PLANTATION LAND SUITABILITY ANALYSIS

Murray Region Forestry Hub

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1. Introduction

1.1 Background

The Murray Region Forestry Hub (the Hub) engaged PF Olsen to conduct a land suitability analysis across the Hub region. PF Olsen collaborated with Spatial Vision to deliver the project.

1.2 Scope

The project defined the physical characteristics required for productive plantations and overlayed this with current land use and tenure to provide a spatial view of the potential land availability across the Hub, and within each relevant Local Government Area.

Assumptions that are impediments to expanding a plantation estate providing a viable outcome for industry in the Hub were explored. For example:

- commercially viable 'wood baskets' based around distance to existing facilities
- potential land availability for new plantations
- constraints of local infrastructure
- physical capability and costs of future harvesting
- minimum economical parcel size.

1.3 Deliverables

Key deliverables of the project include a series of spatial outputs from a modelling framework detailing potential plantation locations, and a series of maps to visualise ideal locations, including 'unconstrained' potential plantation views, and 'constrained' views that consider exclusionary factors.

The spatial outputs are available through an interactive online mapping tool which can be accessed from the Murray Region Forestry Hub:

https://murrayregionforestryhub.com.au/

or directly via this link.

2. Key data inputs and considerations

The initial phase of this project included reviewing with the Project Team and relevant experts to develop an initial cut of several aspects to land availability across the Hub. This review came up with four key focal groups that helped identify suitable land for plantation establishment. These are:

- Biophysical parameters for suitable plantation growth
- Physical constraints that restrict plantation location
- Permit zones and other considerations
- Land values.

These four broad focal groups are described in the following sections considering key data inputs and variables and other considerations.

2.1 Biophysical parameters

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 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 can provide a rational basis for the most favourable utilisation of land resources and land use planning. It has gained a wide acceptance and adoption across a wide range of users including land managers, agriculturalists, and planners.

As a main caveat of this approach, there is a focus on the biophysical suitability on plantation location. Factors relating to management and operational limitations are not accounted for in this focal group. This considers all areas as potentially suitable regardless of limitations. The only factors that can limit suitability will come from the biophysical parameters themselves. Further limitations are explored in the other focal groups.

For plantations, issues to be considered here can include:

- Total annual or monthly rainfall
- Extreme temperatures
- Landscape aspect, slope or altitude
- Soil type, geological structure.

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

These were input into a suitability overlay model that will define grades of areas (e.g., low to high) where plantations can grow.

There were several biophysical parameters explored during the course of the project. This included:

- Total Annual Rainfall
- Extreme Rainfall Events
- Minimum Temperature in June
- Maximum Temperature in February
- Frost Risk over Spring
- Heat Waves
- Landscape – Slope
- Landscape – Aspect
- Soils

Each of these variables were explored for data availability and relevancy to the Hub. Only four variables were seen as necessary or as producing enough of a variation across the project region to be considered relevant. These are described in the following sections.

2.1.1 Climate variables

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

- Total Annual Rainfall
- Frost Risk over Spring – number of days below 2°C

Other climatic variables were explored, but they were seen to be very uniform across key areas in the Murray Region once classified into logical groupings. Variation in some temperature variables were mainly noted in the alpine areas, which can be discounted due to public land overlays (see following section).

Current climate

For both variables, an average climate of the decade between 2010 and 2019 was used. Historical climate data was obtained from weather observations sourced from the SILO Long Paddock Project website. SILO is a database of Australian climate data from 1889 to the present. It provides daily meteorological datasets for a range of climate variables in ready-to-use formats suitable for biophysical modelling, research and climate applications. It presents climatic variables as a continuous surface at a 5km^2 spatial resolution.

Future climate

For both included climatic variables, an average climate set to the years of 2050, 2070 and 2090 were used for future climate analysis. Future climate data was obtained from the Victorian Climate Projections 2019 (VCP19) project data portal (DELWP & CSIRO, 2019). VCP19 is a database of projected future General Circulation Models (GCM) for several future timepoints and for multiple variables. It provides daily projected future data, downscaled to a 5km2 resolution for all of Victoria and the southern part of NSW.

Two future emission scenarios, called Representative Concentration Pathways (RCP) have been used; RCP 4.5 and RCP 8.5. The 4.5 scenario is an intermediate emissions scenario where emissions peak in 2040 then decline thereafter. This is considered a more probable emissions pathway. The 8.5 scenario is where emissions continue to rise throughout the 21st century and is considered a worst-case scenario.

One GCM model has been used for this project, ACCESS 1.0, which was created by the CSIRO and the Bureau of Meteorology. This is considered a middle range model in that it is not an extremely hot/dry GCM or a warm/wet GCM.

Categorisation

These two parameters, for the 2010 to 2019 period and for the future periods of 2050, 2070 and 2090, were collated and averaged to form a single gridded (5km^2 resolution) output. These outputs were then classified into (at most) a five-class system from very poor to ideal. For rainfall, for example, the 700mm total annual rainfall was considered a key threshold. Anything below this level was less suitable for plantation establishment, whereas above this, in increasing bands, was considered more and more ideal. The categories for these are presented below in Table 1 and Table 2.

Table 1- Total annual rainfall categories

Category	Rating
< 700 mm	Poor
701 mm – 800 mm	Moderate
801 mm – 1,000 mm	Good
> 1,000 mm	Ideal

Table 2- Number of days below frost temperature

Category	Rating
> 150 days	Very Poor
100 days – 150 days	Poor
50 – 99 days	Good
< 50 days	Ideal

2.1.2 Landscape

Landscape inputs focussed on the one main variable of slope. Aspect and elevation were considered but were determined to be not as critical for the Hub.

As the Hub spans Victoria and New South Wales, two suitable digital elevation models (DEMs) were sourced. In Victoria, this came from the Victorian Government Open Spatial Data Platform (data.vic.gov.au), as a 10m^2 resolution raster. In NSW, a series of 5m^2 rasters covering the region were sourced from the NSW Elevation Data Service. The NSW rasters were resampled up to a 10m^2 resolution, and these and the Victorian raster were joined together into a single continuous mosaic surface.

Slope was calculated as percentage slope, where 100% would be equal to a 45-degree incline. The classification of this is presented in Table 3. The main consideration of these classes is access to plantations and use of harvesting machinery.

Table 3- Slope classifications

Category	Percent rise	Rating
> 30°	> 57.7%	Very Poor
20° – 30°	36.5 – 57.6%	Moderate
< 20°	<36.4%	Ideal

2.1.3 Soils

For classification of soils in the Hub, the Northcote Factual Key classification was used. This key divides soils into types across the Murray Region which can be defined by soil colour, composition and overall profile. A suitable layer for the region that uses the Northcote system was sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au).

The Primary Profile form of the key was used for Murray Region, which presents four major classes:

- Duplex
- Uniform
- Gradational
- Organic

Duplex soils are good in some places for pine plantations, but not great. The subsoil (B Horizon) tends to waterlog in winter and then get very hard in summer. This means that the roots are limited in how deep they can penetrate. They are also not suitable for winter operations as the subsoil gets very wet which increases the potential for machines to get bogged. The main requirement is a relative deep topsoil (A horizon) and mounding at establishment.

Uniform soils have low fertility but have a good deep soil profile that tree roots can fully utilise. However, other areas can be acidic and have a hard-subsurface layer which can be challenging for root growth and penetration. That said there are a lot of plantations on these types of soils. Winter operations on these soils are possible.

Gradational soils are well structured soils with either sedimentary or basalt parent materials. These are the highest productivity sites in the Murray Region. The ones with basaltic parent material also stand up well to operations in winter.

Soils have been rated for plantation suitability in Table 4.

Table 4- Soils classification

Category	Rating
Duplex	Moderate
Uniform	Good
Gradational	Ideal

2.2 Land exclusions

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

A comprehensive list of important barriers to plantation establishment within both states was reviewed by the Project Team, including:

- Land zoning
- Management overlays
- Current land use and tenure
- Lot or parcel size
- Service areas
- Road and transportation
- Processing facilities
- Existing plantations
- Existing woody vegetation

In the Murray Region, land management practices vary slightly between Victoria and NSW, meaning that certain datasets follow a different structure, or may not have an equivalent in the other state.

2.2.1 Land zoning and management overlays

Planning Zones were sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au) and the NSW Government SEED Portal (live.seed.nsw.gov.au) and Land Management Overlays were sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au). Both these spatial layers are planning layers that define zones and overlays where certain activities and developments can or can't take place, or where additional restrictions apply.

In consideration of plantation establishment, both aspects are critical to be defined as they will limit what activities can take place. Table 5 presents the zones and defines which ones would exclude plantation establishment.

Table 6 presents the overlays that will be used in this study because they must be considered for plantation establishment. Environmental Significance Overlays are generally exclusion zones for plantations, but there are exceptions to this rule where permits can be gained to undergo certain activities. These will be explored in the next section.

Table 5- Land management zones in Murray Region and relevant plantation exclusions

Division	Exclusion
Commercial Zone	Yes
Commonwealth Land Not Controlled by Planning Scheme	No
Comprehensive Development Zone	No
Farming Zone	No
General Residential Zone	Yes
Industrial Zone	Yes
Low Density Residential Zone	Yes
Mixed Use Zone	No
Neighbourhood Residential Zone	Yes
Public Conservation and Resource Zone	Yes
Public Park and Recreation Zone	Yes
Public Use Zone - Cemetery/Crematorium	Yes
Public Use Zone - Education	Yes
Public Use Zone - Health and Community	Yes
Public Use Zone - Local Government	Yes
Public Use Zone - Other Public Use	Yes
Public Use Zone - Service and Utility	Yes
Public Use Zone - Transport	Yes
Residential Growth Zone	Yes
Road Zone	Yes
Rural Activity Zone	No
Rural Conservation Zone	No

Division	Exclusion
Rural Living Zone	No
Special Use Zone	No
Township Zone	Yes
Urban Floodway Zone	Yes
Urban Growth Zone	Yes

Table 6- Land management overlays in Murray Region and relevant plantation exclusions

Division	Exclusion
Airport Environs Overlay	No
Bushfire Management Overlay	No
Design and Development Overlay	No
Development Contributions Plan Overlay	No
Development Plan Overlay	No
Environmental Audit Overlay	No
Environmental Significance Overlay	Yes
Erosion Management Overlay	No
Floodway Overlay	No
Heritage Overlay	Yes
Incorporated Plan Overlay	No
Land Subject to Inundation Overlay	No
Parking Overlay	No
Public Acquisition Overlay	No
Restructure Overlay	No
Road Closure Overlay	No
Salinity Management Overlay	No
Significant Landscape Overlay	No
Special Building Overlay	No
Specific Controls Overlay	No
State Resource Overlay	No
Vegetation Protection Overlay	Yes

2.2.2 Public land management: reserves and crown lease

The Reserves and Crown Lease spatial layer was sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au), under the Public Land Management layer (PLM25). This includes National Parks, State Forests, parks and reserved and unreserved Crown land, including estuarine, coastal and marine areas.

The areas that are excluded from plantation establishment are presented in Table 7.

Table 7- Public land management in Murray Region and relevant plantation exclusions

Division	Exclusion
Alpine Resort	Yes
Coastal Reserve	Yes
Coastal Waters	Yes
Commonwealth Land	No
Community Use Area	Yes
Earth Resources	No
Forest Park	Yes
Historic and Cultural Features Reserve	Yes
Lighthouse Reserve	Yes
Marine National Park	Yes
National Park	Yes
Natural Features Reserve	Yes
Nature Conservation Reserve	Yes
NPA Schedule 3 Other Park	Yes
NPA Schedule 4 Park or Reserve	Yes
Plantation	No
Port and Coastal Facility	Yes
Proposed National Parks Act	Yes
Parks Vic Managed Land	Yes
Regional Park	Yes
Reservoir Park	Yes
Services and Utilities	Yes
State Forest	No
State Park	Yes
Uncategorised Public Land	Yes
Water Body	Yes
Water Production	Yes

2.2.3 Land use - tenure and existing uses

The Tenure and Existing Uses spatial layer was sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au), under the Victorian Land Use Information System (VLUIS). Under the VLUIS spatial layer, 'land use' means the purpose to which the land cover is committed, or the property type. Each land use is attributed at a property level, that is for each property across the Murray Region a land use has been assigned.

Land use is classified into a nine-class system under a three-tier hierarchy. The nine classes include:

- Residential
- Commercial
- Industrial
- Extractive Industry
- Primary Production
- Infrastructure/Utilities
- Community Services
- Sports, Recreation, Culture
- Conservation and Public Land

For the purposes of exclusions relating to plantation establishment, Table 8 demonstrates that most defined land uses are barriers to plantation establishment. However, the Primary Production classification can be divided further, and certain classes then become permitted.

Table 8- Land use exclusions in Murray Region and relevant plantation exclusions

Land use classification	Exclusion
Residential	Yes
Commercial	Yes
Industrial	Yes
Extractive Industry	Yes
Infrastructure/Utilities	Yes
Community Services	Yes
Sports, Recreation, Culture	Yes
Conservation and Public Land	Yes
Primary Production on Native Vegetation	Yes
Agricultural Cropping	No
Livestock Grazing	No
Mixed Farming Grazing	No
Livestock - Special Use	No
Horticulture	No
Horticulture - Special Use	No
Forestry - Commercial Timber Production	No
Aquaculture	Yes

2.2.4 Lot and parcel size

The Lot and Parcel Size spatial layer was sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au), under the Vicmap Property spatial layer. This layer provides a basic breakdown of property location and size for the Murray Region. It also provides a lot number and other details for planning purposes, if so required.

Through the course of analysis, different land groupings (based on lot size in hectares) were used to explore the resulting spatial outcomes:

1. <50, 50-100, >100
2. <30, 30-75, >75
3. <10, 10-40, 40-100, >100

Ultimately, grouping 3 was used for the final analysis.

In relation to plantation establishment, property size alone does not limit plantation suitability, however larger lot sizes can lead to efficiencies (hence cost savings) in plantation establishment, maintenance and harvesting activities. That said, smaller parcel sizes can still be considered as there is potential to group land parcels to form a more desirable plantation size.

2.2.5 Distance to existing processors

It is important when considering the location of future plantations to understand where existing processor facilities are and what they require in terms of log products (i.e. chip logs or sawlogs). A service area assessment was undertaken to assist with this consideration.

To undertake a service area assessment, two key inputs are required:

- Road and transportation network
- Processing facility locations

For the road and transportation network, a spatial layer was sourced from the Victorian Government Open Spatial Data Platform (data.vic.gov.au), under the Vicmap Transport spatial layer. This provides a classification of main transportation routes across Victoria into the following road types:

- Processing facility locations
- Freeway
- Highway
- Arterial
- Sub-arterial
- Collector road
- Local road
- Minor road
- Major track
- Minor track
- Trail

Anything that was classified as local road and above was utilised in the service area analysis. Minor roads are smaller roads in townships that cannot support logging or heavy vehicles. Any tracks are usually 4WD or walking tracks not suitable for heavy vehicles. Any in-site logging truck roads are not included and may limit the service area assessment. The Vicmap product was limited to the relevant selections and the layer was cleaned to provide a continuous network for the analysis.

Processing facility information is presented in Table 9. This information, combined with the road and transportation network, was used to generate a map that shows the distance from the nearest processing facility.

Table 9- Processing facility locations

Company	Products	Address
Carter Holt Harvey	Plywood	251 Myrtleford-Yackandandah Rd, Myrtleford VIC 3737
Alpine MDF	Medium density fibreboard	Lot 1 Crosher Ln, North Wangaratta VIC 3678
AKD NSW	Sawn timber	135-165 Adelong Rd, Tumut NSW 2720
Visy Pulp and Paper	Packaging and paper	1302 Snowy Mountains Hwy, Tumut NSW 2720
Hyne Timber	Sawn timber	3975 Jingellic Rd, Tumbarumba NSW 2653
D&R Henderson	Particleboard	42 Benalla-Yarrawonga Rd, Benalla VIC 3672

2.2.6 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 VLUIS layer (which has categories for forestry operations within the Primary Production classification) and the National Forest Inventory (NFI) Australian Plantations 2016 layer which is used in the State of the Forest reporting.

2.2.7 Existing forested areas

Land that is currently covered by the definition of 'forest' (i.e. greater than 20% canopy cover and single-stemmed trees greater than 2 metres in height) also needs to be excluded in this analysis. Existing forest would not be cleared in order to develop a new tree plantation.

The key data source for this exclusion is the 2021 National Forest and Sparse Woody Vegetation Database. (Commonwealth of Australia, Department of the Environment and Energy – National Greenhouse Gas Inventory). This is a Landsat derived product to detail forest and sparse woody extent and change spatially since 1988, with annual coverage from 2004 to 2020. The data for 2020 was used in this project.

2.3 Land values

Land values were sourced from the annual property sales statistics from Valuer-General Victoria[1]. It provides comprehensive sales data for houses, units, vacant residential land and commercial, industrial and rural properties. Importantly, it breaks down sales by land use that is broadly in line with those presented by the VLUIS spatial layer. It also provides property sales statistics for each LGA.

Appendix A presents the property sales statistics for each of the LGAs represented in the Victorian section of the Hub Region. This is further divided by the Primary Production land uses, which include both excluded and non-excluded property land use types that could potentially support the establishment of a plantation.

For the NSW portion of the Hub Region, there are no readily available land valuations or sales statistics. However, the Victorian areas can provide a useful indication of potential land values due to their close proximity. Appendix A also includes Victorian and County Victoria sales statistics to cover for this area where there are no values available.

3. Analysis and results

The inputs described in the previous section 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 block.

Initial processing was conducted in two parts: land exclusions and key considerations, and biophysical suitability. This stage of the project 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 of 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.

[1] https://www.land.vic.gov.au/valuations/resources-and-reports/property-sales-statistics

3.1 Land exclusions and key considerations

The key variables in land use exclusions, as listed in the previous chapter include:

- Land zoning
- Management overlays
- Public land reserves
- Land use
- Existing plantations

As per Table 5 to Table 8, indicated 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 1 alongside existing plantations across the Murray Region Forestry Hub. National Parks and State Forests have also been mapped separately against other exclusions.

As noted, the majority of exclusions are Public Land Management parks and reserves. However, around townships and the lakes district, there are a number of areas excluded due to zoning restrictions or overlays.

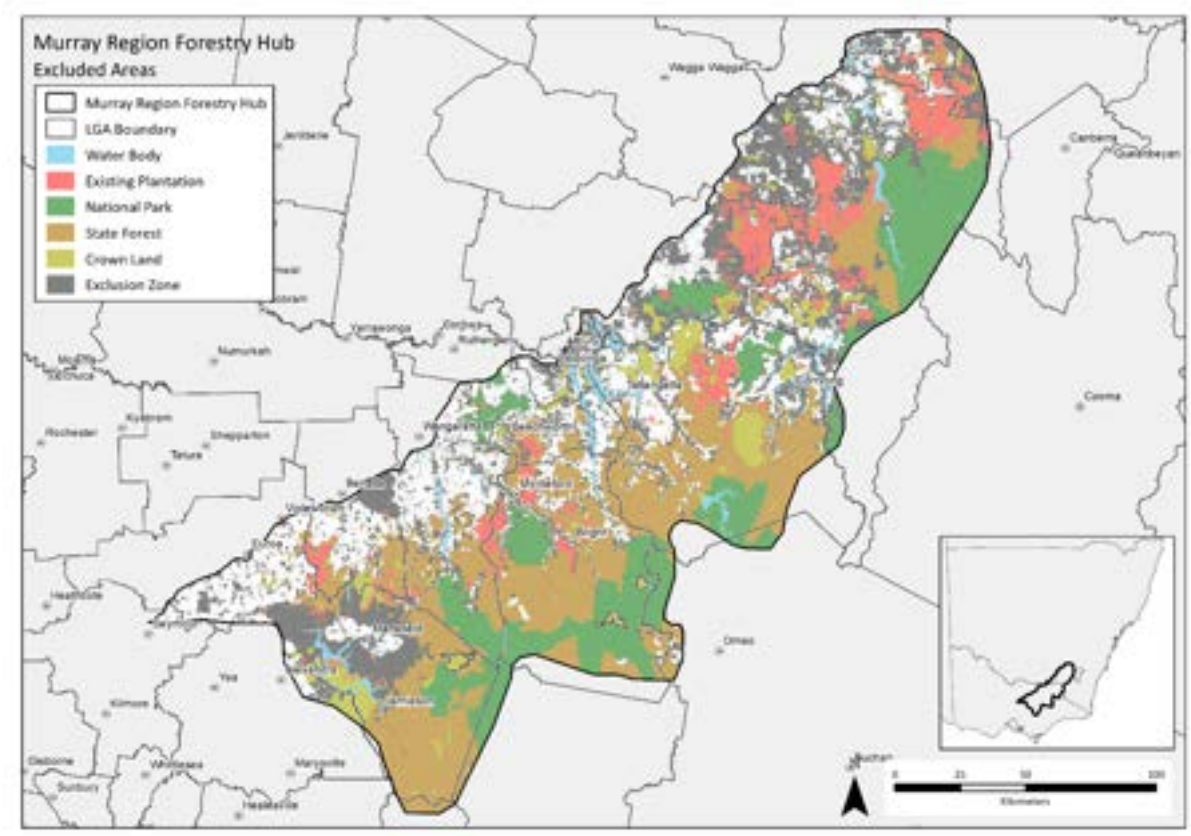

Figure 1- Land exclusions and existing plantation locations

3.2 Land parcel size

Lot size by the four class divisions (refer to Section 2.2.4) is presented as a patchwork of property size classes in Figure 2. Most smaller lot sizes are closer to established townships and are more concentrated into the central areas of the region into the Wodonga City LGA. Larger lots (>100 hectares) tend to be found into the north of the region, mostly in NSW. These properties are often mixed in with the next size class of 40 to 100 hectare properties.

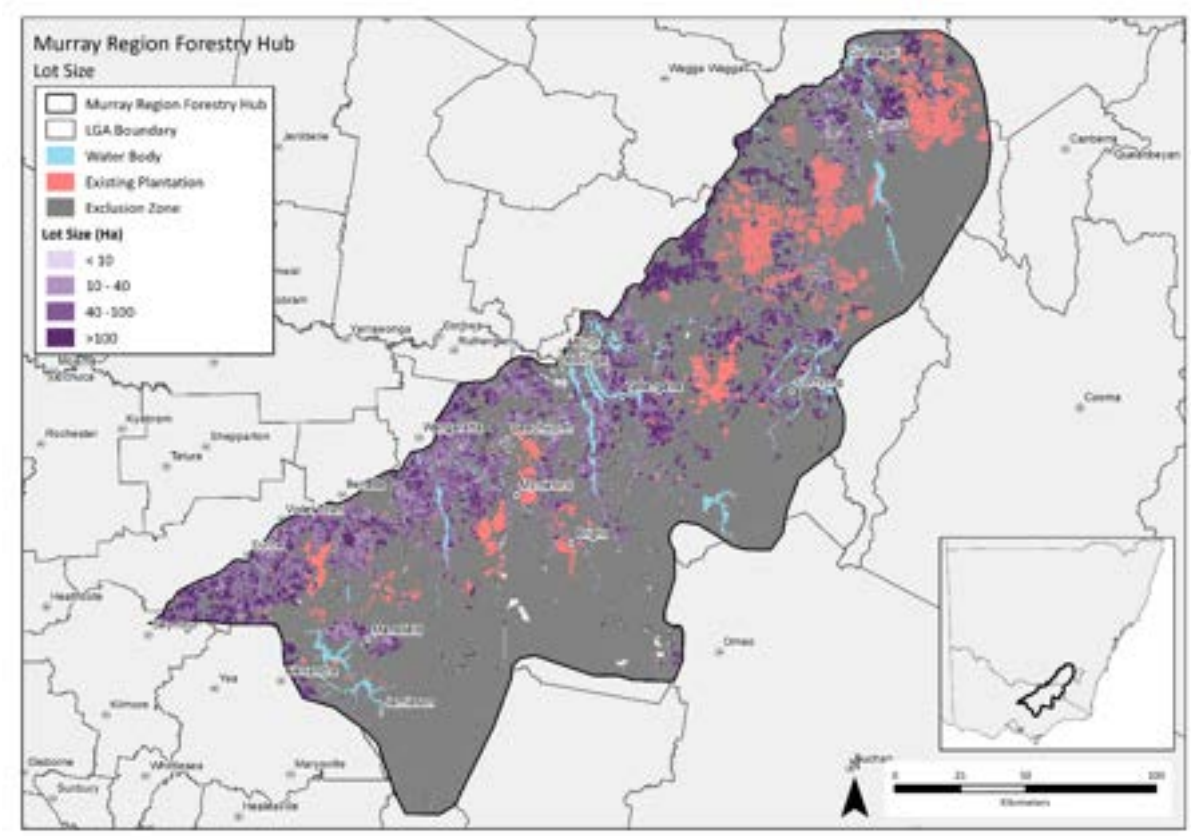

Figure 2- Land parcel size

3.3 Distance from processors

The road transportation input layer was filtered to consider freeways and arterials down to major roads. Minor roads and tracks were excluded due to access limitations for heavy vehicles. This was combined with processing facilities to calculate a service area by distance for plantation operations across the Hub.

Using the processing facilities as centroids in the analysis, a network service area assessment within a GIS software package was run. The ranges were classified into 50km brackets from each facility and are presented in Figure 3.

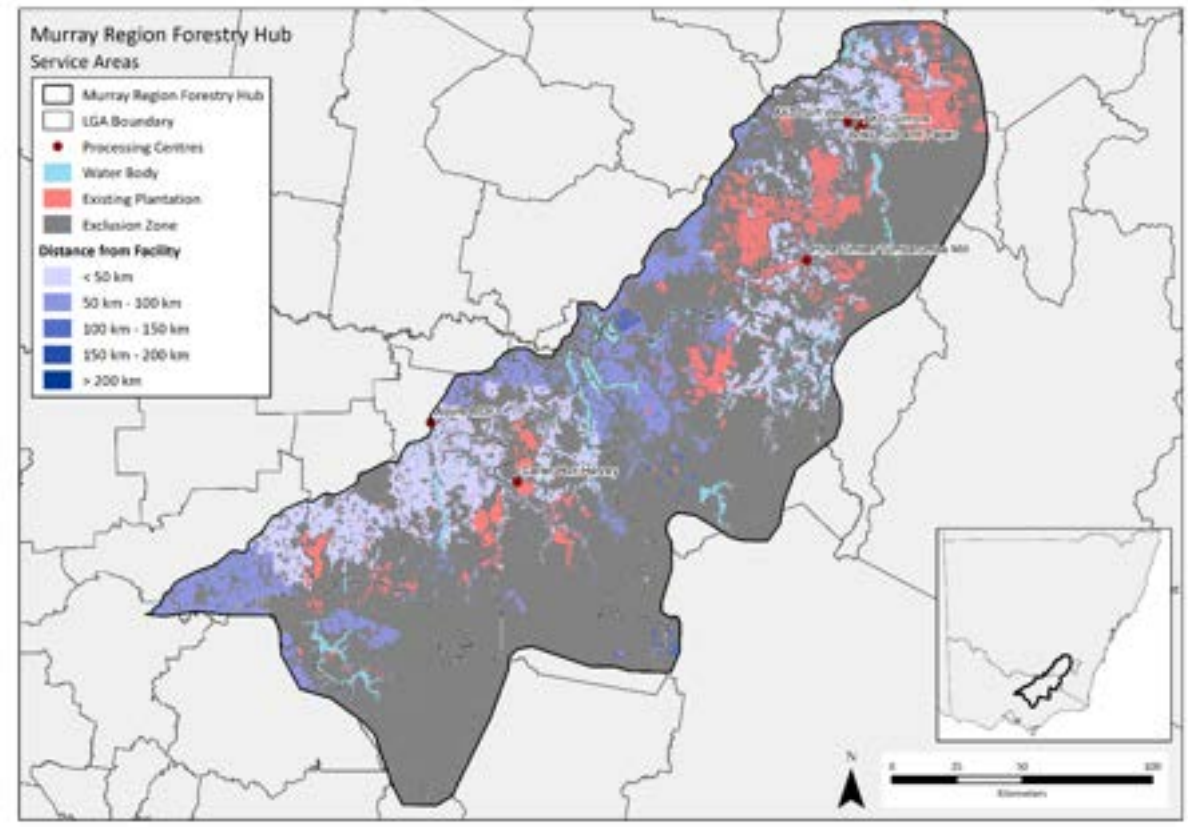

Figure 3- Distance to processing facilities

3.4 Biophysical suitability

Each of the biophysical parameters, as outlined in the previous chapter, are combined into a suitability analysis model. A 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 can provide a rational basis for the most favourable utilisation of land resources and land use planning.

As a main caveat of this approach, management and operational limitations are not accounted for in this assessment. That is, this method considers all areas as a potential location regardless of limitations. The only factors that can limit suitability will come from the biophysical parameters themselves. Further limitations can be incorporated after the model is run to grant a truer representation of suitability.

The method employed in this project is an equal weighted scored overlay approach using the following biophysical parameters as key inputs:

- Total annual rainfall (current, 2050, 2070, 2090)
- Frost risk over spring (current, 2050, 2070, 2090)
- Landscape – slope
- Soils – Northcote factual key

Each of the biophysical parameter inputs are ranked and scored. The ranks are as indicated in Table 1 to Table 4, from Very Poor (score of 1) to Ideal (score of 5).

Within a modelling framework in a GIS platform, each of the biophysical parameters are reclassified based on the ranking and then assigned the relevant score. These scores are then multiplied together with an equal rating for each of the parameters. The product of the scores is then classified into 20% divisions to output a ranking system similar to the original biophysical inputs, that is from Poor to Ideal (Figure 4).

The most suitable areas, shown in darker greens, are primarily seen in the north of the Hub Region, into Yass Valley and Cootamundra-Gundagai and also into Victoria in the Southwest in Wangaratta and Benalla. These are very well aligned with existing plantation locations, as presented. The suitability classification of 3 is more widespread throughout the region and contains the largest area of the suitability categories.

The lower categories are mainly restricted to the lower rainfall areas or areas that have steep slopes.

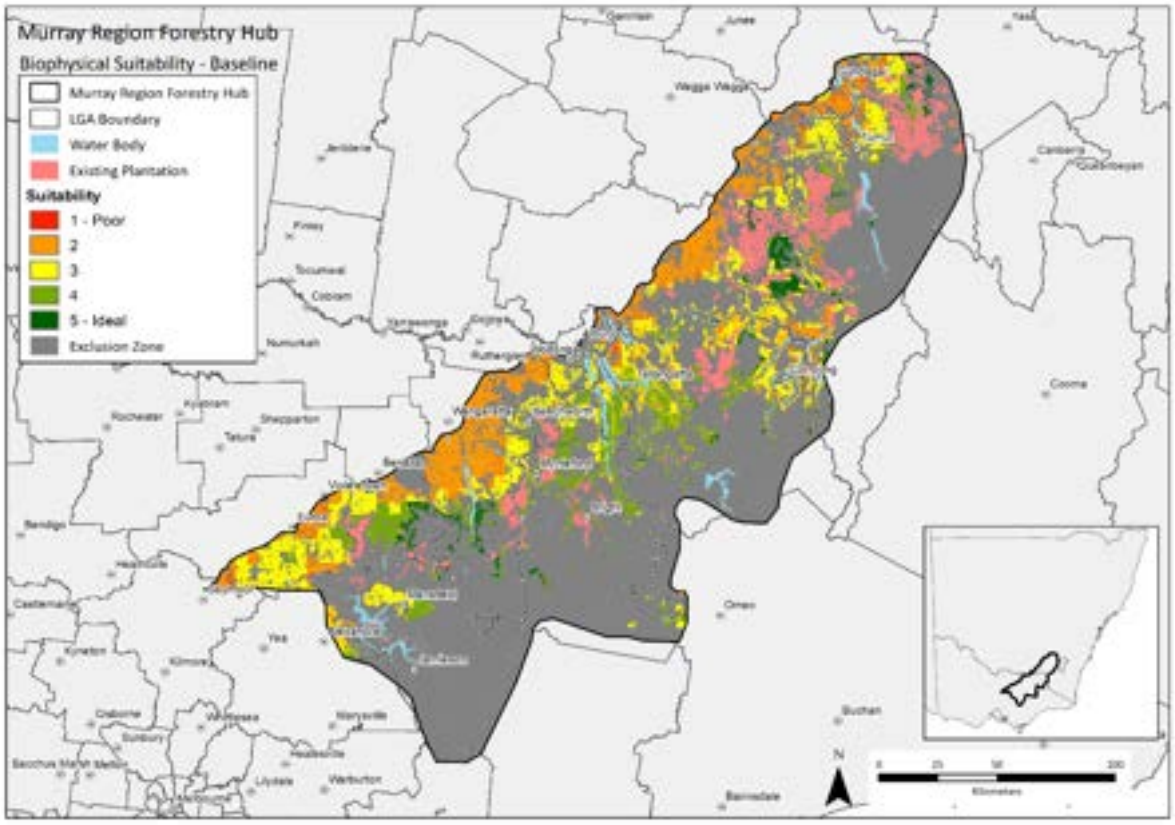

Figure 4- Biophysical suitability output for the current climate with land exclusions

The suitability classes have also been adapted to reflect potential productivity for a radiata pine plantation with a standard silvicultural regime of two commercial thinning operations and final harvest at age 32. Productivity is described as mean annual increment (MAI) in cubic metres per year and is to provide an indication of growth without being absolute. Productivity is presented in Table 10.

Table 10 - Suitability class and indicative productivity

Class	Indicative MAI range (m^3/ha)	Comments
1	Not suitable	Excessive slope
2	15-20	Slope on specific sites may need to be checked
3	15-20	Potential for low survival on some sites
4	20-25	
5	25-30	

Across the Hub, under the current climate scenario, the area within each suitability class by State is presented in Table 11. There is more than twice as much suitable area in Victoria than there is in NSW, and the highest two suitability classes cover just under 185,000 hectares.

Table 11 - Area (ha) of suitable land by State and suitability class - current climate

Class	New South Wales	Victoria	Total
1	131	5,797	5,928
2	85,620	131,932	217,552
3	90,253	216,562	306,815
4	15,537	130,287	145,824
5	19,393	19,672	39,065
Total	**210,934**	**504,250**	**715,184**

In comparison, Figure 5 to Figure 7 shows the output sequence for a projected 2050, 2070 and 2090 likely future under a RCP 4.5 emissions scenario. For RCP 8.5 outputs, refer to Appendix B.

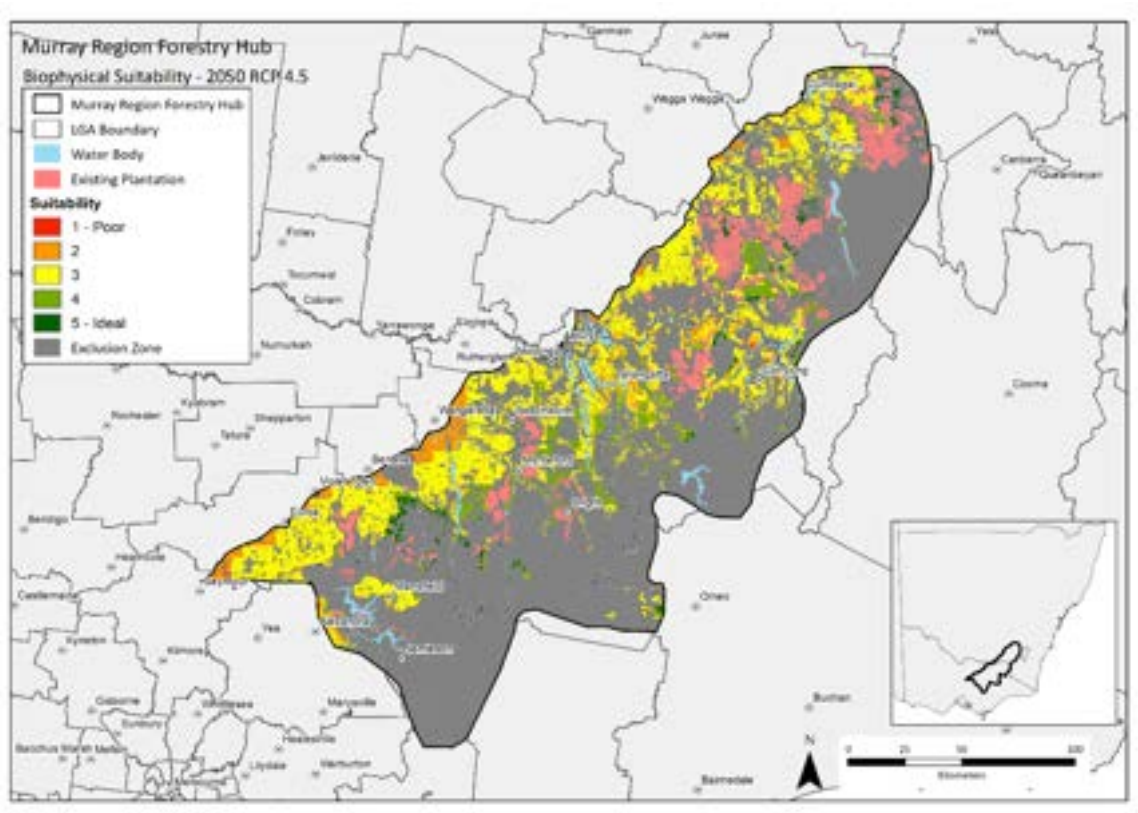

Figure 5 - Biophysical suitability for a 2050 RCP4.5 climate output with land exclusions

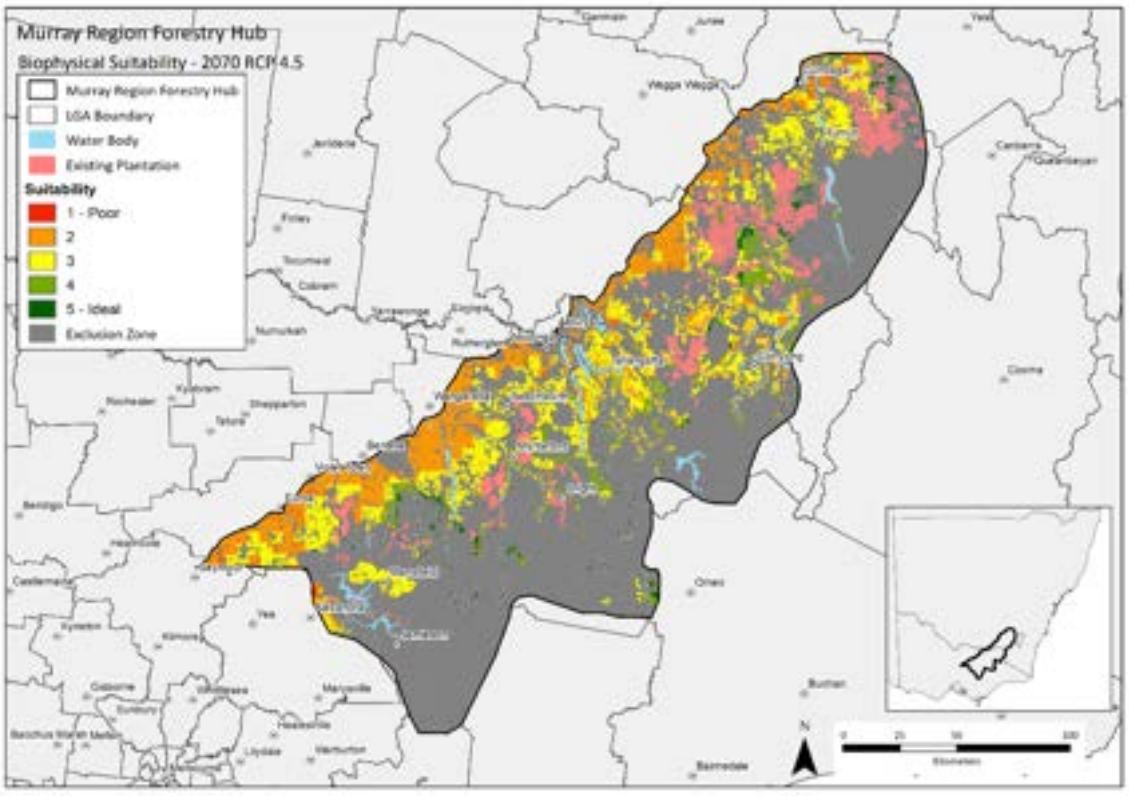

Figure 6 - Biophysical suitability for a 2070 RCP4.5 climate output with land exclusions

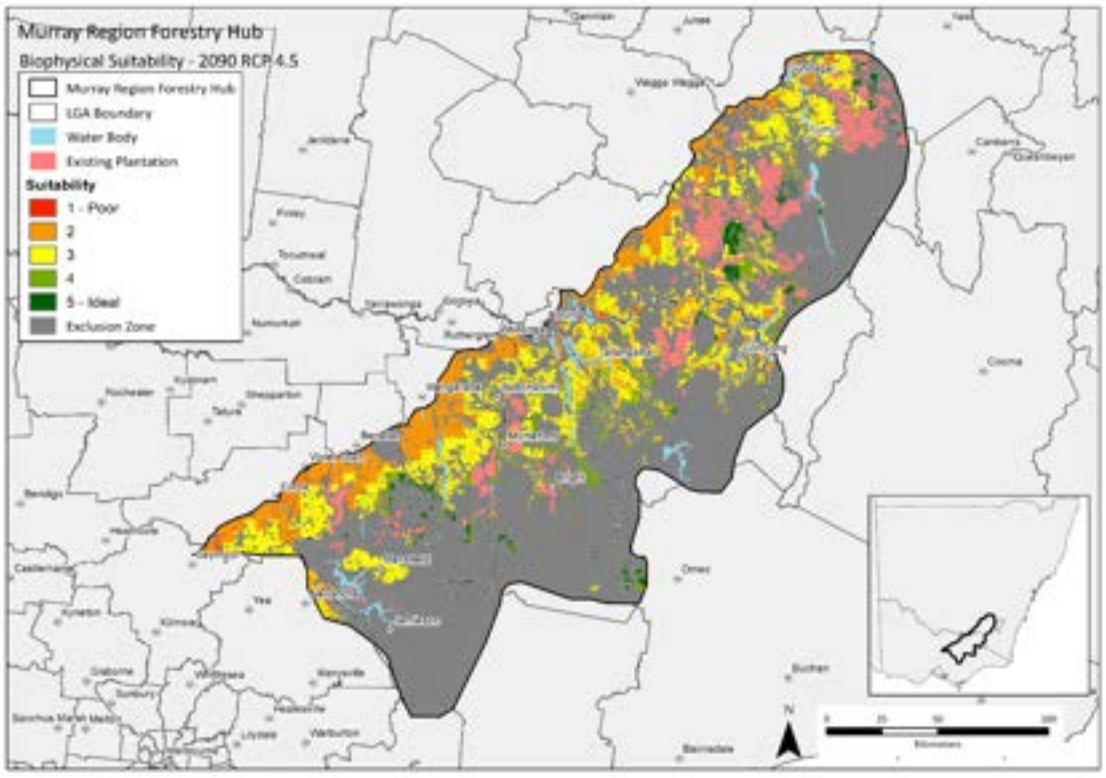

Figure 7 - Biophysical suitability for a 2090 RCP4.5 climate output with land exclusions

The higher suitability areas, shown in darker greens, are primarily seen in NSW in the north of the Hub, into Yass Valley and Cootamundra-Gundagai and also in Victoria in the southwest in Wangaratta and Benalla.

These are in contrast to the current baseline analysis in Figure 4 where there is less land in the 'ideal' category. This is primarily due to the reduction in frost days that are seen in current conditions and the retention of total annual rainfalls in these high land areas.

However, in all future scenarios, there is a noted increase in the distribution of 3rd–ranked land (designated in yellow in the above figures). In the lower altitudes along the western boundaries, there is seen to be an increase up into the higher elevational areas. This is in line with decreasing rainfalls below the 600mm threshold.

Figure 8 presents the change in area within each of the suitability classes starting from the current climate (2020) and projected forward with the 'intermediate' climate scenario (RCP 4.5). For this scenario, we can see that there is a decrease in area for the two most suitable classes (4 and 5) through the time projections. There is a reduction in area for Class 2, and a corresponding increase in area for Class 3 between the current climate and the projected 2050 climate. This increase in suitability is most likely due to a reduction in the number of frost days within the Hub region, the areas then mostly revert back and this is likely to be influenced by the reduction in annual rainfall.

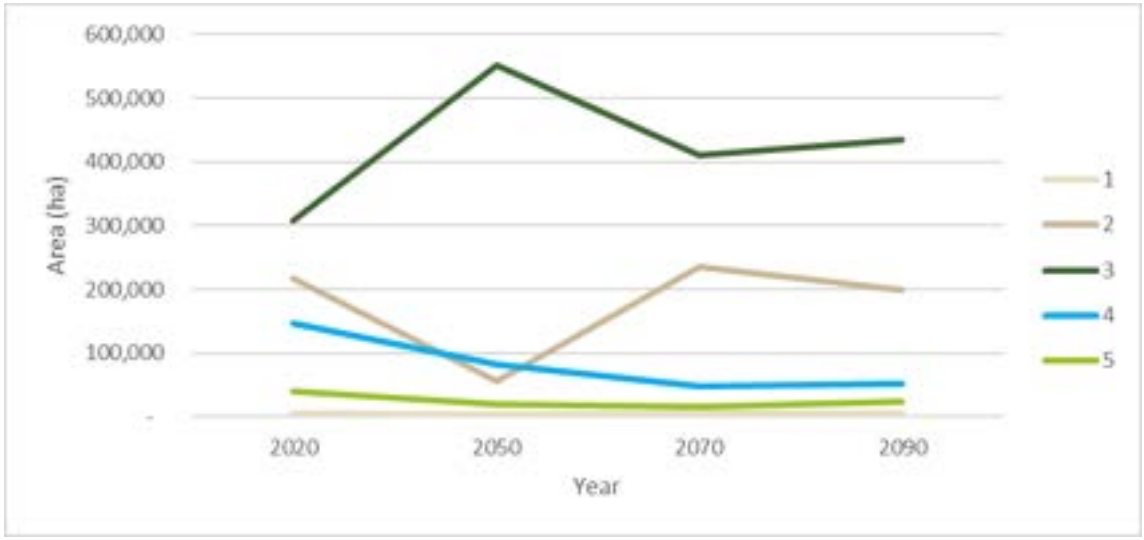

Figure 8 - Area by suitability class and projected climate based on RCP 4.5

There are some similarities between the intermediate scenario and the 'worst-case' scenario (Figure 9). In this climate scenario, there is also a more significant decline in area of the two most suitable classes. There is a less pronounced increase in Class 3 area from the current climate to 2050, and a significant drop in area by 2090.

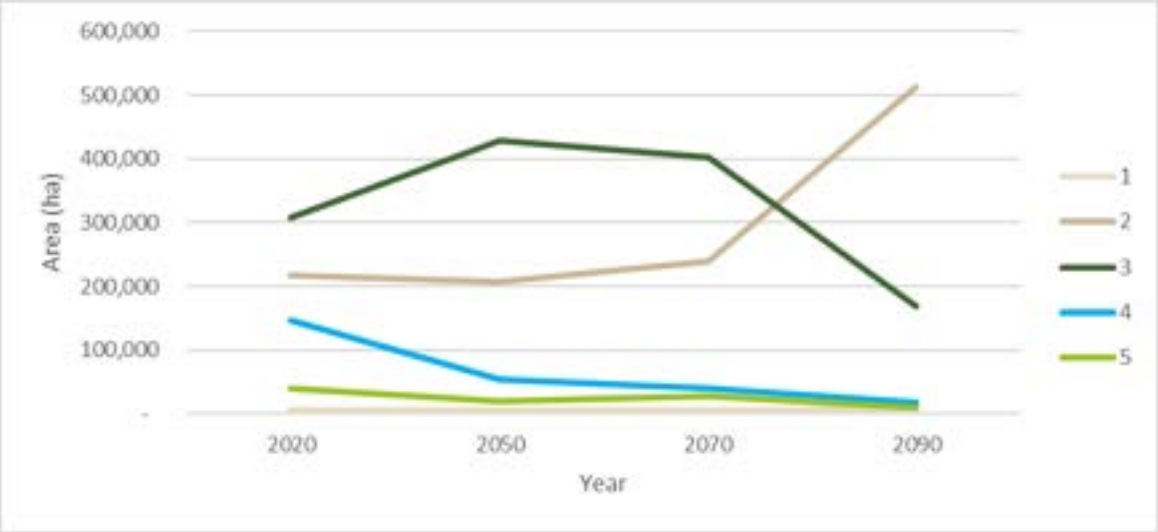

Figure 9 - Area by suitability class and projected climate based on RCP 8.5

4. Conclusion

The Murray Region Forestry Hub has just under 185,000 hectares of highly suitable land that could be developed for future radiata pine plantations. Under two climate scenarios, an 'intermediate' scenario would see the highly suitable land decrease from 185,000 hectares to less than 80,000 hectares by 2090, and the 'worst-case' scenario would see a significant reduction by 2090 to below 30,000 hectares.

Appendix A- Victorian land sales data

Analysis of Property Sales 2021

Victoria (Total) Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Cattle Feed Lot	6	$651,615	$639,000	$5,300	$5,900
Commercial Flower & Plant	1	$900,000	$900,000	$27,100	$27,100
Crop – Fodder Crops	9	$775,833	$670,000	$7,900	$13,600
Domestic Livestock Grazing	487	$985,679	$610,000	$11,600	$16,300
General Cropping >20ha Unspecified	372	$1,244,073	$715,680	$13,700	$6,600
Glasshouse Plant or Vegetable	1	$1,750,000	$1,750,000	$188,300	$188,300
Hardwood Plantation	7	$793,920	$810,000	$7,500	$7,400
Horse Stud	1	$5,100,000	$5,100,000	$203,800	$203,800
Horse Unspecified	25	$1,623,900	$1,450,000	$37,600	$64,800
Kennel or Cattery	5	$9,885,000	$700,000	$1,891,500	$1,205,700
Livestock – Beef	302	$1,809,766	$900,000	$28,500	$28,900
Livestock – Dairy	267	$1,363,249	$960,000	$18,500	$16,800
Livestock – Sheep	107	$1,962,851	$879,100	$5,300	$14,000
Market Garden Vegetable <20ha	30	$2,369,338	$985,000	$101,800	$153,500
Mixed Farm and Infrastructure	373	$1,892,243	$1,050,000	$15,400	$18,300
Mixed Farm no Infrastructure	181	$2,110,442	$830,000	$7,400	$26,600
Mixed Farm & Grazing - Unspecified	1073	$1,491,173	$864,870	$46,600	$8,900
Native Bushland and Agreement	1	$340,000	$340,000	$7,400	$7,400
Native Animals	1	$370,000	$370,000	$4,200	$4,200
Native Bushland	63	$904,586	$259,000	$27,500	$15,800
Native Hardwood	22	$467,150	$350,000	$7,900	$7,000
Non-Native Animals	3	$395,833	$434,999	$14,800	$28,100
Orchard Plantations	60	$5,849,305	$718,326	$43,700	$16,500
Piggery	7	$1,650,571	$1,375,000	$29,900	$33,000
Plant/Tree Nursery	31	$1,439,240	$987,500	$49,400	$57,200
Poultry – Open Range	2	$580,000	$580,000	$25,900	$20,700

Poultry Broiler	9	$2,543,333	$2,600,000	$181,900	$52,100
Poultry Egg	2	$6,350,000	$6,350,000	$208,100	$184,900
Softwood Plantation	20	$1,418,035	$485,000	$5,300	$13,600
Specialised Cropping	7	$1,517,578	$1,319,050	$15,800	$15,500
Vineyard	98	$1,519,517	$1,005,900	$31,400	$51,700

Country Victoria (Non-Metro) Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Cattle Feed Lot	6	$651,615	$639,000	$5,300	$5,900
Commercial Flower & Plant	1	$900,000	$900,000	$27,100	$27,100
Crop – Fodder Crops	9	$775,833	$670,000	$7,900	$13,600
Domestic Livestock Grazing	475	$953,022	$601,348	$1,200	$15,600
General Cropping >20ha Unspecified	371	$1,242,251	$714,806	$12,600	$6,600
Glasshouse Plant or Vegetable	1	$1,750,000	$1,750,000	$188,300	$188,300
Hardwood Plantation	7	$793,920	$810,000	$7,500	$7,400
Horse Unspecified	18	$1,423,750	$1,075,000	$70,100	$45,300
Kennel or Cattery	3	$558,333	$680,000	$113,300	$63,900
Livestock – Beef	270	$1,197,782	$750,644	$20,900	$18,000
Livestock – Dairy	262	$1,307,280	$932,465	$16,900	$16,000
Livestock – Sheep	103	$1,810,923	$850,000	$12,000	$12,600
Market Garden Vegetable <20ha	17	$910,323	$730,000	$166,000	$38,500
Mixed Farm and Infrastructure	370	$1,723,801	$1,040,000	$8,200	$16,600
Mixed Farm no Infrastructure	179	$1,255,866	$825,000	$7,400	$15,900
Mixed Farm & Grazing - Unspecified	981	$1,347,890	$800,000	$36,800	$7,500
Native Bushland and Agreement	1	$340,000	$340,000	$7,400	$7,400
Native Animals	1	$370,000	$370,000	$4,200	$4,200
Native Bushland	57	$800,209	$225,000	$9,600	$11,700
Native Hardwood	21	$403,085	$350,000	$6,000	$5,800
Non-Native Animals	3	$395,833	$434,999	$14,800	$28,100
Orchard Plantations	60	$5,849,305	$718,326	$43,700	$16,500

Piggery	7	$1,650,571	$1,375,000	$29,900	$33,000
Plant/Tree Nursery	20	$626,322	$383,788	$37,100	$18,200
Poultry – Open Range	2	$580,000	$580,000	$25,900	$20,700
Poultry Broiler	3	$1,310,000	$850,000	$5,500	$10,500
Poultry Egg	1	$10,800,000	$10,800,000	$177,900	$177,900
Softwood Plantation	20	$1,418,035	$485,000	$5,300	$13,600
Specialised Cropping	7	$1,517,578	$1,319,050	$15,800	$15,500
Vineyard	79	$988,656	$750,000	$69,900	$30,900

Alpine Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	4	$1,462,500	$1,537,500	$38,500	$27,100
Livestock – Beef	3	$849,666	$900,000	$18,400	$16,500
Mixed Farm & Grazing - Unspecified	7	$6,576,585	$1,490,000	$168,800	$930,000

Benalla Rural City Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	6	$654,500	$350,000	$15,500	$9,000
General Cropping >20ha Unspecified	1	$365,000	$365,000	$10,200	$10,200
Livestock – Beef	4	$5,253,750	$865,000	$51,400	$13,500
Livestock – Sheep	4	$736,250	$572,500	$6,300	$15,200
Mixed Farm and Infrastructure	2	$1,385,000	$1,385,000	$8,600	$8,800
Mixed Farm no Infrastructure	2	$615,000	$615,000	$12,700	$13,400
Mixed Farm & Grazing - Unspecified	35	$1,866,554	$670,000	$25,400	$5,800
Native Bushland	1	$248,000	$248,000	$5,300	$5,300
Vineyard	1	$865,000	$865,000	$39,900	$39,900

East Gippsland Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	82	$729,178	$552,500	$9,800	$13,900
General Cropping >20ha Unspecified	3	$1,213,666	$650,000	$12,100	$27,800
Kennel or Cattery	1	$700,000	$700,000	$3,500,000	$3,500,000
Livestock – Beef	4	$527,500	$425,000	$2,900	$6,500
Livestock – Sheep	1	$2,534,000	$2,534,000	$10,600	$10,600
Mixed Farm and Infrastructure	1	$770,000	$770,000	$36,700	$36,700
Mixed Farm no Infrastructure	3	$578,333	$490,000	$3,900	$7,100
Mixed Farm & Grazing - Unspecified	24	$651,750	$522,500	$6,900	$11,600
Native Bushland	5	$173,000	$160,000	$2,100	$4,000
Native Hardwood	4	$380,750	$287,500	$3,400	$4,600
Plant/Tree Nursery	1	$390,500	$390,500	$43,900	$43,900
Vineyard	1	$350,000	$350,000	$526,100	$526,100

Indigo Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	21	$861,677	$745,000	$19,300	$29,600
General Cropping >20ha Unspecified	4	$990,292	$922,307	$14,600	$18,200
Horse Unspecified	2	$2,250,000	$2,250,000	$101,700	$101,700
Livestock – Beef	9	$820,259	$673,400	$12,900	$10,100
Livestock – Dairy	3	$1,920,833	$2,453,745	$37,800	$17,400
Livestock – Sheep	1	$270,000	$270,000	$17,300	$17,300
Mixed Farm & Grazing - Unspecified	11	$1,023,313	$850,000	$16,100	$16,600
Orchard Plantations	2	$1,253,000	$1,253,000	$35,000	$31,300
Plant/Tree Nursery	1	$71,500	$71,500	$83,900	$83,900

Mansfield Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Cattle Feed Lot	1	$920,000	$920,000		
Domestic Livestock Grazing	5	$1,405,840	$1,250,000	$14,500	$9,500
General Cropping >20ha Unspecified	1	$3,000,000	$3,000,000	$58,800	$58,800
Livestock – Beef	1	$6,020,000	$6,020,000	$43,200	$43,200
Livestock – Sheep	3	$1,416,666	$825,000	$33,600	$75,200
Mixed Farm & Grazing - Unspecified	47	$1,250,219	$935,000	$18,800	$55,800
Native Hardwood	1	$780,000	$780,000	$19,300	$19,300
Softwood Plantation	2	$761,000	$761,000	$12,300	$14,800

Mitchell Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	8	$767,724	$735,000	$14,100	$9,800
Livestock – Beef	3	$1,437,413	$1,687,564	$21,900	$52,100
Livestock – Sheep	3	$483,333	$577,000	$6,000	$7,200
Mixed Farm and Infrastructure	29	$1,565,643	$1,300,000	$25,600	$39,100
Mixed Farm no Infrastructure	14	$895,320	$657,250	$17,300	$19,000
Mixed Farm & Grazing - Unspecified	11	$1,167,272	$1,060,000	$36,900	$63,000
Native Bushland	2	$12,779,614	$12,779,614	$7,100	$7,100
Non-Native Animals	1	$520,000	$520,000	$27,600	$27,600

Murrindindi Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	4	$1,295,000	$1,055,000	$32,400	$68,500
General Cropping >20ha Unspecified	2	$159,000	$159,000	$8,800	$8,800
Livestock – Beef	14	$1,399,861	$969,912	$18,000	$18,100
Livestock – Dairy	1	$3,964,914	$3,964,914	$21,300	$21,300
Livestock – Sheep	1	$427,987	$427,987	$8,400	$8,400
Market Garden Vegetable <20ha	2	$872,500	$872,500	$60,000	$72,100
Mixed Farm & Grazing - Unspecified	55	$1,890,327	$1,320,000	$25,900	$14,800
Native Bushland	2	$695,000	$695,000	$20,100	$127,100
Native Hardwood	4	$549,250	$470,000	$22,200	$44,300
Orchard Plantations	1	$590,000	$590,000	$32,500	$32,500
Plant/Tree Nursery	1	$500,000	$500,000	$1,794,000	$1,794,000
Poultry Broiler	1	$850,000	$850,000	$21,600	$21,600
Softwood Plantation	2	$858,000	$858,000	$4,300	$4,600

Strathbogie Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	14	$1,656,451	$636,650	$25,900	$70,400
General Cropping >20ha Unspecified	11	$822,668	$601,350	$12,900	$8,200
Horse Unspecified	7	$1,755,357	$1,520,000	$42,300	$39,700
Livestock – Beef	4	$873,750	$760,000	$25,000	$28,000
Livestock – Sheep	3	$511,666	$310,000	$12,000	$9,500
Mixed Farm and Infrastructure	1	$536,000	$536,000	$8,500	$8,500
Mixed Farm & Grazing - Unspecified	72	$937,219	$745,000	$11,300	$10,800
Native Bushland	3	$374,913	$409,740	$15,900	$27,900
Orchard Plantations	1	$425,000	$425,000	$21,300	$21,300
Piggery	2	$1,375,000	$1,375,000	$22,000	$23,600
Vineyard	2	$700,000	$700,000	$51,900	$69,400

Towong Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	29	$1,188,236	$1,000,000	$13,400	$20,900
Livestock – Beef	8	$1,526,687	$677,500	$24,700	$15,800
Livestock – Dairy	1	$500,000	$500,000	$10,900	$10,900
Mixed Farm & Grazing - Unspecified	5	$1,194,583	$740,000	$8,400	$6,700
Native Bushland	1	$120,000	$120,000	$1,200	$1,200
Native Hardwood	1	$295,000	$295,000	$8,400	$8,400
Softwood Plantation	5	$381,000	$365,000	$3,200	$4,800

Wangaratta Rural City Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Cattle Feed Lot	1	$750,000	$750,000	$314,600	$314,600
Domestic Livestock Grazing	22	$1,093,941	$837,500	$15,200	$19,900
General Cropping >20ha Unspecified	2	$440,000	$440,000	$6,500	$8,400
Livestock – Beef	12	$839,500	$755,000	$16,400	$11,100
Livestock – Sheep	1	$765,000	$765,000	$6,200	$6,200
Mixed Farm & Grazing - Unspecified	40	$1,161,786	$852,500	$14,500	$8,500
Native Bushland	2	$425,000	$425,000	$30,800	$30,500
Orchard Plantations	1	$1,270,000	$1,270,000	$31,000	$31,000
Vineyard	4	$1,460,000	$1,245,000	$11,800	$25,200

Wellington Shire Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Commercial Flower & Plant	1	$900,000	$900,000	$27,100	$27,100
Domestic Livestock Grazing	21	$569,620	$460,000	$10,900	$22,200
Hardwood Plantation	2	$989,720	$989,720	$7,900	$8,800
Livestock – Beef	12	$549,625	$445,800	$5,100	$11,900
Livestock – Dairy	11	$1,006,463	$1,118,660	$17,600	$19,200
Livestock – Sheep	1	$1,850,000	$1,850,000	$14,100	$14,100
Mixed Farm and Infrastructure	103	$1,320,133	$850,000	$13,700	$15,400
Mixed Farm no Infrastructure	6	$195,555	$190,000	$5,400	$5,900
Mixed Farm & Grazing - Unspecified	21	$968,728	$375,000	$9,200	$6,600
Native Animals	1	$370,000	$370,000	$4,200	$4,200
Native Bushland	12	$254,666	$228,750	$7,500	$9,300
Native Hardwood	1	$475,000	$475,000	$6,200	$6,200
Non-Native Animals	1	$232,500	$232,500	$14,800	$14,800
Orchard Plantations	1	$252,439,632	$252,439,632	$13,300	$13,300
Softwood Plantation	2	$315,000	$315,000	$5,300	$5,000
Vineyard	1	$410,000	$410,000	$25,300	$25,300

Wodonga City Land use	Num. of Sales	Mean Sales Price ($)	Median Sales Price ($)	Median Price per Unit Area ($/Ha)	Mean Price per Unit Area ($/Ha)
Domestic Livestock Grazing	8	$2,648,125	$1,705,000	$25,900	$54,400
Livestock – Beef	3	$1,764,904	$2,310,000	$29,700	$21,900
Mixed Farm & Grazing - Unspecified	4	$3,356,750	$1,968,750	$36,200	$73,700

Appendix B - Land suitability maps for the 'worst case' climate scenario (RCP8.5)

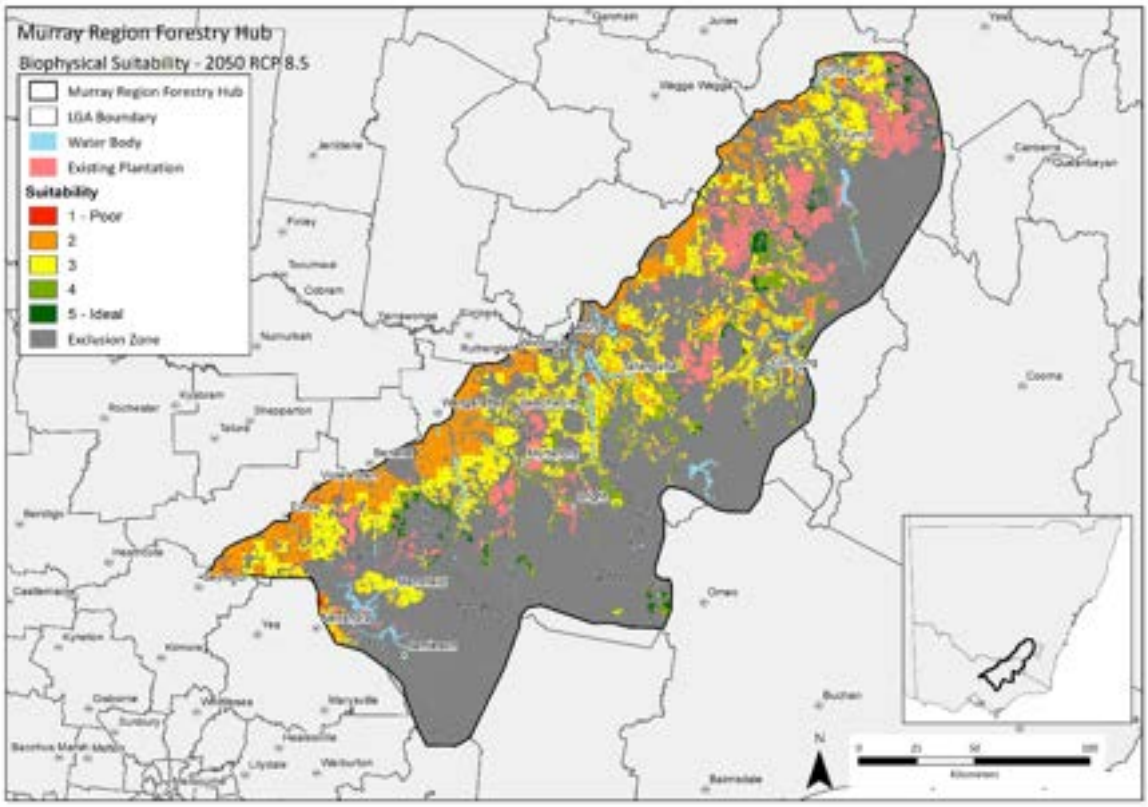

Figure 10 - Biophysical suitability for a 2050 RCP8.5 climate output with land exclusions

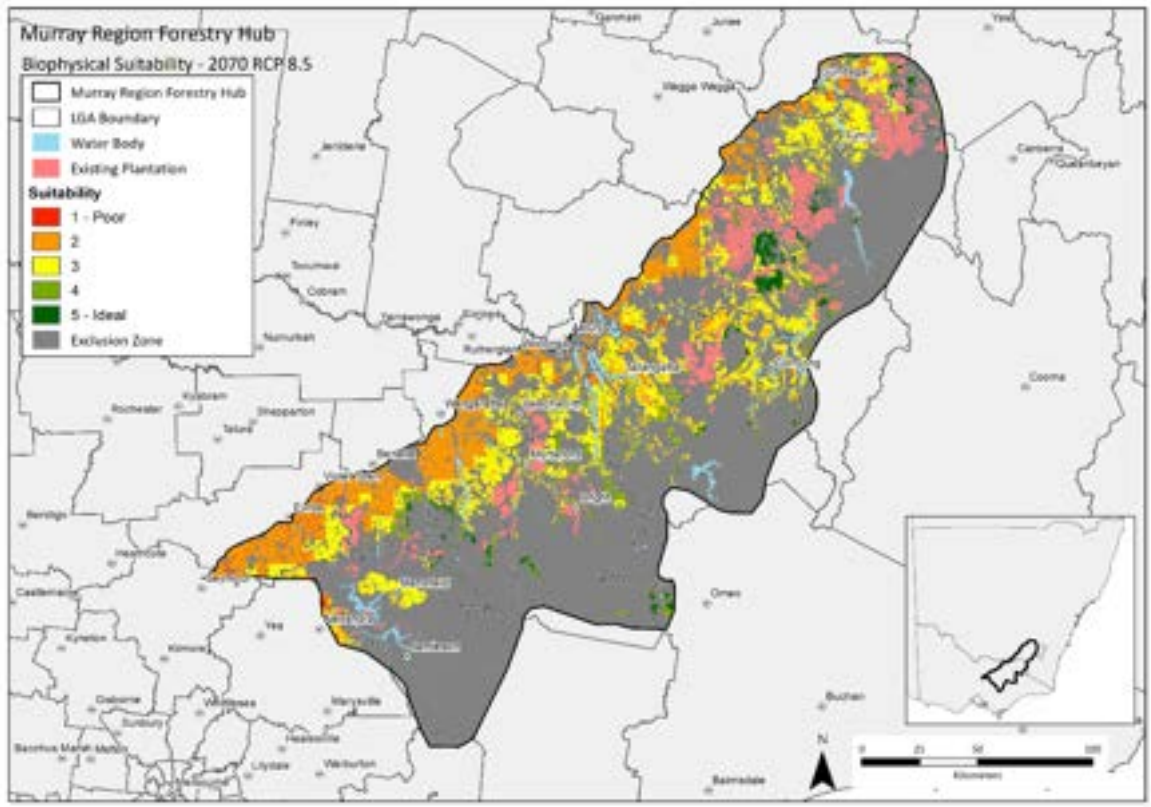

Figure 11 - Biophysical suitability for a 2070 RCP8.5 climate output with land exclusions

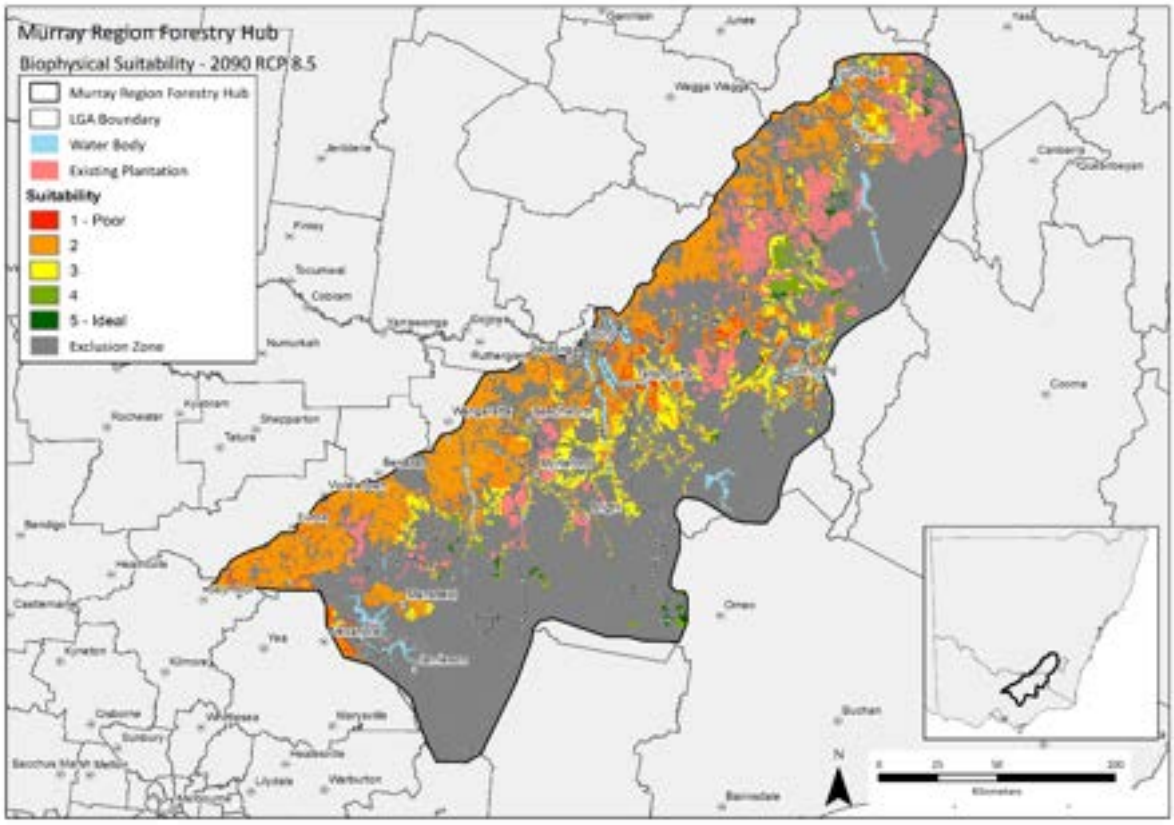

Figure 12 - Biophysical suitability for a 2090 RCP8.5 climate output with land exclusions