial results for each of the four species. Hoop pine, Southern pine and Gympie messmate have 'focus area' maps which to illustrate local variations, as the region-wide maps show little variation. All data is provided to the Hub for future integration on spatial systems.

In addition, tables are provided that present the total non-excluded area by classification, and the proportion of Class 2 and 3 area.

Hoop pine

Much of the Hub region is limited in suitability for Hoop pine (Table 19), with regions closer to the coast poor and then moderate in suitability. Significant areas which otherwise would have been moderate are covered by various exclusions.

The total non-excluded area in Classes 2 and 3 is 189,080 ha.

Table 19- Hoop pine non-excluded area by classification and proportion of area classified as 2 or 3

Score	Area (Ha)	Proportion of Class 2&3
1		
2	2,441	1.3%
3	186,639	98.7%
4	442,466	
5	12,945,208	
Total	13,576,754	

Figure 6 presents the Hub region suitability output for Hoop pine, showing all exclusion areas.

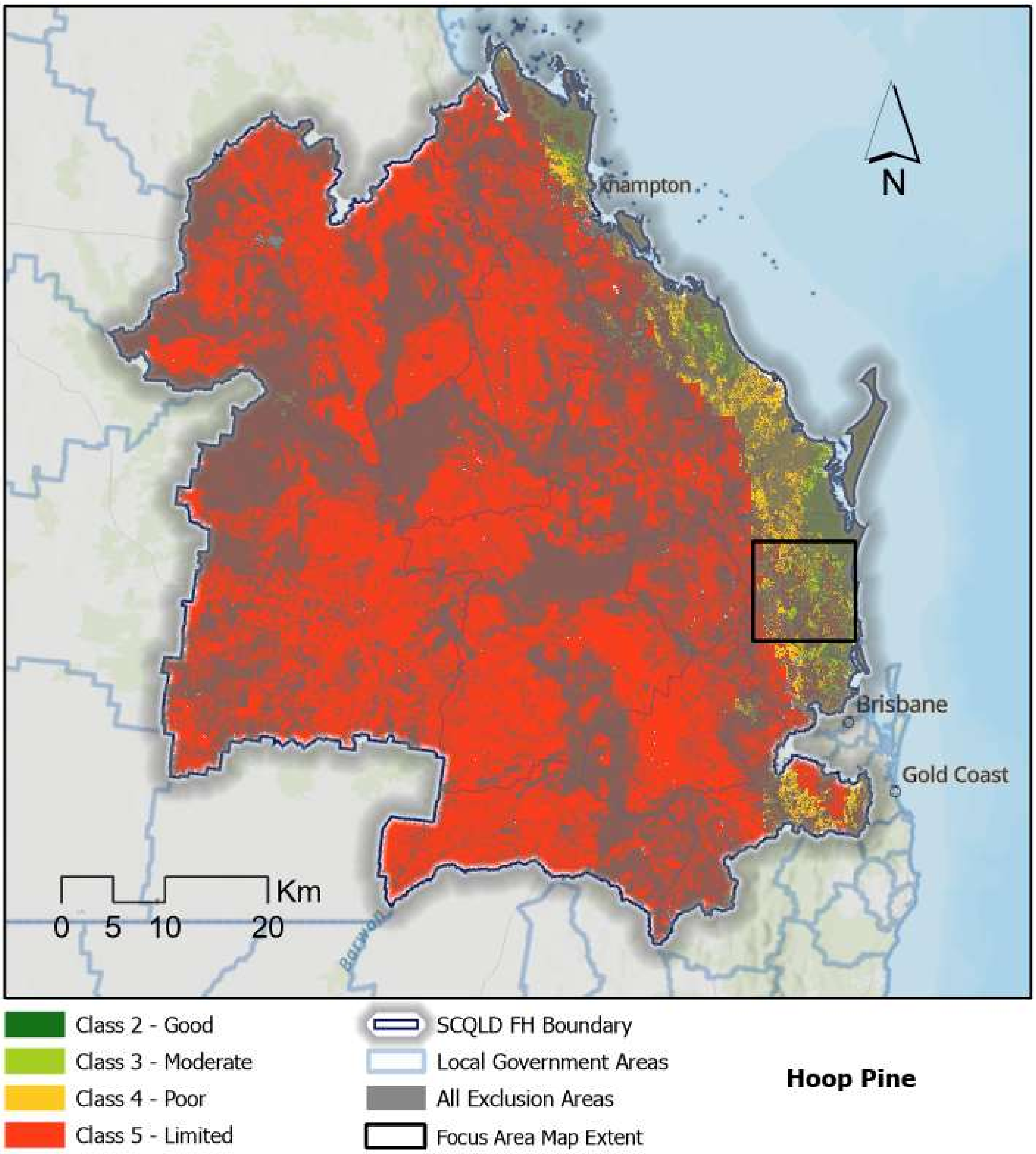

Figure 6- Region-wide biophysical suitability for Hoop Pine with land exclusions.

Figure 7 is a focus area map shows large areas of moderately suitable land, as-well as some good land interspersed with less suitable land in the south-east.

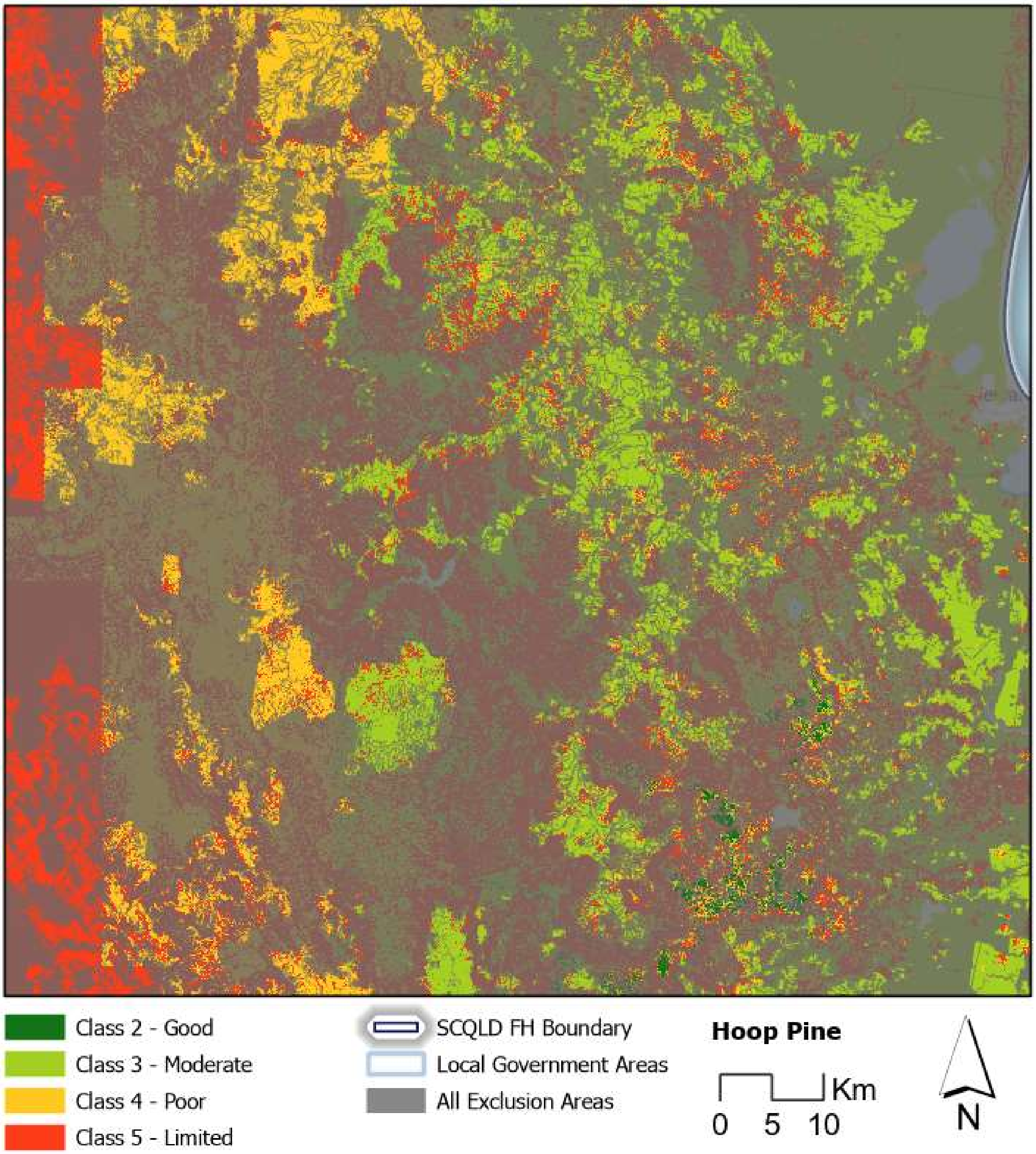

Figure 7- Focus area of biophysical suitability for Hoop pine with land exclusions.

Southern pine

At a region-wide scale, Southern pine is similar to Hoop pine, with an additional 1,000 ha of Class 2 land suitable for this species (Table 20). There are small areas of moderate suitability which aren't covered by land exclusions, generally near the coast in the east.

The total non-excluded area in Classes 2 and 3 is 198,767 ha.

Table 20- Southern pine non-excluded area by classification and proportion of area classified as 2 or 3

Score	Area (Ha)	Proportion of Class 2&3
1		
2	3,407	1.7%
3	194,590	98.3%
4	464,447	
5	12,915,538	
Total	13,577,982	

Figure 8 presents the Hub region suitability output for Southern pine, showing all exclusion areas.

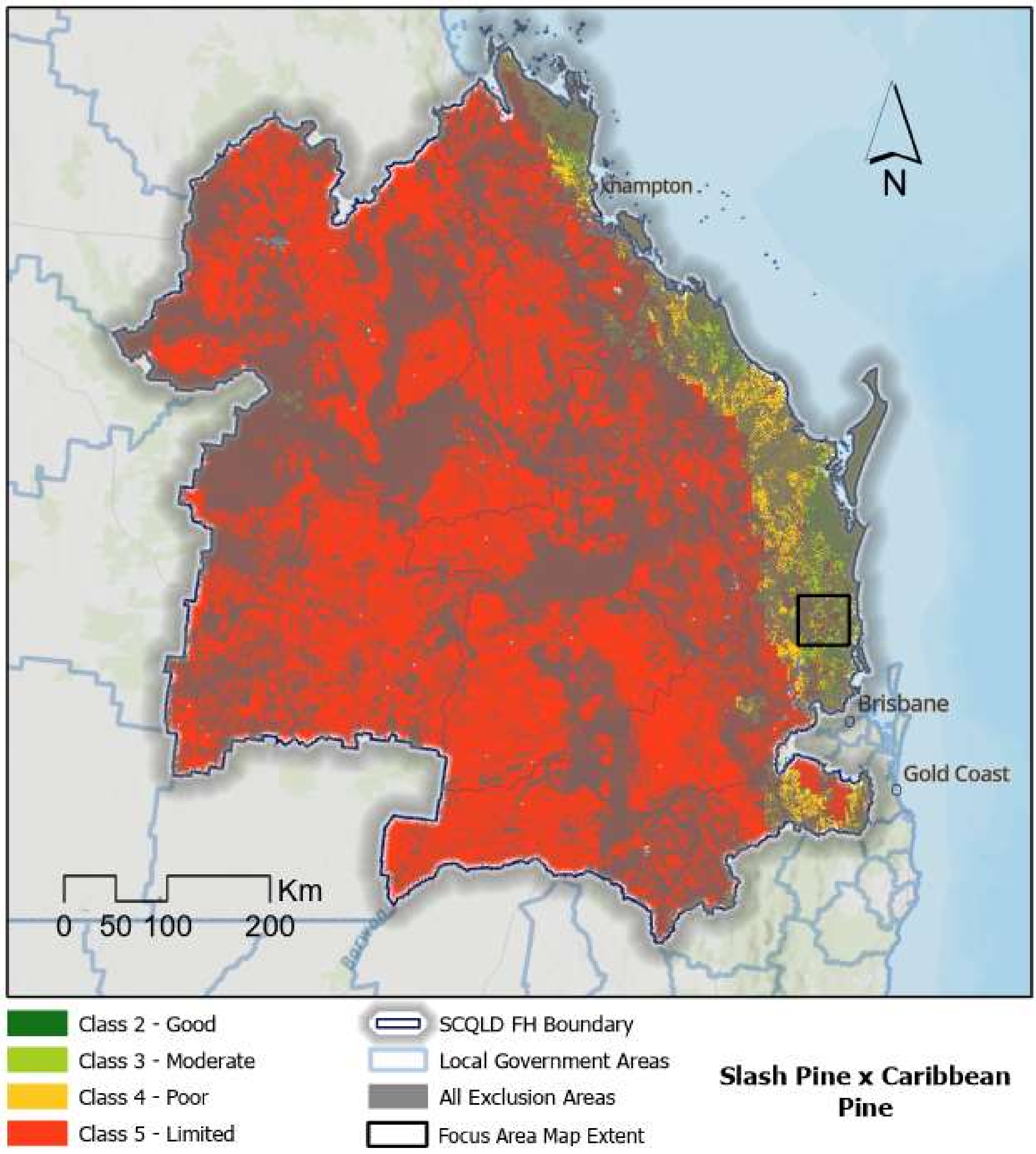

Figure 8- Region-wide biophysical suitability for Southern pine with land exclusions

In the focus area (Figure 9), there are large areas of Moderate suitability, as-well as a significant amount of good suitability area – more than there was for Hoop pine.

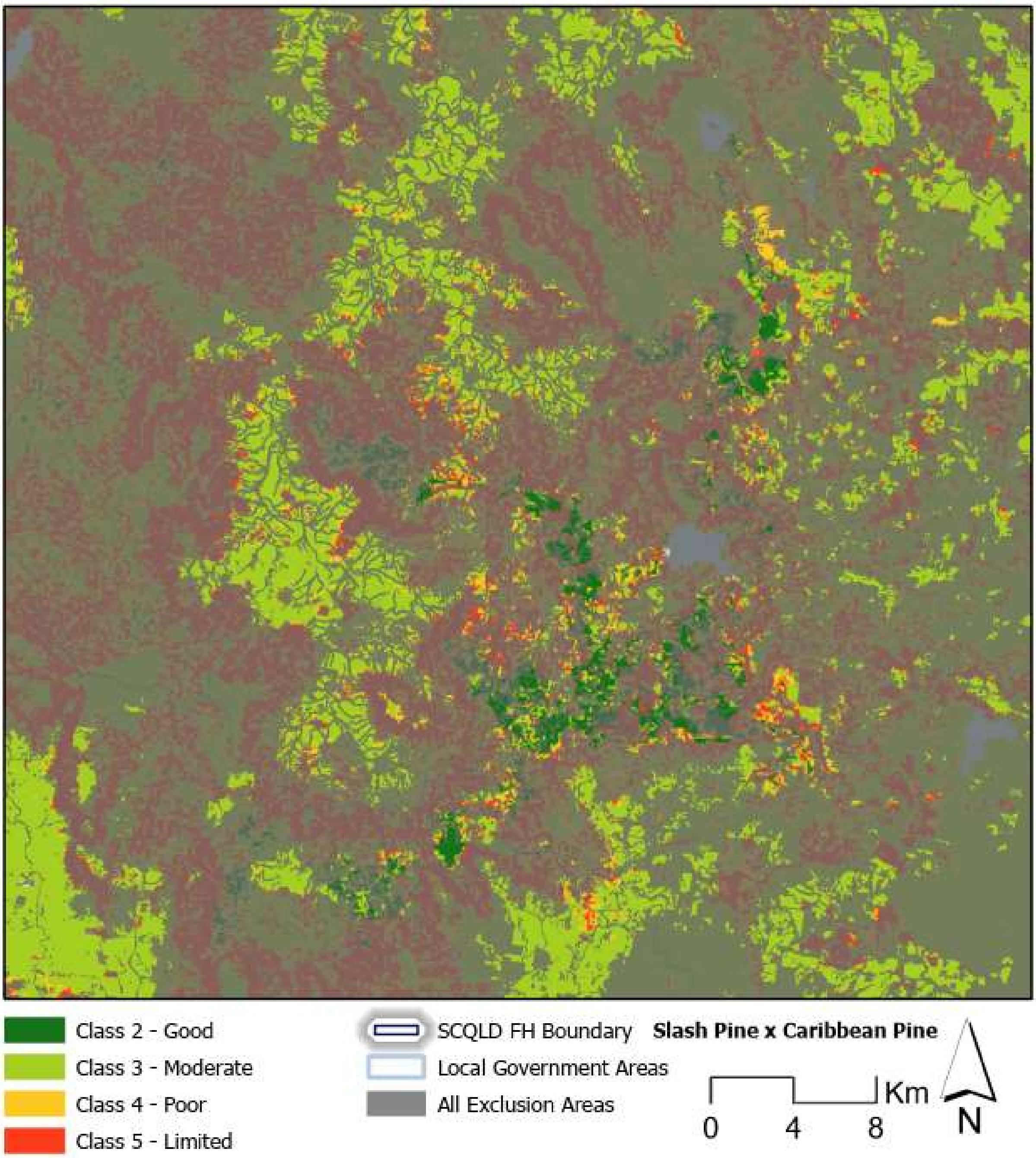

Figure 9- Focus area biophysical suitability for Southern pine with land exclusions

Gympie messmate

Plantation suitability for Gympie messmate is similar in Class 3 area to Southern pine, but an additional 1,000 ha of Class 2 land (Table 21).

The total non-excluded area in Classes 2 and 3 is 197,990 ha.

Table 21- Gympie messmate non-excluded area by classification and proportion of area classified as 2 or 3

Score	Area (Ha)	Proportion of Class 2&3
1		
2	4,334	2.2%
3	194,433	97.8%
4	478,072	
5	12,901,650	
Total	13,578,489	

Figure 10 presents the Hub region suitability output for Gympie messmate, showing all exclusion areas.

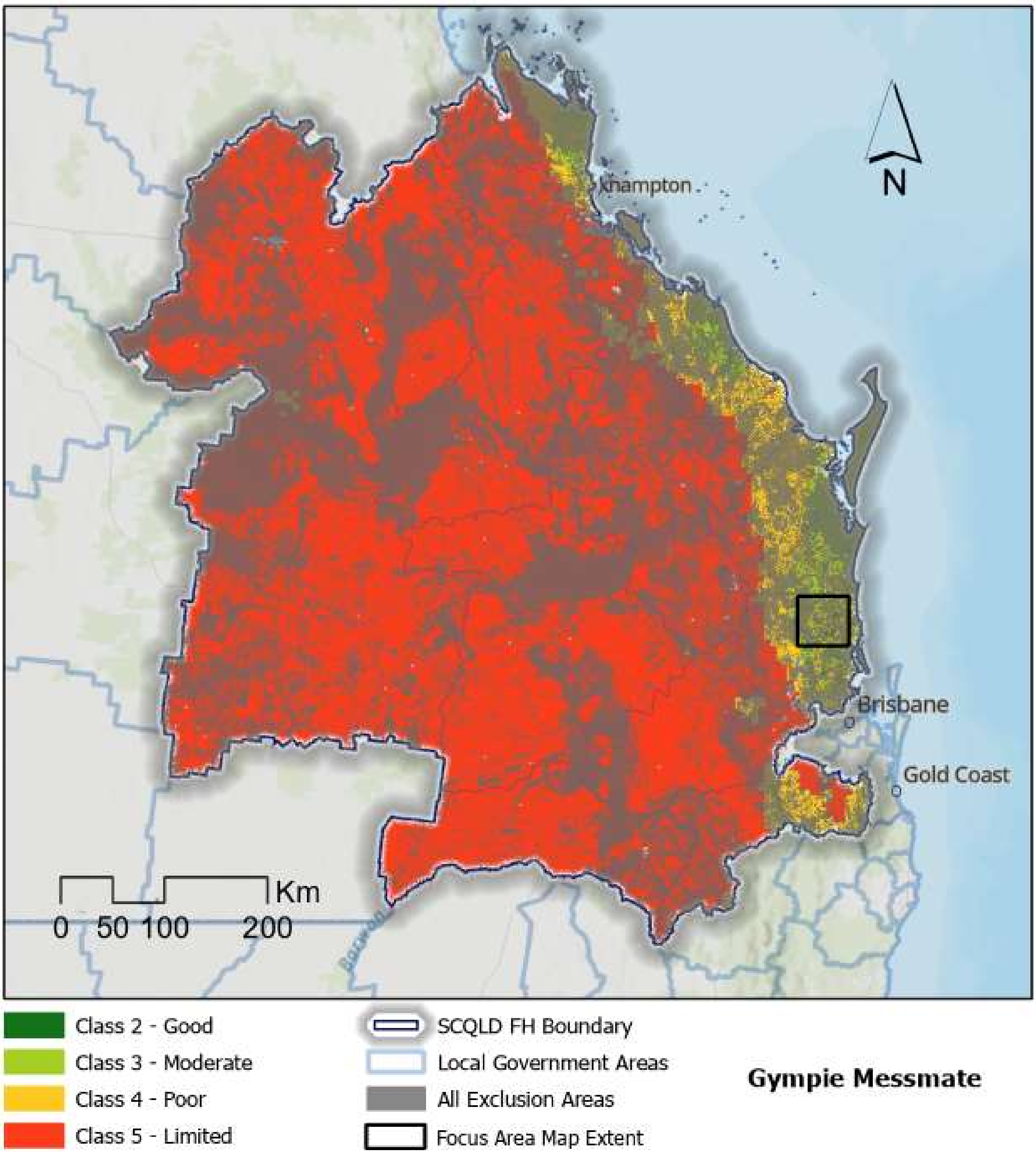

Figure 10- Region-wide biophysical suitability for Gympie Messmate with land exclusions

The focus area (Figure 11) shows large areas with Good (Class 2) suitability for Gympie messmate, as-well as significant moderate areas.

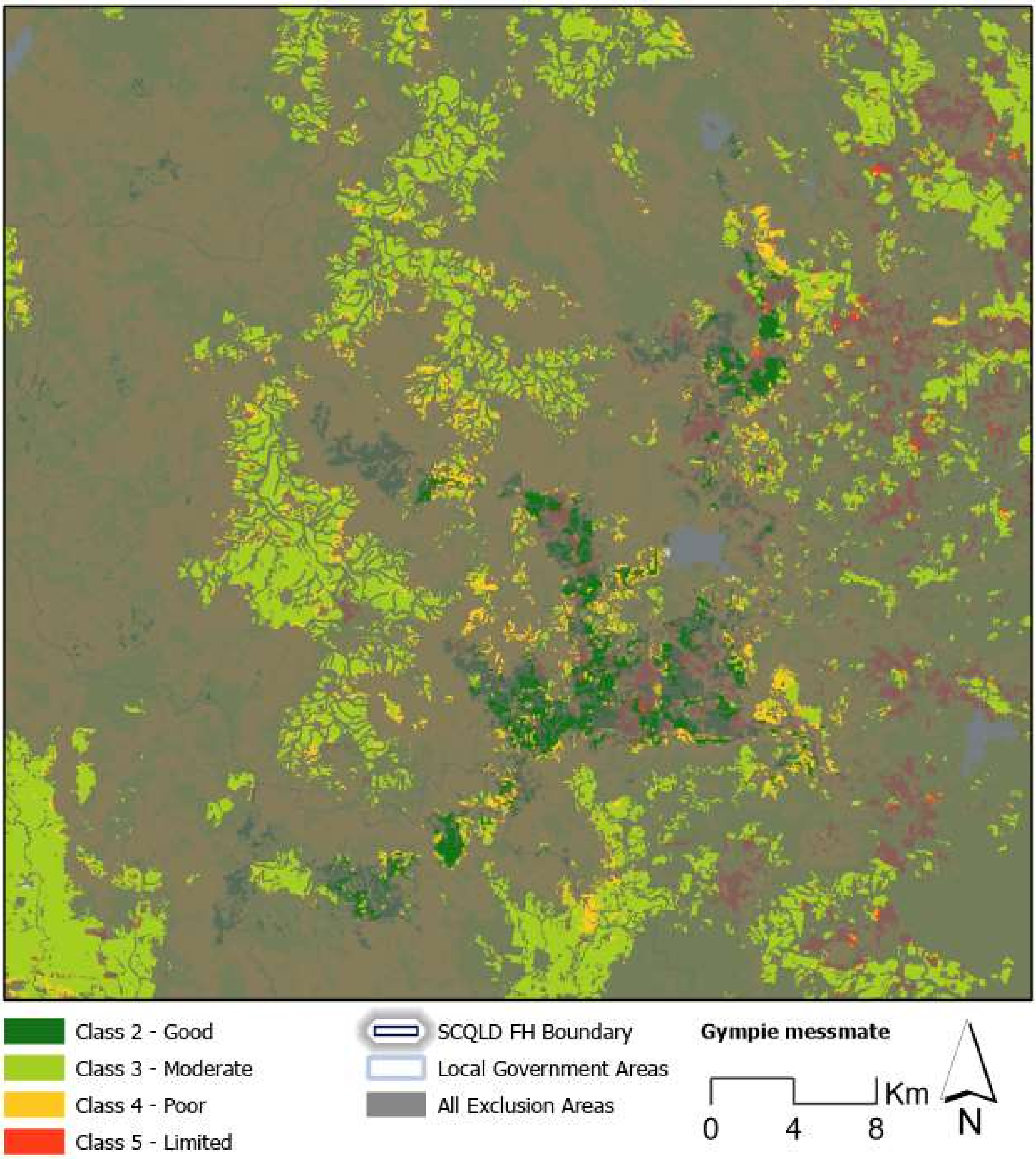

Figure 11- Focus area biophysical suitability for Gympie Messmate with land exclusions

Spotted gum

The Spotted gum has the most suitable land of the four species considered (Table 22). Significant areas of the eastern and northern Hub region are Moderately suitable, as-well as some areas in the south (Figure 12).

The total non-excluded area in Classes 2 and 3 is 2,496,073 ha.

Table 22- Spotted gum non-excluded area by classification and proportion of area classified as 2 or 3

Score	Area (Ha)	Proportion of Class 2&3
1		
2	2,571	0.1%
3	2,493,502	99.9%
4	7,017,121	
5	4,043,091	
Total	13,556,285	

Figure 12 presents the Hub region suitability output for Spotted gum, showing all exclusion areas.

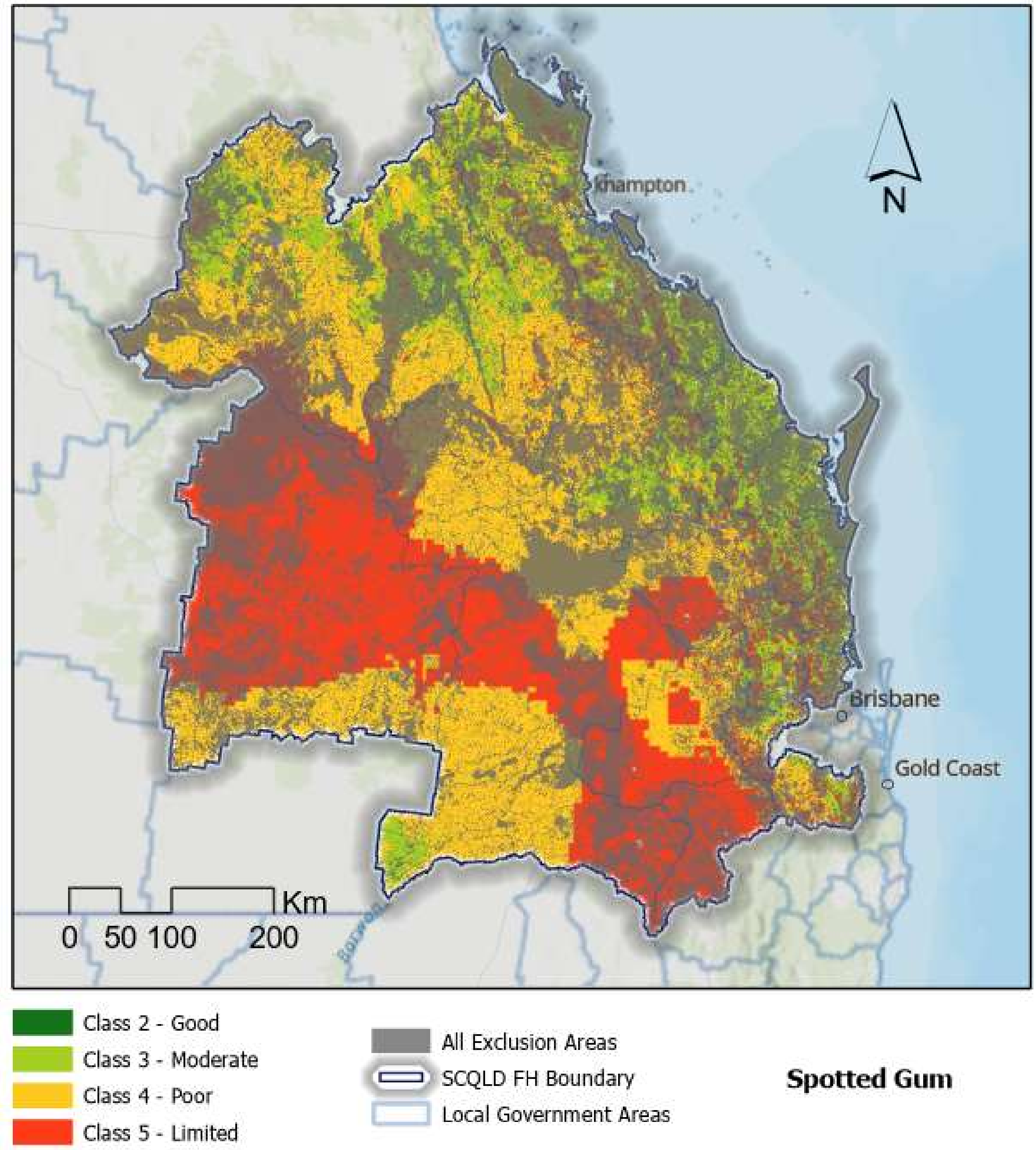

Figure 12- Region-wide biophysical suitability for Spotted gum with land exclusions

3.3.4 Plantation suitability by current landuse

Once all excluded land is assessed it then can be related to the remaining landuses from the ALUM landuse input. As detailed in Table 17, this is only for primary production landuse such as cropping or grazing land. The table in Appendix B provides the area by suitability class for each of the relevant ALUM landuse categories.

These areas were calculated using rasterised landuse and suitability, which means that the values have been aggregated and there may be some minor (>0.1%) errors in the values.

4. Economic assessment of future plantations

This section of the report presents the results of the economic analysis for the four species. The economic analysis is comprised of the following three aspects of potential commercial land use:

- Plantation timber – this is a planting of trees of the same species that are evenly spaced in rows with the ultimate purpose of selling logs to various markets.
- Carbon sequestration – this is recognising the quantity and value of carbon stored in the trees. It does not include the carbon stored in the soil.
- In-plantation grazing – this is utilising cattle to graze underneath the plantation trees after the trees have grown above grazing damage height. For this project, we introduced grazing at age three.

In this section, we outline the details of each of these aspects and the modelling assumptions. The results of the modelling and sensitivity analysis on key variables are provided at the end of the section. A visual overview of the inputs and outputs of the model is presented in Figure 13.

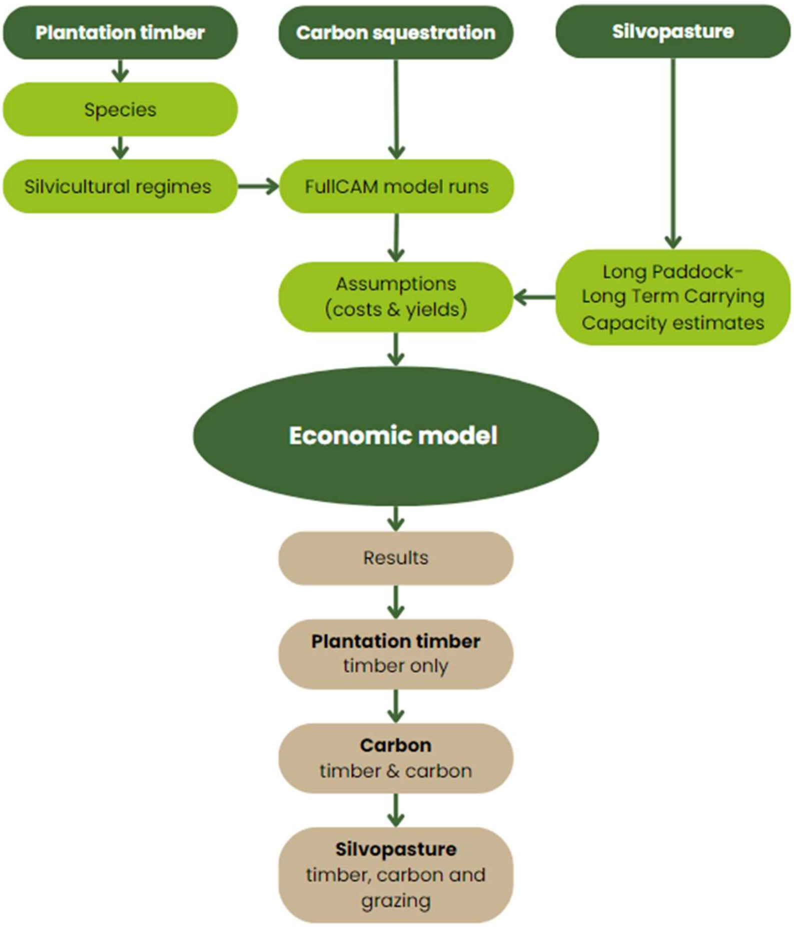

Figure 13 - Economic model overview

Silvicultural regimes are described in Section 4.1, and these are used as the basis for the estimation of carbon and timber volume. The outputs of the carbon analysis (see Section 4.3) provide the context and some of the data to enable economic modelling of:

- Timber production only.
- Timber production and carbon sequestration.
- Timber production, carbon sequestration and grazing (i.e. silvopasture).

The outcome of the economic modelling for each of the species silvicultural regimes is presented later in this chapter. How this information can be extrapolated across the Hub region is described at the end of this chapter.

4.1 Timber production

Queensland's timber industry is the state's third most valuable agricultural processing industry (Timber Queensland, 2023). There are significant existing markets within the Hub region for plantation timber products. There are also well-established export log and chip markets. Processors include sawmills (hardwood and softwood), engineered wood products (such as glulam, plywood and particleboard), and pellet production. Key to growing commercial plantations is to understand what the markets are seeking, in terms of log quality and dimensions.

As described in Section 2.3, long-term demand for wood products will be greater than what will be supplied domestically. This means that local timber plantation growers should expect ongoing demand for their logs if they are managed with the intention to produce good quality logs. The production of good quality logs requires silvicultural regimes that reflect the growth habits of the individual species.

4.2 Silvicultural regimes

The four species used in this analysis have different silvicultural requirements during their lifecycle to maximise economic returns and product outcomes. All modelling processes within this project have considered each species-specific requirements for the following variables:

- Stocking at planting
- Weed control
- Fertiliser application
- Timing and intensity of thinning
- Clearfall age.

For two species, two regimes were included. For Hoop pine, a thin and no-thin option was modelled, and for Southern pine and low rainfall and high rainfall option was modelled (Table 23).

Table 23- Silvicultural regimes by species for FullCAM modelling

Species	Initial stocking (per ha)	Weed control spray	Fertiliser	Thinning age (yrs.)	Thin stocking (per ha)	Clearfall age (yrs)
FullCAM 2020						
Mixed species enviro planting	500	Yes	Yes	n/a	n/a	n/a
FullCAM 2016- Plantation Method						
Mixed species enviro planting	default	Yes	Yes	n/a	n/a	n/a
Southern pine - Low Rainfall	833	Yes	Yes	17	450	28
Southern pine - High Rainfall	1200	Yes	Yes	15	600	27
Hoop Pine- Thin	925	Yes	Yes	20	500	45
Hoop Pine- No Thin	800	Yes	Yes	n/a	n/a	45
Spotted gum	1000	Yes	Yes	10	250	35
Gympie messmate	1000	Yes	Yes	17	500	30

4.3 Carbon

The carbon and timber volume inputs for the economic model are produced from the Federal Government's Full Carbon Accounting Model (FullCAM). The methodology for calculating carbon sequestration in trees is outlined below.

4.3.1 FullCAM

Overview

FullCAM was developed under the National Carbon Accounting System (NCAS) at the then Australian Greenhouse Office to provide a dynamic account of the changing stocks of carbon across Australia's land systems since 1970. FullCAM estimates carbon stock change and greenhouse gas emissions at a fine spatial and temporal scale and uses a wide range of spatially referenced data.

Modelling

For the purpose of this project, we developed FullCAM estimates for all of the silvicultural regimes described in Section 4.1. For each of the silvicultural regimes the appropriate and standardised FullCAM methodology (Clean Energy Regulator, 2022) was utilised (Figure 14).

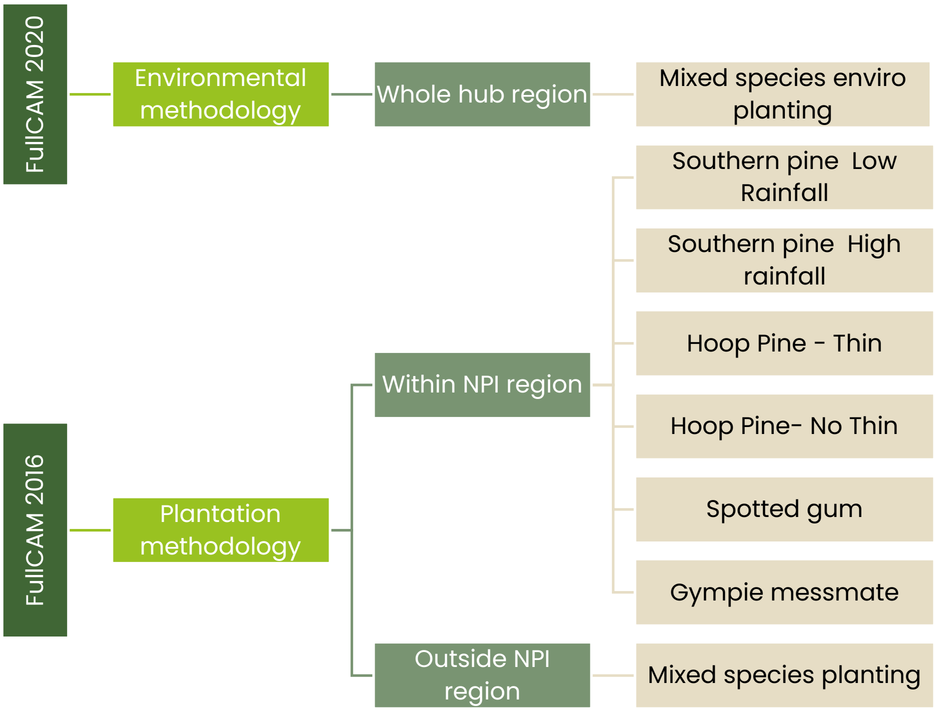

Figure 14- FullCAM model breakdown

The FullCAM model estimates yields for a single geographical point (referred to as the model point or plot location). FullCAM downloads the latest spatial data based on the coordinates for that point. For this project, we analysed the carbon potential across the Hub region by applying a 15km gridded point array (Figure 15).

Log products

The FullCAM model proportions the expected wood products for the species in a particular location. These proportions are predefined and cannot be adjusted. Table 24 outlines the mandated proportions.

Table 24- FullCAM log product proportion of harvested volume

FullCAM Group	Species	Thinning # or CF	Dead-wood	Paper & Pulp	Fibre-board	Construction	Mill Residue
Other eucalypts	Gympie messmate & mixed species eucalypts	1	20%	80%	0%	0%	0%
		2	20%	40%	2.9%	20%	17.1%
		CF	10%	34.4%	4%	27.8%	23.8%
Other softwoods	Hoop Pine Thin & No Thin	1	15%	28.6%	4%	36.3%	16.1%
		CF	10%	30.2%	4.3%	38.4%	17.1%
Pine hybrids (Southern Pine)	Southern Pine- High & Low rainfall	1	15%	25.4%	51.1%	4%	4.5%
		2	15%	28%	12.9%	30.2%	13.9%
		CF	10%	30%	8.1%	35.8%	16.1%
Spotted gum	Spotted gum	1	20%	69.3%	0.8%	5.3%	4.6%
		2	20%	52%	2%	14%	12%
		CF	10%	28.8%	4.4%	30.6%	26.2%

For this project, we categorised woodchip to include paper and pulp & fibreboard percentages whilst sawlog includes construction & mill residue percentages.

The results of each regime analysis are spatially displayed in the following section providing 'heat maps' of carbon variability.

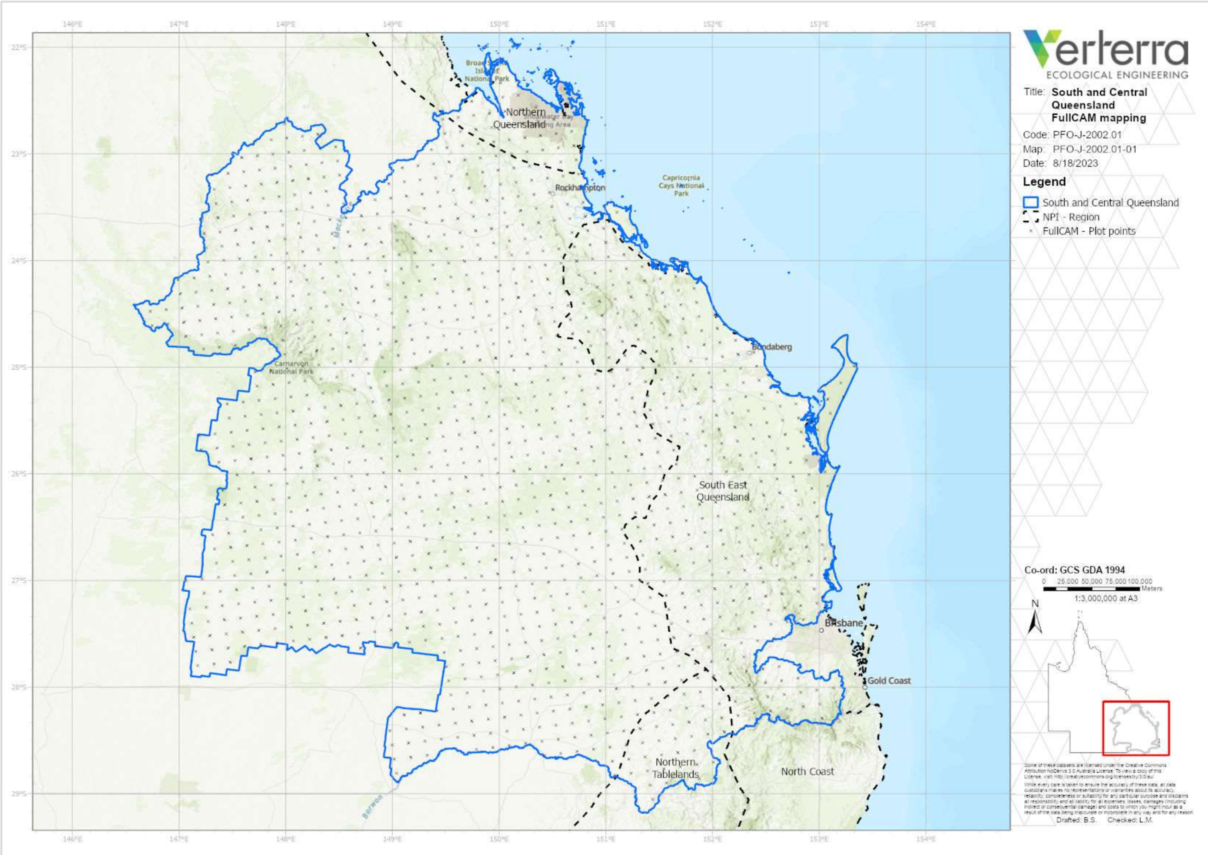

Figure 15- FullCAM Modelling point locations within the Hub Region, as well as the NPI Regions

Larger versions of the mapping results are provided in Appendix E.

Mapping results- environmental plantings

A run was undertaken across the entire Hub area of a mixed species environmental planting using the FullCAM 2020 model (Figure 16). The output of this analysis can be used to compare with the plantation methodology i.e., what carbon the planting would sequester with no harvesting of timber.

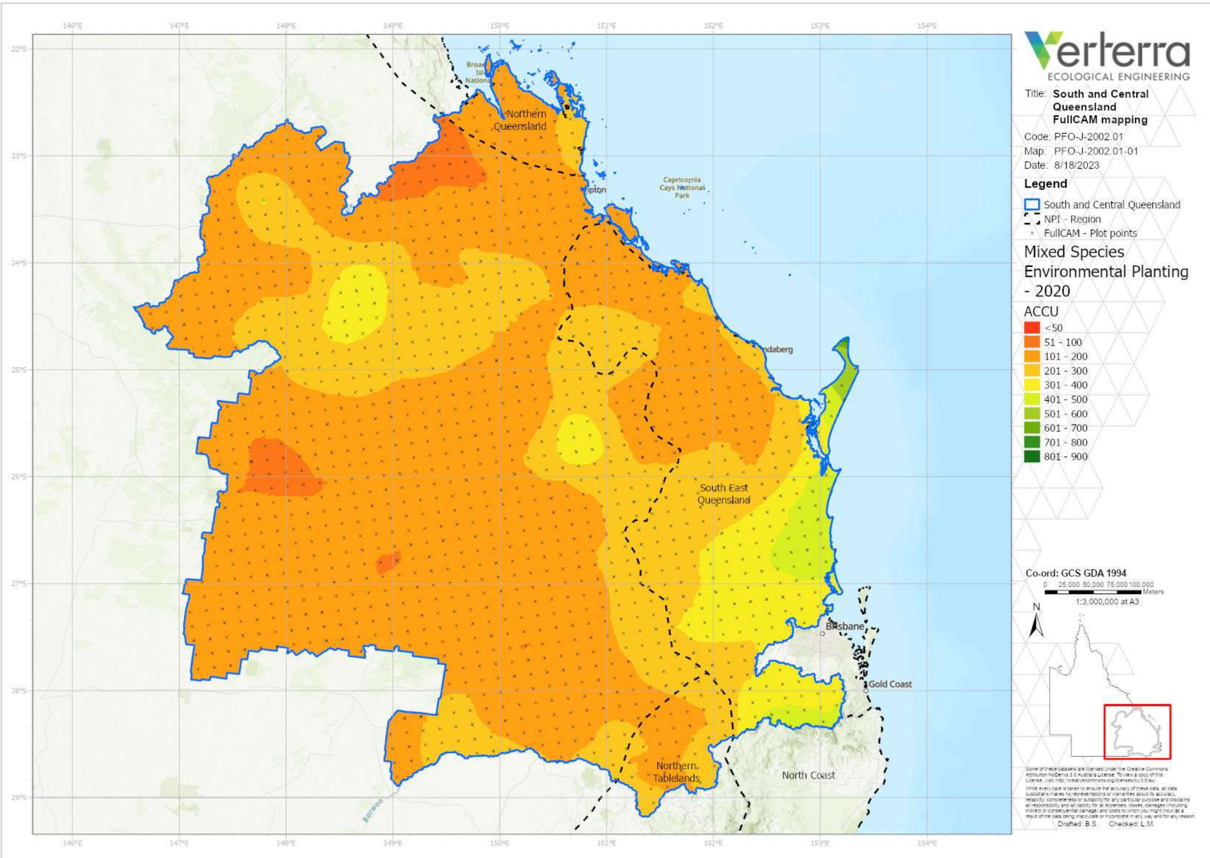

Figure 16- Mixed species environmental planting FullCAM results

A model run of mixed species environmental planting was used to estimate the carbon for areas outside of the NPI region (Figure 17). Species specific model inputs are not available outside of the NPI regions. There is a notable difference between the mixed species plantings in FullCAM 2020 to FullCAM 2016.

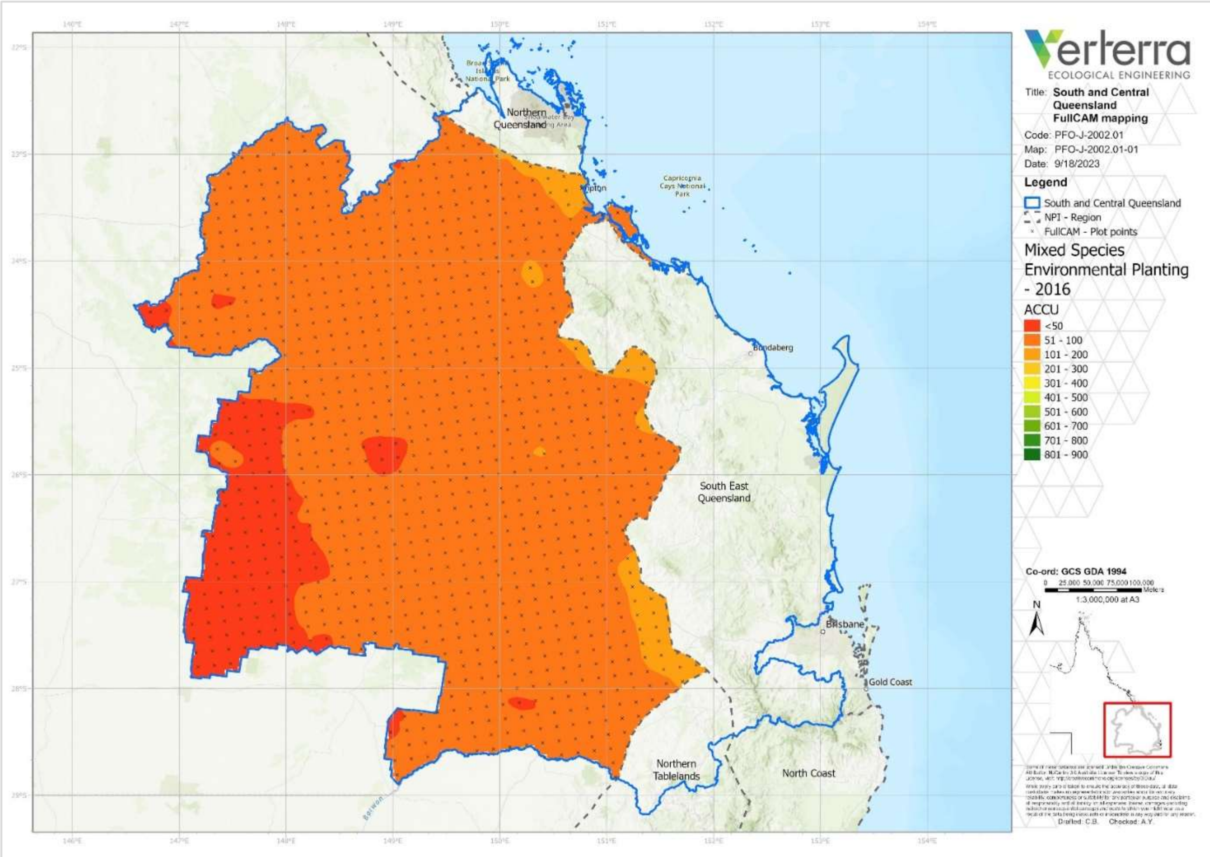

Figure 17- Mixed species environmental planting- FullCAM 2016 outside NPI region

Mapping results - species specific

For each of the species and their specific silvicultural regimes a model run was conducted within the NPI regions (from Figure 18 to Figure 23). These results show that the highest amount of ACCU credits are in the southeastern region of the Hub.

These ACCU estimates reach a peak of 900 ACCU credits per hectare for Hoop pine with no thinning (Figure 21) and Spotted gum (Figure 22), however these areas are very limited.

Figure 19 highlights the site-specific nature of Gympie messmate, with areas of the Hub only generating ACCU estimates of <50 ACCUs per hectare inland with contrasting 600-700 ACCUs per hectare closer to the coast.

To comply with ACCU Scheme guidelines, the plantation species mapping only occurs within the NPI regions.

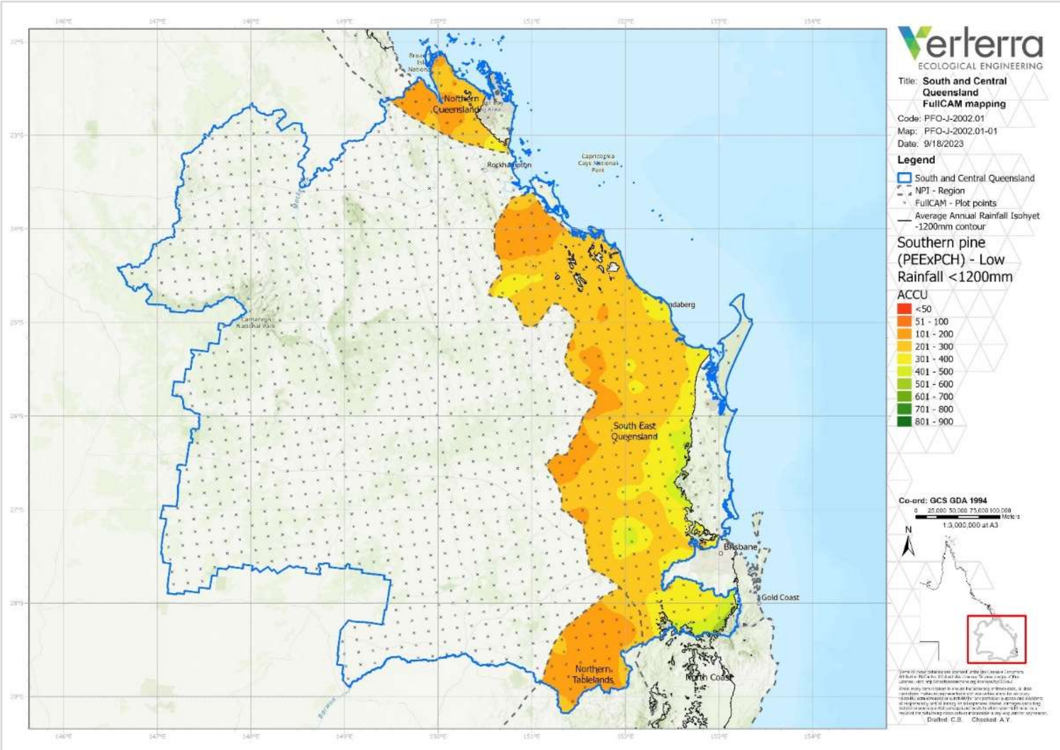

Figure 18- Southern pine - Low rainfall- FullCAM 2016 within NPI region

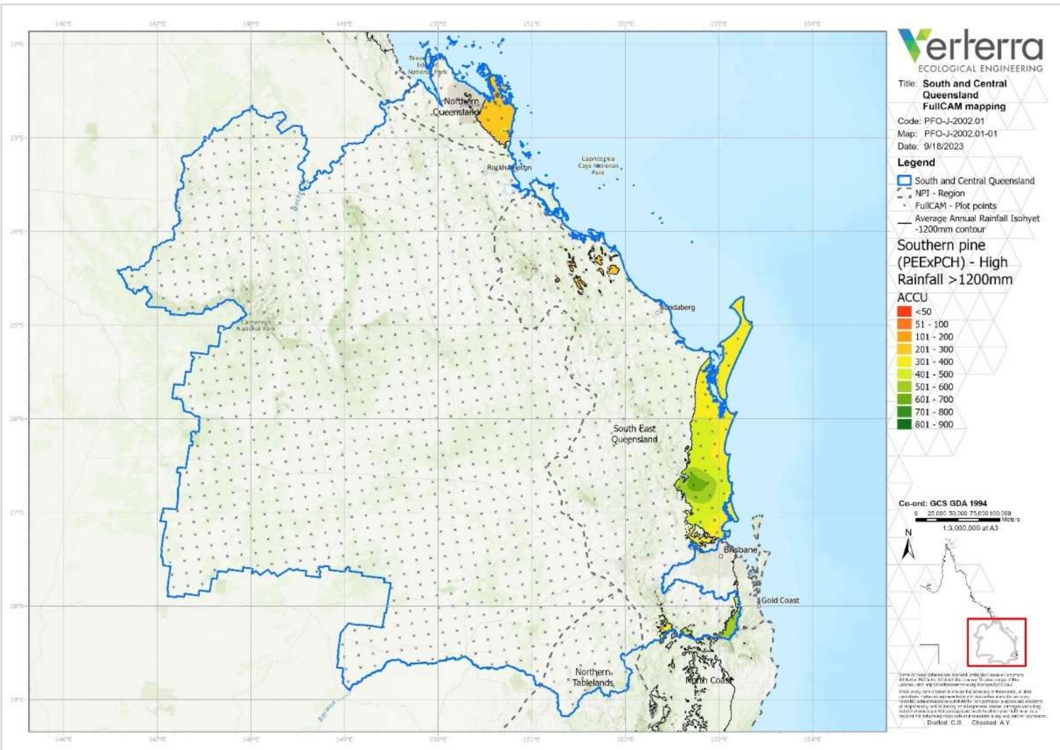

Figure 19- Southern pine - High rainfall- FullCAM 2016 within NPI region

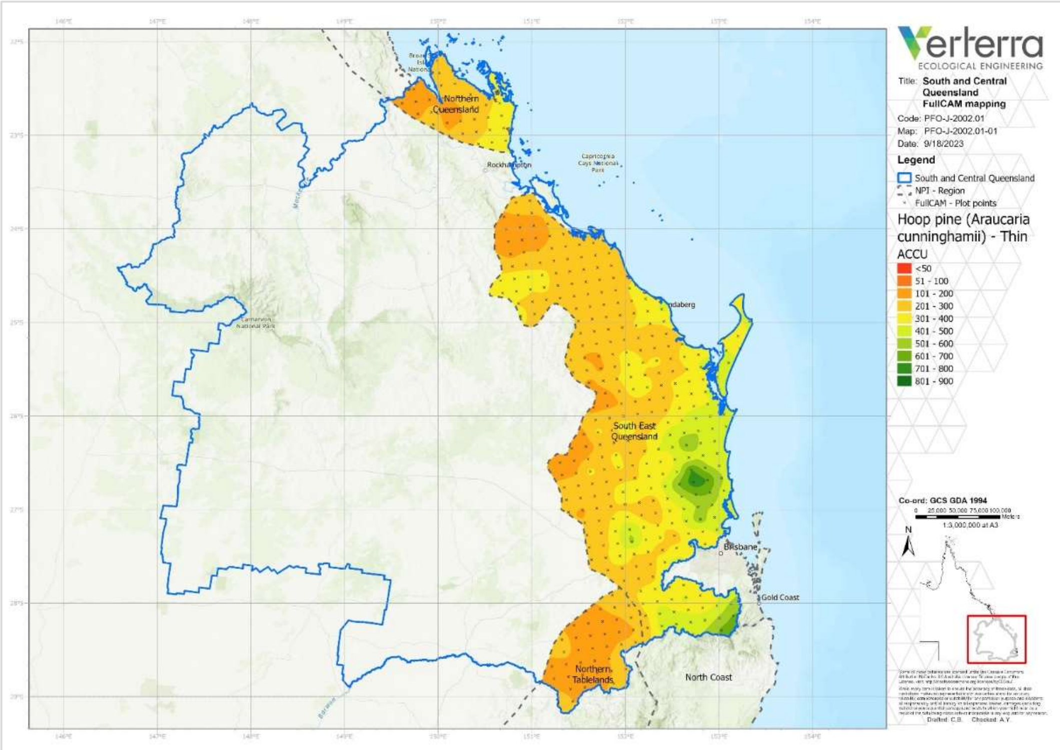

Figure 20- Hoop Pine- Thin FullCAM results

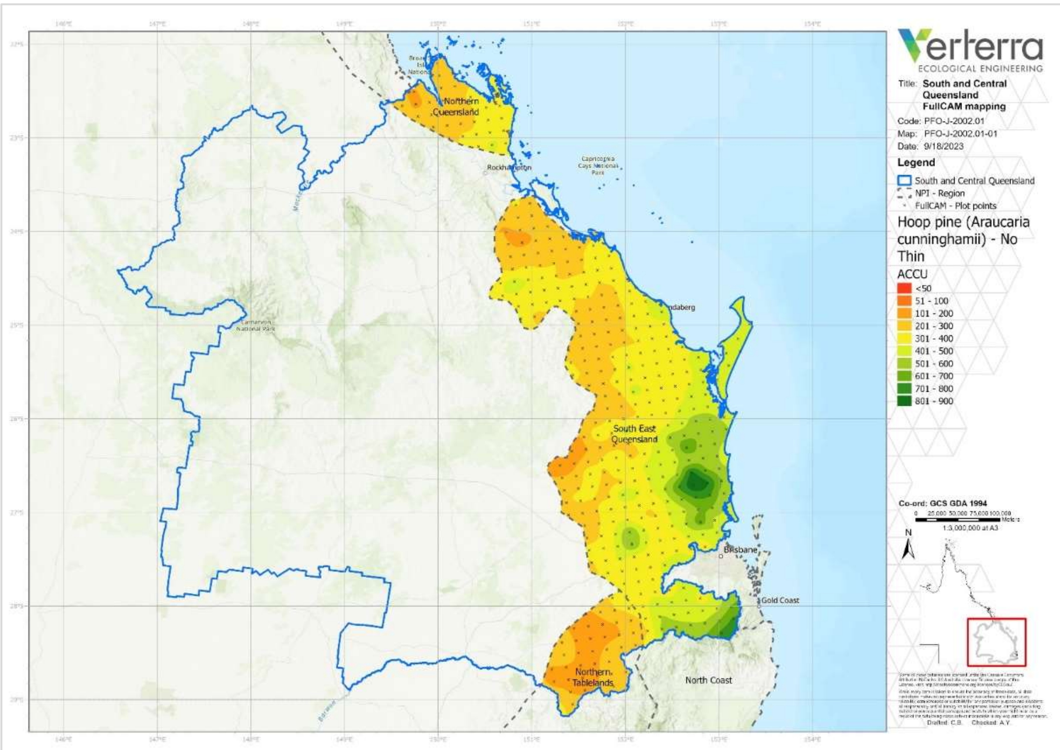

Figure 21- Hoop Pine – No thin FullCAM results

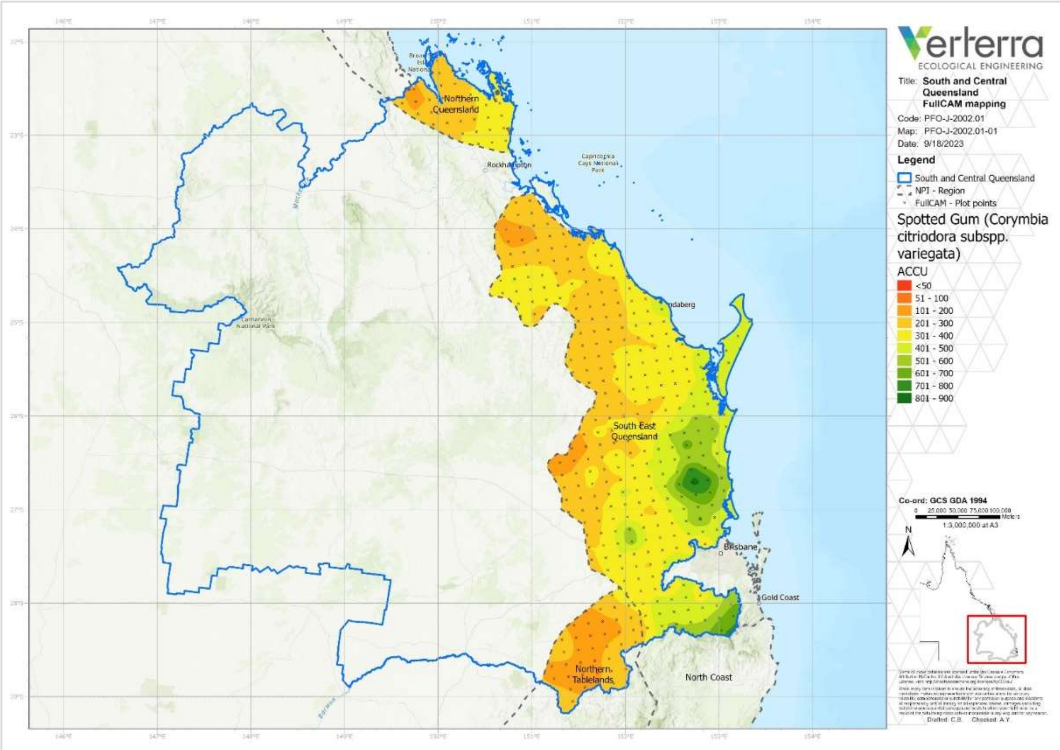

Figure 22- Spotted gum FullCAM results

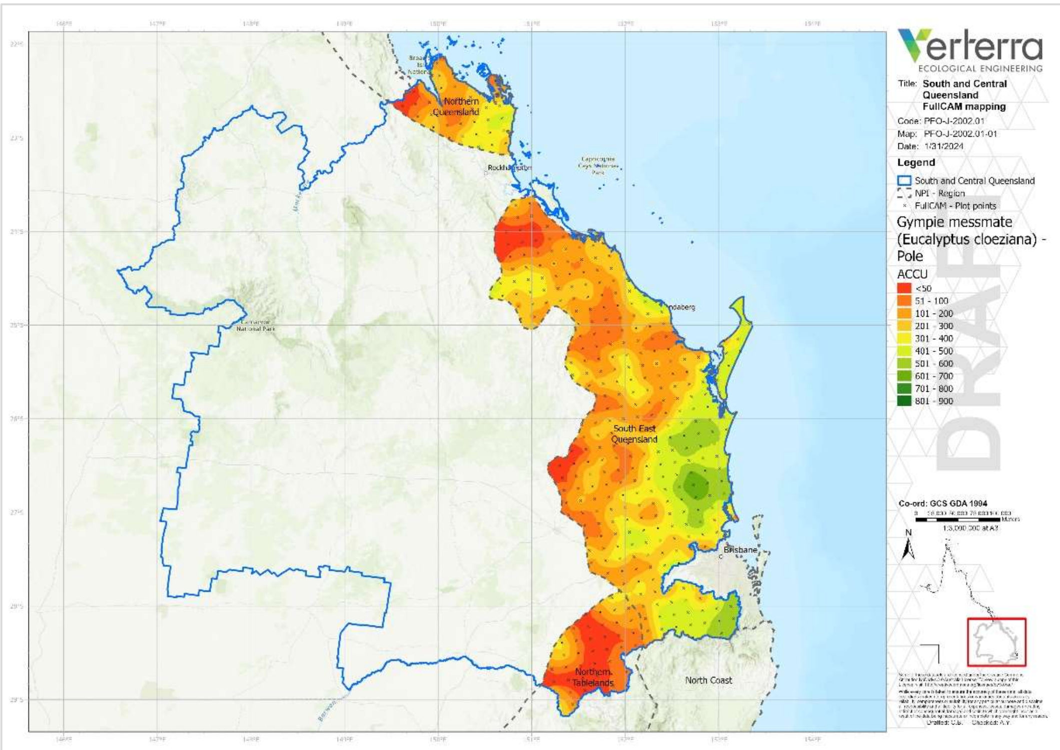

Figure 23- Gympie messmate FullCAM results

4.4 Silvopasture

To integrate livestock into the economic model, we needed to determine the stocking rate for the particular land parcel. The livestock are assumed to be able to freely range throughout the plantation area. We also estimated the liveweight gain from relevant literature and determined a per-head per-year husbandry cost.

For each of the six regime locations, the Long-Term Carrying Capacity (LTCC) was derived from the Long Paddock online tool available from the Queensland Government[11]. This tool enables the user to select a property on a map and request a report that provides the LTCC for that property.

In the report provided, the LTCC is defined as the total adult equivalents (AEs; 450 kg cattle consuming 8kg DM/day) that can be safely carried for a paddock or property and is also shown as hectares required per AE unit. The calculation of the LTCC is based on several factors, including: the long-term median annual pasture growth; the safe utilisation rate of the pastures; the distance to watering points; topography and tree density.

The LTCC is adjusted based on the land condition on a range from A (good) to D (poor). For this project the land condition was assumed to be A. The number of animal equivalents was calculated from the total area of the plantation.

The annual return from grazing was calculated by multiplying annual liveweight gain (assumed to be 100 kg/AE/yr.) by the number of animal equivalents. For the three years following planting, there was no grazing in the model. This three-year exclusion is to allow the young trees to establish without the risk of mortality from being grazed upon. Following this, in order to recognise the slow reduction in feed availability from the increasing plantation growth, the liveweight gain was reduced by 5% per year until it was capped at 30% of the maximum.

Although this approach does not reflect the fluctuating revenues from grazing on an annual basis, it does provide a credible and repeatable method for estimating long-term annual grazing returns over the length of a tree crop.

A summary table of the silvopasture model assumptions is provided in Section 4.6. An alternative silvopasture regime that uses 'alley cropping' (wide alleys of pasture combined with two or three rows of trees) is described and presented in Section 5.

[11] *http://www.longpaddock.qld.gov.au/FORAGE*

4.5 Model points

The base economic model was replicated for each of the species and silvicultural regimes in this project (refer to Table 23). In order to develop realistic numbers for the six regimes, we selected six locations based on the FullCAM ACCU outputs produced in Section 4.3.1. We calculated the average ACCU for each regime then selected the point location that was the closest to this average value (Table 25 and Figure 24).

Each of these models was adjusted to reflect the specific attributes of that location.

Table 25- Analysis model point information

	ID no#	ACCU	NPI Region	LGA
Spotted gum	37	339	SE QLD	Somerset
Southern pine low	547	362	SE QLD	Fraser Coast
Southern pine high	531	357	SE QLD	Sunshine Coast
Hoop pine thin	525	389	SE QLD	Gympie
Hoop no thin	525	456	SE QLD	Gympie
Gympie messmate	473	531	SE QLD	Gympie

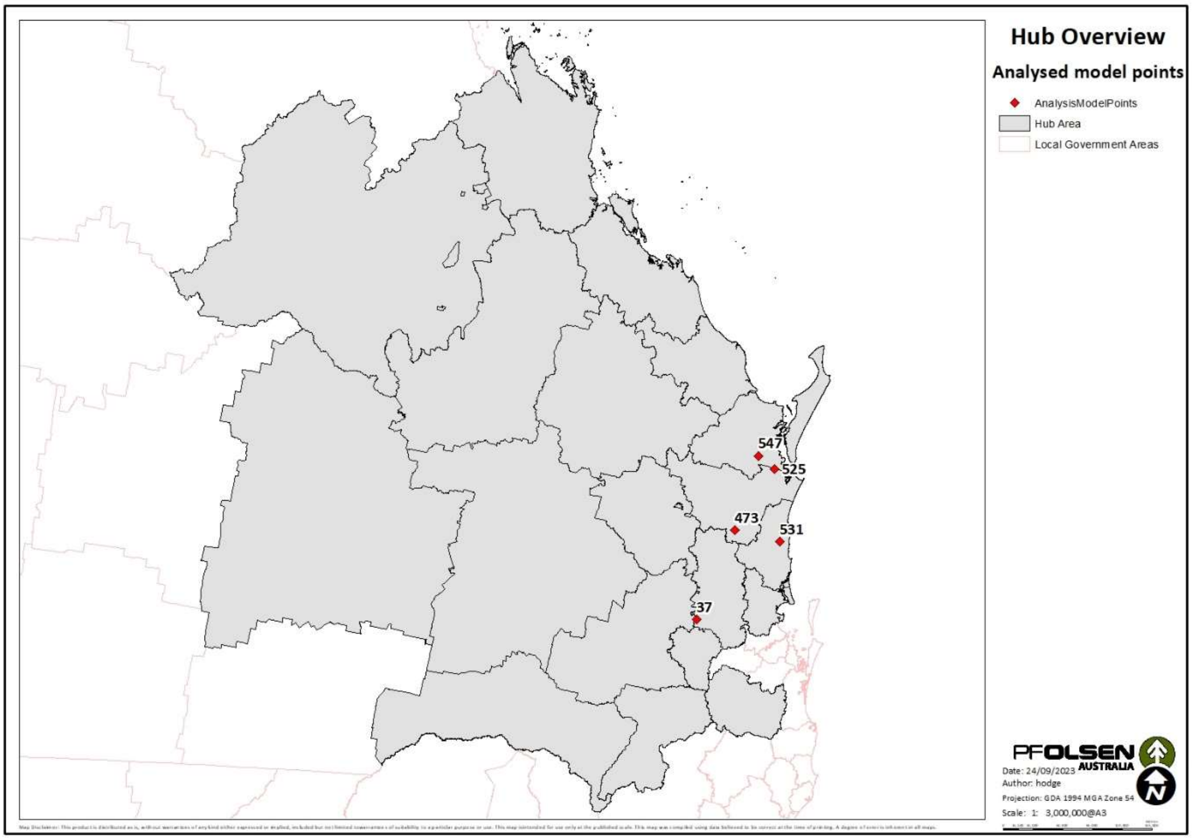

Figure 24- Site locations for economic modelling

4.6 Model assumptions

This section outlines the assumptions that were used in the economic model.

4.6.1 Land costs

The land area used for this model was 20 hectares to align with the minimum area requirement of the Support Plantation Establishment program of the Federal Government (refer to Section 6.5.1).

Land values vary considerably across the Hub Region and are further described below. For the purpose of enabling a comparison of silviculture regimes, the land value was fixed at $8,000/ha. In terms of land related variables in the model, a notional land rental and council rates were included (Table 26). The notional land rental is an estimate of the net income foregone as a result of choosing to grow trees on the land instead of some other activity. Another term for this is 'opportunity cost' and it is important to note that the NPVs presented in this report are the NPVs of switching from some alternative land use to plantation forestry. If the reader wants to compare forestry NPVs against other land uses that don't include the cost of land, the NPVs presented in this section of the report should be increased by the values in Table 27.

Table 26 - Land value model inputs

Activity	Units	Cost
Council rates	% of land value	0.4%
Land value	$ per ha	$8,000
Notional land rental	% of land value	0.02%

Table 27 - NPV ($/ha) of the notional land rental for each species and regime

NPV ($/ha)	Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
Notional land rental	2,385	2,345	2,845	2,845	2,620	2,460

Although land values have been fixed at $8,000/ha for this economic analysis, it is helpful to understand the variation in land values across the Hub region. Land values for each Local Government Area (Table 28) within the Hub region were obtained from the Australian Farmland Values report (Rural Bank, 2023). The range in values across the Hub region are presented in (Figure 25).

Table 28- Land values by LGA

LGA	Land Value $	LGA	Land Value $
Banana (S)	6,243	Rockhampton (R)	7,386
Bundaberg (R)	6,423	Scenic Rim (R)	15,459
Central Highlands (R)	2,396	Somerset (R)	11,512
Fraser Coast (R)	6,695	South Burnett (R)	7,120
Gladstone (R)	6,576	Southern Downs (R)	10,359
Goondiwindi (R)	3,663	Sunshine Coast (R)	25,813
Gympie (R)	11,285	Toowoomba (R)	12,161
Lockyer Valley (R)	12,778	Western Downs (R)	4,057
Maranoa (R)	5,023	Woorabinda (S)	n/a-
Moreton Bay (R)	17,227	Cherbourg (S)	n/a-
North Burnett (R)	5,193		

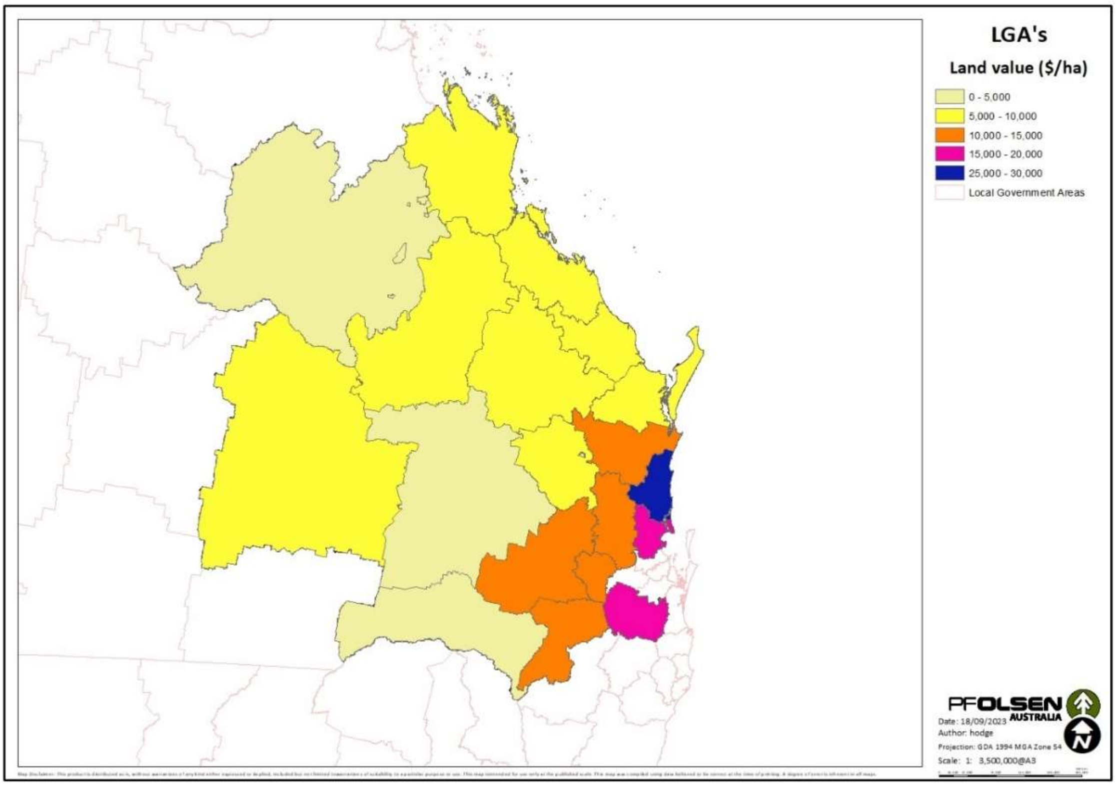

Figure 25- Land value by LGA

4.6.2 Plantation establishment and maintenance costs

Plantation establishment costs from site preparation and planting through to weed control and fertiliser is presented in Table 29. Annual maintenance costs following establishment include such activities as pest and disease control, fence, firebreak and track maintenance. These costs can vary year by year, so an average annual cost has been applied.

Plantation insurance has not been included in the model. The engagement of a third-party to project manage the plantation estate is also not included (see Section 4.7 for more details).

Table 29- Plantation establishment and maintenance activities assumptions

Activity	Units	Cost
Yr 0-1 Site prep and establishment	$/ha	2,000
Yr 1 silviculture (fertiliser)	$/per operation	278
Yr 1-2 silviculture (weed control)	$/per operation	550
Ongoing- maintenance	$/ha/ann	60

4.6.3 Timber harvesting and roading

Costs

The costs of harvesting (Table 30) vary between hardwood and softwood and also between thinning and final harvest. In reality, these costs are variable because each site is different, factors such as location on the property, slope, amount of woody weeds and seasonality all affect the cost of harvesting.

The haulage cost is a formula based on the distance to market. To enable direct comparison across the sites, the distance to market was fixed at 100 km.

Roading costs are applied just prior to harvesting to ensure the road network is suitable for heavy machinery.

Table 30- Harvesting activities assumptions

Activity	Units	Cost
Softwood Thinning 1	$/tonne	24
Softwood Clearfall	$/tonne	30
Hardwood Thinning 1	$/tonne	26
Hardwood Clearfall	$/tonne	33
Haulage (all species)	$/tonne/km	2.50+(km*0.15)
Haulage (all species @ 100km)	$/tonne	17.50
Roading	$/tonne	3

Returns

The mill door value of logs vary by species, log size and quality. The price also fluctuates depending on market conditions, sawmill capacity, and log availability. The prices presented in Table 31 are indicative only and cannot be guaranteed in any log sale negotiation.

The total returns to the landowner for timber equates to the mill door price less the costs of roading, harvesting and haulage.

The volume of woodchip and sawlog is based on the volume output from FullCAM.

Table 31- Mill door prices ($/tonne)

	Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
Chip	70	70	70	70	75	75
Sawlog	140	140	160	160	180	180

4.6.4 Carbon

Costs

The costs involved in registering a project with the CER include eligibility assessment, mapping, FullCAM runs, forest management plan, and the first report to the CER. Although this is presented in Table 32 as a fixed amount, some service providers offer an alternative where they absorb these costs in return for a proportion of project ACCUs.

Other costs are annual reporting and third-party auditing. Third-party audits are required periodically throughout the life of the carbon project. Generally, there are four third-party audits.

Table 32- Carbon project assumptions

Variables	Units	Amount
Project registration	Fixed	$15,000
Annual reporting	Per CEA (carbon estimation area)	$1,000
Third-party auditing	Per audit	$14,000

Returns

For this analysis, it is assumed that all ACCUs generated from the project are sold. The carbon price has been set at $30 per ACCU (based on average prices at the time of analysis). We are aware of private sales of plantation generated ACCUs that are achieving almost double this price due to the high credibility and intrinsic natural capital values of plantations.

4.6.5 Silvopasture

The liveweight farmgate price is based on that used by Francis *et al* (2022) in their economic study of silvopastoral systems in southern Queensland. The silvopasture variables have been described in Section 4.4 and the assumptions used in the model are presented in Table 33.

Table 33- Silvopastoral assumptions

Variables	Units	Amount
Long Term Carrying Capacity (from Long Paddock)	ha/AE	Varies by site
Liveweight gain	Kg/AE/ann	100
Liveweight gain adjustment (due to less feed)	%/ann	5
Maximum adjustment to liveweight gain	%	30
Liveweight farmgate price	$/kg	2.54
Grazing start	Years after planting	3
Cost of husbandry	$/AE	20

4.7 Third-party management

The model does not include the management fees of a third-party service provider. If an owner would like to outsource their plantation management the following prices are a general indication (Table 34).

Note: these prices are for management only and do not cover the operational costs.

Table 34- Management fee indication

Type	Price
Establishment management	$150-$400 (per hectare for Yr. 0,1,2) site location dependent
Plantation management	$40-70 (per hectare per year)
Harvest management	$4.50 - $6.00 (per m^3 harvested)

4.8 Economic analysis by species and regime

In this section, we present a tabular summary of the outcomes of the economic analysis for each species and silvicultural regime. The three scenarios for each location are:

- Timber only
- Timber and carbon
- Timber, carbon and grazing.

There is currently the opportunity to apply for Federal Government funding for the establishment of new long-rotation plantations for timber products. The funding is for up to $2,000/ha and is described in more detail in Section 6.5.1. The economic analysis with and without this government grant is provided for each species and silvicultural regime (Table 35).

We report the economic analysis in terms of net present value (NPV) and internal rate of return (IRR). NPV is the value of all future cash flows (positive and negative) over the entire life of an investment discounted to the present. The discount rate used to calculate NPV was 5%. IRR is the compound annual rate of return expected from the project. In other words, IRR is the discount rate that makes the net present value of a project zero.

Detailed results are presented in Appendix C.

Table 35- Economic analysis by species and regime summary

		Scenario	Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
Net present value $/ha (5%)	With govt. grant	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
		Timber & carbon	(235)	105	165	350	(325)	5,115
		Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
	Without govt. grant	Timber only	(4,340)	(4,395)	(3,560)	(3,785)	(4,195)	(390)
		Timber & carbon	(2,195)	(1,855)	(1,795)	(1,605)	(2,285)	3,155
		Timber, carbon & grazing	(1,730)	(1,200)	(945)	(755)	(1,865)	3,525
Internal rate of return	With govt. grant	Timber only	0.30%	0.60%	3.00%	3.40%	1.80%	6.60%
		Timber & carbon	4.40%	5.30%	5.30%	5.40%	4.30%	12.10%
		Timber, carbon & grazing	5.60%	6.90%	6.80%	6.50%	5.20%	12.90%
	Without govt. grant	Timber only	-1.20%	-0.90%	1.80%	2.50%	0.50%	4.70%
		Timber & carbon	1.30%	2.10%	3.10%	3.80%	2.10%	8.00%
		Timber, carbon & grazing	2.1%	3.0%	3.9%	4.4%	2.5%	8.4%

4.9 Summary of findings from economic analysis

With a discount rate of 5%, the NPV of timber alone with no Government Grant is negative for all scenarios. It is evident that the Government Grant scheme has a big influence on the returns from timber in all scenarios. This $2,000/ha injection of cash at the start of a long-term project brings forward the timing of the transition to positive cashflow and significantly lifts the NPV of timber alone for each scenario.

It is important to discuss the impact of including a notional land rental in the economic analysis. As described in Section 4.6.1, the cost of land for the plantation area, or opportunity cost, decreases the NPV by the amounts presented in Table 27. As an example, the impact of removing the notional land rental for the 'Timber only' NPV is presented in Table 36.

Table 36 – NPV ($/ha) of timber only including Government Grant and excluding notional land rental

NPV ($/ha)	Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
Timber only	5	(95)	1,245	1,020	380	4,025

The inclusion of carbon in any of the scenarios has a significant impact on cash flow and a notable increase to the IRR. With the Government Grant, most projects show a positive NPV.

Agriculture also provides a moderate increase in NPV for every scenario. Although it isn't factored into the economic analysis, an additional benefit of grazing is to manage the grass load and understory which reduces the risk of fire impacting the plantation.

As each of the revenue elements (timber, carbon and grazing) are added to the cashflow, there is an increase in NPV. This is understandable because each of these elements provide a positive return. Therefore, the greatest return on investment is one that includes timber, carbon and grazing, regardless of the species or silvicultural regime.

4.10 Sensitivity analysis

It is important to understand how influential key variables are on the financial outcome of each of the scenarios. This section presents the results of sensitivity analysis across the following variables:

- Timber price (-20%, current market rate, 20%)
- Distance (100kms, 200kms, 300kms)
- Carbon price ($25, $30, $35)
- Discount rate (3%, 5%, 7%)
- Land value ($6,000, $8,000, $10,000)
- Live weight farm gate price ($2.5, $3.0, $3.5).

As outlined in the previous section, the Government Grant scheme makes a big contribution to the economic outcome. In this section, we present the sensitivity analysis with the inclusion of the Government Grant.

4.10.1 Timber price

An increase in timber price of 20% generally relates to an increase in NPV of around $1,000 per hectare, with minor differences between species and regimes (Table 37).

Table 37- Timber price sensitivity analysis per hectare with grant

NPV 5% ($ per ha)		Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
-20%	Timber only	(3,565)	(3,695)	(2,790)	(2,605)	(3,450)	(350)
	Timber & carbon	(1,420)	(1,150)	(1,025)	(430)	(1,540)	3,200
	Timber, carbon & grazing	(955)	(500)	(175)	420	(1,120)	3,565
Current Market	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(235)	105	165	350	(325)	5,115
	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
20%	Timber only	(1,195)	(1,185)	(410)	(1,045)	(1,025)	3,480
	Timber & carbon	950	1,360	1,355	1,130	885	7,030
	Timber, carbon & grazing	1,415	2,015	2,205	1,980	1,305	7,395

4.10.2 Distance to processor

The haulage distance impacts the NPV by around $1,000 to $2,500 per hectare for every 100 km (Table 38). The range is due to the variation in harvested volume for the different species and regimes.

Table 38- Distance to processor sensitivity analysis per hectare with grant

NPV 5% ($ per ha)		Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
100km	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(235)	105	165	350	(325)	5,115
	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
200km	Timber only	(4,415)	(4,600)	(3,160)	(2,860)	(4,055)	(910)
	Timber & carbon	(2,270)	(2,055)	(1,400)	(685)	(2,145)	2,640
	Timber, carbon & grazing	(1,805)	(1,400)	(550)	165	(1,720)	3,005
300km	Timber only	(6,445)	(6,755)	(4,725)	(3,895)	(5,870)	(3,385)
	Timber & carbon	(4,305)	(4,210)	(2,960)	(1,720)	(3,960)	165
	Timber, carbon & grazing	(3,835)	(3,560)	(2,110)	(870)	(3,535)	530

4.10.3 Carbon price

A five dollar change in carbon price equates to a $750 to $950 per hectare change in NPV for each of the projects (Table 39). The variation is due to the quantity of ACCUs for each of the species and regimes.

Table 39- Carbon price sensitivity analysis per hectare with grant

NPV 5% ($ per ha)		Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
$25/ACCU	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(1,035)	(680)	(645)	(540)	(1,080)	4,170
	Timber, carbon & grazing	(570)	(30)	205	310	(660)	4,535
$30/ACCU	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(235)	105	165	350	(325)	5,115
	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
$35/ACCU	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	560	890	975	1,245	425	6,060
	Timber, carbon & grazing	1,030	1,545	1,825	2,095	845	6,425

4.10.4 Discount Rate

At a discount rate of 3%, and with the Government Grant, all of the projects have a positive NPV when including timber and carbon (Table 40). In addition, all projects are positive at a 5% discount rate when grazing is included.

Table 40- Discount rate sensitivity analysis per hectare with grant

Discount rate		Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
3%	Timber only	(1,870)	(1,825)	(30)	765	(1,270)	5,120
	Timber & carbon	735	1,260	2,175	3,605	1,005	9,380
	Timber, carbon & grazing	1,315	2,065	3,305	4,730	1,540	9,840
5%	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(235)	105	165	350	(325)	5,115
	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
7%	Timber only	(2,550)	(2,665)	(2,135)	(2,595)	(2,545)	(325)
	Timber & carbon	(780)	(555)	(730)	(920)	(920)	2,655
	Timber, carbon & grazing	(395)	(15)	(65)	(255)	(580)	2,955

4.10.5 Land value

In the model, land value influences the cost of council rates and the notional land rental. A $2,000 increase in land value equates to a $600 to $730 per hectare decrease in NPV (Table 41). The reason for the range in NPV is due to the variation in timing of final harvest (i.e. the length of the project).

Table 41- Land value sensitivity analysis per hectare with grant

NPV 5% ($ per ha)		Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
$6,000/ha	Timber only	(1,765)	(1,835)	(870)	(1,095)	(1,565)	2,200
	Timber & carbon	380	710	895	1,085	345	5,750
	Timber, carbon & grazing	845	1,360	1,745	1,935	770	6,115
$8,000/ha	Timber only	(2,380)	(2,440)	(1,600)	(1,825)	(2,240)	1,565
	Timber & carbon	(235)	105	165	350	(325)	5,115
	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
$10,000/ha	Timber only	(2,995)	(3,045)	(2,330)	(2,555)	(2,915)	930
	Timber & carbon	(850)	(500)	(565)	(380)	(1,000)	4,480
	Timber, carbon & grazing	(385)	155	285	470	(580)	4,850

4.10.6 Live weight farm gate price

A fifty-cent increase in live weight farm gate price equates to an increase in NPV of $75 to $185 per hectare across the projects (Table 42). The variation is due to the initial long term carrying capacity of the site.

Table 42- Live weight farm gate price per hectare with govt. grant

NPV 5% ($ per ha)		Sth pine low rainfall	Sth pine high rainfall	Hoop pine thin	Hoop pine no thin	Spotted gum	Gympie messmate
$2.50	Timber, carbon & grazing	230	755	1,015	1,200	95	5,480
$3.00	Timber, carbon & grazing	320	885	1,180	1,370	175	5,555
$3.50	Timber, carbon & grazing	420	1,025	1,365	1,550	265	5,635

4.11 Extrapolation across the Hub region

Based on the scenarios in Section 4.8, Gympie messmate with carbon and grazing produces the greatest IRR. This species is endemic to the Hub region, grows well on the right sites, and has highly favourable wood properties in terms of durability, strength and density. It also has the potential for logs to be sold for poles which can generate higher returns than sawlogs. The value of poles was not factored into our economic analysis, so the returns from timber may be greater than what we calculated.

In terms of the most suitable locations for Gympie messmate, much of the area that generates the highest ACCUs (south of K'gari or Fraser Island, Figure 23) is also the land that has the highest value (Figure 25). This means that it is unlikely that investors would purchase land in this area for the purpose of developing a plantation project. However, such a project is likely to provide decent returns to an existing landowner.

The most suitable area that has land values below $8,000 is in the southern end of the Gladstone LGA. This area also generates reasonable ACCUs and is within 150 km of existing hardwood sawmills.

Southern pine demonstrated the lowest returns of the four species in this project. It is possibly more suited to large-scale industrial plantations where there are efficiencies of scale and where active management can ensure that the products are within tight log specifications for the available market. There are significant penalties for growing logs that are too small or too large for the processor. Efficiencies are realised at the processor when there is little variation between logs in size and quality. These log specifications may be more difficult to achieve at a smaller scale and the price paid for such logs may not justify the investment.

The upside of Southern pine is that there is a well-established industry in the region. There are nurseries with experience in growing large quantities of softwood seedlings, and there are a number of large processors that are set up to extract the most value from the wood, from framing timber through to medium-density fibreboard.

As with the other species, return on investment is greatly improved with the addition of carbon, and slightly improved with the addition of grazing. Grazing, however, provides more benefits than monetary return alone such as reducing the potential for catastrophic fire and protection for livestock.

The potential for Spotted gum plantations is probably the greatest for the Hub region, in terms of reasonable economic returns and land suitability (Figure 12). As we have determined, the highest returns are achieved with a combination of timber, carbon and grazing. With carbon in the mix, the available area must be within the NPI regions (refer to Section 2.6.3). Although this restricts the potential areas for planting Spotted gum, there are still significant areas classed as 'moderate' that also enable good returns from carbon.

As with Gympie messmate, Spotted gum has desirable wood properties and is sought after for sawlogs and poles (Ergon Energy have their own Spotted gum plantations in Queensland for this reason). Our economic analysis did not include poles, so the returns from timber for this species are likely to be higher than what we have presented.

Hoop pine is also endemic to the Hub region, and it requires the longest time from planting to final harvest to achieve suitable log sizes. Financial return for this species is also reasonable and it produces high yields of ACCUs. The land suitability for this species is limited to areas inland of the coast and, as with Gympie messmate, the most suitable high highest ACCU yielding areas are in the LGAs with the highest land values. Again, similar to Gympie messmate, there is an area in the southern part of the Gladstone LGA with good suitability.

5. Alternative silvopasture system

Silvopasture has been described in the literature review chapter of this report (Section 2.7). In this chapter, we explore an alternative silvopasture system that could be employed by landowners - an alley-based planting system. Three of the species in the project are appropriate for this alternative silvopasture system - Southern pine, Spotted gum and Gympie messmate.

The alley-based system consists of a 20m row of pasture with no trees, followed by two rows of hardwood trees (Figure 26) or three rows of softwood trees (Figure 27) with five metres between the rows. In essence, there are concentrated rows of plantation trees with standard spacing (5m x 2m) beside alleys of regular pasture.

This system allows for the maintenance of higher quality pasture in the open areas and concentrated trees allowing for more efficient management. The system enables a higher number of livestock to be maintained throughout the project when compared to a regular plantation/grazing scenario as described in the previous chapter.

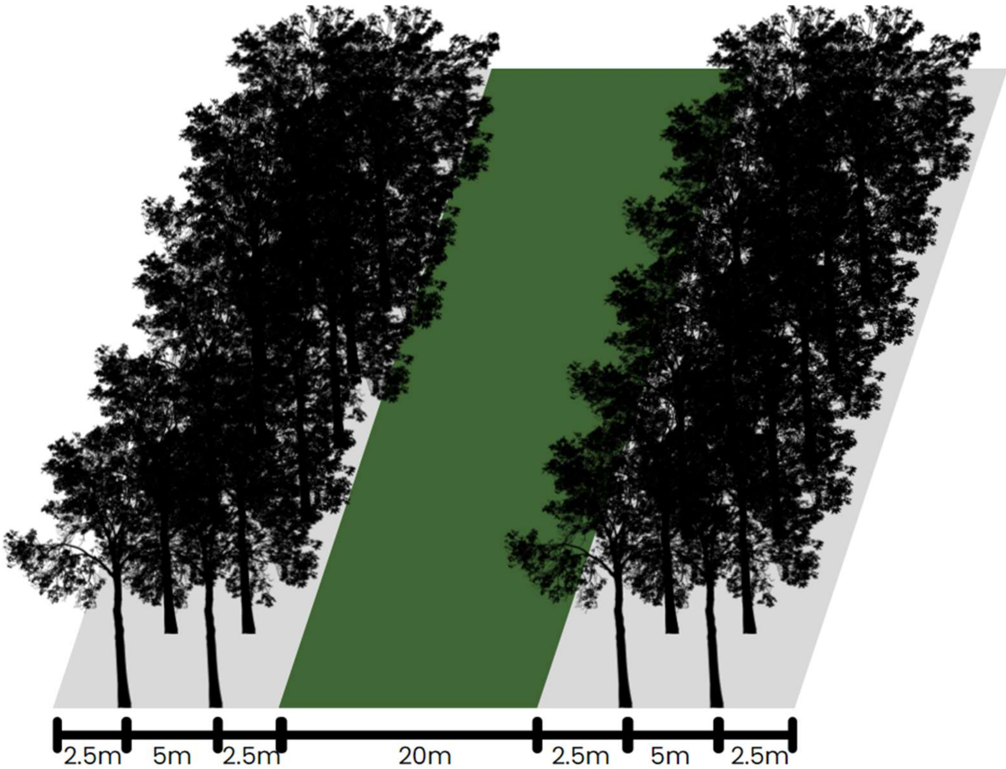

Figure 26- Hardwood silvopastoral layout

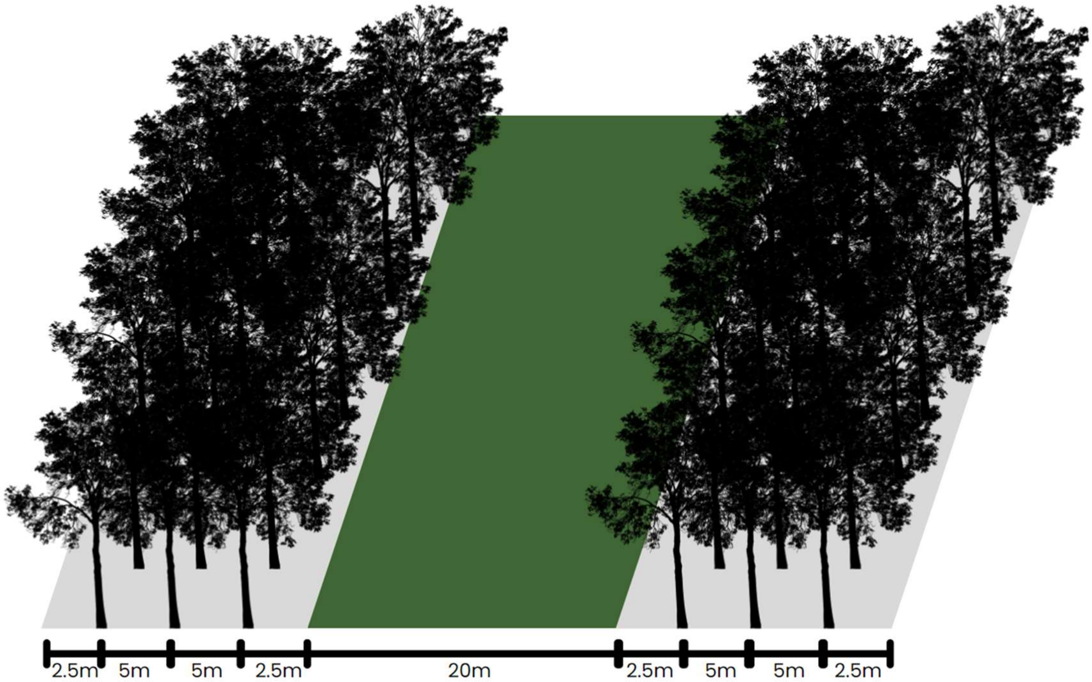

Figure 27- Softwood silvopastoral layout

In considering the layout and economic analysis of these systems, we have calculated the total project area needed to achieve 20 hectares of planted land. The reason for 20 hectares is the same as the previous chapter; 20 hectares of plantation is the minimum area required to apply for the Government Grant (refer to Section 6.5.1).

For the hardwood silvopasture system, a total land area of 60 hectares is required to acheive 20 hectares of plantation (i.e. 10/30, or 0.33 of every hectare is planted). For the softwood system, a total land area of 46 hectares is required (i.e. 15/35, or 0.429 of every hectare is planted).

5.1 Silvicultural regimes

The three species used in this analysis have different silvicultural requirements during their lifecycle to maximise economic returns and product outcomes (Table 43). All modelling processes within this project have considered each species-specific requirements for the following variables:

- Stocking at planting
- Weed control
- Fertiliser application
- Timing and intensity of thinning
- Clearfall age.

Table 43- Alternative silvopastoral silvicultural regimes

Species	Initial stocking (per ha*)	Weed control spray	Fertiliser	Thinning age (yrs.)		Thin stocking (per ha*)		Clearfall age (yrs)
FullCAM 2016- Plantation Method								
Southern pine	833	Yes	Yes	6	15	500	250	25
Spotted gum	1000	Yes	Yes		4	250		30
Gympie messmate	1000	Yes	Yes	5	20	375	250	30

* Per planted hectare, not per hectare of the total project area

5.2 FullCAM mapping results

For each of the species and their specific silvicultural regimes a model run was conducted within the NPI regions (from Figure 28 to Figure 30).

To comply with ACCU Scheme guidelines, the plantation species mapping only occurs within the NPI regions.

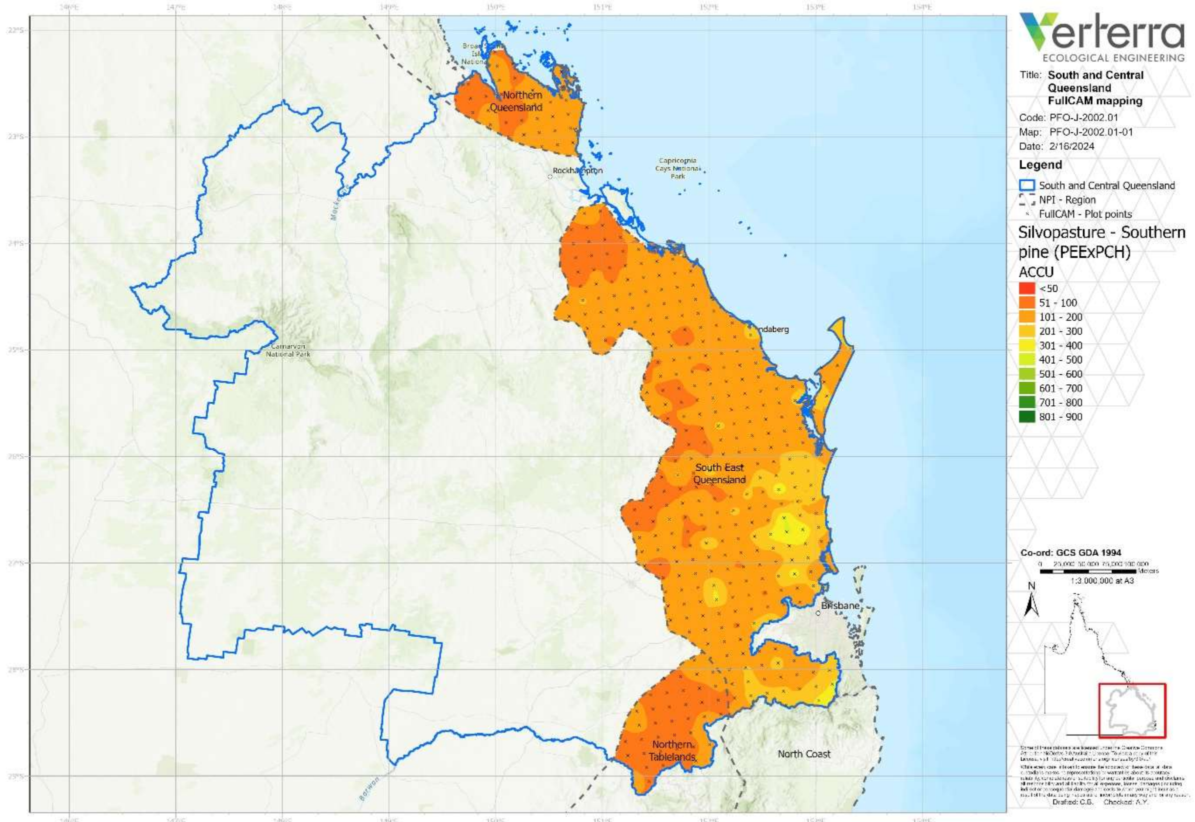

Figure 28-Alternative silvopastoral Southern pine- FullCAM 2016 within NPI region

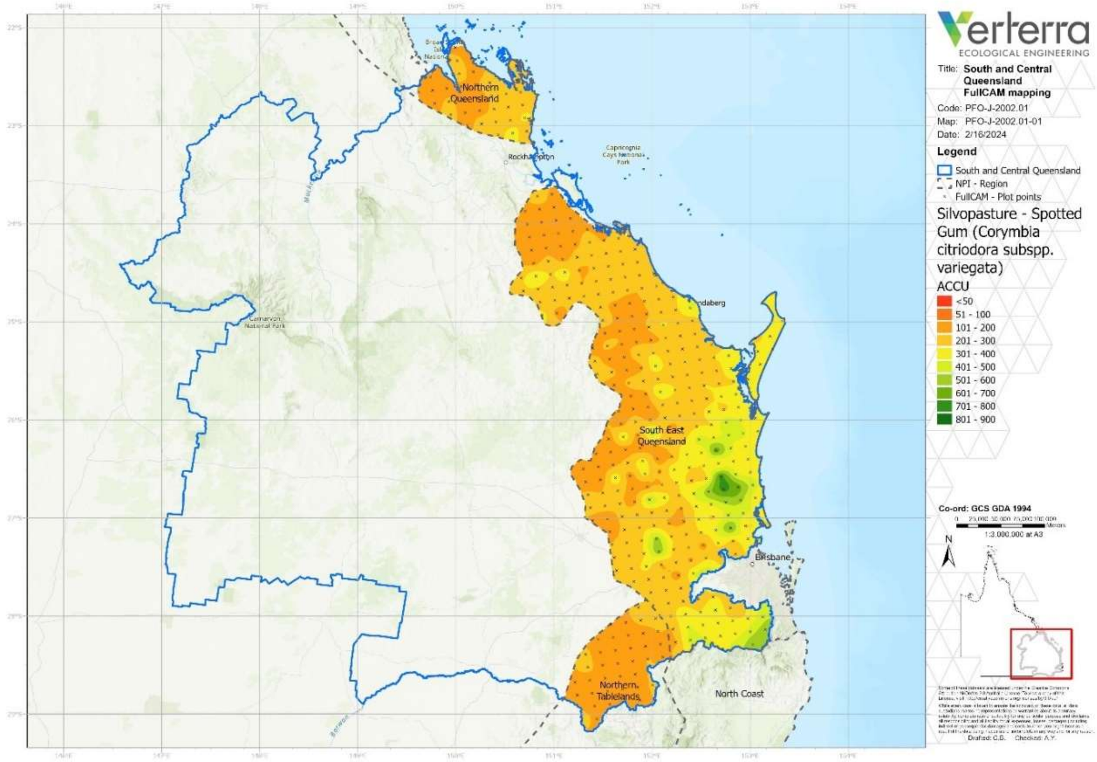

Figure 29- Alternative silvopastoral Spotted gum- FullCAM 2016 within NPI region

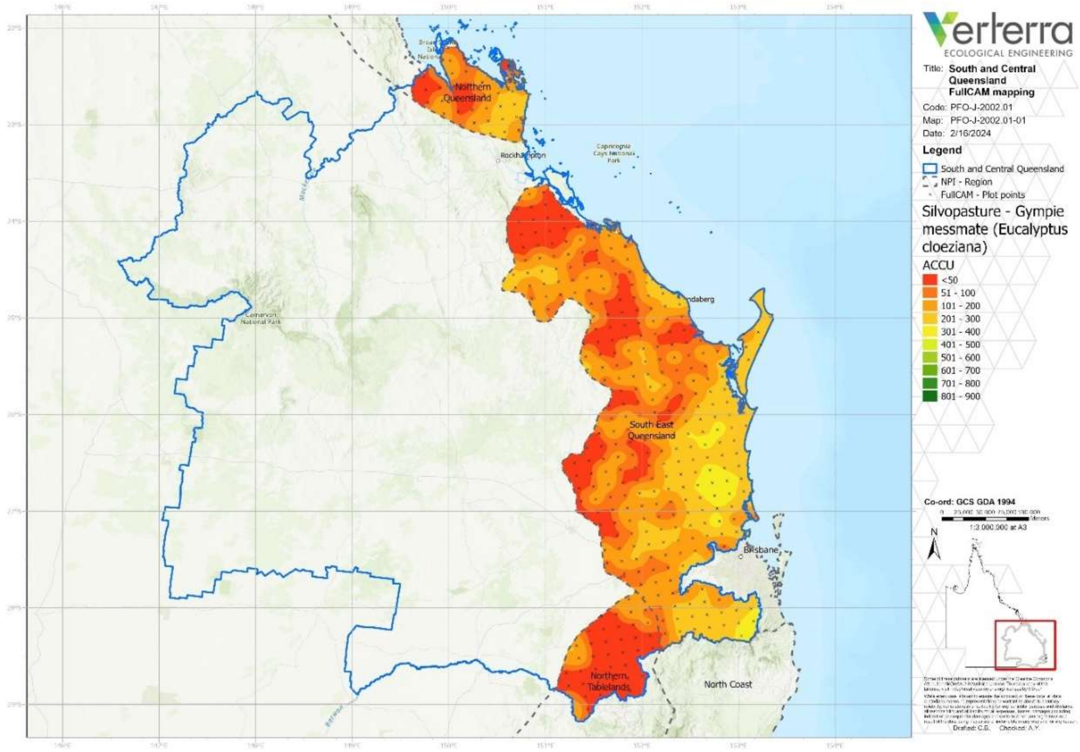

Figure 30- Alternative silvopastoral Gympie messmate - FullCAM 2016 within NPI region

5.3 Silvopastoral model assumptions

This section outlines the assumptions that were used in the alternative silvopastoral economic model.

5.3.1 Land area and costs

This model required larger parcels of land to achieve a planted area 20 hectares to align with the minimum area requirement of the Government Grant. For the hardwood projects, the land area was set at 60 hectares, and for the softwood project the land area was 46 hectares.

Costs associated with land, and the land value were set to be the same as the analysis in the previous section. These are presented in Table 44.

Table 44- Land assumptions

Activity	Units	Cost
Council rates	% of land value	0.4
Land value	$ per ha	$8,000
Land rental of the plantation area only (20 ha)	% of land value	0.02

5.3.2 Plantation establishment and maintenance costs

Plantation establishment costs from site preparation and planting through to weed control and fertiliser are presented in Table 45. In these scenarios, and additional weed control activities have been included in the Yr 1-3 cost as it is anticipated that canopy closure will not be achieved as quickly as with the regimes in the previous section.

Plantation insurance costs and the engagement of a third-party to project manage the plantation estate are not included as per the previous section.

Critical to the production of high-quality sawlogs in this scenario is pruning the lower limbs of the trees. Pruning is often conducted in three 'lifts' over a number of years, with the aim of having no branches up to 6.4 m above ground level. The cost of this activity has not been included as it is assumed that the landowner will carry this out.

Table 45- Plantation establishment and maintenance costs activities assumptions

Activity	Units	Cost
Yr 0-1 Site prep and establishment	$/ha	2,000
Yr 1 silviculture (fertiliser)	$/per operation	278
Yr 1-3 silviculture (weed control)	$/per operation	550
Ongoing- maintenance	$/ha/ann	60

5.3.3 Timber harvesting and roading

Costs

All harvesting, haulage and roading costs are the same as the previous analysis in Section 4.

Returns

The mill door prices are the same as the previous analysis.

5.3.4 Carbon

Carbon costs and returns are the same as the previous analysis.

5.3.5 Silvopasture

The assumptions relating to livestock are different from the previous analysis in that the availability of feed is expected to be higher throughout the project. The 'liveweight gain adjustment' is altered to take this into account (instead of 5% it is 1%). These assumptions are presented in Table 46.

Table 46- Silvopastoral assumptions

Variables	Units	Amount
Long Term Carrying Capacity (from Long Paddock)	ha/AE	Varies by site
Liveweight gain	Kg/AE/ann	100
Liveweight gain adjustment (reduction due to less feed)	%/ann	1
Maximum adjustment to liveweight gain	%	75
Liveweight farmgate price	$/kg	2.54
Grazing start	Years after planting	3
Cost of husbandry	$/AE	20

5.4 Model points

The base economic model was replicated for each of the species, silvicultural and silvopastoral regimes in this section (refer to Table 43). In order to enable comparison with the previous economic analysis, we selected the same three locations for Spotted gum, Southern pine (low rainfall), and Gympie messmate.

Each of these models were adjusted to reflect the specific attributes of that location.

Table 47- Analysis model point information

	ID no#	ACCU	NPI Region	LGA
Spotted gum	37	518	SE QLD	Somerset
Southern pine	547	373	SE QLD	Fraser Coast
Gympie messmate	473	553	SE QLD	Gympie

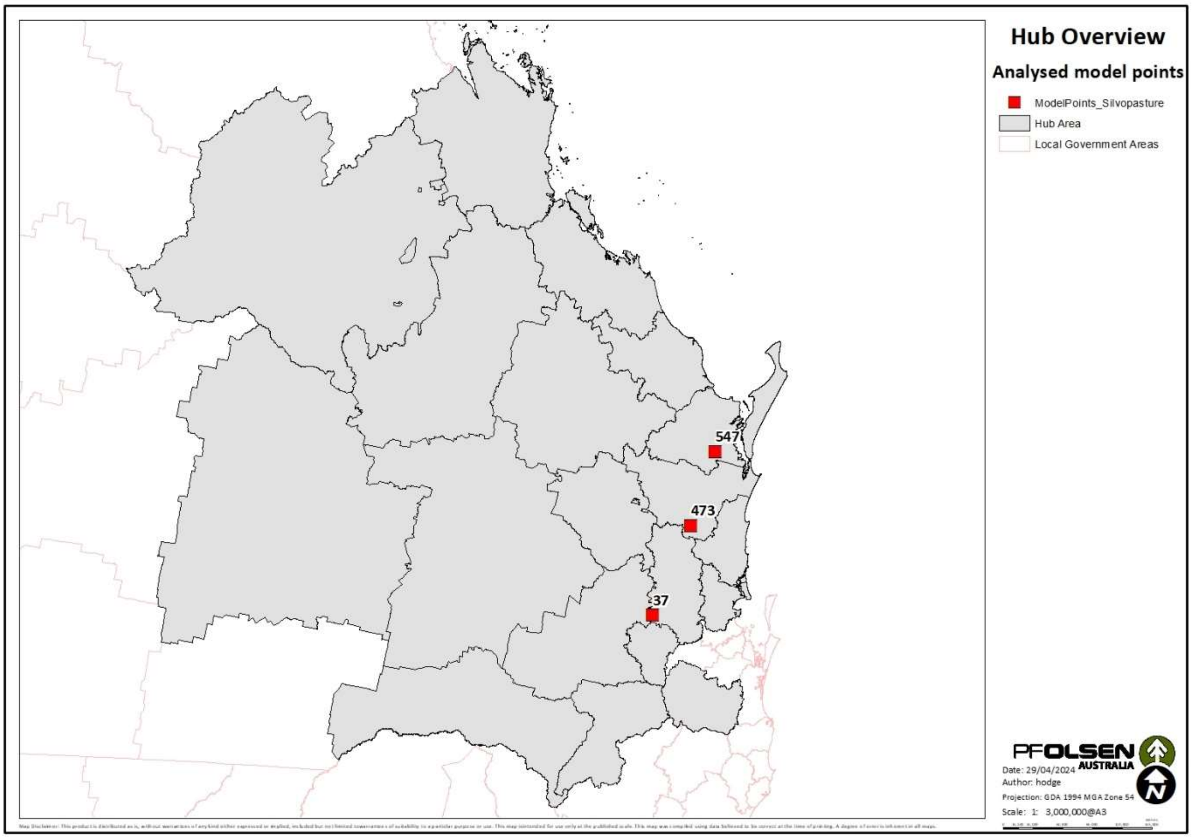

Figure 31- Silvopastoral model analysis points

5.5 Economic analysis by species

The results from the economic modelling (timber, carbon and grazing) are summarised in Table 48. Every regime returns a positive NPV with a discount rate of 5%. Of the three regimes, Gympie messmate is the most favourable, but the financial outcome is not as high as the outcome from the previous chapter. The greatest difference from the previous chapter is Spotted gum; the NPV from the previous chapter was $95/ha (with grant) compared to $1,765/ha under this regime. The alternative silvopasture regime for Spotted gum produced more timber volume, ACCUs and liveweight gain from cattle.

Table 48- Economic analysis per hectare by species and regime summary – timber, carbon and grazing

		Southern pine	Spotted gum	Gympie messmate
With grant	NPV 5% ($ per ha)	1,030	1,765	2,055
Without grant	NPV 5% ($ per ha)	178	1,112	1,403
With grant	IRR	8.8%	11.1%	12.9%
Without grant	IRR	5.5%	7.7%	8.7%

One of the limitations of using FullCAM is that the tree growth estimates may not necessarily reflect the potential for these alley-crop systems. In these systems, each tree has one side that has greater access to light because there is no crown competition from trees in a neighbouring row. With more access to light, it follows that these trees will grow faster than the same trees in a traditional plantation situation. We look at the influence increased volume and other key variables have on NPV in the following section.

5.6 Sensitivity analysis

This section presents the results of sensitivity analysis for the following variables:

- Timber volume and carbon (+25%, +50%)
- Live weight farm gate price ($2.50, $3.00, $3.50)
- Carbon project permanence period (25yrs vs 100yrs)

5.6.1 Timber volume

A 25% increase in timber volume leads to around a $500/ha increase in NPV (Table 49). These types of gains over the modelled FullCAM output are not unrealistic. A project that measured the edge effect of Blue gum trees in plantations across 32 sites in Western Australia found that "the volume of wood produced in the edge row was approximately twice that of the second row" (Albertson, Eckersley, Blennerhassett, Moore, & Hingston, 2000).

Table 49- Timber volume sensitivity analysis per hectare with grant

NPV 5% ($ per ha)	Southern pine	Spotted gum	Gympie messmate
Original	1,030	1,765	2,055
25% increase	1,498	2,230	3,172
50% increase	1,967	2,697	3,613

5.6.2 Live weight farm gate price

A $0.50/kg increase in live weight farm gate price increases the NPV by $100 to $200 (Table 50).

Table 50- Live weight farm gate price sensitivity analysis per hectare with grant

NPV 5% ($ per ha)	Southern pine	Spotted gum	Gympie messmate
$2.50	1,030	1,765	2,055
$3.00	1,237	1,888	2,173
$3.50	1,443	2,012	2,292

5.6.3 Carbon project permanence period

All of the modelling in this project has assumed a 25-year permanence period, and this incurs a deduction of 20% off the total ACCUs that could be claimed from the project (see Section 2.6.2 for more information). In this analysis, we explore the NPV change if all the ACCUs can be claimed.

The result of selecting the 100-year permanence period leads to a gain in NPV of around $400 (Table 51).

Table 51- Carbon project length sensitivity analysis per hectare with grant

NPV 5% ($ per ha)	Southern pine	Spotted gum	Gympie messmate
25-year project permanence	1,030	1,765	2,055
100-year project permanence	1,417	2,172	2,447

6. Policy

The management of forests in Australia is a complex matter as it involves Commonwealth, state, and territorial governments. Forest policies often reflect a balance between economic, social and environmental interests in forests.

Key points that are generally part of plantation forest policy include:

- *Economic development and timber production*: Plantation forestry is a means to meet the growing demand for timber and wood products while reducing the pressure on native forests.
- *Biodiversity and environmental considerations*: While plantation forestry is primarily focused on timber production, forest policy recognises the importance of integrating biodiversity conservation and environmental protection into plantation management. This might involve incorporating buffer zones, maintaining habitat, and adhering to guidelines that reduce the impact on water quality and ecosystems.
- *Climate change and carbon sequestration*: Plantation forests play a crucial role in capturing carbon dioxide from the atmosphere, contributing to climate change mitigation. Some government policies include provisions to promote reforestation and afforestation as part of broader climate change strategies.
- *Indigenous land management*: Forest policies recognise the cultural and traditional connections of Indigenous communities to forests. Efforts are made to involve Indigenous peoples in forest management decisions to support their role in conservation and sustainable land management.
- *Research and monitoring*: Forest management relies on scientific research and monitoring. This could involve improving tree genetics for better timber quality and growth rates, developing pest and disease management strategies, and exploring innovative plantation management techniques.
- *Community engagement*: Plantation Forest policies often aim to involve local communities, stakeholders, and the public in decision-making processes related to forest management. This could include consultation on issues like landuse and harvesting.
- *International agreements*: Australia's forest policies are influenced by international agreements and conventions related to biodiversity conservation, sustainable development, and climate change.

Commonwealth and state governments perform sensitive balancing act in order to manage the wide array of conflicting demands and challenges.

Additionally, landuse competition driven by the increasing demand for food, housing, agricultural commodities, and bioenergy is providing a barrier to plantation forestry expansion. As these competing demands become more intense, barriers to plantation forestry will continue (Barua & et al , 2014). Due to a surge of demand for land, land prices are increasing resulting in fewer opportunities for market entry. This increased competition has left confusion between establishing plantations for timber production or utilising land to improve ecosystems (Conor & Regan, 2022)

Despite these complexities, the Commonwealth, state, and territory governments understand the importance of the forestry sector and are actively exploring pathways to enable the expansion of the plantation forestry estate.

6.1 Federal Government Forest policy

The management of Australia's forests is guided by the 1992 National Forest Policy Statement (NFPS) (Commonwealth of Australia, 1992). The NFPS was signed by the Federal Government and all mainland state and territory governments in December 1992 and by the Tasmanian Government in April 1995. Increasing the plantation timber resource was a key forest policy objective of NFPS.

In 2017, Commonwealth, state and territory forestry ministers issued a joint ministerial statement, reaffirming support for the forestry industry. The Statement collectively endorses the objectives of a Forest Industry Advisory Council's (FIAC) report, *Transforming Australia's forest products industry,* that the forestry industries will lead the transition to a bioeconomy and the objectives of:

- Having the right trees in the right place at the right scale
- Producing bioproducts using all parts of the tree to a cellular level
- Being environmentally friendly, socially responsible and valued by the community.

In addition to the NFPS, historic Federal Government policy included the *National Forest Industries Plan* which was launched in 2018. The overarching principle of the *National Forest Industries Plan* was to support Australia's forest industries to:

- Meet the challenges of the future.
- Underpin growth in the renewable timber and wood-fibre industries.
- Innovate and use forest resources smarter.
- Assist industry to realise its ambition to plant a billion new plantation trees during the decade to 2030.

The Plan effectively superseded the earlier *Plantations for Australia*: *the 2020 Vision.* The overarching principle of the 2020 Vision was to enhance regional wealth creation and international competitiveness through a sustainable increase in Australia's plantations., This increase was based on a notional target of trebling the area of commercial tree crops to around three million hectares by 2020.

The 2018 Plan updated the theme of the 2020 Vision. Among other things,, the 2018 Plan established the framework for investment in the Regional Forestry Hubs.

A Better Future for our Regions and A Future Grown in Australia, establishes the government's commitment to Australia's forest industries. The aim is to strengthen and support a sustainable forestry sector. The (2023) Government announced a suite of initiatives totalling over $300 million to innovate and improve the capacity and capability of the forestry sector.

These initiatives include funding to support the establishment of new long-rotation softwood and hardwood plantations in Australia by:

- Increasing future plantation forest resources available for processing, for plantation forest management, plus harvesting and haulage employment.
- Supporting the private industry, First Nations businesses, farm foresters and state and territory government forestry bodies to expand the Australian plantation forest estate.
- Contributing to meeting Australia's carbon emission reduction targets.
- Supporting a forestry workforce training program.
- Extending funding for the Regional Forestry Hubs to 2027.
- Accelerating the adoption of wood processing innovation.
- Protecting Australia from illegal logging.

Nevertheless, it is important to note that forest policies vary between the states and territories within Australia due to the division of powers between the federal and state governments.

6.1.1 Carbon farming framework

Carbon farming in Australia is managed under Federal Government legislation. The ***Carbon Credits** (Carbon Farming Initiative)* ***Act 2011*** (CFI Act) passed through Parliament in August 2011. This allowed participating farmers and landholders to receive a tradeable carbon credit, referred to as an Australian Carbon Credit Unit (ACCU) for projects that avoid the release of greenhouse gas emissions or remove and sequester carbon from the atmosphere.

In 2014, under a newly elected Governments 'Direct Action Plan', amendments to the Act allowed for the creation of the Emissions Reduction Fund (ERF) and the purchase of ACCUs through Government auctions. In June 2023, the ERF was renamed as the ACCU Scheme. The ACCU Scheme has three key elements: crediting, purchasing, and safeguarding emissions reductions.

- Crediting - For each tonne of carbon dioxide equivalent (tCO2-e) stored or avoided by a project, an ACCU is earnt.
- Purchasing – The Government initially allocated $2.55 billion to the scheme, with an additional $2 billion through the Climate Solutions Fund (CSF) in 2019..
- Safeguard mechanism – The Safeguard Mechanism complements the emissions reduction elements of the ACCU Scheme by sending a signal to businesses to avoid increases in emissions beyond business-as-usual levels. It achieves this by placing a legislated obligation on Australia's largest greenhouse gas emitters to keep net emissions below their emissions limit (or baseline).

Two ERF vegetation methodologies enable timber production:

1. Plantation Forestry (4 schedules):
    - Schedule 1 – Establishing a new plantation
    - Schedule 2 – Converting an existing plantation from a short to long rotation
    - Schedule 3 – Continuing plantation forestry activities
    - Schedule 4 – Transition to a permanent (not-for-harvest) forest
2. Farm Forestry Plantations
    - Permanent plantings
    - Harvest plantations

These methods account for the carbon sequestered through the growth of trees, plus the benefit of carbon stored in post-harvest timber products. Other vegetation methods exist, however they do not directly allow for timber production during the term of the project. These include:

- Reforestation by environmental or mallee planting
- Human-induced regeneration of a permanent even-aged native forest
- Avoided clearing of native regrowth
- Native forest from managed regrowth
- Reforestation and afforestation

The 2022 plantation forestry method is an update from the 2017 method that aims to sequester carbon from trees as they grow and are stored in timber products. Calculation of carbon includes the total mass of carbon in tress, forest debris, and harvested wood products. While four schedules exist under the method, establishing a new plantation (Schedule 1) is of particular relevance to this project.

A significant update from the 2017 Plantation Forestry Method is new plantations can now be established in areas outside the National Plantation Inventory (NPI) regions (Figure 4). However, all new plantations located outside NPI regions are required to use the mixed-species environmental plantings calibration within FullCAM.

To enable greater uptake of the Plantation Methodology, the Federal Government has recently removed a well-known barrier to project participation, referred to as the 'water rule'. Further, the government has committed to update FullCAM species calibrations to better reflect plantation forestry, i.e. eliminate the need to use mixed species in areas outside NPI regions.

6.2 State Government policy

Under the Australian Constitution, State Governments have primary responsibility for landuse decision making and management. The states and territories have enacted legislation that allocates forest land tenures and specifies the administrative framework and policies within which public and private forests are managed. Relevant Queensland legislation includes:

- Forestry Act 1959
- Land Act 1994
- Vegetation Management Act 1999
- Native Title Act 1993
- Local Government Act 2009
- Planning Act 2016

6.2.1 Land management

In Queensland, a range of entities are responsible for land management for a range of land tenures. Land tenure is an overarching keystone in Queensland forestry. The occupation of the land can be defined under two broad tenure headings:

- Freehold land
- Non-freehold land.

Freehold land is the most complete form available for land division from the State. However, ownership by the titleholder is not absolute as the State is allowed to withhold certain rights, such as the right to any minerals or petroleum. In addition, use of the land may be controlled by legislation- e.g., *Forestry Act 1959* or the *Local Government Act 2009*.

Approximately 30 percent of the state is held as freehold land, which is not subject to the *Land Act 1994*. However, landholders must be aware of the *Vegetation Management Act 1999*. This Act regulates the clearing of native vegetation on private land (i.e. freehold). The Act aims to conserve vegetation, avoid land degradation, prevent loss of biodiversity, maintain ecological processes, and allow sustainable landuse. The Act determines the different vegetation types and details the activities that can occur.

Non-freehold land is land under the control of the State of Queensland, which may be subject to a lease, licence, or permit, reserved for a community purpose, or dedicated as a road. Under the broad tenure headings, there can be a range of leases, which ultimately influence the land management legislation, administrative rights, and relevant land manager.

6.2.2 Plantations on State-owned land (including Forest Consent areas)

The ownership of new plantations on State land (including State Forest, Timber Reserve, Forest Entitlement Areas, State-owned lease), or private land subject to a Forest Consent Area, is deemed to rest with the State Government. Either through the Department of Agriculture and Fisheries (DAF), or the Department of Resources (DOR). Permission to establish plantations must be sought from DOR for State land or DAF for Forest Entitlement or Forest Consent Areas.

6.2.3 Plantations on private land (excluding Forest Consent areas)

New plantation development in Queensland requires planning approval. Plantation establishment is considered a material change in landuse which is subject to the Planning Act 2016 and the relevant local government development assessment requirements.

6.2.4 Plantation Code of Practice

The *Timber Plantation Operations Code of Practice for Queensland* provides guidance on operational activities associated with commercial timber plantations in Queensland to comply with all laws and with accepted principles for sound plantation management.

The Code defines the voluntary standards developed for use by all parties with an interest in commercial timber plantations in Queensland, including the landowner, the plantation owner, the plantation manager, the harvest manager and any employees and contractors employed to work in a plantation (plantation operators).

Adoption of the Code will assist plantation operators to meet legislative and other requirements applicable to the establishment and management of existing plantation areas and new plantation areas. The Code is 'tenure blind'. That is, it can be voluntarily applied by plantation operators over any land tenure in Queensland. The relationship between the Timber Plantation Operations Code and other instruments is demonstrated in the flow chart shown in Figure 32 (directly from the Code).

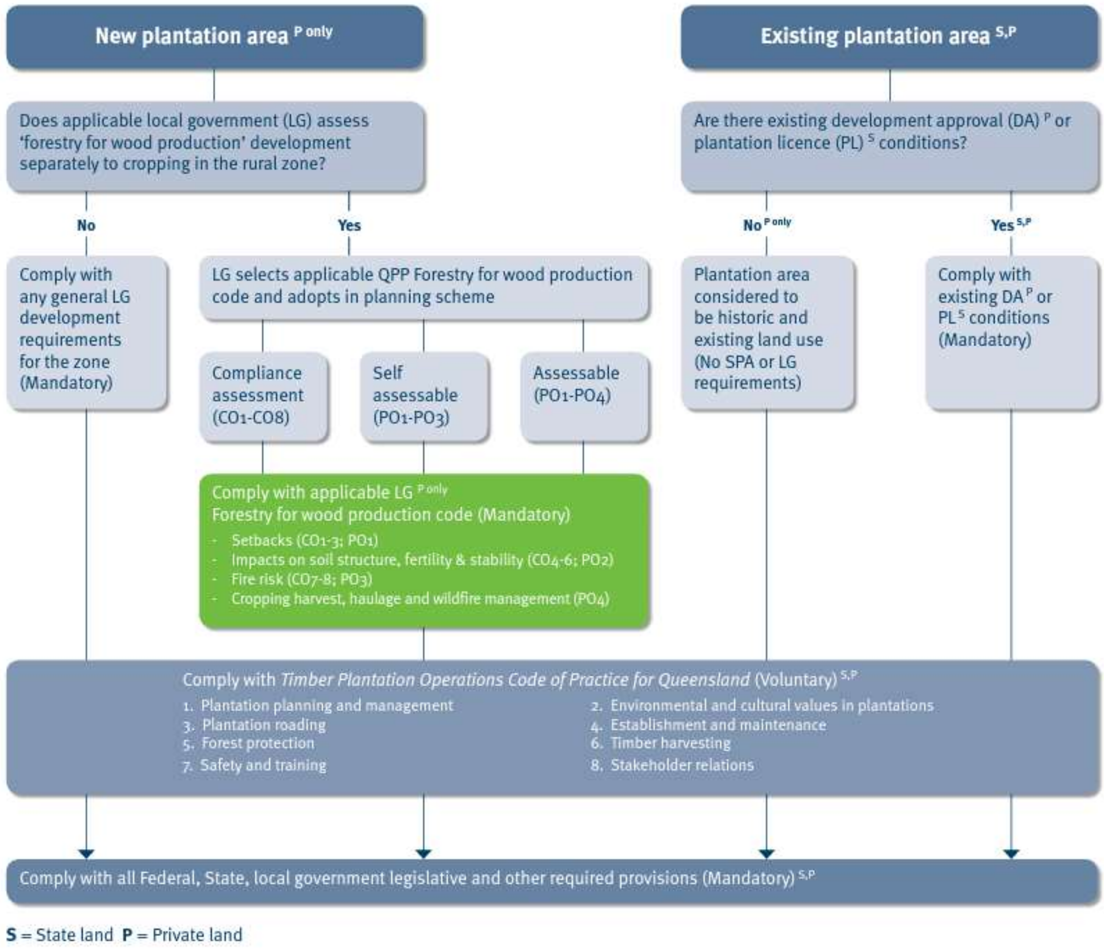

Figure 32-Relationship between the Timber Plantation Code and other instruments Source: (Timber Queensland, 2015)

6.2.5 Koala conservation

Plantations that include *Corymbia* and *Eucalyptus* species are regulated by the koala conservation plan and management program in some areas of Queensland (koala districts A and B). This regulation complies with the Nature Conservation Act 1992 (State of Queensland, 2022).

6.3 Timber supply and demand

Results from the '*Australian plantation statistics and log availability*' report aims to support strategic forest industry planning and decision-making (ABARES, 2023). The report presents information on total plantation area, new planting, and ownership along with forecasts of future softwood and hardwood sawlog and pulp log availability. Key findings from the latest report about supply and demand are below.

6.3.1 Supply

Australia's commercial plantation area in 2019-20 was 1,774,660ha. This area is 198,700ha (10%) less than the area recorded in the prior 5 years, in 2014-15. The total softwood plantation was relatively stable, declining by only 7,300ha (0.7%). The total hardwood plantation area decreased by 204,900ha (22%) because of low commerciality plantations not being replanted after harvest and some lease agreements with landholders not being renewed.

A total of 9,700ha were established between 2014-15 and 2019-20, comprising 7,800ha of softwood plantations and 2,000ha of hardwood plantations.

Total log availability from Australia's commercial plantation estate is forecast to decline from an annual average of 27.7 million cubic meters in the 2015–2019 period to approximately 24.9 million cubic meters in the 2020–2024 period, including a decrease in both hardwood and softwood availability.

The total plantation area for Queensland was 205,000 hectares in 2019, consisting of 89% softwoods, 10% hardwoods and less than 1% mixed species. The total plantation estate decreased by 35,000 ha (15%) between the years 2016 and 2019. Most of the plantation estate is in the southeast, with a total area of 180,000 ha. North Queensland has 23,000 ha, with approximately 2,000 ha outside these regions.

6.3.2 Domestic demand

By 2050, Forest & Wood Products Australia (FWPA) (Woods & Houghton , 2022) predicts that Australia's population will reach between 34 to 40 million people with a new housing demand of around 259,000 dwellings annually. Softwood timber demand will rise to 6.5 million m^3 annually which is almost 2.0 million m^3 per annum higher than in 2021. However, softwood timber production will remain static at between 3.6 and 3.8 million m^3 annually as we reach Australia's current plantation estate yield limits.

The FWPA anticipates that the implied gap of 2.6 million m^3 per annum could be met by establishing 468,000 hectares of new plantations and by increasing Australia's timber import program. Whittle *et al* (2019) however suggests that, under current market conditions, new plantation development is not economically viable. Therefore, to develop new plantations, Australia will need to develop new investment models that exploit a broader range of value opportunities (such as carbon farming, agroforestry, processor investment models).

6.3.3 Regional demand

The Australian Bureau of Statistics (ABS) projects that Queensland's population will increase to 7.5 million by 2050 (Figure 33), a factor of 1.53 times the current population.

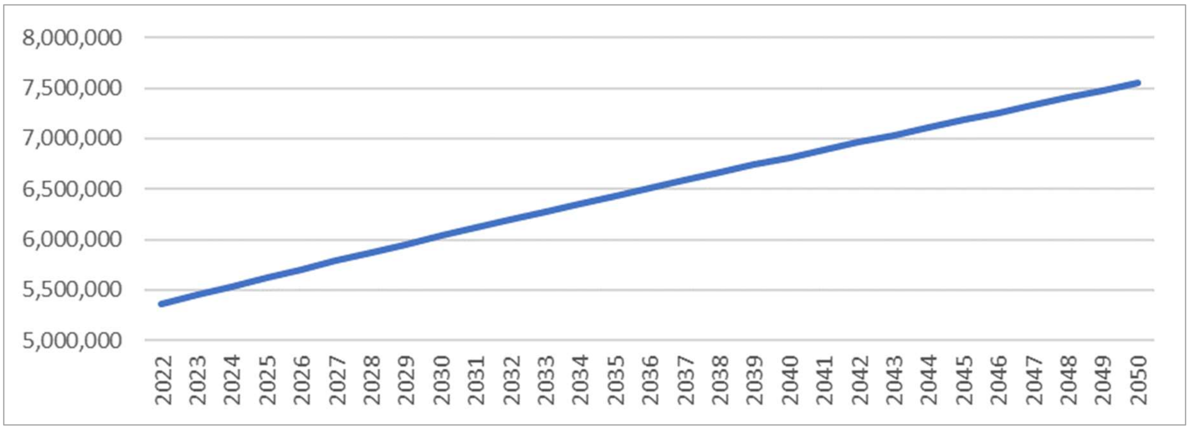

Figure 33- Population projections, Queensland Source: (Australian Bureau of Statistics, 2017)

Timber consumption is highly correlated with population growth. Using this trend, demand for timber in southern and central Queensland will increase.

6.4 Carbon (ACCU) supply and demand

The Carbon Market Institute (2023) published a market brief on ACCU supply and demand. Key findings from this brief include:

- There is currently a broad range of supply sources for ACCUs, which has seen the domestic Australian carbon market grow steadily since 2011. There was 11.4 million ACCUs issued in 2022, suggesting growth in supply has slowed in recent years.
- Demand sources for ACCUs are set to step up because of the passing of the Safeguard Mechanism reforms, as well as future state and territory commitments, and corporate and individual voluntary purchasing strategies.
- Key factors determining supply levels will be the implementation of the Independent Review of ACCUs (or 'Chubb Review') recommendations, progress of method development, as well as the likely market impacts of changes of government policy in managing carbon abatement contracts.

- The Federal Government's role in the market will continue to be important but will need to adjust with increasing private investment. While demand from the Safeguard Mechanism reforms may be a demand driver to generate new supply of ACCUs, appropriate policy and method development, regulation, and strategic government funding (particularly for co-benefits) will be crucial to ensure an adequate supply of high integrity ACCUs.
- While the ACCU Scheme focuses on a diversity of sectors including energy, facilities, mining, oil and gas, waste, and wastewater, 70% of the projects to date relate to vegetation and soil management. The average price for ACCUs after the last auction (March 2023) was $17.12, with the spot price trading higher over recent years (Figure 34), currently at $31.25 (August 2023). The spot price did reach $58 before a decision by the CER to remove obligations on some Carbon Abatement Contract delivery in 2022.

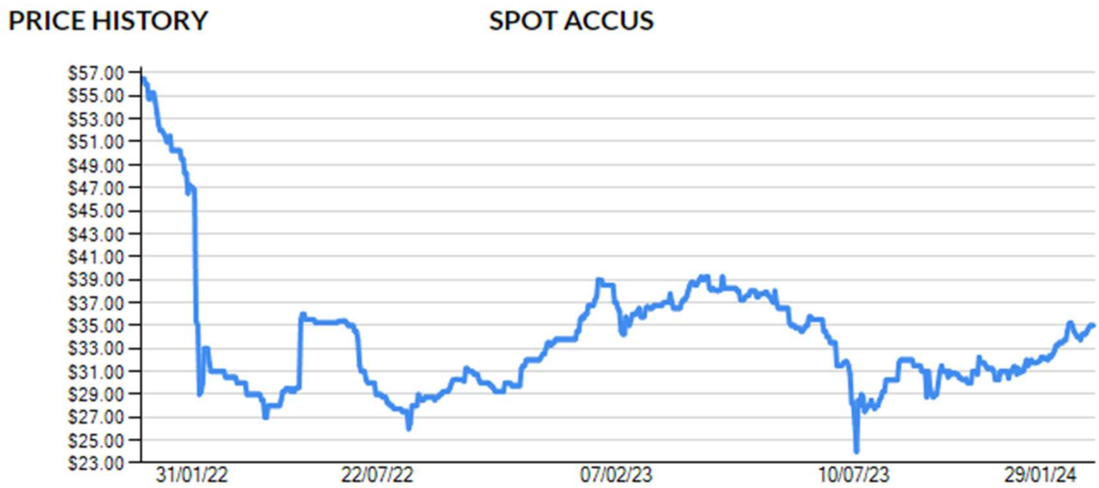

Figure 34- ACCU spot price history. Source : accus.com.au

- Further downward pressure resulted from the release of over 150,000 ACCUs over two large soil carbon projects in mid-2023. Notwithstanding this recent downward pressure, demand for ACCUs is expected to increase over the coming years and decades.
- Beyond Federal Government ACCU Scheme funding, state governments are now contributing funding through their own emission reduction targets. For example, the Queensland Government aims to achieve a 30% reduction in emissions by 2030, with net-zero by 2050. The Queensland and Western Australia governments have introduced their own carbon purchasing funds, with the Queensland Land Restoration Fund (LRF) (Queensland Government, 2023) being the first fund to include a price for 'co-benefits' linked to carbon farming projects.

Further investment in carbon farming will be significant. The Carbon Market Institute (CMI) is the peak carbon farming industry body in Australia. They commissioned a report on a 'Road Map' to increase growth in the carbon market sector (Carbon Market Institute, 2021). The road map suggests between $10 - 24 billion will be spent on carbon farming in Australia up to 2030.

6.5 Enabling plantation expansion

Barriers to plantation expansion in Queensland are not new. In 2010, the Department of Employment, Economic Development and Innovation identified a range of focus areas within the *Queensland Timber Plantation Strategy 2020* to enable plantation expansion. This strategy has not been updated post 2020 and limited information is available on the success of the strategy. A policy gap now exists. However, funding opportunities do exist to encourage plantation establishment.

6.5.1 Government funding

The Federal Government is aiming to strengthen Australia's sustainable timber supply, with $73.76 million in grants to establish new forestry plantations. The Support Plantation Establishment program will provide grant funding over four years (2023-27) to help establish new long-rotation softwood and hardwood plantation forests. The program will seek to establish up to 36,000 hectares of new plantation across Australia.

The grants are open to private industry, First Nations businesses, farm foresters, and state and territory government forestry bodies. Applicants are required to provide a co-contribution at least equal to the grant amount awarded. This can be demonstrated by the value of the land the new plantation forests will be established on, financial means, or state, territory, or local grant funding.

The Government will provide funding of $2,000 (GST exclusive) per one hectare of new long-rotation plantation forest established, with a minimum plantation area of 20 hectares to be eligible for a grant.

6.5.2 Agroforestry

Timber Queensland and the Regional Forestry Hubs (funded by the Australian Government) are working on various projects to enable the expansion of the plantation estate. Of particular interest is the recognition of the opportunities and benefits to landholders in agroforestry. Benefits include:

- *Improved livestock health and well-being*: Trees in silvopasture systems provide shade for livestock, reducing heat stress and minimising the risk of heat-related health issues. Shade also contributes to improved animal welfare and overall livestock comfort.
- *Enhanced forage quality and quantity*: silvopasture systems can incorporate grasses, forage crops, and other vegetation suitable for livestock grazing. The presence of trees can create microclimates that promote better growth of forage plants, resulting in higher-quality and more abundant feed for livestock.

- *Climate resilience*: Trees in silvopasture systems contribute to carbon sequestration, helping to mitigate climate change by capturing and storing carbon dioxide from the atmosphere. These systems can also help reduce greenhouse gas emissions through improved soil health and reduced livestock stress due to shading.
- *Long-term sustainability*: silvopasture systems have the potential to be more resilient to extreme weather events and changing climate conditions. The integration of trees can provide a buffer against the impacts of drought and flooding, leading to more sustainable agricultural practices.
- *Diverse income streams*: silvopasture allows farmers to generate income from multiple sources, including timber, and livestock. This diversification can provide greater financial stability for farmers.

6.5.3 Carbon farming

The 2022 Plantation Forestry Method under the ACCU Scheme is an update from the 2017 method and aims to increase project participation. A significant update is that new plantations (Schedule 1) can now be established in areas outside the National Plantation Inventory (NPI) regions. Additionally, the 'water rule' is effectively eliminated, meaning plantation establishment can occur in areas that receive >600mm of annual rainfall.

The Queensland Government's Land Restoration Fund (LRF) supports landholders, farmers, and First Nations peoples to generate new, regular income streams through carbon farming projects whilst providing valuable co-benefits such as healthier waterways, increased habitat for threatened species, and more resilient landscapes. LRF objectives include:

- To facilitate a pipeline of Queensland based carbon offset projects.
- To pursue environmental, economic, and social co-benefits as defined by the Queensland Government.
- To invest in research and development into emerging carbon farming areas where Queensland has a comparative advantage.

Plantation forestry is not identified as an economic or social co-benefit under the LRF. However, Timber Queensland could lobby for this given the obvious benefits of plantation expansion to Queensland.

6.5.4 Processor investment

There is no evidence of large-scale processor investment in expanding the plantation forest estate in Queensland. However, it is known that industry 'off take' agreements occur in other states. These guarantee a future market for sawlogs with prices agreed upfront and CPI indexed for 25 years. Further, industry in some cases is underwriting first thinning events with profits returned to landholders.

6.5.5 Overcoming potential barriers

Enabling plantation expansion could be enhanced by addressing existing barriers, such as:

- Reducing or further providing funding of plantation establishment costs.
- Enhancing support from banks and investors, particularly in relation to carbon farming projects.
- Reducing competition for landuse by integration for plantations in current farming systems.
- Increasing community understanding on the benefits of plantations and enabling greater involvement.
- Providing clear pathways for certified wood.

6.6 Factors impacting tree plantations – what can be done?

In terms of how to encourage more commercial tree plantations within the Hub, we present the following ideas for consideration:

- Re-think the nature (perception) of plantations i.e., move away from broad acre single land use to embedding plantation forestry into agricultural systems. This could be planting unproductive grazing lands, planting large interrows, windrows or riparian plantings, cattle camps. The ActivAcre Program in Tasmania might provide a framework for consideration.

    'The ActivAcre Program sees farmers lease part of their less productive land in return for a reliable, annual income. In addition to increasing the productivity of existing farm activities, the program aims to enhance environmental outcomes such as climate change mitigation and improving biodiversity, soil conservation and water quality.'[12]

- Work with the Queensland Government to include plantation establishment within the Land Restoration Fund, i.e., list timber production for local use and job creation as a carbon farming 'co-benefit'. The Land Restoration Fund supports land sector projects that expand the carbon farming opportunities whilst also delivering environmental and social co-benefits.

[12] *https://activacre.com.au/*

- Work with the Queensland Government to ensure a 'right to harvest' commercial plantations is in place. A *Timber Plantations (Harvest Guarantee) Bill 1999* was introduced to the Queensland Parliament as a Private Members Bill on the 27th of October 1999. The Queensland Legislation website[13] shows that this Bill lapsed on the 23rd of January 2001. Perhaps such a Bill could be reintroduced to provide more confidence for those considering a new plantation. In NSW the *Timber Plantations (Harvest Guarantee) Act 1995* provides this surety for plantation growers in that State.
- Develop an aggregated carbon farming project to reduce risk and barriers to entry. A key issue with most carbon farming projects is the ongoing expenditure on third party audits. For a small grower, this cost might exceed the overall value of carbon. Project aggregation can occur where a single Hub project is registered that includes all interested landholders. This will result in shared audit costs, plus a larger selling block of timber and carbon into markets. The Hub could work with carbon farming project developers to explore the practicality of this.
- Integrate plantation establishment with the Reef Credit sediment abatement method being developed by Verterra (due for realise early 2024). Under this scheme, grazing land managers in Reef Catchments can generate payments for increasing ground cover and reducing sediment runoff. Wide spaced plantation forests would be modelled as an increase in ground cover and reduce overall sediment export. Stacking Reef Credits with Carbon Farming will be permitted.
- Use the suitability mapping provided within this report to identify 'hotspots' for plantation establishment, then promote to landholders. This can occur through an 'alliance' of Hub project proponents for integrated delivery of plantation establishment, carbon farming, and delivery of reef credits. The alliance could build on Verterra's existing 'Pilot' project with carbon farming proponents (linking soil carbon with sediment abatement) and be expanded to include plantation forestry. (Australian Bureau of Statistics, 2017)
- Explore the potential of developing a Decision Tree tool that is specific for the Hub such as that developed by the South West Timber Hub.[14], and under development at the Gippsland Forestry Hub.
- Explore Spotted gum plantation data within the Hub region but outside the NPI regions. If there is sufficient data, a case could be put forward to the Department of Climate Change, Energy, the Environment and Water to allow for the range of this species to be expanded for more accurate carbon estimations.

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[13] *https://www.legislation.qld.gov.au/view/html/bill.first.exp/bill-1999-635/lh*

[14] *https://www.decisiontreewa.com.au/*

6.7 Stakeholder engagement methodology

Currently land holders are bombarded with voices (Figure 35), including the government, local groups, and the broader community. This wide variety of voices creates confusion and can be very overwhelming for a landowner.

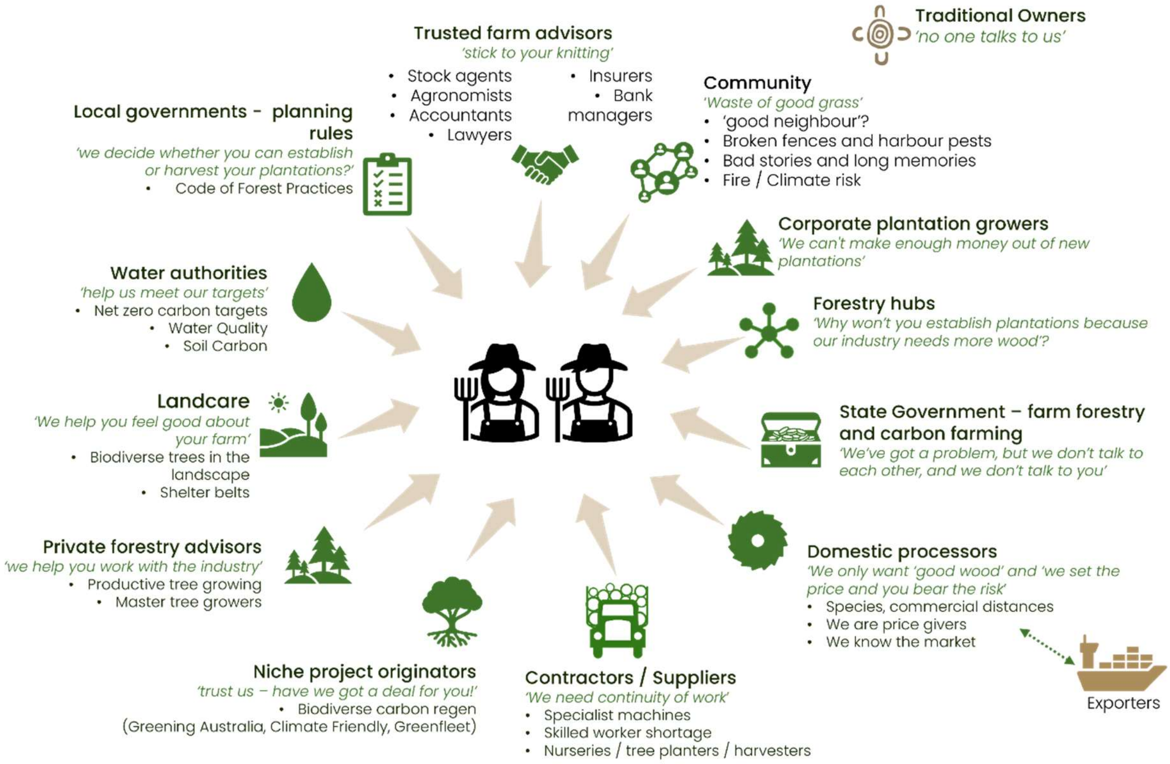

Figure 35- Current stakeholder voices.[15]

The Hub has an opportunity to decrease the confusion and burden of information around trees on farms. The Hub can adopt the landholder centric approach (Figure 36) to be the information and advisory interface between the timber industry, regulators and the land holders.

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15 PF Olsen developed diagram also appearing in the Gippsland Forestry Hub 'Investing in Gippsland Sustainable Forestry Future- altered and adapted for the QLD context

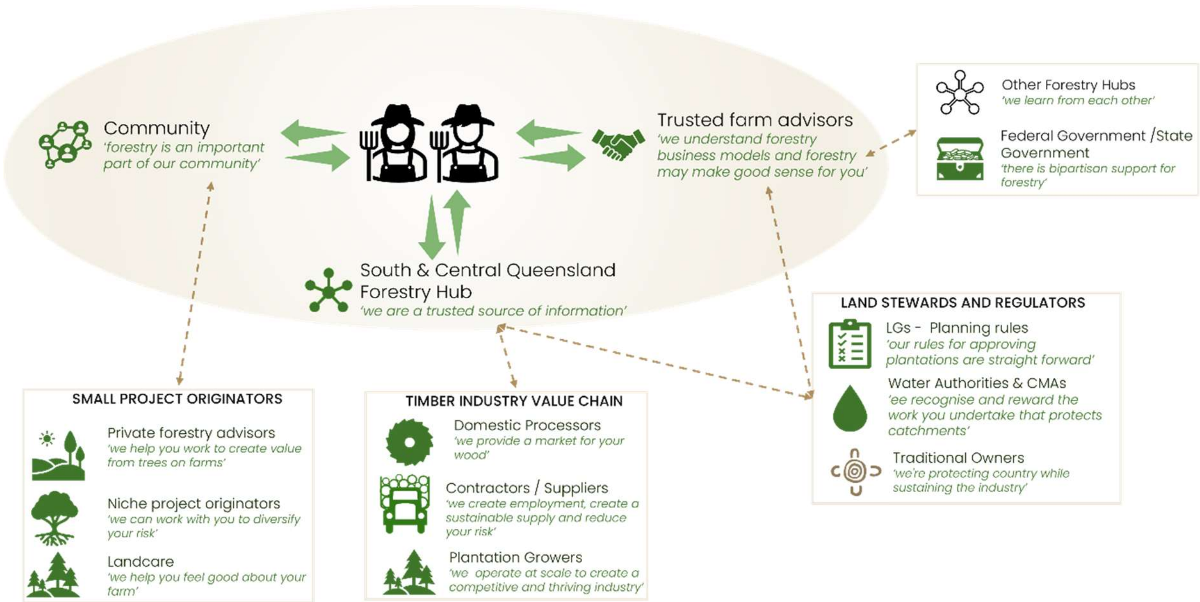

Figure 36- Landholder centric approach.[16]

The landholder approach involves the Hub being the trusted advisors on Trees on Farms by telling a clear and consistent story. The key role of the Hub could include:

- We propose that the landholders' trusted advisors, the Hub and community, become the key points of communication.
- The role of the Hub is to interpret, educate and advocate (with other industry bodies) the value of forestry.
- Provide a value proposition (marketing pitch) directed at farmers to encourage them to plant more trees.
- The Hub actively engages with regional institutions to embed the forestry industry in their strategic plans.
- It aligns its work with leading advocacy and industry leaders (e.g., Timber Queensland) to promote more trees for harvest.

16 PF Olsen developed diagram also appearing in the Gippsland Forestry Hub 'Investing in Gippsland Sustainable Forestry Future- altered and adapted for the QLD context

7. Conclusions

Our review of the existing published literature regarding biophysical characteristics enabled us to identify those that are most important to plantation development. We used this information to classify each characteristic into levels of suitability for each of the four species in the project. These levels of suitability were combined to create a classification of plantation suitability of five classes from 'ideal' to 'unsuitable'. In parallel, we identified land within the Hub region that would be excluded from future plantations due to current land use (such as national park, existing forest, zoning limitations, existing plantations). We then produced maps that presented areas of plantation suitability by class within the Hub region. These maps also showed the areas that were excluded.

We found that the areas that are most suitable for future commercial plantations are in the eastern part of the Hub, which is where the highest rainfall is. In terms of species differences, Spotted gum has the greatest area of suitability, and the other three species are reasonably similar in their extent.

Economic analysis was conducted across the four species and included two separate silvicultural regimes for Hoop pine (thin and no thin) and Southern pine (low rainfall and high rainfall). In the process of building up the dataset for the economic analysis, we used FullCAM to estimate the carbon sequestration potential across the Hub region, for the six regimes. The outcome of this was the production of carbon 'heat maps' that display the total ACCU's per hectare estimated across the Hub area. These maps will allow landowners to get an estimate of the ACCUs for their land by the different species.

The economic analysis was used to analyse the four species regimes in three different landscape management scenarios (timber only, timber + carbon and timber + carbon + grazing). The outcomes from the economic analysis found that the only species with a positive NPV from timber alone is Gympie messmate. The addition of the government grant, carbon revenue and grazing have a significant positive impact on cashflow. The scenarios which include all three land management options of timber + carbon + grazing return the greatest NPV.

An alternative silvopasture system was also explored in which alleys of pasture are planted on either side by two or three rows of trees for commercial production of timber. This system enables a greater amount of feed available for livestock over the life of the project. Economic modelling of this scenario resulted in highly favourable NPV outcomes, even without the Government Grant. The volume outputs from FullCAM are very likely to be underestimating the true growth potential of this system and a sensitivity analysis demonstrated that greater returns could be achieved with a 25% increase in volume.

The project also analysed the policy settings at a State and Federal level to determine what factors are impacting new plantation establishment. The key barriers to establishing new plantations include the initial cost of establishment, community understanding of integrated plantings within a farming system and the need to enhance the support from banks and investors. The landholder-centric methodology for the Hub was outlined as a framework for the Hub to address these barriers for new plantation establishment in the Hub region. The Hub is uniquely positioned to help remove some of these barriers, especially around landowner knowledge in integrated farming systems to include timber and carbon alongside traditional farming.

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Appendix A - Key data inputs and sources

Dataset Name	Suitability Criteria	Dataset Source
Digital elevation models 25metre by catchment areas series	Drainage Water Hazard	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={133239BA-584B-45FE-9CCA-33C5C66BAF66}
Queensland floodplain assessment overlay	Flooding	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid=%7B0944E8CD-8618-4100-B7DC-8C87CC74736C%7D
Annual and monthly potential frost days	Frost	http://www.bom.gov.au/climate/maps/averages/frost/
Cadastral data weekly - whole of State Queensland	Landscape complexity	https://esoil.io/TERNLandscapes/Public/Pages/SLGA/GetData-COGSDataStore_SLGA.html
Total Phosphorus	Nutrient Deficiency	https://esoil.io/TERNLandscapes/Public/Pages/SLGA/GetData-COGSDataStore_SLGA.html
pH CaCl2	Nutrient toxicity	https://esoil.io/TERNLandscapes/Public/Pages/SLGA/GetData-COGSDataStore_SLGA.html
Average annual, seasonal and monthly rainfall maps	Rainfall	http://www.bom.gov.au/climate/maps/averages/rainfall/
Soil and Landscape Grid National Soil Attribute Maps - Coarse Fragments (3" resolution) - Dominant Class	Rockiness	https://esoil.io/TERNLandscapes/Public/Pages/SLGA/GetData-COGSDataStore_SLGA.html
Depth of Soil	Soil depth	https://esoil.io/TERNLandscapes/Public/Pages/SLGA/GetData-COGSDataStore_SLGA.html
Available Water Capacity	Soil Water Availability	https://esoil.io/TERNLandscapes/Public/Pages/SLGA/GetData-COGSDataStore_SLGA.html
Digital elevation models 25metre by catchment areas series	Topography	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={133239BA-584B-45FE-9CCA-33C5C66BAF66}
Australian Soil Classification Map	Vertosols	https://aussoilsdsm.esoil.io/slga-version-2-products/australian-soil-classification-map
Digital elevation models 25metre by catchment areas series	Water Erosion (Slope)	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={133239BA-584B-45FE-9CCA-33C5C66BAF66}
Soils - universal soil loss equation - K factor	Water Erosion (RUSLE K-Factor)	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={8A72D6B8-2DBD-4538-A2DC-84ACAE66DFCE}

Appendix B – Non-excluded land by suitability class

Remaining Landuse by Suitability Class		
Southern pine		
Landuse / Class	Area (Ha)	Area (km^2)
Cropping	2,283,649.79	22,836.50
3	4,812.43	48.12
4	3,511.29	35.11
5	2,275,326.06	22,753.26
Grazing irrigated modified pastures	18,539.60	185.40
2	115.39	1.15
3	4,482.22	44.82
4	3,412.79	34.13
5	10,529.19	105.29
Grazing modified pastures	109,705.66	1,097.06
2	108.82	1.09
3	681.06	6.81
4	1,686.70	16.87
5	107,229.09	1,072.29
Grazing native vegetation	10,926,227.82	109,262.28
2	3,124.80	31.25
3	158,959.46	1,589.59
4	388,919.67	3,889.20
5	10,375,223.89	103,752.24
Intensive animal production	4,319.93	43.20
2	2.81	0.03
3	158.54	1.59
4	71.30	0.71
5	4,087.29	40.87
Irrigated cropping	443,579.73	4,435.80
2	8.44	0.08
3	12,464.48	124.64
4	57,197.60	571.98
5	373,909.20	3,739.09
Irrigated land in transition	1,456.86	14.57
2	3.75	0.04

3	122.89	1.23
4	773.93	7.74
5	556.29	5.56
Irrigated perennial horticulture	16,903.56	169.04
2	32.83	0.33
3	3,241.12	32.41
4	4,458.77	44.59
5	9,170.83	91.71
Irrigated seasonal horticulture	42,456.36	424.56
2	1.88	0.02
3	1,979.38	19.79
4	10,195.23	101.95
5	30,279.87	302.80
Land in transition	7,699.89	77.00
3	5,149.21	51.49
4	636.03	6.36
5	1,914.65	19.15
Perennial horticulture	5,782.42	57.82
2	22.51	0.23
3	3,494.41	34.94
4	238.28	2.38
5	2,027.23	20.27
Seasonal horticulture	75.99	0.76
3	5.63	0.06
5	70.36	0.70

Gympie messmate		
Landuse / Class	Area (Ha)	Area (km^2)
Cropping	2,283,649.79	22,836.50
3	4,810.56	48.11
4	3,549.76	35.50
5	2,275,289.48	22,752.89
Grazing irrigated modified pastures	18,541.47	185.41
2	124.77	1.25
3	4,473.78	44.74
4	3,429.68	34.30
5	10,513.24	105.13

Grazing modified pastures	109,703.78	1,097.04
2	117.26	1.17
3	672.61	6.73
4	1,685.76	16.86
5	107,228.15	1,072.28
Grazing native vegetation	10,926,640.59	109,266.41
2	4,009.42	40.09
3	158,830.01	1,588.30
4	402,513.63	4,025.14
5	10,361,287.53	103,612.88
Intensive animal production	4,319.93	43.20
2	2.81	0.03
3	158.54	1.59
4	71.30	0.71
5	4,087.29	40.87
Irrigated cropping	443,578.79	4,435.79
2	8.44	0.08
3	12,464.48	124.64
4	57,198.54	571.99
5	373,907.32	3,739.07
Irrigated land in transition	1,456.86	14.57
2	3.75	0.04
3	122.89	1.23
4	773.93	7.74
5	556.29	5.56
Irrigated perennial horticulture	16,900.74	169.01
2	40.34	0.40
3	3,234.56	32.35
4	4,471.90	44.72
5	9,153.94	91.54
Irrigated seasonal horticulture	42,453.54	424.54
2	1.88	0.02
3	1,982.20	19.82
4	10,206.49	102.06
5	30,262.98	302.63
Land in transition	7,701.77	77.02

3	5,149.21	51.49
4	638.84	6.39
5	1,913.72	19.14
Perennial horticulture	5,784.30	57.84
2	22.51	0.23
3	3,496.28	34.96
4	268.30	2.68
5	1,997.21	19.97
Seasonal horticulture	75.99	0.76
3	5.63	0.06
5	70.36	0.70
Hoop pine		
Landuse / Class	Area (Ha)	Area (km^2)
Cropping	2,283,648.85	22,836.49
3	4,916.56	49.17
4	3,273.96	32.74
5	2,275,458.34	22,754.58
Grazing irrigated modified pastures	18,545.22	185.45
2	114.45	1.14
3	4,363.09	43.63
4	3,463.45	34.63
5	10,604.24	106.04
Grazing modified pastures	109,714.10	1,097.14
2	105.07	1.05
3	693.25	6.93
4	1,639.79	16.40
5	107,275.99	1,072.76
Grazing native vegetation	10,924,907.92	109,249.08
2	2,153.87	21.54
3	150,363.69	1,503.64
4	367,449.47	3,674.49
5	10,404,940.90	104,049.41
Intensive animal production	4,317.12	43.17
2	1.88	0.02
3	154.79	1.55
4	70.36	0.70

5	4,090.10	40.90
Irrigated cropping	443,589.11	4,435.89
2	7.50	0.08
3	13,238.41	132.38
4	56,403.03	564.03
5	373,940.15	3,739.40
Irrigated land in transition	1,456.86	14.57
2	2.81	0.03
3	125.70	1.26
4	766.42	7.66
5	561.92	5.62
Irrigated perennial horticulture	16,914.81	169.15
2	28.14	0.28
3	3,221.42	32.21
4	4,451.27	44.51
5	9,213.98	92.14
Irrigated seasonal horticulture	42,465.74	424.66
2	0.94	0.01
3	1,913.72	19.14
4	10,176.47	101.76
5	30,374.62	303.75
Land in transition	7,698.96	76.99
3	5,151.09	51.51
4	619.14	6.19
5	1,928.73	19.29
Perennial horticulture	5,779.61	57.80
2	17.82	0.18
3	3,420.30	34.20
4	248.60	2.49
5	2,092.89	20.93
Seasonal horticulture	75.99	0.76
3	5.63	0.06
5	70.36	0.70
Spotted gum		
Landuse / Class	Area (Ha)	Area (km^2)
Cropping	2,283,342.10	22,833.42

3	90,682.95	906.83
4	1,374,466.66	13,744.67
5	818,192.50	8,181.92
Grazing irrigated modified pastures	18,518.02	185.18
2	114.45	1.14
3	8,933.49	89.33
4	8,396.90	83.97
5	1,073.18	10.73
Grazing modified pastures	109,633.43	1,096.33
2	105.07	1.05
3	12,093.94	120.94
4	91,591.96	915.92
5	5,842.46	58.42
Grazing native vegetation	10,905,459.31	109,054.59
2	2,272.07	22.72
3	2,296,773.76	22,967.74
4	5,431,366.86	54,313.67
5	3,175,046.62	31,750.47
Intensive animal production	4,320.87	43.21
2	1.88	0.02
3	771.12	7.71
4	1,578.82	15.79
5	1,969.06	19.69
Irrigated cropping	443,401.49	4,434.01
2	16.89	0.17
3	87,303.92	873.04
4	232,002.45	2,320.02
5	124,078.23	1,240.78
Irrigated land in transition	1,454.99	14.55
2	2.81	0.03
3	1,335.85	13.36
4	106.00	1.06
5	10.32	0.10
Irrigated perennial horticulture	16,895.11	168.95
2	30.02	0.30
3	11,216.82	112.17

4	1,536.60	15.37
5	4,111.68	41.12
Irrigated seasonal horticulture	42,373.81	423.74
2	1.88	0.02
3	17,848.22	178.48
4	22,406.43	224.06
5	2,117.28	21.17
Land in transition	7,694.27	76.94
3	5,485.05	54.85
4	775.81	7.76
5	1,433.41	14.33
Perennial horticulture	5,785.24	57.85
2	17.82	0.18
3	3,677.34	36.77
4	716.71	7.17
5	1,373.37	13.73
Seasonal horticulture	75.05	0.75
3	20.64	0.21
4	40.34	0.40
5	14.07	0.14

Appendix C- Economic analysis results by species and regime

Southern pine – low rainfall

Silvicultural regime		
Initial stocking (trees per ha)	833	
Weed control spray	Yes	
Fertiliser	Yes	
Thinning age (yrs)	17	
Thin stocking (trees per ha)	450	
Clearfall age (yrs)	28	
Project outcomes		
Total ACCUs	5,189	
Total timber (m³)	5,024	
Property area (ha)	20	
Plantation area (ha)	20	
Total kilograms gained (kgs)	11,476	
Total number of head start \ finish	5.59 \ 1.76	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	(2,380)	(4,340)
timber + carbon	(235)	(2,195)
timber + carbon + grazing	230	(1,730)

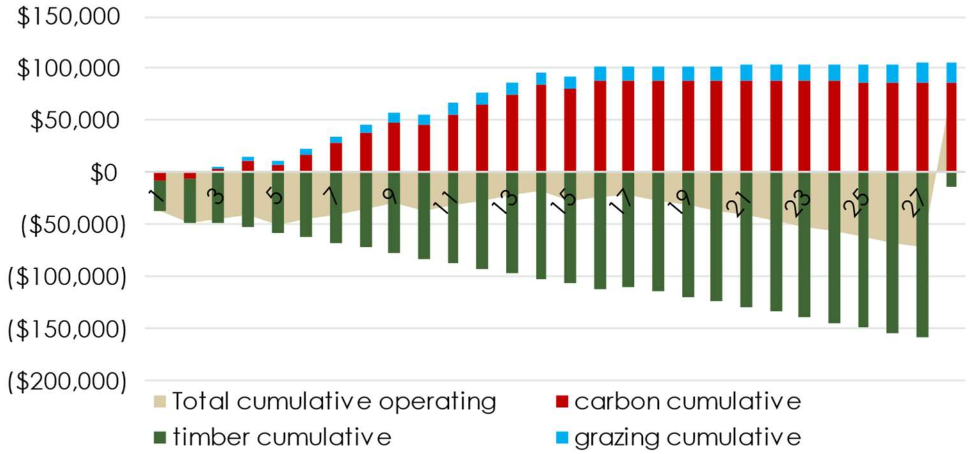


Figure 37- Cumulative net operating cashflows ($) with government grant

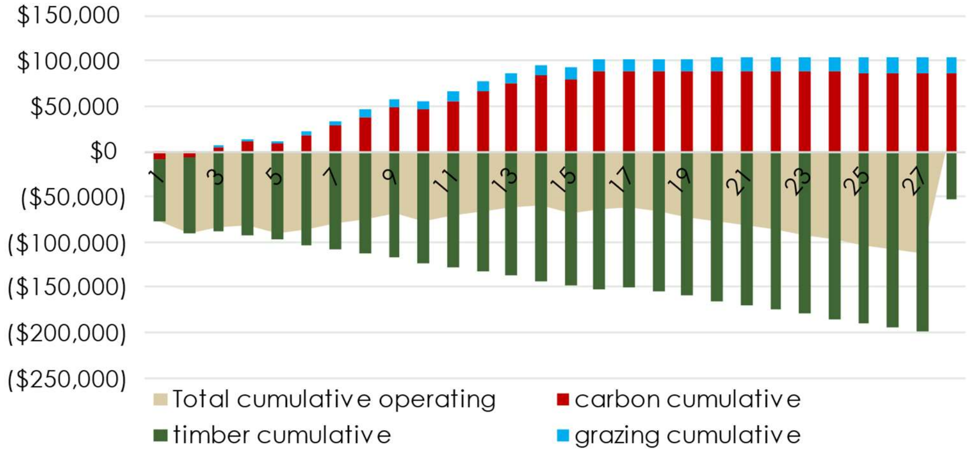


Figure 38- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant			
	$	$/ha	$	$/ha
Timber				
Softwood	448,349	22,417	448,349	22,417
Govt. grant	200,000	2,000	-	-
Total timber revenue	648,349	24,417	448,349	22,417
ACCUs				
Softwood	154,767	7,738	154,767	7,738
Agriculture				
Grazing return	18,004	900	18,004	900
Total revenue	661,120	33,056	621,120	31,056
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	2,000	40,000	2,000
Property maintenance	32,400	1,620	32,400	1,620
Silviculture	32,720	1,636	32,720	1,636
Roading, harvest and haulage	286,368	14,318	286,368	14,318
Property - other	110,608	5,530	110,608	5,530
Total Timber expenses	502,096	25,105	502,096	25,105
Carbon				
Carbon registration and reporting	67,959	3,398	67,959	71
Agriculture				
Grazing	1,418	71	1,418	71
Total operating outflows	571,473	28,574	571,473	28,574
NET total return	89,648	4,482	49,648	2,482

Southern pine - high rainfall

Silvicultural regime		
Initial stocking (trees per ha)	1200	
Weed control spray	Yes	
Fertiliser	Yes	
Thinning age (yrs)	15	
Thin stocking (trees per ha)	600	
Clearfall age (yrs)	27	
Project outcomes		
Total ACCUs	5,082	
Total timber (m³)	4,990	
Property area (ha)	20	
Plantation area (ha)	20	
Total kilograms gained (kgs)	11,190	
Total number of head start \ finish	7.92 \ 2.50	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	(2,440)	(4,395)
timber + carbon	105	(1,855)
timber + carbon + grazing	755	(1,200)

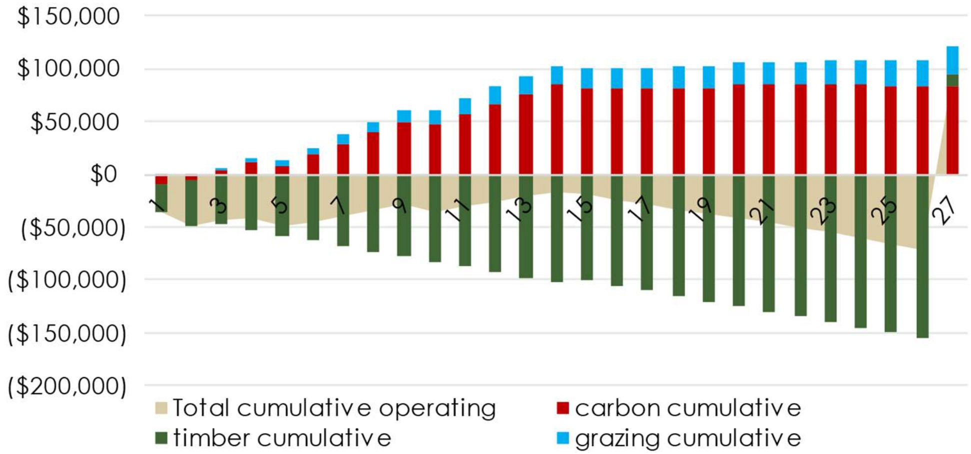


Figure 40- Cumulative net operating cashflows ($) with government grant

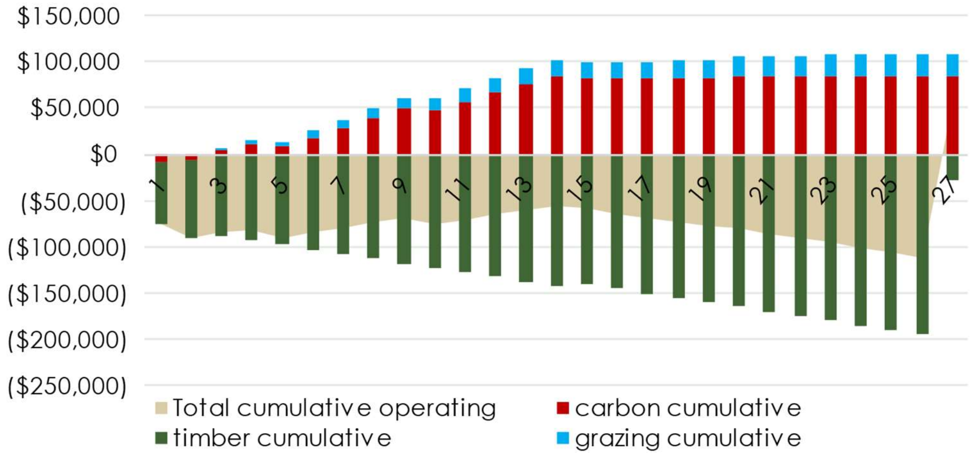


Figure 39- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Softwood	446,124	22,306	446,124	22,306
Govt. grant	200,000	2,000	-	-
Total timber revenue	646,124	24,306	446,124	22,306
ACCUs				
Softwood	151,308	7,565	151,308	7,565
Agriculture				
Grazing return	24,871	1,244	24,871	1,244
Total revenue	662,303	33,115	622,303	31,115
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	2,000	40,000	2,000
Property maintenance	31,200	1,560	31,200	1,560
Silviculture	32,720	1,636	32,720	1,636
Roading, harvest and haulage	263,262	13,163	263,262	13,163
Property - other	106,872	5,344	106,872	5,344
Total Timber expenses	474,054	23,703	474,054	23,703
Carbon				
Carbon registration and reporting	67,844	3,392	67,844	98
Agriculture				
Grazing	1,958	98	1,958	98
Total operating outflows	543,856	27,193	543,856	27,193
NET total return	118,447	5,922	78,447	3,922

Hoop pine - thin

Silvicultural regime		
Initial stocking (trees per ha)	800	
Weed control spray	Yes	
Fertiliser	Yes	
Thinning age (yrs)	20	
Thin stocking (trees per ha)	500	
Clearfall age (yrs)	45	
Project outcomes		
Total ACCUs	5,660	
Total timber (m^3)	7,148	
Property area (ha)	20	
Plantation area (ha)	20	
Total kilograms gained (kgs)	16,333	
Total number of head start \ finish	9.05 \ 2.86	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	(1,600)	(3,560)
timber + carbon	165	(1,795)
timber + carbon + grazing	1,015	(945)

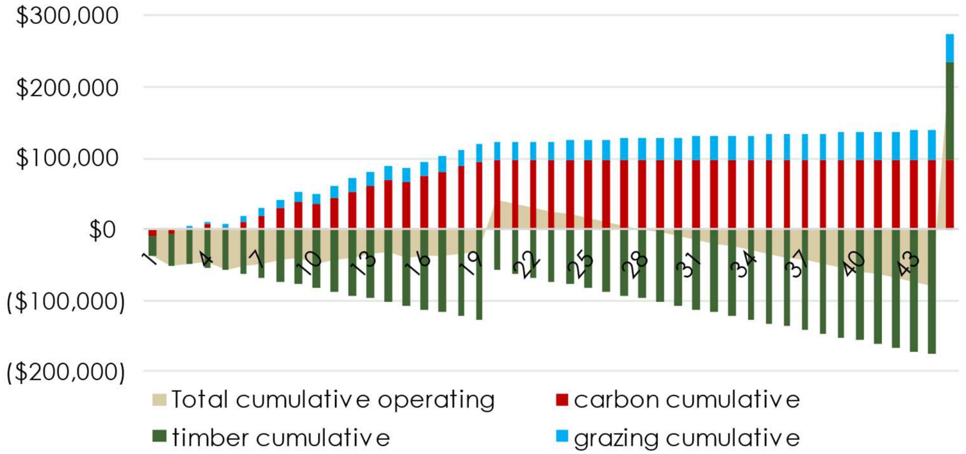


Figure 41- Cumulative net operating cashflows ($) with government grant

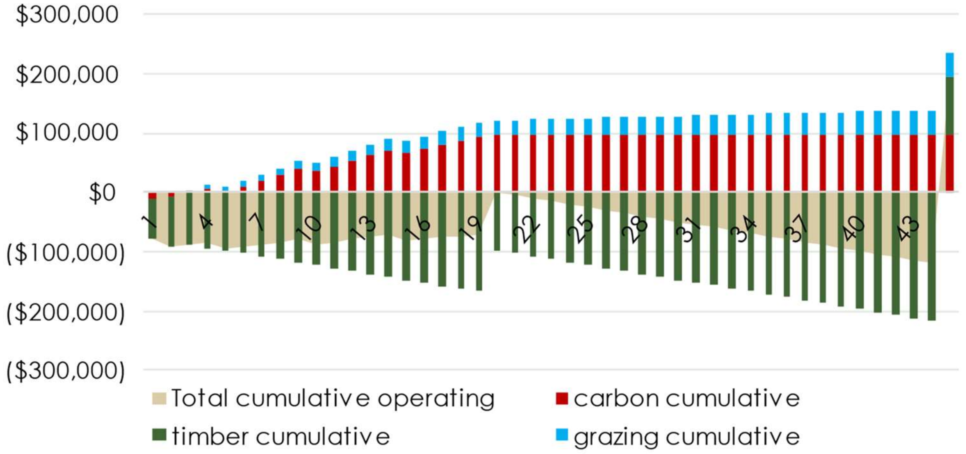
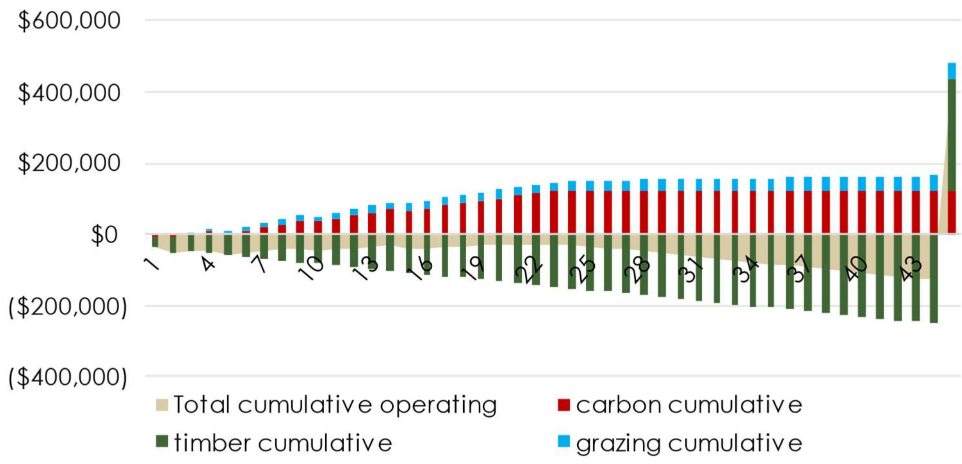


Figure 42- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Softwood	797,957	39,898	797,957	39,898
Government grant	200,000	2,000	-	-
Total timber revenue	997,957	41,898	797,957	39,898
ACCUs				
Softwood	169,144	8,457	169,144	8,457
Agriculture				
Grazing return	41,487	2,074	41,487	2,074
Total revenue	1,048,588	52,429	1,008,588	50,429
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	2,000	40,000	2,000
Property maintenance	52,800	2,640	52,800	2,640
Silviculture	27,360	1,368	27,360	1,368
Roading, harvest and haulage	407,436	20,372	407,436	20,372
Property - other	174,120	8,706	174,120	8,706
Total Timber expenses	701,716	35,086	701,716	35,086
Carbon				
Carbon registration and reporting	71,438	3,572	71,438	163
Agriculture				
Grazing cost	3,267	163	3,267	163
Total operating outflows	776,421	38,821	776,421	38,821
NET total return	272,167	13,608	232,167	11,608

Hoop pine - no thin

Silvicultural regime		
Initial stocking (trees per ha)	925	
Weed control spray	Yes	
Fertiliser	Yes	
Thinning age (yrs)	n/a	
Thin stocking (trees per ha)	n/a	
Clearfall age (yrs)	45	
Project outcomes		
Total ACCUs	6,666	
Total timber (m^3)	7,110	
Property area (ha)	20	
Plantation area (ha)	20	
Total kilograms gained (kgs)	16,333	
Total number of head start \ finish	9.05 \ 2.86	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	(1,825)	(3,785)
timber + carbon	350	(1,605)
timber + carbon + grazing	1,200	(755)



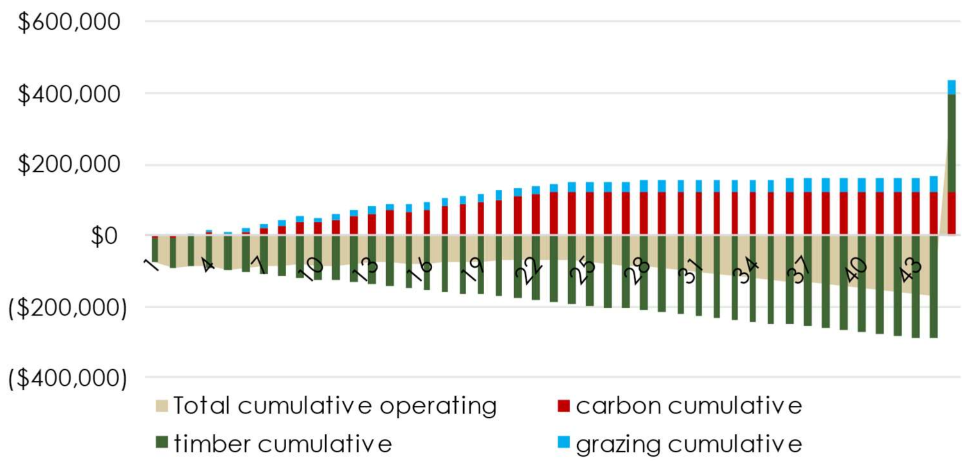


Figure 43- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Softwood	803,075	40,154	803,075	40,154
Government grant	200,000	2,000	-	-
Total timber revenue	1,003,075	42,154	803,075	40,154
ACCUs				
Softwood	199,317	9,966	199,317	9,966
Agriculture				
Grazing return	41,487	2,074	41,487	2,074
Total revenue	1,083,878	54,194	1,043,878	52,194
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	2,000	40,000	2,000
Property maintenance	52,800	2,640	52,800	2,640
Silviculture	27,360	1,368	27,360	1,368
Roading, harvest and haulage	234,630	11,732	234,630	11,732
Property - other	174,120	8,706	174,120	8,706
Total Timber expenses	528,910	26,446	528,910	26,446
Carbon				
Carbon registration and reporting	76,444	3,822	76,444	163
Agriculture				
Grazing cost	3,267	163	3,267	163
Total operating outflows	608,621	30,431	608,621	30,431
NET total return	475,257	23,763	435,257	21,763

Spotted gum

Silvicultural regime		
Initial stocking (trees per ha)	1,000	
Weed control spray	Yes	
Fertiliser	Yes	
Thinning age (yrs)	10	
Thin stocking (trees per ha)	250	
Clearfall age (yrs)	35	
Project outcomes		
Total ACCUs	4,915	
Total timber (m^3)	4,782	
Property area (ha)	20	
Plantation area (ha)	20	
Total kilograms gained (kgs)	13,476	
Total number of head start \ finish	4.75 \ 1.50	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	(2,240)	(4,195)
timber + carbon	(325)	(2,285)
timber + carbon + grazing	95	(1,865)

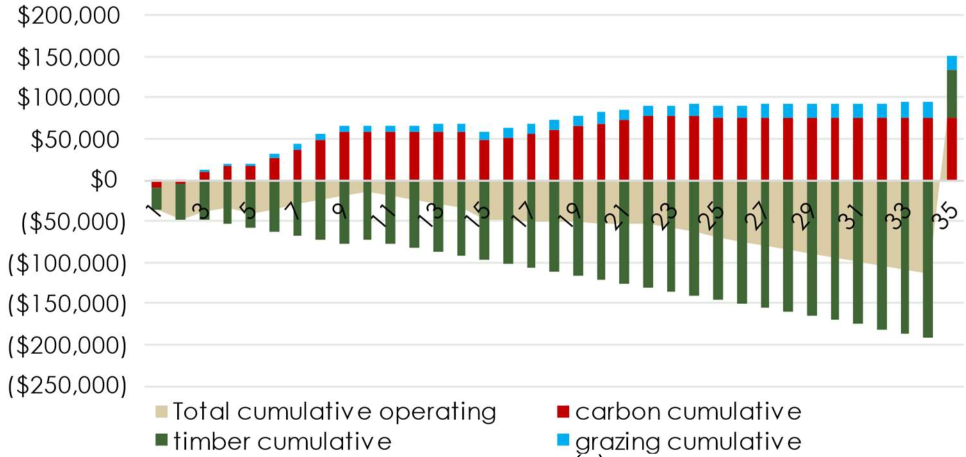


Figure 46- Cumulative net operating cashflows ($) with government grant

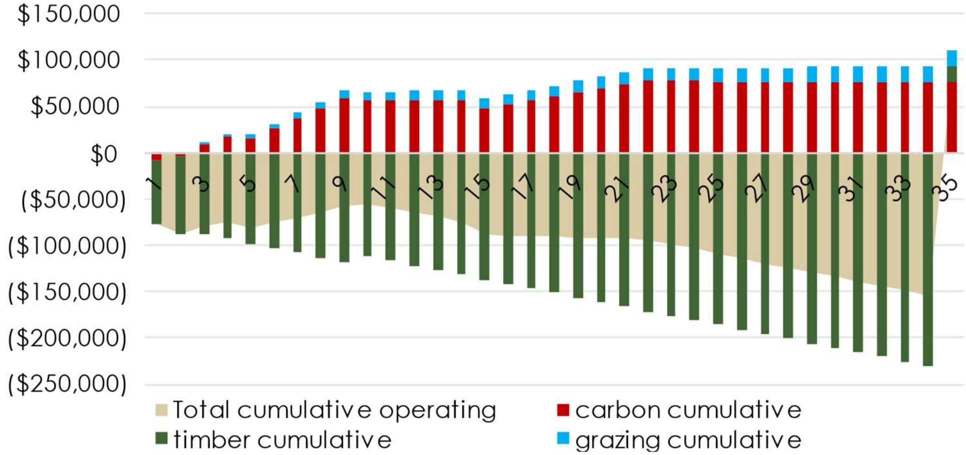


Figure 45- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Hardwood	539,889	26,994	539,889	26,994
Government grant	200,000	2,000	-	-
Total timber revenue	739,889	28,994	539,889	26,994
ACCUs				
Hardwood	146,219	7,311	146,219	7,311
Agriculture				
Grazing return	17,971	899	17,971	899
Total revenue	744,079	37,204	704,079	35,204
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	2,000	40,000	2,000
Property maintenance	40,800	2,040	40,800	2,040
Silviculture	32,720	1,636	32,720	1,636
Forest management	-	-	-	-
Roading, harvest and haulage	272,574	13,629	272,574	13,629
Property - other	136,760	6,838	136,760	6,838
Total Timber expenses	522,854	26,143	522,854	26,143
Carbon				
Carbon registration and reporting	69,674	3,484	69,674	71
Agriculture				
Grazing cost	1,415	71	1,415	71
Total operating outflows	593,943	29,697	593,943	29,697
NET total return	150,136	7,507	110,136	5,507

Gympie messmate

Silvicultural regime		
Initial stocking (trees per ha)	1000	
Weed control spray	Yes	
Fertiliser	Yes	
	Non- com	2nd
Thinning age (yrs)	7	18
Thin stocking (trees per ha)	500	250
Clearfall age (yrs)	30	
Project outcomes		
Total ACCUs	5,959	
Total timber (m^3)	7,376	
Property area (ha)	20	
Plantation area (ha)	20	
Total kilograms gained (kgs)	12,048	
Total number of head start \ finish	4.32 \ 1.36	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	1,565	(390)
timber + carbon	5,115	3,155
timber + carbon + grazing	5,480	3,525

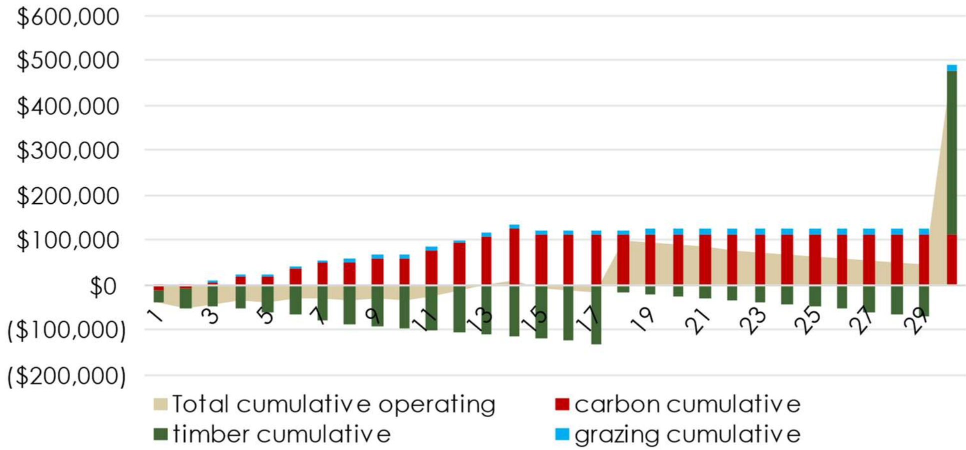


Figure 48- Cumulative net operating cashflows ($) with government grant

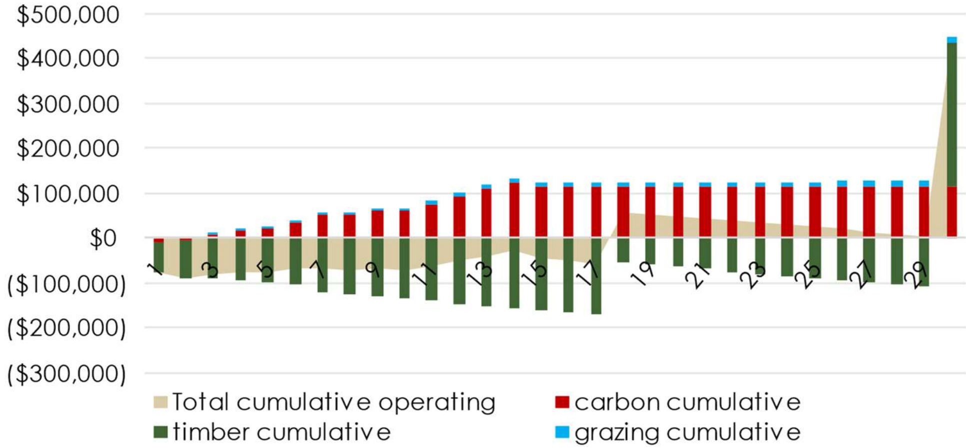


Figure 47- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Hardwood	776,239	38,812	776,239	38,812
Government grant	200,000	2,000	-	-
Total timber revenue	976,239	40,812	776,239	38,812
ACCUs				
Hardwood	178,096	8,905	178,096	8,905
Agriculture				
Grazing return	14,605	730	14,605	730
Total revenue	1,008,940	50,447	968,940	48,447
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	2,000	40,000	2,000
Property maintenance	34,800	1,740	34,800	1,740
Silviculture	27,360	1,368	27,360	1,368
Roading, harvest and haulage	233,760	11,688	233,760	11,688
Property - other	118,080	5,904	118,080	5,904
Total Timber expenses	454,000	22,700	454,000	22,700
Carbon				
Carbon registration and reporting	64,737	3,237	64,737	58
Agriculture				
Grazing cost	1,150	58	1,150	58
Total operating outflows	519,887	25,994	519,887	25,994
NET total return	489,053	24,453	449,053	22,453

Appendix D – Annual cashflows– standard regime

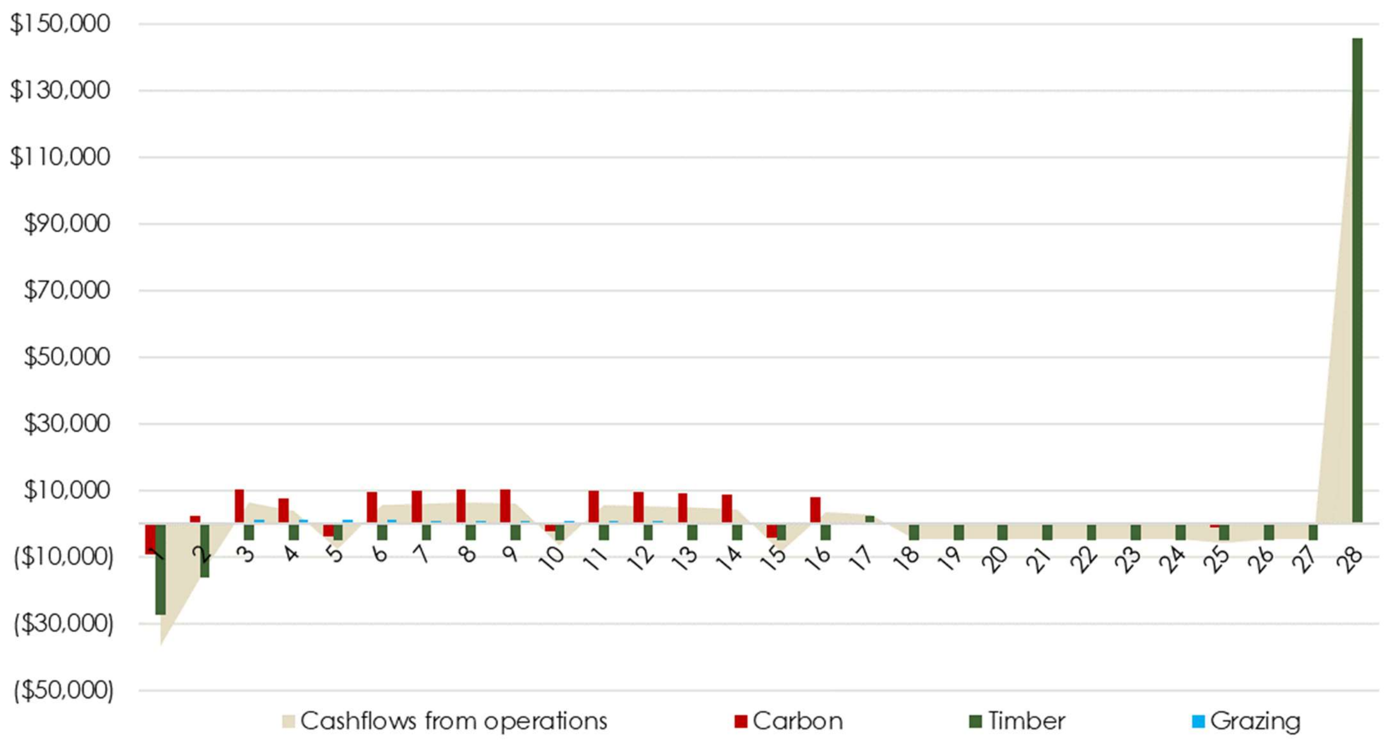


Figure 49- Annual cashflow Southern pine low rainfall

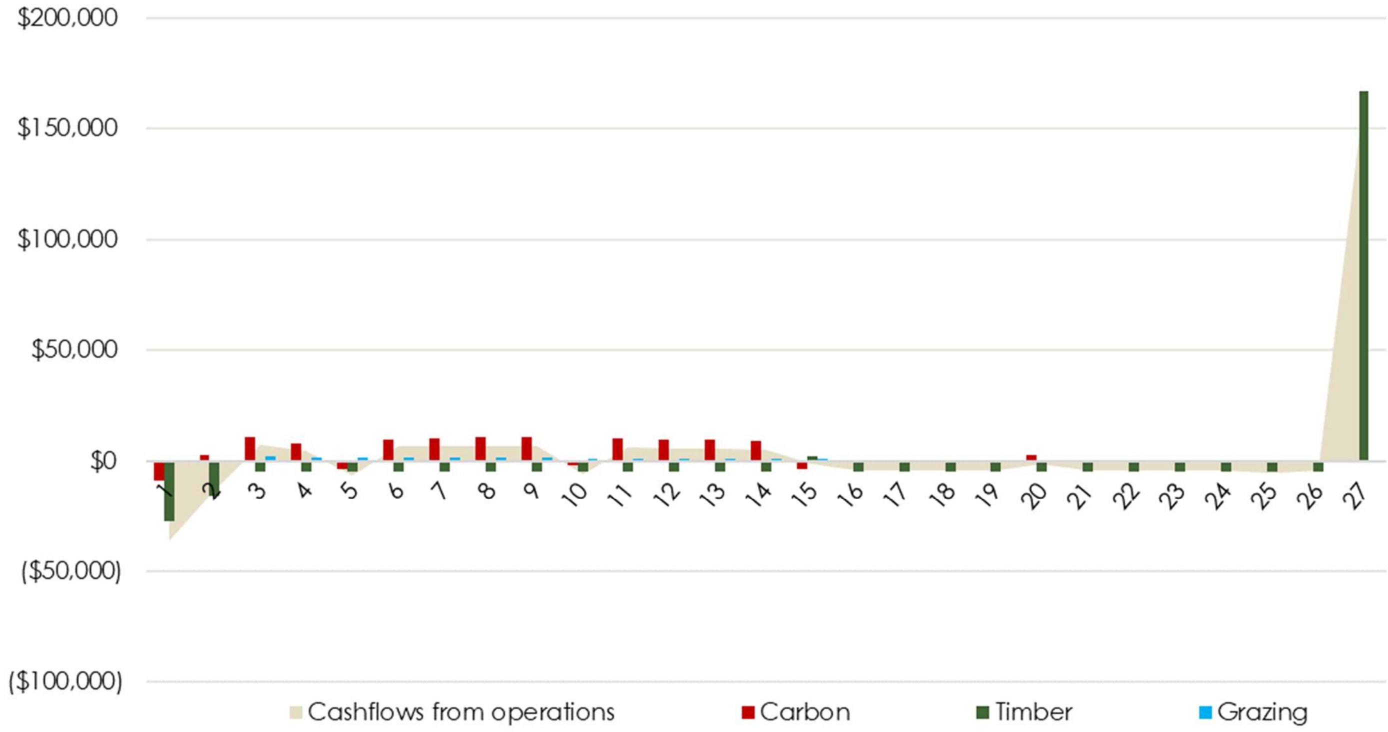


Figure 50- Annual cashflow Southern pine high rainfall

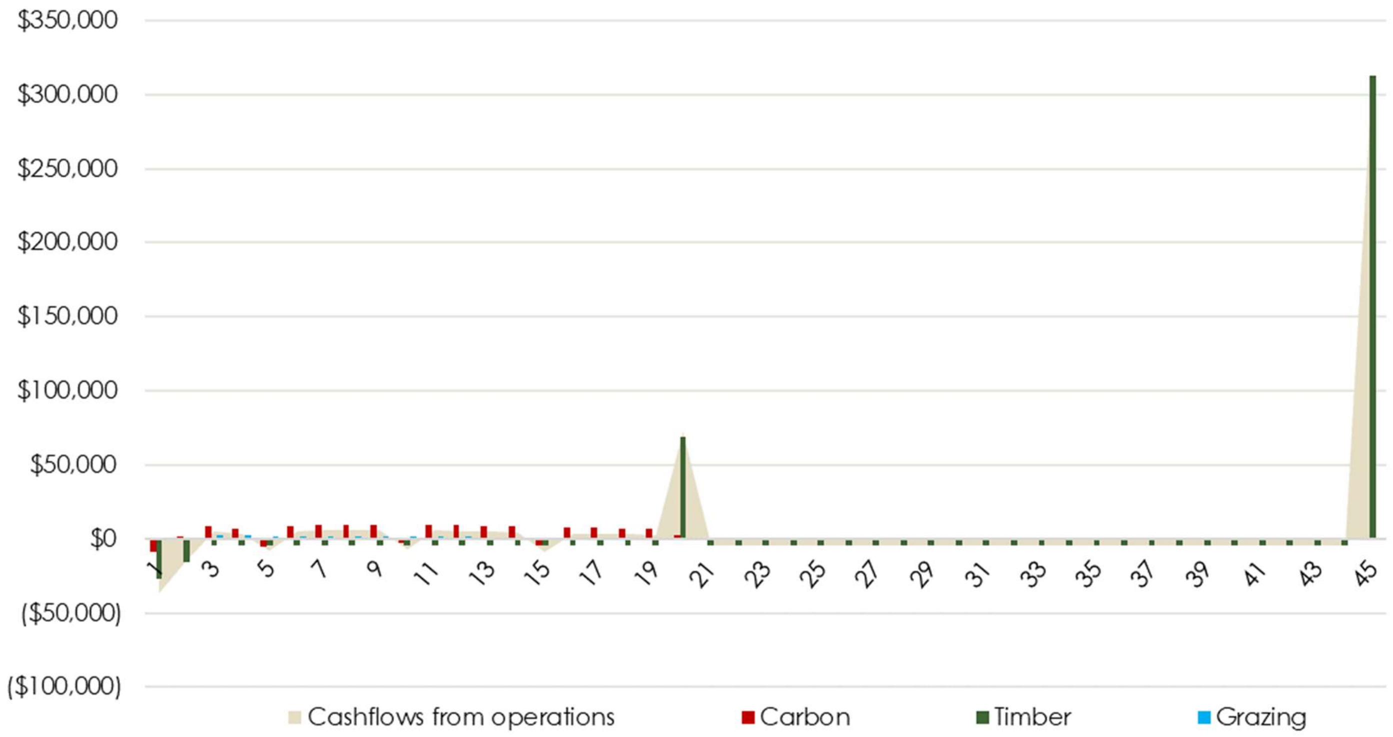


Figure 51- Annual cashflow Hoop pine thin

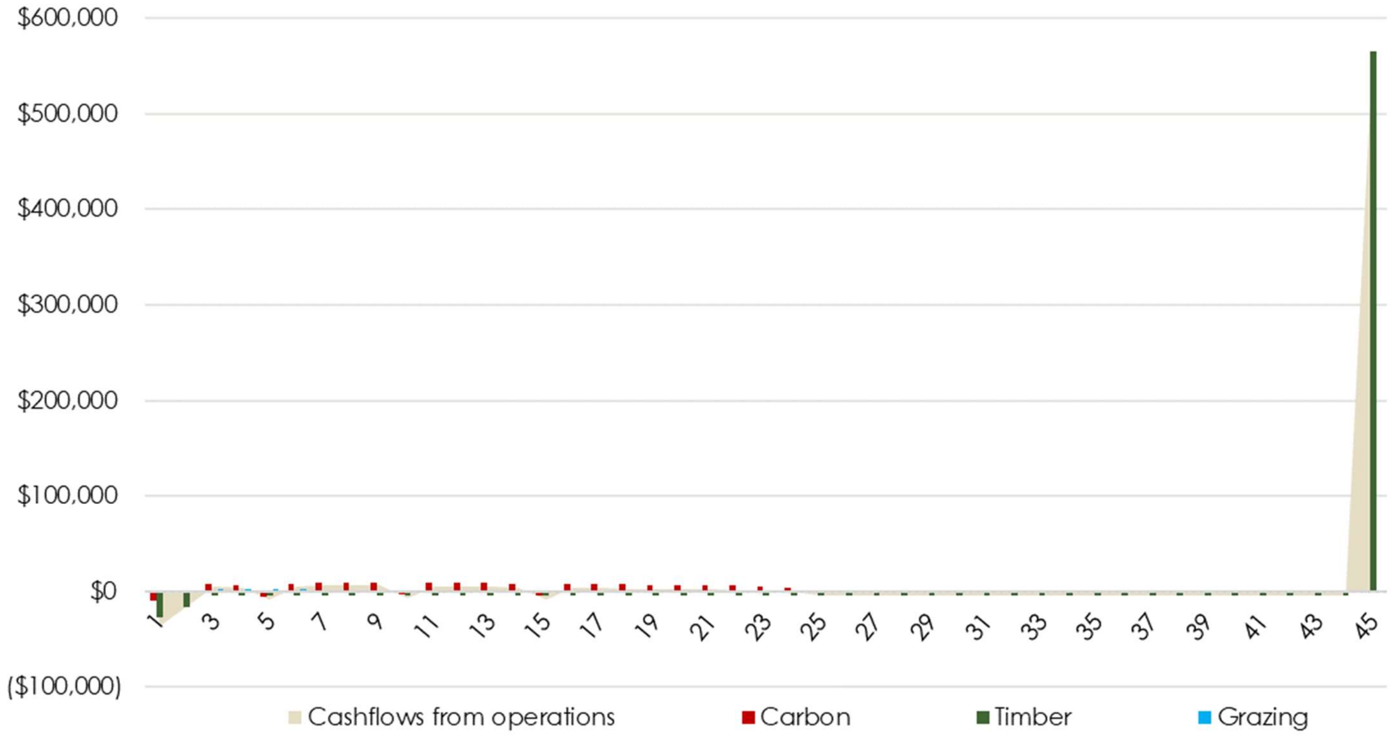


Figure 52- Annual cashflow Hoop pine no thin

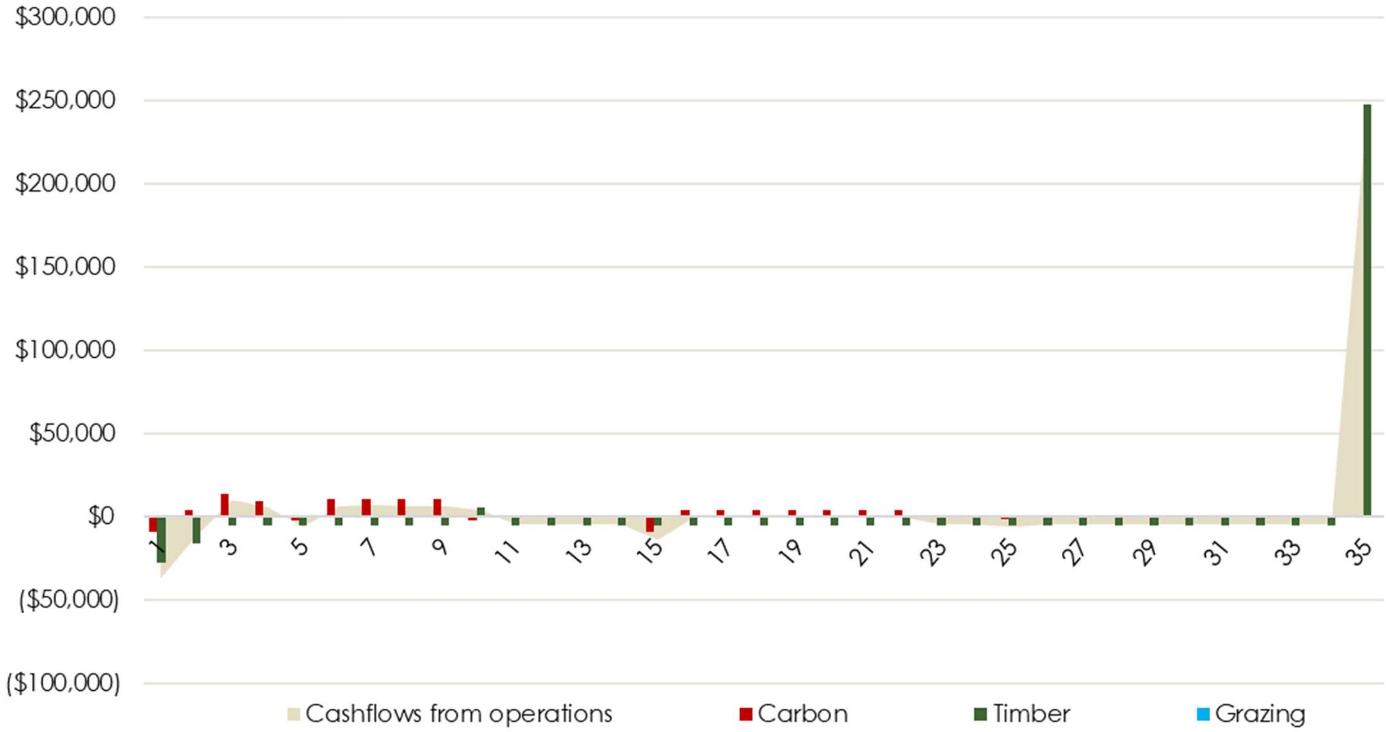


Figure 53- Annual cashflow Spotted gum

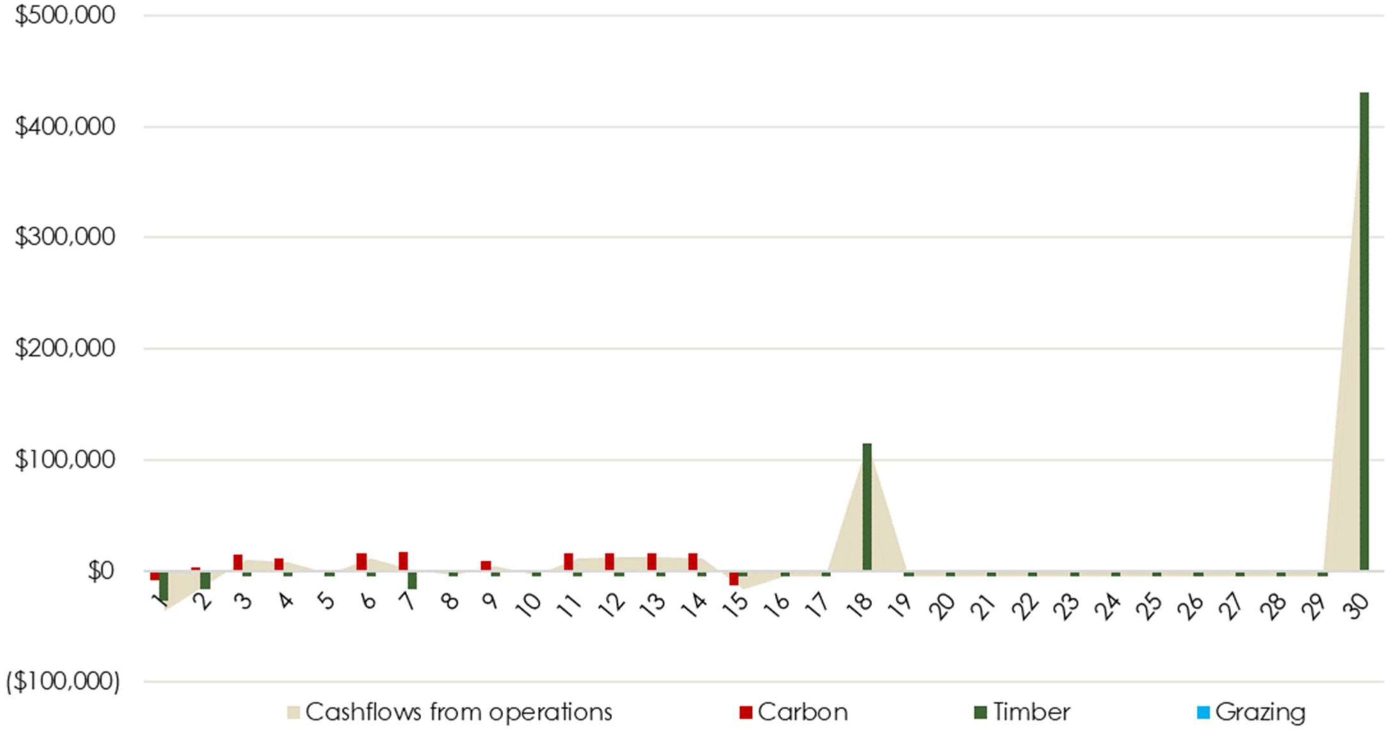
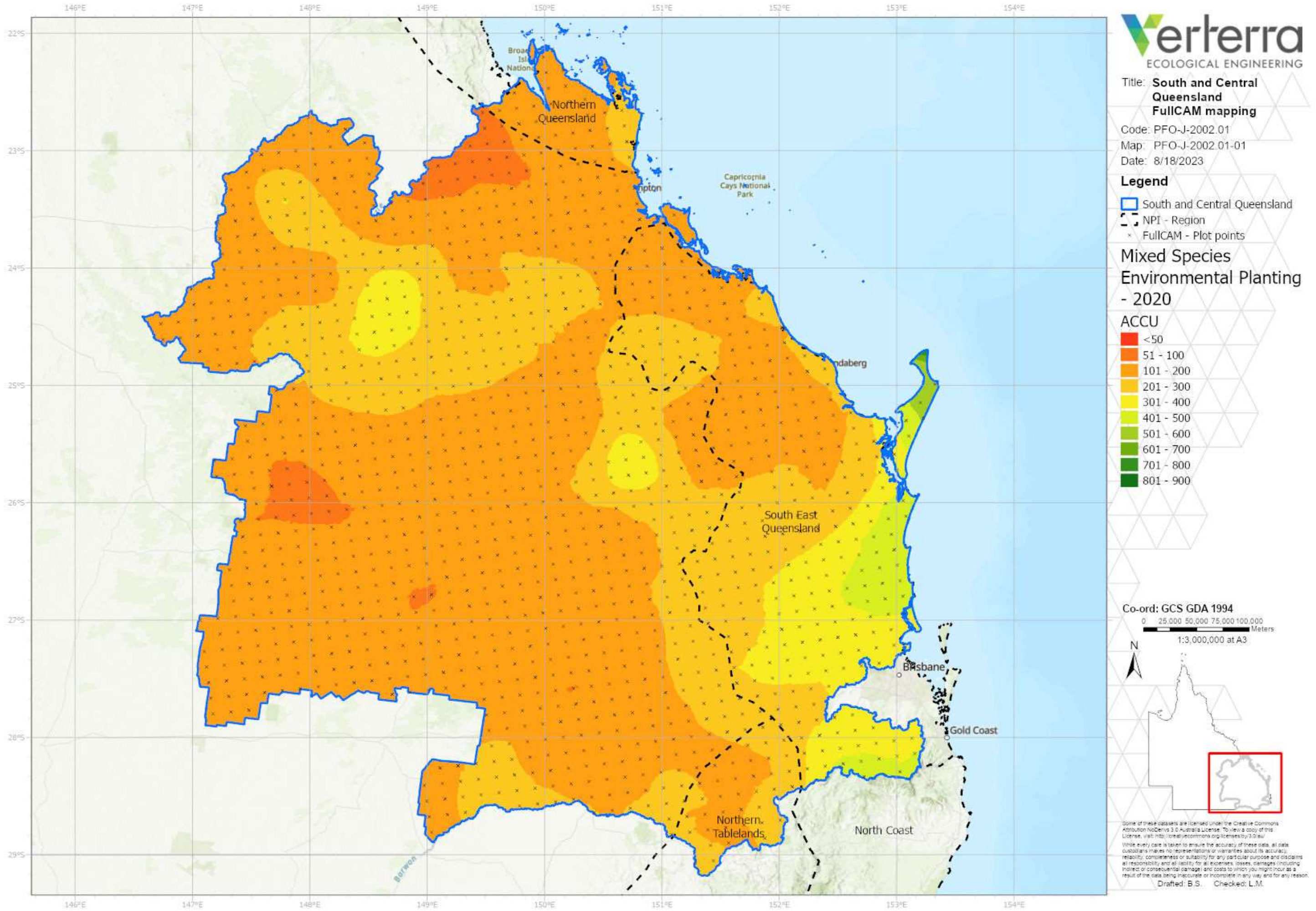
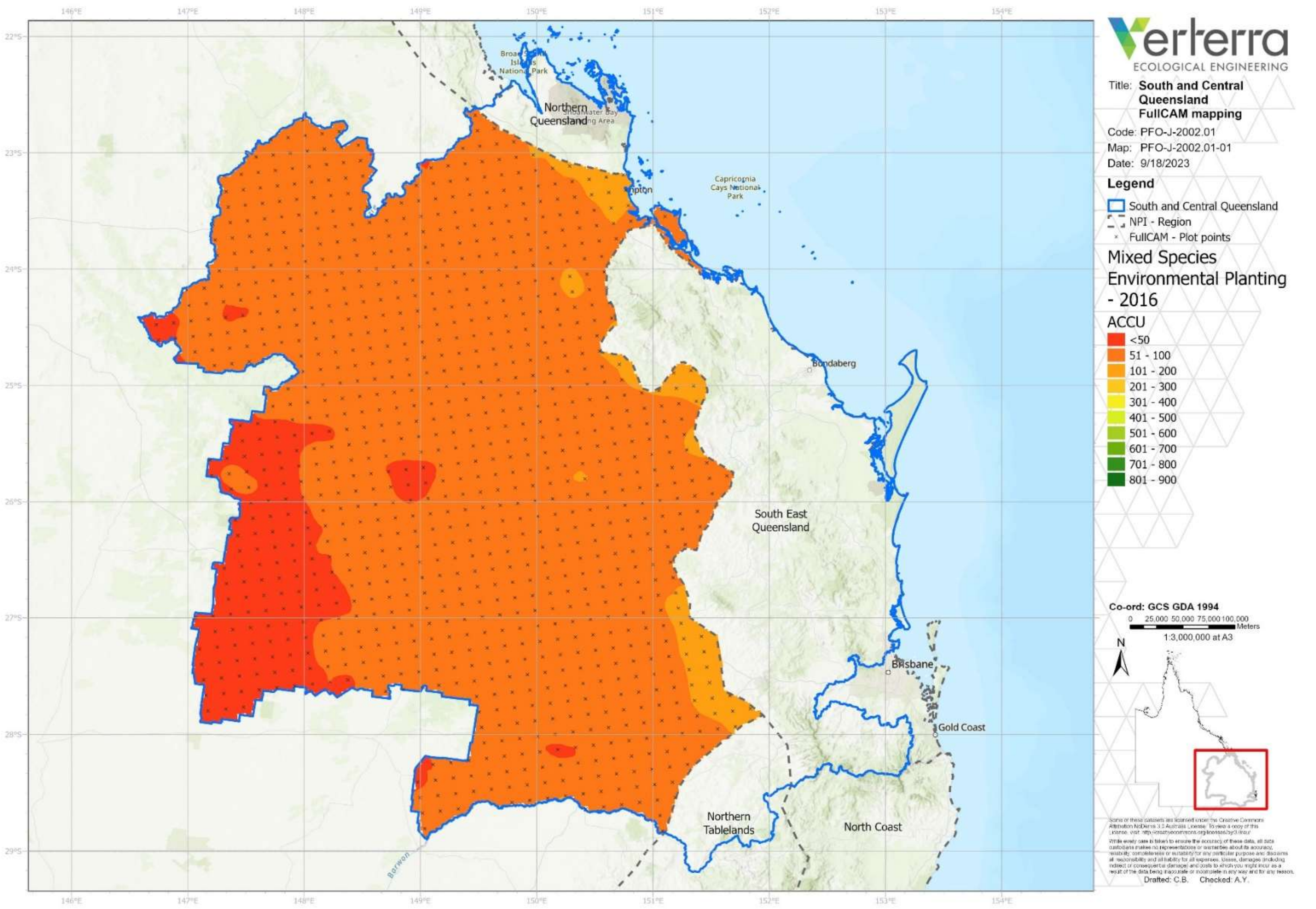


Figure 54- Annual cashflow Gympie messmate

Appendix E -Carbon heat maps– standard regime

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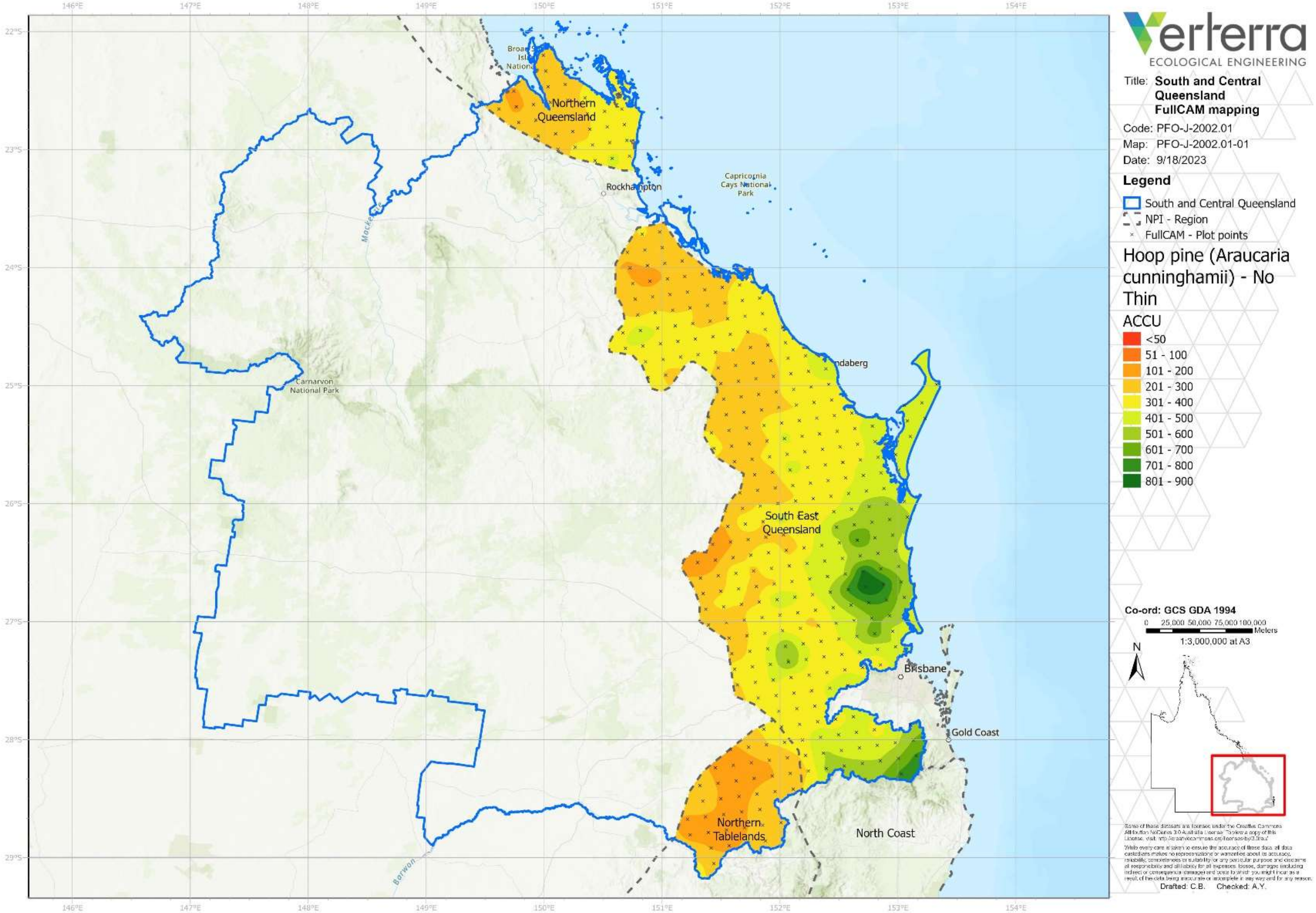
Code: PFO-J-2002.01
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Mixed Species Environmental Planting - 2016
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
1:3,000,000 at A3
N
Northern Queensland
Capricornia Cays National Park
Bundaberg
South East Queensland
Brisbane
Gold Coast
Northern Tablelands
North Coast
Drafted: C.B. Checked: A.Y.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ECOLOGICAL ENGINEERING
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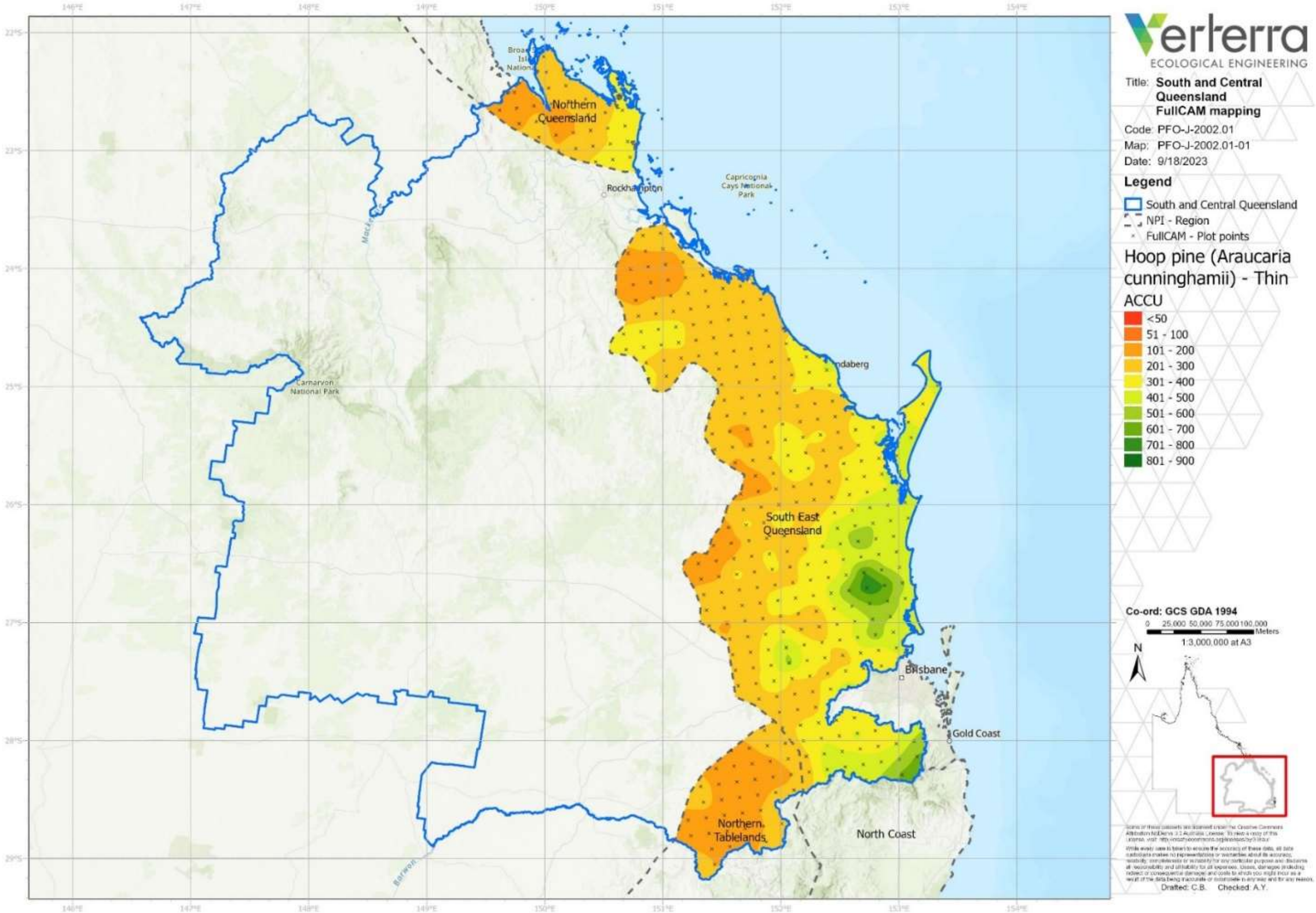
Code: PFO-J-2002.01
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Hoop pine (Araucaria cunninghamii) - No Thin
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
1:3,000,000 at A3
Drafted: C.B. Checked: A.Y.
Northern Queensland
Rockhampton
South East Queensland
Brisbane
Gold Coast
Northern Tablelands
North Coast
Carnarvon National Park
Capricornia Cays National Park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Code: PFO-J-2002.01
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Hoop pine (Araucaria cunninghamii) - Thin
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
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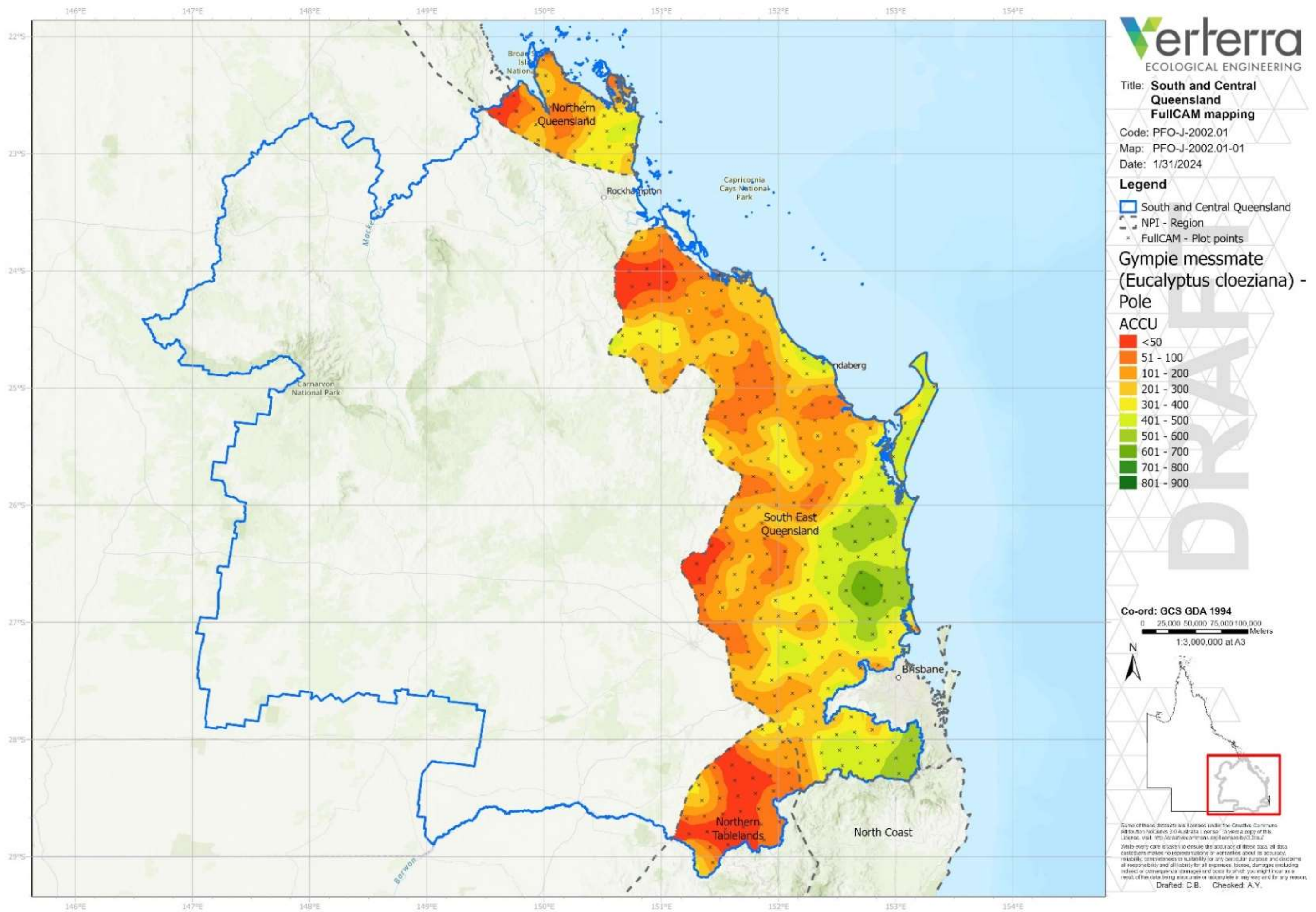
N
Northern Queensland
Rockhampton
Capricornia Cays National Park
South East Queensland
Brisbane
Gold Coast
North Coast
Northern Tablelands
Carnarvon National Park
Drafted: C.B. Checked: A.Y.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Code: PFO-J-2002.01
Map: PFO-J-2002.01-01
Date: 1/31/2024
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Gympie messmate (Eucalyptus cloeziana) - Pole
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
DRAFT
Co-ord: GCS GDA 1994
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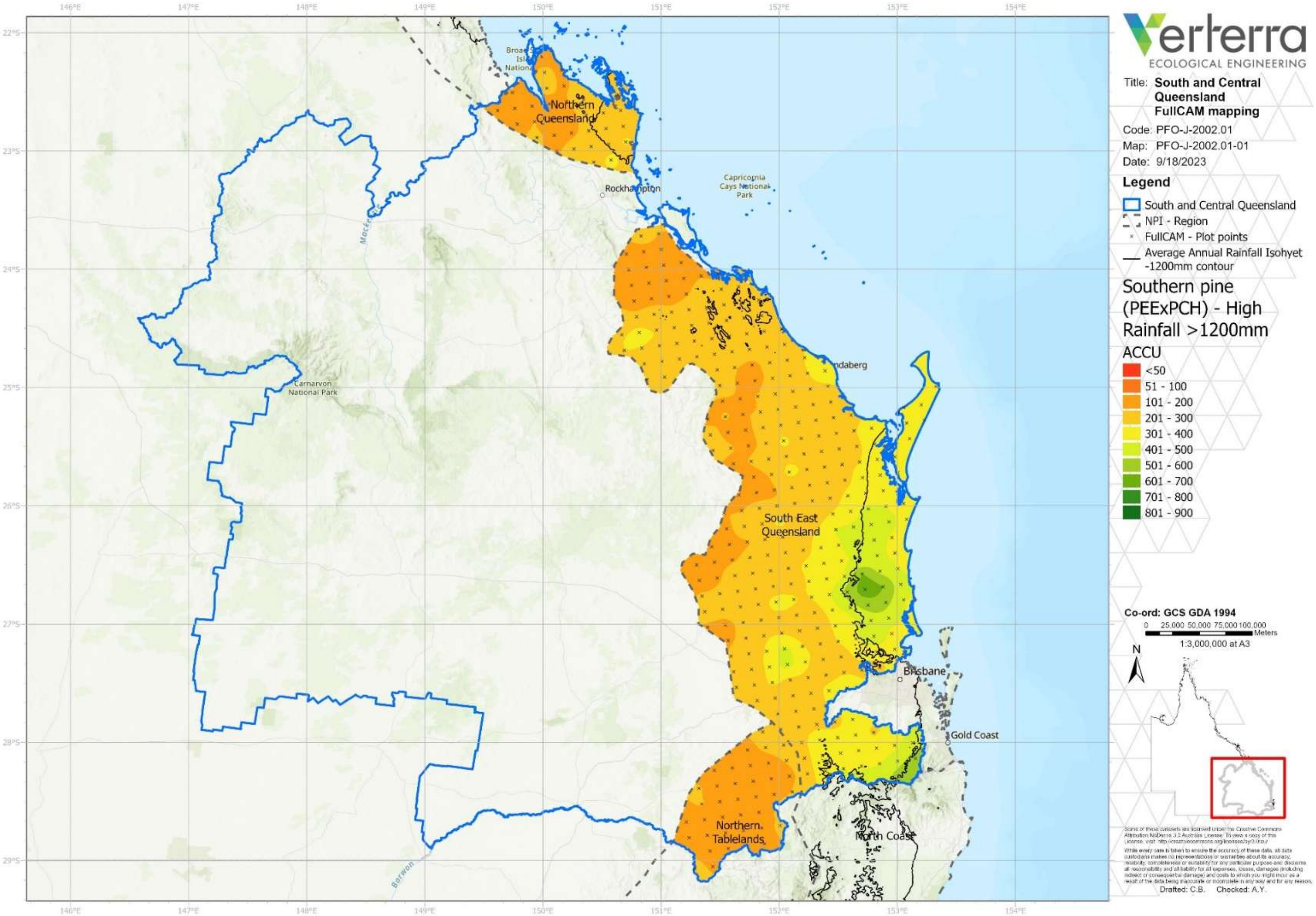
Northern Queensland
Rockhampton
Capricornia Cays National Park
Carnarvon National Park
South East Queensland
Brisbane
Northern Tablelands
North Coast
Drafted: C.B. Checked: A.Y.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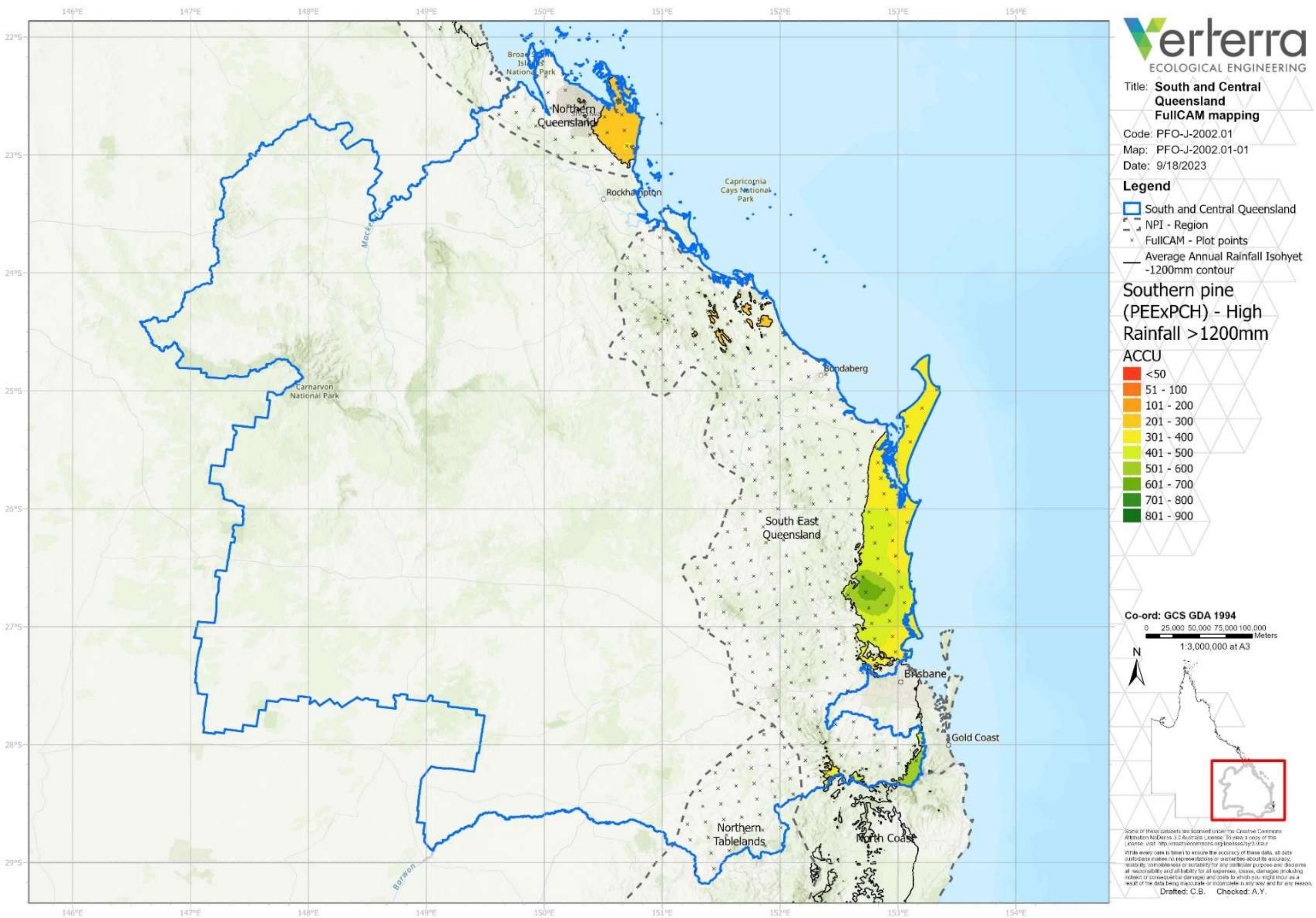
Code: PFO-J-2002.01
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Average Annual Rainfall Isohyet -1200mm contour
Southern pine (PEExPCH) - High Rainfall >1200mm
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
1:3,000,000 at A3
N
Northern Queensland
Rockhampton
Capricornia Cays National Park
Carnarvon National Park
South East Queensland
Brisbane
Gold Coast
Northern Tablelands
Drafted: C.B. Checked: A.Y.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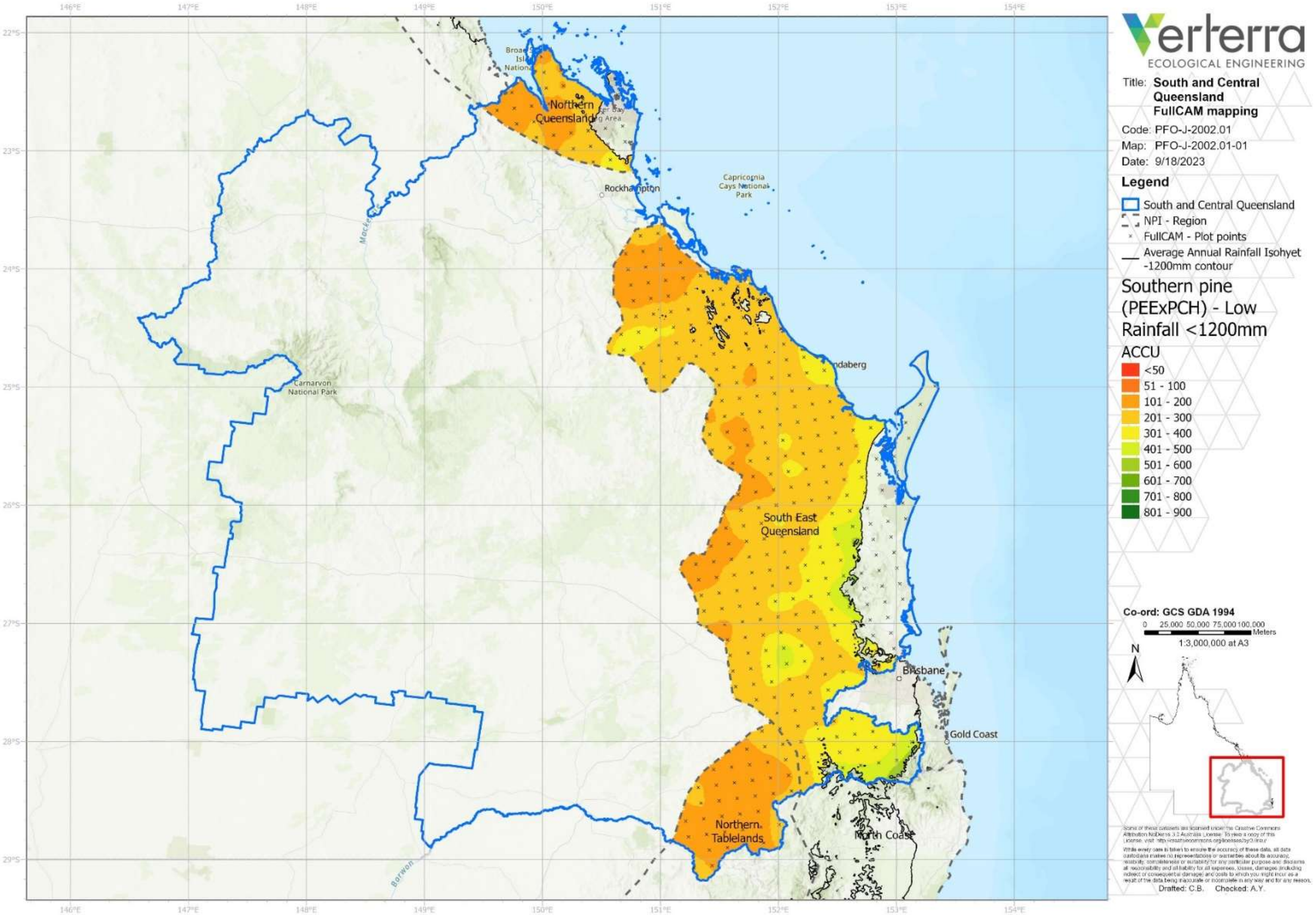
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Average Annual Rainfall Isohyet -1200mm contour
Southern pine (PEExPCH) - High Rainfall >1200mm
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
0 25,000 50,000 75,000 100,000 Meters
1:3,000,000 at A3
N
Drafted: C.B. Checked: A.Y.
Northern Queensland
Rockhampton
Capricornia Cays National Park
Carnarvon National Park
Bundaberg
South East Queensland
Brisbane
Gold Coast
Northern Tablelands
North Coast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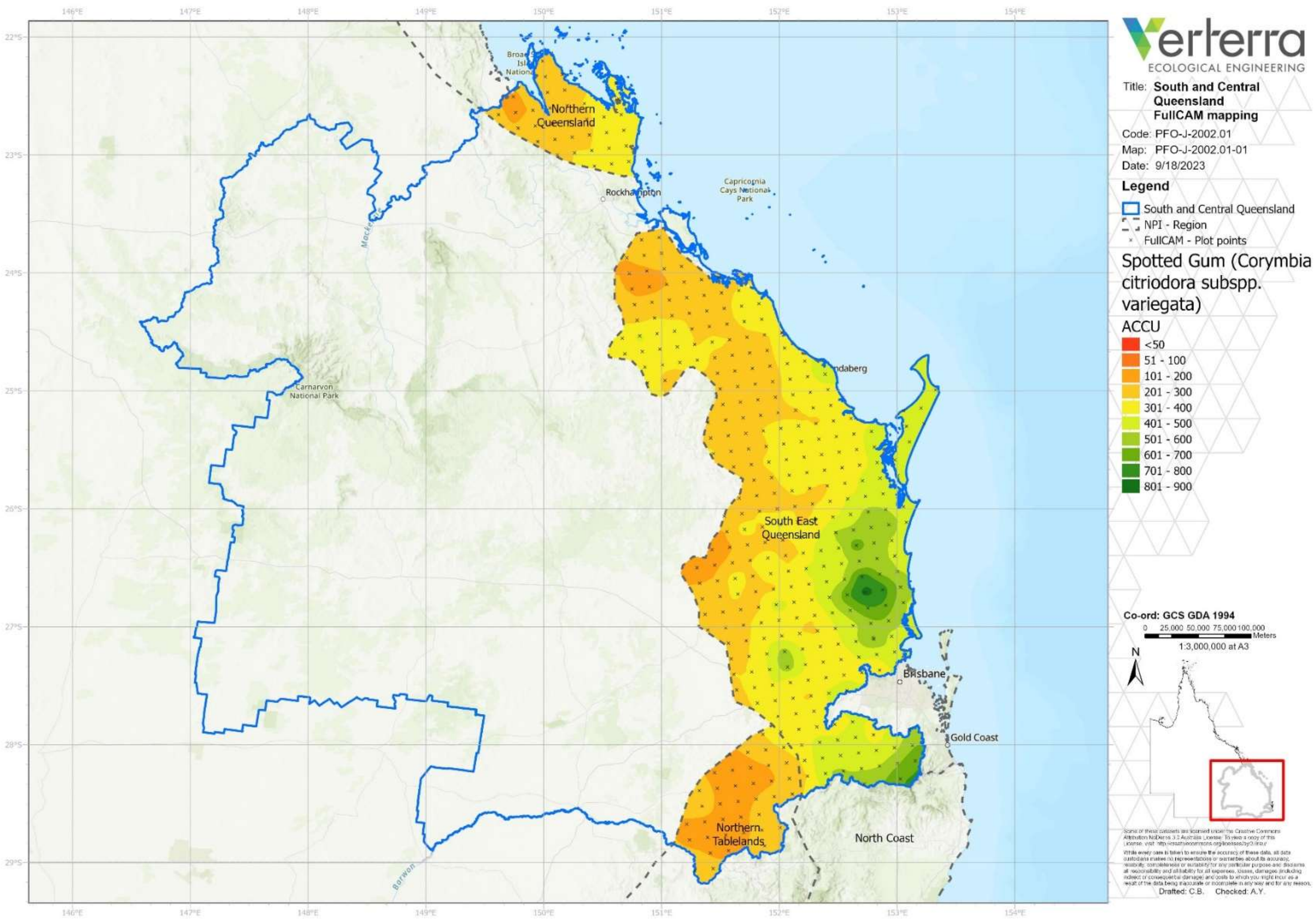
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Average Annual Rainfall Isohyet -1200mm contour
Southern pine (PEExPCH) - Low Rainfall <1200mm
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
1:3,000,000 at A3
Drafted: C.B. Checked: A.Y.
Northern Queensland
Rockhampton
Capricornia Cays National Park
Carnarvon National Park
South East Queensland
Brisbane
Gold Coast
Northern Tablelands
North Coast


Verterra
ECOLOGICAL ENGINEERING
Title: South and Central Queensland FullCAM mapping
Code: PFO-J-2002.01
Map: PFO-J-2002.01-01
Date: 9/18/2023
Legend
South and Central Queensland
NPI - Region
FullCAM - Plot points
Spotted Gum (Corymbia citriodora subspp. variegata)
ACCU
<50
51 - 100
101 - 200
201 - 300
301 - 400
401 - 500
501 - 600
601 - 700
701 - 800
801 - 900
Co-ord: GCS GDA 1994
1:3,000,000 at A3
Meters
N
Drafted: C.B. Checked: A.Y.
Northern Queensland
Rockhampton
Capricornia Cays National Park
Carnarvon National Park
South East Queensland
Brisbane
Gold Coast
Northern Tablelands
North Coast

Appendix F -Alternative silvopastoral regime economic results by species and regime

Southern pine

Silvicultural regime		
Initial stocking (trees per ha)	1,000	
Weed control spray	Yes	
Fertiliser	Yes	
	Non- com	2nd
Thinning age (yrs)	6	15
Thin stocking (trees per ha)	500	250
Clearfall age (yrs)	25	
Project outcomes		
Property area (ha)	46	
Plantation area (ha)	20	
Total ACCUs	5,304	
Total timber (m^3)	6,140	
Total kilograms gained (kgs)	38,774	
Total number of head start \ finish	16.26\14.34	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	(974)	(1,826)
timber + carbon	465	(387/0
timber + carbon + grazing	1,417	565

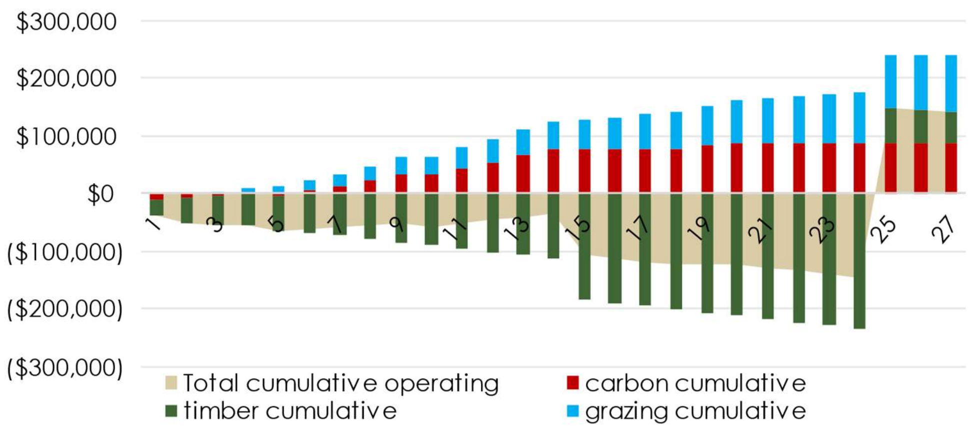


Figure 55- Cumulative net operating cashflows ($) with government grant

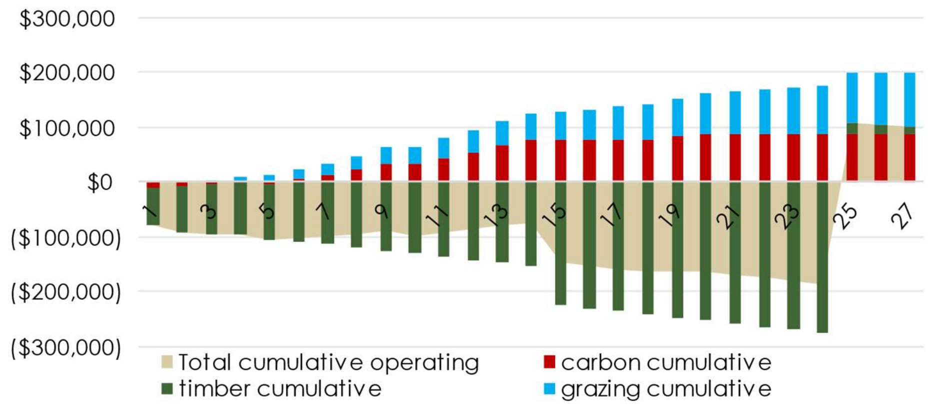


Figure 56- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Hardwood	411,226	8,940	411,226	8,940
Govt. grant	200,000	2,000	-	-
Total timber revenue	611,226	10,940	411,226	8,940
ACCUs				
Hardwood - long - all species	158,482	3,445	158,482	3,445
Agriculture				
Grazing return	98,486	2,141	98,486	2,141
Total revenue	708,194	15,396	668,194	14,526
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	870	40,000	870
Property maintenance	28,800	626	28,800	626
Silviculture	27,360	595	27,360	595
Forest management	-	-	-	-
Roading, harvest and haulage	177,780	3,865	177,780	3,865
Property - other	125,686	2,732	125,686	2,732
Total Timber expenses	399,626	8,688	399,626	8,688
Carbon				
Carbon registration and reporting	69,083	1,502	69,083	169
Agriculture				
Grazing	7,755	169	7,755	169
Total operating outflows	476,463	10,358	476,463	10,358
NET total return	231,731	5,038	191,731	4,168

Spotted gum

Silvicultural regime		
Initial stocking (trees per ha)	1,000	
Weed control spray	Yes	
Fertiliser	Yes	
Thinning age (yrs)	4	
Thin stocking (trees per ha)	250	
Clearfall age (yrs)	30	
Project outcomes		
Property area (ha)	60	
Plantation area (ha)	20	
Total ACCUs	7,415	
Total timber (m^3)	5,886	
Total kilograms gained (kgs)	31,212	
Total number of head start \ finish	12.75\9.44	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	417	(237)
timber + carbon	1,195	543
timber + carbon + grazing	1,765	1,112

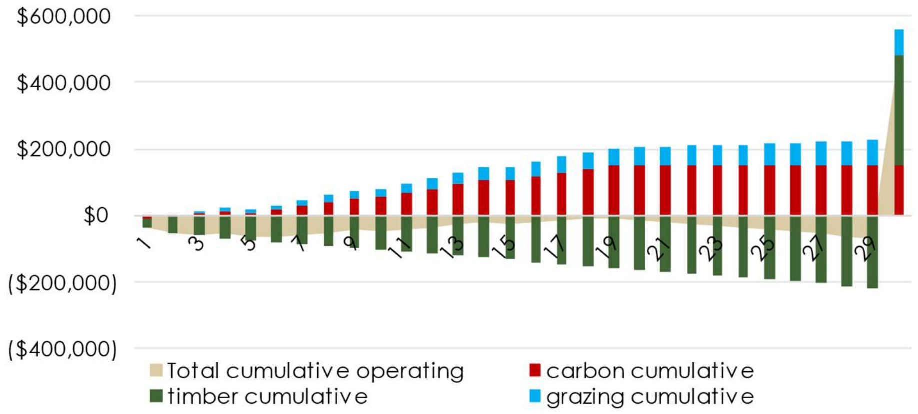


Figure 58- Cumulative net operating cashflows ($) with government grant

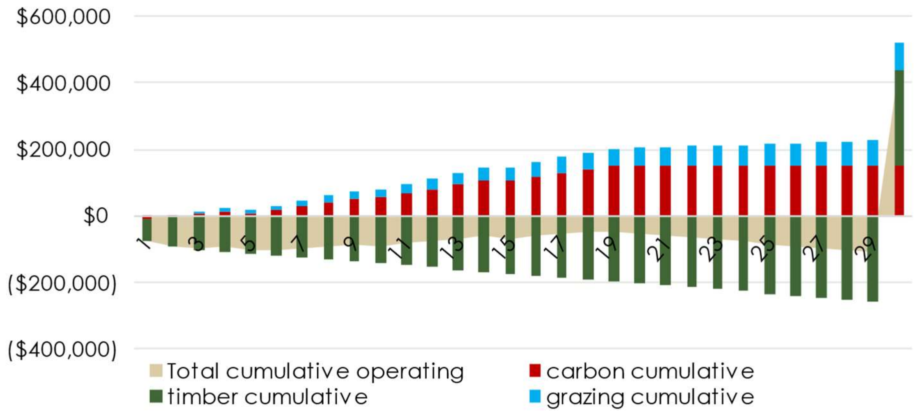


Figure 57- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Hardwood	748,339	12,472	748,339	12,472
Govt. grant	200,000	2,000	-	-
Total timber revenue	948,339	14,472	748,339	12,472
ACCUs				
Hardwood - long - all species	221,795	3,697	221,795	3,697
Agriculture				
Grazing return	79,278	1,321	79,278	1,321
Total revenue	1,089,411	18,157	1,049,412	17,490
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	667	40,000	667
Property maintenance	34,800	580	34,800	580
Silviculture	38,360	639	38,360	639
Forest management	-	-	-	-
Roading, harvest and haulage	194,236	3,237	194,236	3,237
Property - other	150,239	2,504	150,239	2,504
Total Timber expenses	457,634	7,627	457,634	7,627
Carbon				
Carbon registration and reporting	72,193	1,203	72,193	104
Agriculture				
Grazing	6,242	104	6,242	104
Total operating outflows	536,070	8,934	536,070	8,934
NET total return	553,342	9,222	513,342	8,556

Gympie messmate

Silvicultural regime		
Initial stocking (trees per ha)	1,000	
Weed control spray	Yes	
Fertiliser	Yes	
	Non- com	2nd
Thinning age (yrs)	5	20
Thin stocking (trees per ha)	375	250
Clearfall age (yrs)	30	
Project outcomes		
Property area (ha)	60	
Plantation area (ha)	20	
Total ACCUs	6,425	
Total timber (m^3)	6,952	
Total kilograms gained (kgs)	30,565	
Total number of head start\finish	11.59\10.43	
NPV ($ per ha) (discount rate 5%)	**Including grant**	**Excluding grant**
timber	212	(440)
timber + carbon	1,513	860
timber + carbon + grazing	2,055	1,403

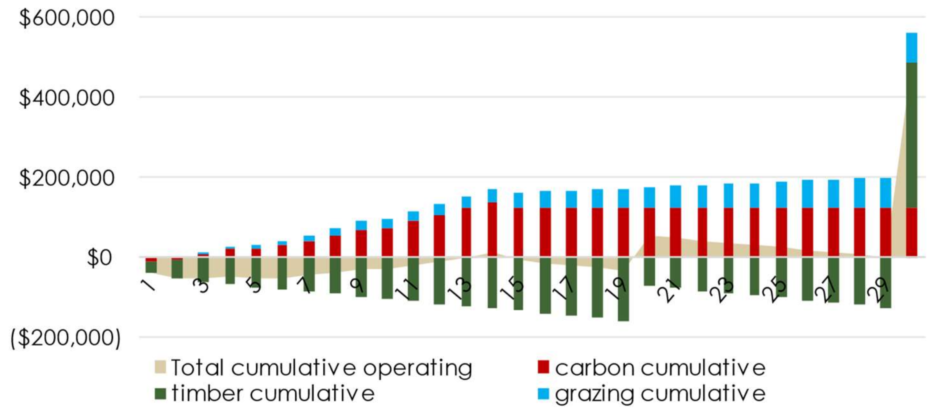


Figure 60- Cumulative net operating cashflows ($) with government grant

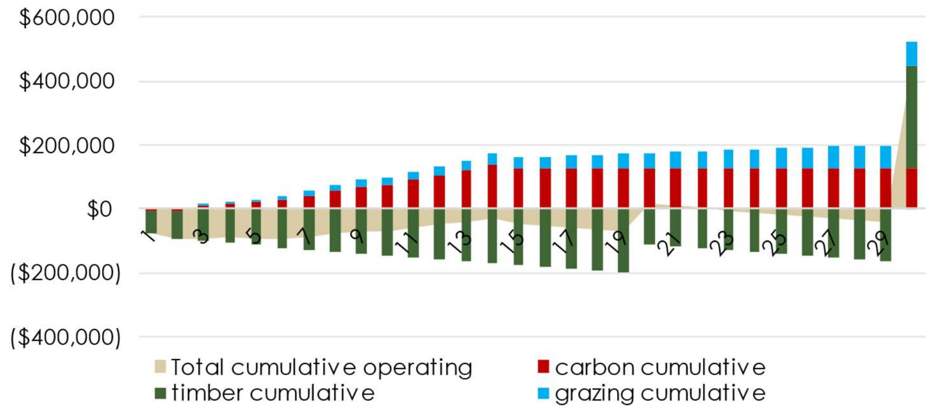


Figure 59- Cumulative net operating cashflows ($) without government grant

Operating inflows	Including Govt. Grant		Excluding Govt. Grant	
	$	$/ha	$	$/ha
Timber				
Hardwood	813,922	13,565	813,922	13,565
Govt. grant	200,000	2,000	-	-
Total timber revenue	1,013,922	15,565	813,922	13,565
ACCUs				
Hardwood - long - all species	192,075	3,201	192,075	3,201
Agriculture				
Grazing return	76,413	1,274	76,413	1,274
Total revenue	1,122,410	18,707	1,082,410	18,040
Operating outflows				
Timber				
Establishment (preparation and planting)	40,000	667	40,000	667
Property maintenance	34,800	580	34,800	580
Silviculture	38,360	639	38,360	639
Forest management	-	-	-	-
Roading, harvest and haulage	229,416	3,824	229,416	3,824
Property - other	150,240	2,504	150,240	2,504
Total Timber expenses	492,816	8,214	492,816	8,214
Carbon				
Carbon registration and reporting	66,202	1,103	66,202	102
Agriculture				
Grazing	6,113	102	6,113	102
Total operating outflows	565,132	9,419	565,132	9,419
NET total return	557,279	9,288	517,279	8,621

Appendix G – Annual cashflows– alternative silvopastoral regime

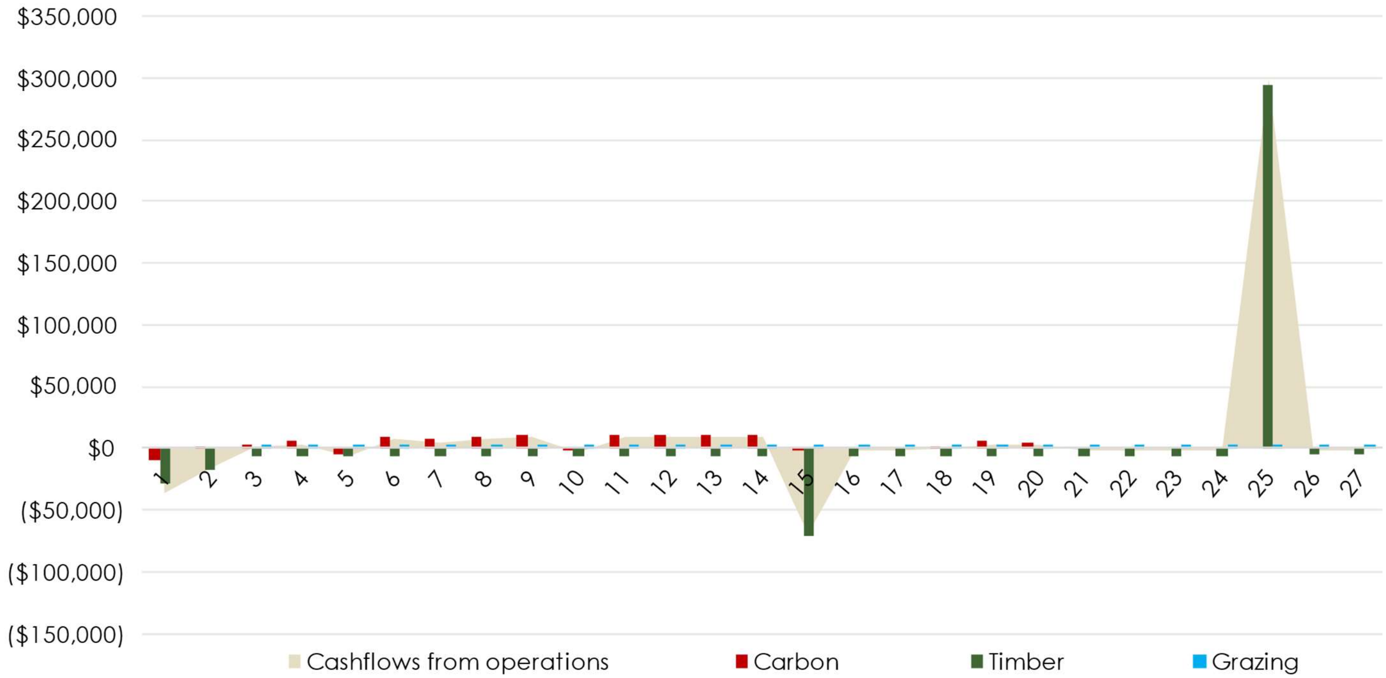


Figure 61- Annual cashflows for Southern pine in alternative silvopastoral regime

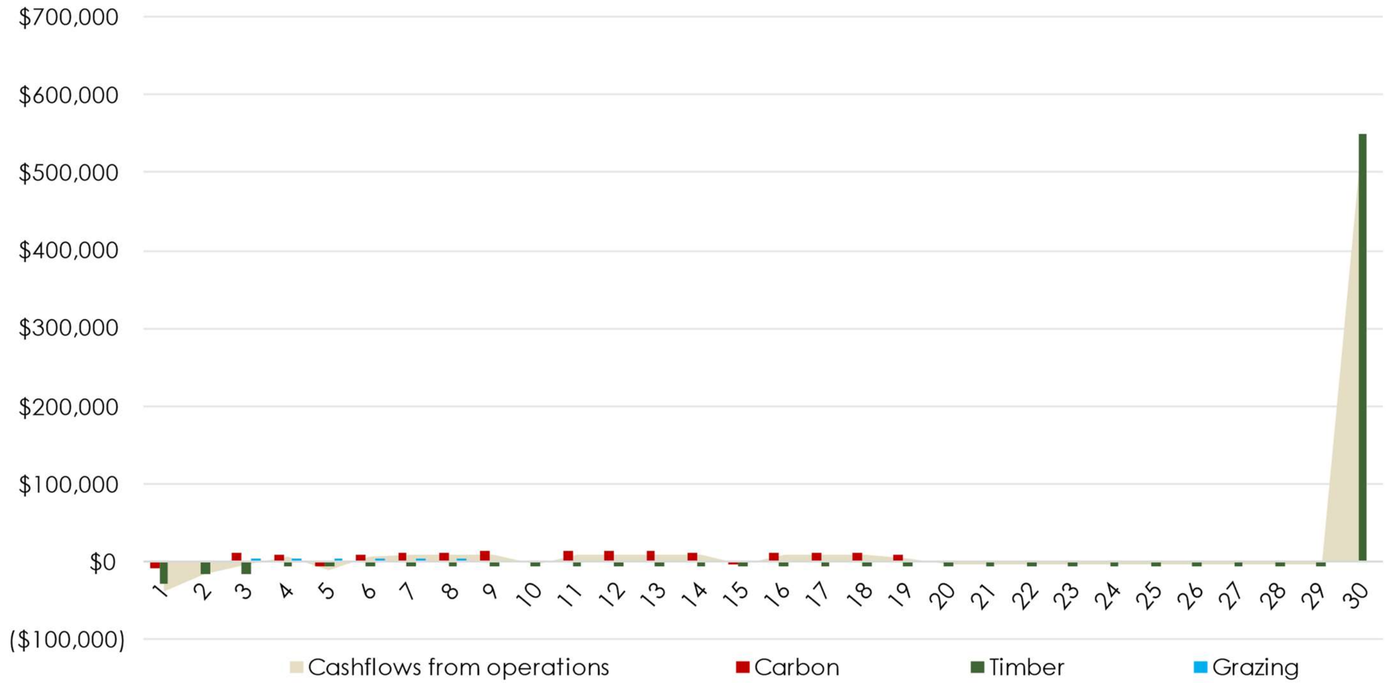


Figure 62- Annual cashflows for Spotted gum in alternative silvopastoral regime

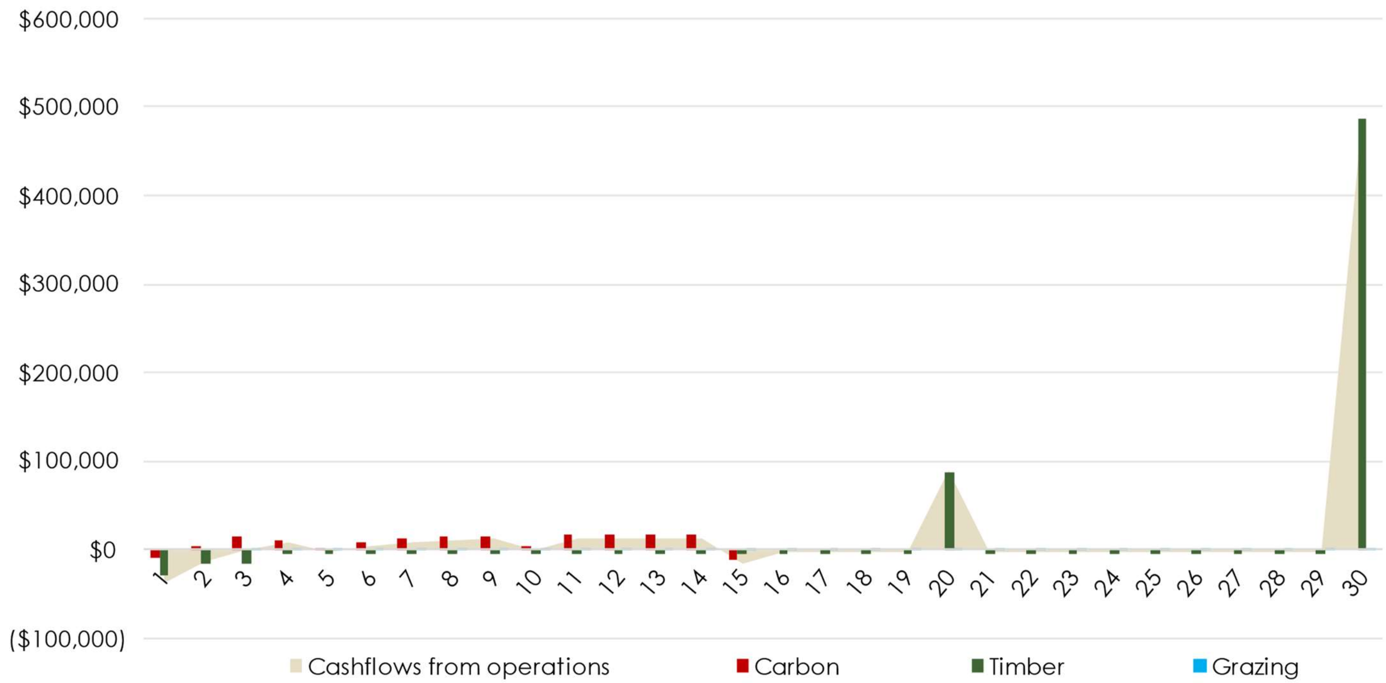


Figure 63- Annual cashflows for Messmate in alternative silvopastoral regime

Appendix H – Carbon heat maps- alternative silvopastoral regime

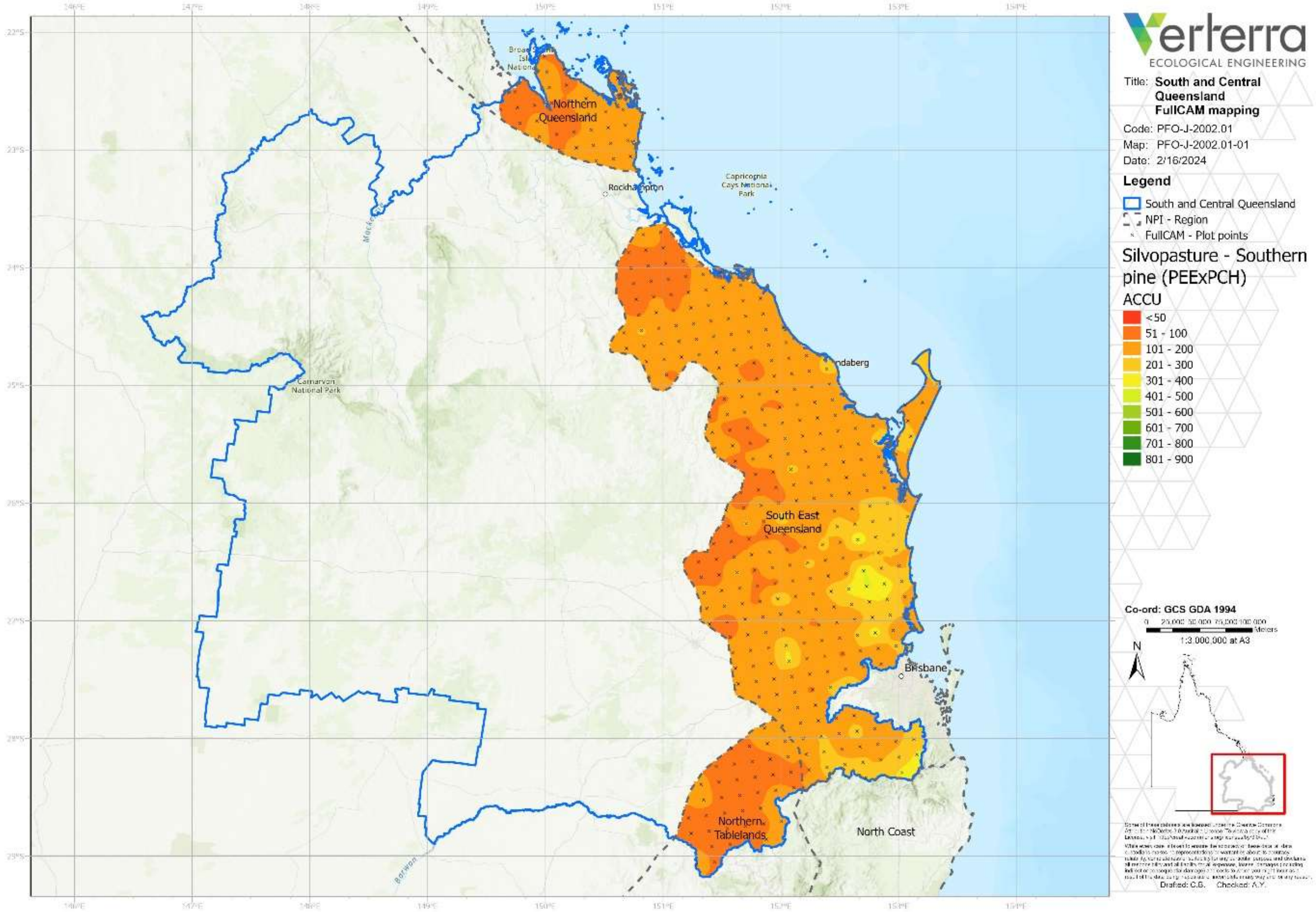


Figure 64-Alternative silvopastoral Southern pine- FullCAM 2016 within NPI region

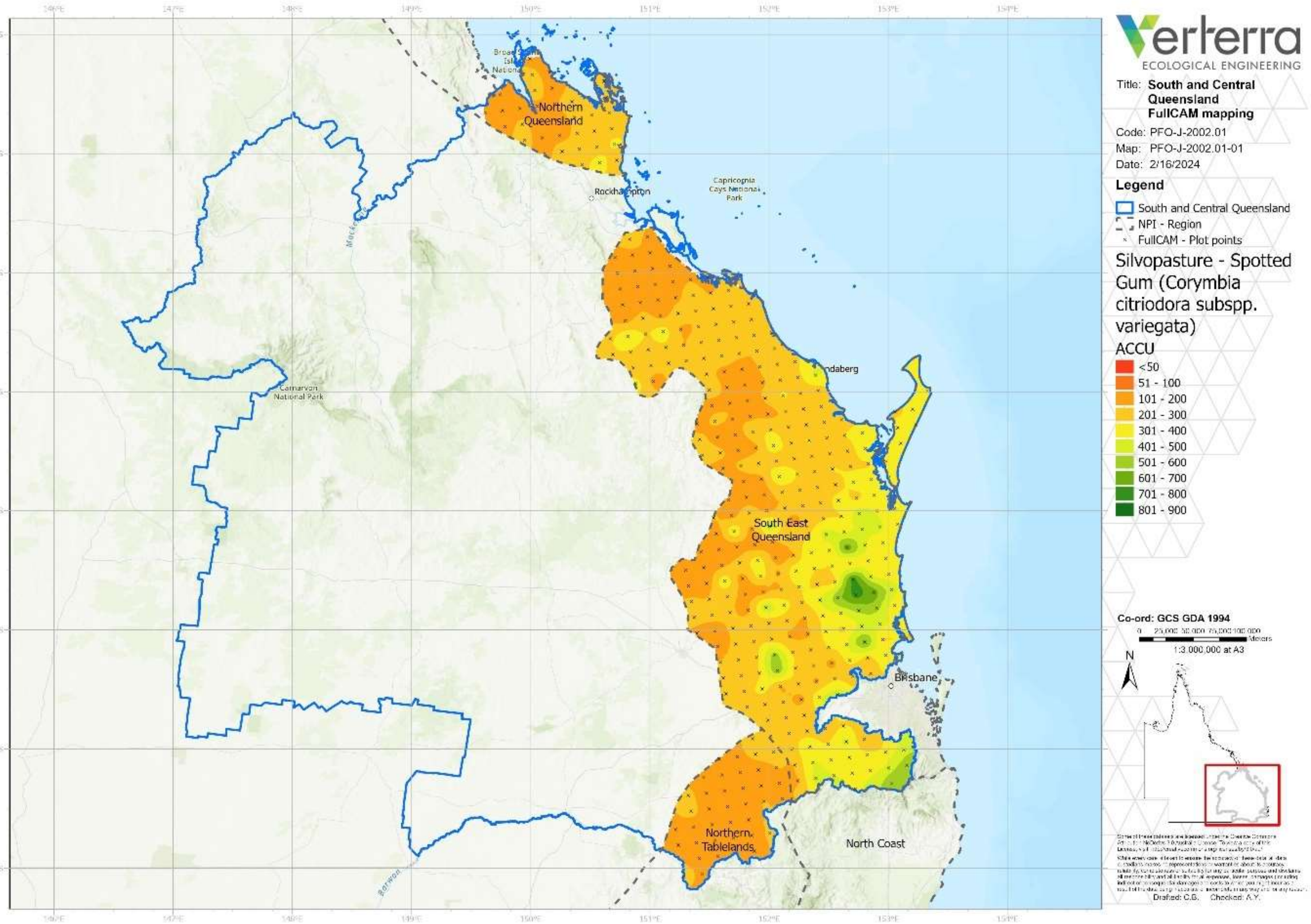


Figure 65- Alternative silvopastoral Spotted gum- FullCAM 2016 within NPI region.

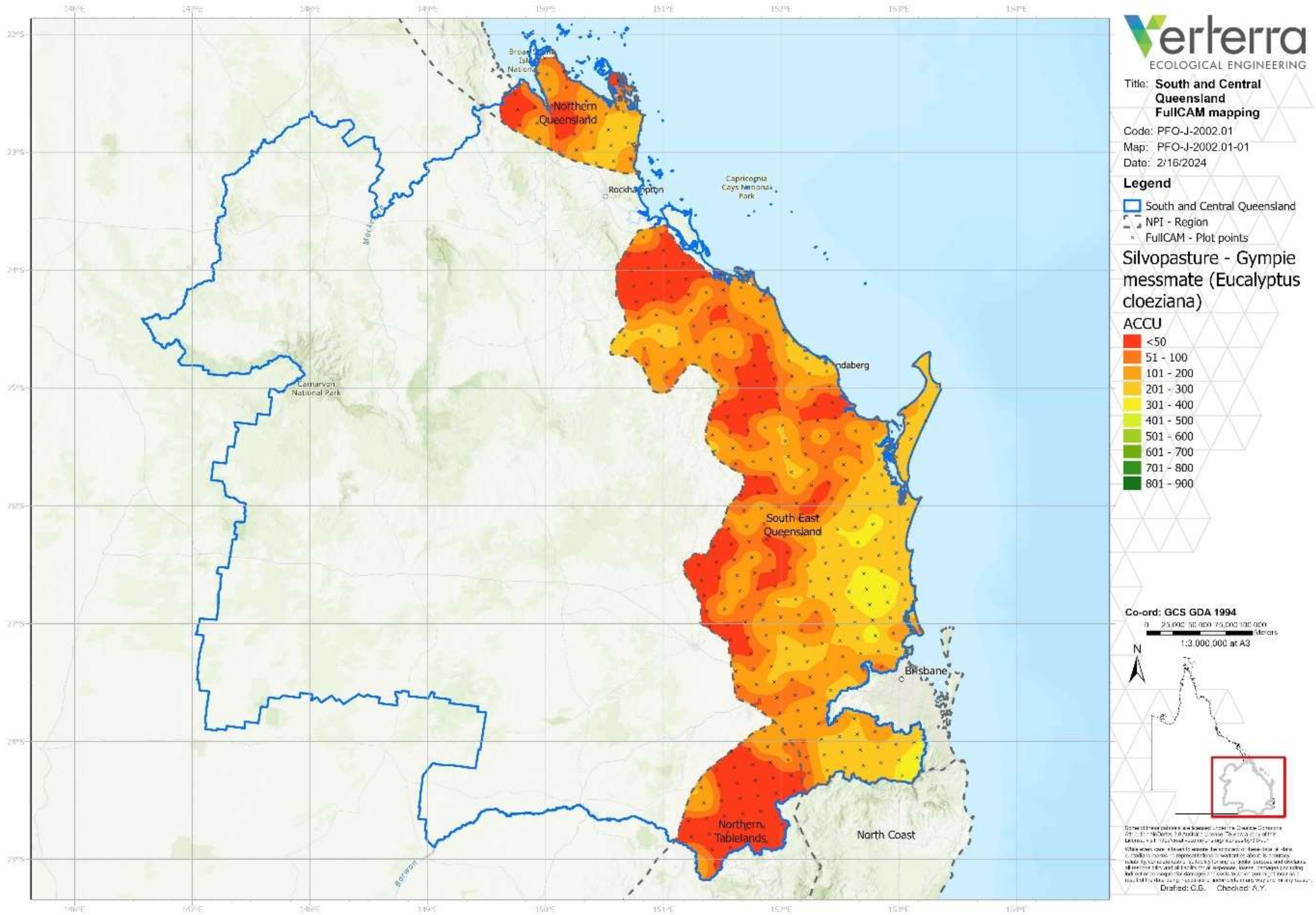


Figure 66- Alternative silvopastoral Gympie messmate - FullCAM 2016 within NPI region