GREENWOOD STRATEGY

PLANTATION CAPABILITY MAPPING

Report Prepared for the Central West NSW Forestry Hub

Project reference: CWFH003

February 2022

CENTRAL WEST NSW FORESTRY HUB

CONTENTS

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EXECUTIVE SUMMARY

Plantation capability modelling undertaken for the Central West NSW Forestry Hub identified approximately 1.04 million ha (about 46% of the 2.28 million ha Hub area after accounting for excluded areas) which is Moderately Capable or Capable (estimated productivity ranging of 11 to 20 m^3/ha/y[1]) of supporting commercially viable plantations of *Pinus radiata.* This includes approximately 114,000 ha modelled as being capable of supporting plantation growth at ≥17 m^3/ha/y.

Plantation capability and productivity mapping is based on a limiting factor model where input parameters were resampled into a 50 m X 50 m grid across the Hub region. This modelling approach addresses reliance on a limited suite of datasets used to develop a strategic regional model. The approach has limitations. In particular, it tends to produce a conservative outcome because it is defined by the lowest rating value of any input parameter returned for each grid cell. However, there are opportunities to consider application of actual productivity data from the existing plantation estate to improve reliability of the modelling, subject to willingness of regional growers to provide the required data.

The outputs from this project will be made publicly available as a layer in the Spatial Database developed as part of CWFH001 (refer to Appendix 7 for a snapshot from the databse).

[1] Mean annual increment at clearfell; nominally 35 years.

INTRODUCTION

Greenwood Strategy Solutions Pty Ltd (Greenwood Strategy) has been engaged by the Central West NSW Forestry Hub (the Hub) to undertake this project (CWFH003) to complete a plantation capability mapping exercise for the region covered by the Hub.

This is one of three inter-related projects which the Hub has commissioned Greenwood Strategy to complete. The other projects are:

CWFH001: Development of a spatial database for the Central West Forestry Hub.

CWFH002: Potential for increased plantation productivity, utilisation and recovery of harvested products for the Central West Forestry Hub.

This report presents a summary of the methodology and approach undertaken to develop the softwood plantation capability map.

About the Hub

The Hub was established in 2020 with funding under the Commonwealth Government's National Forest Industry Plan[2].

The Hub is located across parts of the Central Tablelands and Southern Tablelands of New South Wales (see Appendix 1: Input – The Hub boundary). The majority of the region's commercial plantation forests are concentrated in the Oberon Local Government Area (LGA), in the central-east, with important outliers located between Bathurst and Lithgow and around Orange in the north of the region. There are also smaller plantation areas scattered throughout the region, including south of the Abercrombie River.

The forest and wood products sector within the Hub is focused more or less exclusively on plantation grown *Pinus radiata* as the fibre source for wood products manufacturing, with most of that fibre processed at Oberon and, to a lesser extent, Burraga and Raglan.

The Hub's key objectives are to:

- Analyse the constraints that affect the productivity and efficiency of the forestry sector.
- Pinpoint opportunities for future investment in infrastructure and technology, and areas for potential expansion by forest industries.
- Identify and support business cases for the investment in new infrastructure, such as roads, bridges, ports, telecommunications and training facilities, thereby assisting forest service industries to better plan their futures.
- Determine the potential for future plantation expansion within appropriate transport distances and near other existing sources of wood and fibre.

[2] Commonwealth of Australia (2018) *National Forest Industries Plan: Growing a Better Australia – A Billion Trees for Jobs and Growth*

Rationale for the project

One of the Hub's key objectives is to assist expansion of the plantation estate within the supply zone of the Hub's processing industries. In that context, the primary rational for this project is to better understand the potential for plantation expansion based on biophysical, climate, and tenure constraints, and any planning and land zoning restrictions that might impact potential development of new plantations.

The project scope specifically requested the plantation capability mapping deliver maps and a report which:

- Delineate the areas that have the potential for new plantations within the Hub boundary.
- Classify the potential productivity of those areas (mapped in bands of mean annual increment).
- Describe the methodology used.
- Report on the key findings.
- Models total area of potential new plantations.
- Calculates rea by productivity classes.
- Differentiates total area and area by productivity classes within each local government area.
- Describes any specific impediments identified during the process, for example, the need to upgrade infrastructure to enable new plantation development.

METHODOLOGY AND MODELLING LOGIC

This section details the modelling methodology applied to develop plantation capability and productivity mapping outputs.

Modelling approach

Plantation modelling was based on a 50 m X 50 m grid across the Hub region. Datasets used are presented in Table 1. Available data were resampled into the model grid structure. Cells were modelled on a binary basis (exclusion modelling) or using a limiting factor analysis (category modelling). With limiting factor analysis, each of the input parameters are identified and value ranges for each parameter are assigned a rating from 1 (highest) to 5 (lowest) for each grid cell. Capability class for each grid cell was defined by the single highest value (lowest capability classification) returned for any specific parameter. This is a useful modelling approach where there is reliance on limited datasets applied to develop a strategic model. However, it does have limitations. In particular, it tends to produce a conservative outcome as it favours the lowest rating value returned for a grid cell.

Table 1: Model Input parameters used to determine plantation availability and capability

Modelling step	Input feature dataset	Modelling approach
Step 1	1 - Land zoning	Exclusion
	2 - Elevation	Exclusion
	3 - Native vegetation	Exclusion
	4 - Existing plantation estate	Exclusion
Step 2	5 - Rainfall	Category
	6 - Slope	Category
	7 - Soil fertility	Category

Model logic

The model logic for developing the plantation capability mapping is detailed below and summarised in Figure 1.

Step 1: Potential land suitability for commercial plantations

The first step was to determine what land was suitable to support commercial plantation development, independent of the availability land base is capable. The importance of undertaking this step initially is that by modelling suitability across the entire region allowed a qualitative 'sense check' against the existing plantation estate to determine whether the model settings were appropriate. The suitability assessment was based on data inputs including:

- Rainfall (*Source: Federal Gov. Data Portal - https://data.gov.au*).

- Slope (*Source: CSIRO - https://www.clw.csiro.au*).
- Soil Fertility (*Source: NSW Data - https://data.nsw.gov.au*).

Step 2: Potential land availability for commercial plantations

The second step was to determine what land is potentially available to support expansion of the plantation estate within the Hub boundary. This was undertaken by determining which land is excluded, based on data inputs including:

- Land zoning restrictions which prevent establishing plantations (based on local government zoning schemes and regulation) (*Source: NSW Planning Portal - https://www.planningportal.nsw.gov.au*).
- Presence of native vegetation (including Crown land and protected native vegetation on private land) (*Source: NSW Spatial Data Portal - https://portal.spatial.nsw.gov.au*).
- Presence of plantations (*Source: CWFH001*).
- Elevation (*Source: Federal Gov. Data Portal - https://data.gov.au*).

Step 3: Potential land capability for commercial plantations

The next step was to determine what land within the available land base is capable of supporting a commercial plantation. This was based on combining the outputs of Steps 1 and 2.

Step 4: Potential land productivity for commercial plantations

The final step was to assign productivity classes by mean annual increment (MAI) bands to the land capable of supporting commercial plantations. This step was informed by data provided by Forestry Corporation of NSW.

Model inputs - data sets

Pre-processing of data

Prior to developing models, the following pre-processing actions were undertaken:

- Input data were re-projected into a common projected coordinate system.
- Data were clipped to the Hub boundary (see Appendix 1: Input – The Hub boundary).
- Data were resampled into a raster grid format with a 50 m cell size (50 m x 50 m) and aligned to a common origin.

The input data were modelled to produce two sets of outputs (capability - reflected as capability categories; and productivity – reflected as MAI).

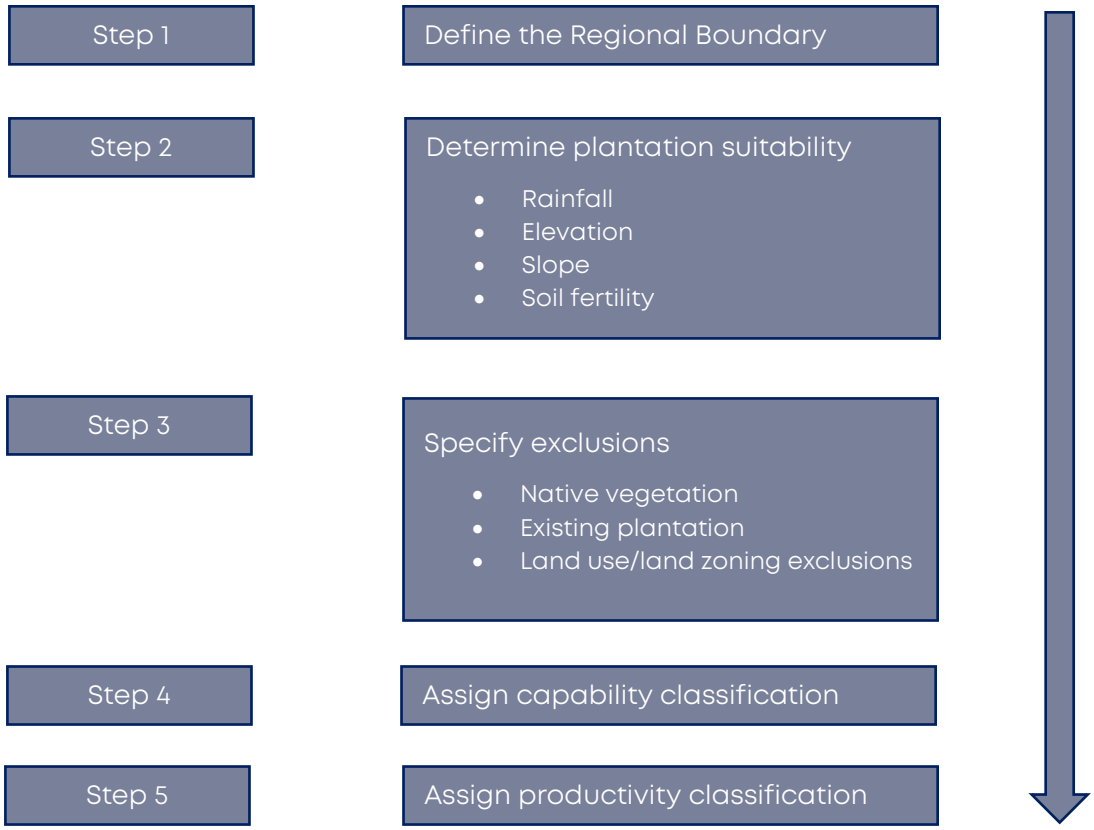

Figure 1: Model logic for the plantation capability mapping project

The datasets and modelling application

Grid cell data was used to categorise attributes of each cell with different modelling treatment based on modelling step. Table 2 presents the data types and treatment in the model; land availability was binary (available or not) and capability was assigned on a 4 grade scale (Error! Reference source not found.).

If a grid cell was defined as having a capability rating code of 11111 (N/A) then it was excluded from modelling. If a feature input had duplicate values within its category table, the lowest value was used to define the category.

The category values for exclusion input features were the same except for the 11111 (N/A) category.

Therefore, all features or cells? satisfying the 11111 (N/A) category were excluded and the rest given a category value of 1 (Highly Capable).

Table 2: Plantation capability rating codes assigned in the model

Rating code	Rating description
1	Highly capable
2	Capable
3	Moderately capable
4	Incapable
11111	N/A

Modelling steps undertaken

Step 1: Potential land suitability for commercial plantations

The input layers for physical and environmental characteristics included in the modelling were combined to develop a plantation suitability layer. That is, suitability of land to support plantation expansion regardless of any land-use exclusions. Exclusions were overlaid to produce a capability layer. That is, land which is suitable to support plantation expansion based on physical and environmental values.

Rainfall

Rainfall for the Hub region is presented in Appendix 3: Input – Rainfall. Rainfall is a category parameter (see Table 9). Rainfall less than 550 mm/y is excluded (as unsuitable) and the remaining values categorised.

Table 3: Rainfall input categories applied in the model

Rating description	Category parameter value range (Rainfall mm/y)
Highly capable	900-10,000
Capable	700-900
Moderately capable	550-700
Incapable	550-700
N/A	0-550

Land slope

Land slope for the Hub region is presented in Appendix 4: Input – Slope. Land slope is a category parameter (see Table 10). Land with slopes greater than 84 degrees are excluded. Slopes between 58 and 84 degrees are deemed unsuitable. Other slopes are categorised and the remaining values categorised.

Table 4: Slope input categories

Rating description	Category parameter value range (Slope – degrees)

Highly capable	0-26
Capable	26-36
Moderately capable	36-58
Incapable	58-84
N/A	84-10,000

Soil Fertility

The source soil fertility input data contained 6 classes sourced from the NSW land and soil capability assessment scheme (State of NSW and Office of Environment and Heritage). This was modified to include *not assessed* land and water bodies (see Table 11). The soil types used to define the Soil Fertility Classes are based on the Inherent Soil Fertility classes of Great Soil Groups[3] (see Appendix 5: Soil fertility classification). Each class was assigned an input value for the model (Table 12). See Appendix 6: Input – Soil Fertility for mapped outcomes of this data.

Table 5: Grid cell values – soil fertility classes in the source classification system

Soil fertility ID	Category parameter value range (Soil fertility class)
1	Low
2	Moderately low
3	Moderate
4	Moderately high
5	High
98	Not assessed
99	Water

Table 6: Soil fertility model input categories

Rating description	Category parameter input range (Soil fertility)
Highly capable	5
Capable	3,4
Moderately capable	1,2
Incapable	1,2
N/A	98,99

[3] These are defined in Department of Planning, Industry and Environment, 2020, Estimated Inherent Soil Fertility of NSW, Version 4, NSW Department of Planning, Industry and Environment, Parramatta. https://data.nsw.gov.au/search/dataset/ds-nsw-ckan-071729c0-a9d1-4320-a584-896d49894f20/details?q=inherent%20soil%20fertility

Step 2: Potential land availability for commercial plantations

Land Zoning

Land zoning is an inclusion/exclusion parameter. Table 3 presents the values applied based on grid cell condition, with green entries representing land zoning where plantation development is possible under the NSW Planning Scheme and included as available. Table 4 presents the category values incorporated into the model.

Table 7: Grid cell values for NSW Planning Scheme land zoning categories and availability for plantations (green)

Grid Cell Value	Description
1	Business Development
2	Business Park
3	Commercial Core
4	Deferred Matter
5	Enterprise Corridor
6	Environmental Conservation
7	Environmental Living
8	Environmental Management
9	Forestry
10	General Industrial
11	General Residential
12	Heavy Industrial
13	Infrastructure
14	Large Lot Residential
15	Light Industrial
16	Local Centre
17	Low Density Residential
18	Medium Density Residential
19	Mixed Use
20	National Parks and Nature Reserves
21	Natural Waterways
22	Neighbourhood Centre
23	Primary Production
24	Primary Production Small Lots

25	Private Recreation
26	Public Recreation
27	Recreational Waterways
28	Rural Landscape
29	Special Activities
30	Tourist
31	Transition
32	Village

Table 8: Availability rating treatment by NSW Planning Scheme land zoning filter

Rating description	Grid cell value filter
Highly capable	9, 14, 23, 24, 28
Capable	9, 14, 23, 24, 28
Moderately capable	9, 14, 23, 24, 28
Incapable	9, 14, 23, 24, 28
N/A	1,2,3,4,5,6,7,8,10,11,12,13,15,16,17,18,19,20,21,22,25,26,27,29,30,31,32

Elevation

Elevation is an inclusion/exclusion parameter (see Table 5). Land with an elevation greater than 1,300 m above mean sea level (AMSL) is excluded and all other elevations are included.

Table 9: Elevation input categories treatment

Rating description	Category parameter value range (Elevation m AMSL)
Highly capable	0-1,300
N/A	1,300-10,000

Native Vegetation

Native vegetation is an inclusion/exclusion parameter. Table 6 presents the values applied based on attributes of that grid cell, with red entries representing native vegetation exclusions (note that this also includes water bodies). Table 7 presents the category values from Table 6 incorporated in the model.

Table 10: Grid cell values for native vegetation and availability for plantations (red = unavailable)

Grid Cell Value	Type	Description
0	Not Native	Not Native Vegetation
1	Tree Cover	Trees > 2m height
2	Candidate Native grasslands	Potential native grassland visually assessed from a single data 50cm aerial image
3	Forestry Plantations	Softwood plantations
4	Water	All water bodies
5	Tree Cover Matrix	Not woody pixels between native woodland trees.

Table 11: Availability rating based on native vegetation filter

Rating description	Grid cell value filter
Highly capable	0, 2, 5
Capable	0, 2, 5
Moderately capable	0, 2, 5
Incapable	0, 2, 5
N/A	1, 3, 4, 5

Existing Plantation Estate

Existing plantation estate is an exclusion parameter (see Table 8). Any currently mapped plantation is excluded.

Table 12: Availability rating treatment of existing plantation estate

Rating description	Grid cell value filter
Highly capable	0
Capable	0
Moderately capable	0
Incapable	0
N/A	1

Step 3: Potential land capability for commercial plantations

Land capability is a combination of availability and suitably.

The final value (capability class) for each grid cell is defined by the single highest value (lowest capability classification) returned for any specific parameter. In simple

terms, if a grid cell scores a rating of 2 (capable) for rainfall and a 4 (incapable) for soil fertility, then the capability rating is 4 (incapable).

Step 4: Potential land productivity for commercial plantations

Productivity modelling is presented as *P. radiata* mean annual increment (MAI) classes defined by total yield after a 35 year rotation. Although there is a considerable history of capability mapping having been undertaken across the region, published literature or previously reported information was not available to the project team to support translation of that historic work into quantifiable productivity. The project team sought advice from Forestry Corporation of NSW to define MAI classes based on correlations between elevation AMSL and rainfall (mm/y). In general terms, higher elevation and higher rainfall are reflected in higher MAI values (see Table 13).

Table 13: Productivity classification based on correlation between rainfall and elevation[4]

Elevation (m AMSL)	MAI (m^3/y)	
	Rainfall >850 mm/y	Rainfall <850 mm/y
<900	15	11
900-1100	17	13
1100-1300	20	17

[4] This matrix is derived from productivity estimates provided by Forestry Corporation of NSW (15 October 2021).

RESULTS

Step 1: Potentially suitable land for plantation expansion

Plantation suitability was based on physical and environmental parameters; slope, elevation, soil fertility and rainfall. Modelling identified 0 ha as highly suitable, 0.40 million ha as suitable, 1.86 million ha as moderately suitable and 0.02 million ha as unsuitable (refer Table 14 and Figure 2).

Table 14: Land suitability for plantation establishment

Local Government Authority	Suitable (ha)	Moderately suitable (ha)	Unsuitable (ha)	Total (ha)
Bathurst Regional Council	49,595	329,746	535	379,876
Blayney Shire Council	78,191	73,717	281	152,189
Blue Mountains Shire Council	15	4,087	226	4,328
Cabonne Shire Council	41,395	109,523	148	151,066
Cowra Shire Council	7,649	33,807	809	42,265
Dubbo Regional Council	-	1,489	-	1,489
Goulburn-Mulwaree Shire Council	983	83,870	149	85,002
Lithgow City Council	14,941	427,186	8,217	450,344
Mid-western Regional Council	16,800	48,254	96	65,150
Oberon Shire Council	74,306	238,638	3,828	316,772
Orange City Council	16,217	11,995	164	28,376
Upper Lachlan Shire Council	103,010	489,545	2,501	595,056
Wingecarribee Shire Council	196	8,317	535	9,048
Total	403,298	1,860,174	17,489	2,280,961

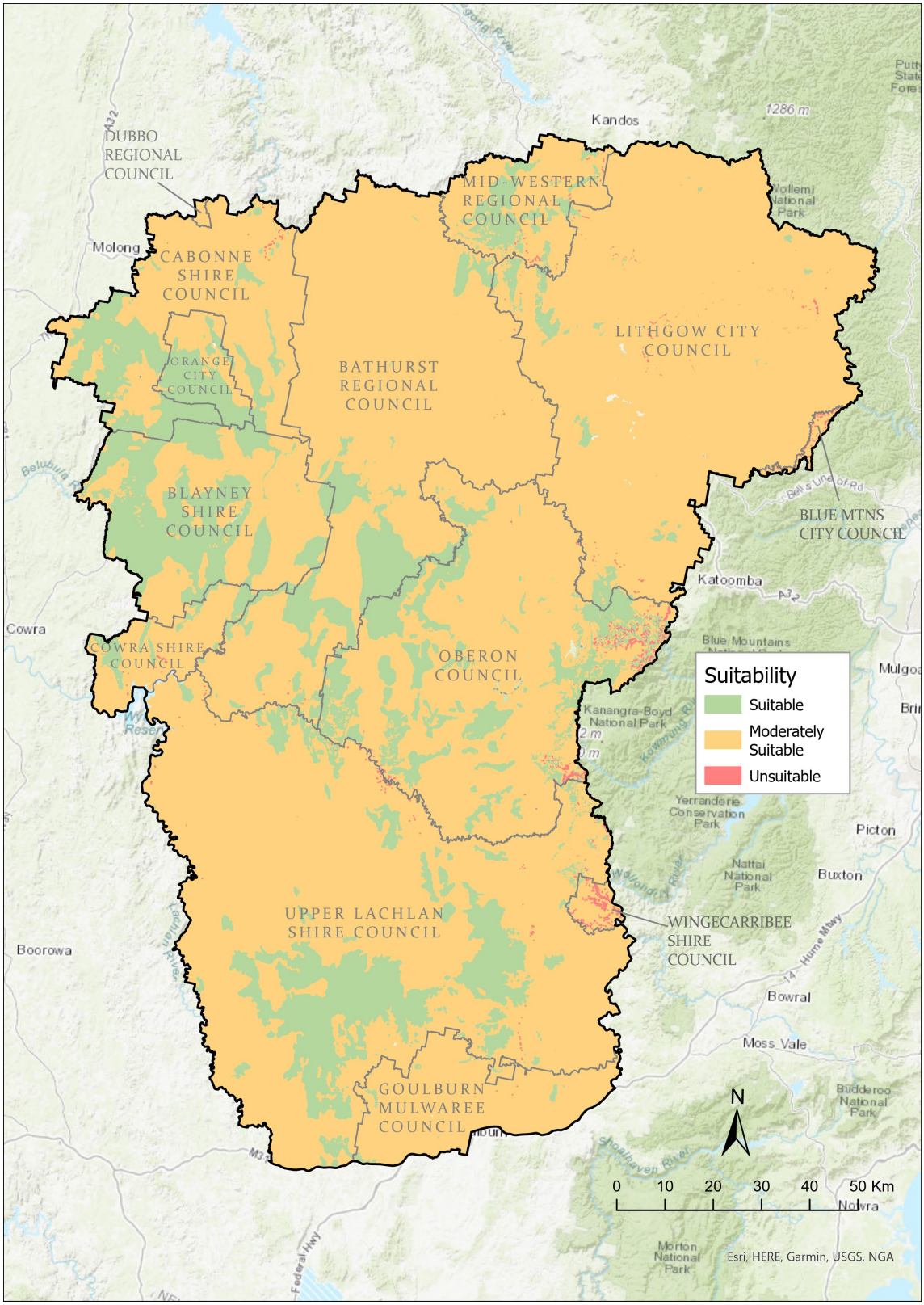

Figure 2: Spatial arrangement of modelled potential land suitability for P. radiata plantations in the Hub region

Step 2: Potentially available land for plantation expansion

The Hub region comprises 2.28 million ha of land of which about 1.04 million ha is potentially available based on exclusion criteria applied (refer Table 14 and Figure 3). Land potentially available for plantation establishment was identified based on pre-determined exclusions (see Table 15). Exclusions were based on land-uses, presence of existing plantations and presence of Crown land tenures (e.g. state forest and national park).

Table 15: Potential land availability for plantation expansion by LGA

Local Government Authority	Excluded areas (ha)	Included areas (ha)	Total (ha)
Bathurst Regional Council	185,097	194,779	379,876
Blayney Shire Council	27,523	124,666	152,189
Blue Mountains Shire Council	4,328		4,328
Cabonne Shire Council	66,208	84,858	151,066
Cowra Shire Council	28,347	13,918	42,265
Dubbo Regional Council	358	1,131	1,489
Goulburn-Mulwaree Shire Council	48,606	36,396	85,002
Lithgow City Council	365,143	85,200	450,343
Mid-western Regional Council	37,624	27,526	65,150
Oberon Shire Council	197,854	118,919	316,773
Orange City Council	23,899	4,478	28,377
Upper Lachlan Shire Council	247,126	347,929	595,055
Wingecarribee Shire Council	9,046	2	9,048
Total	1,241,159	1,039,802	2,280,961

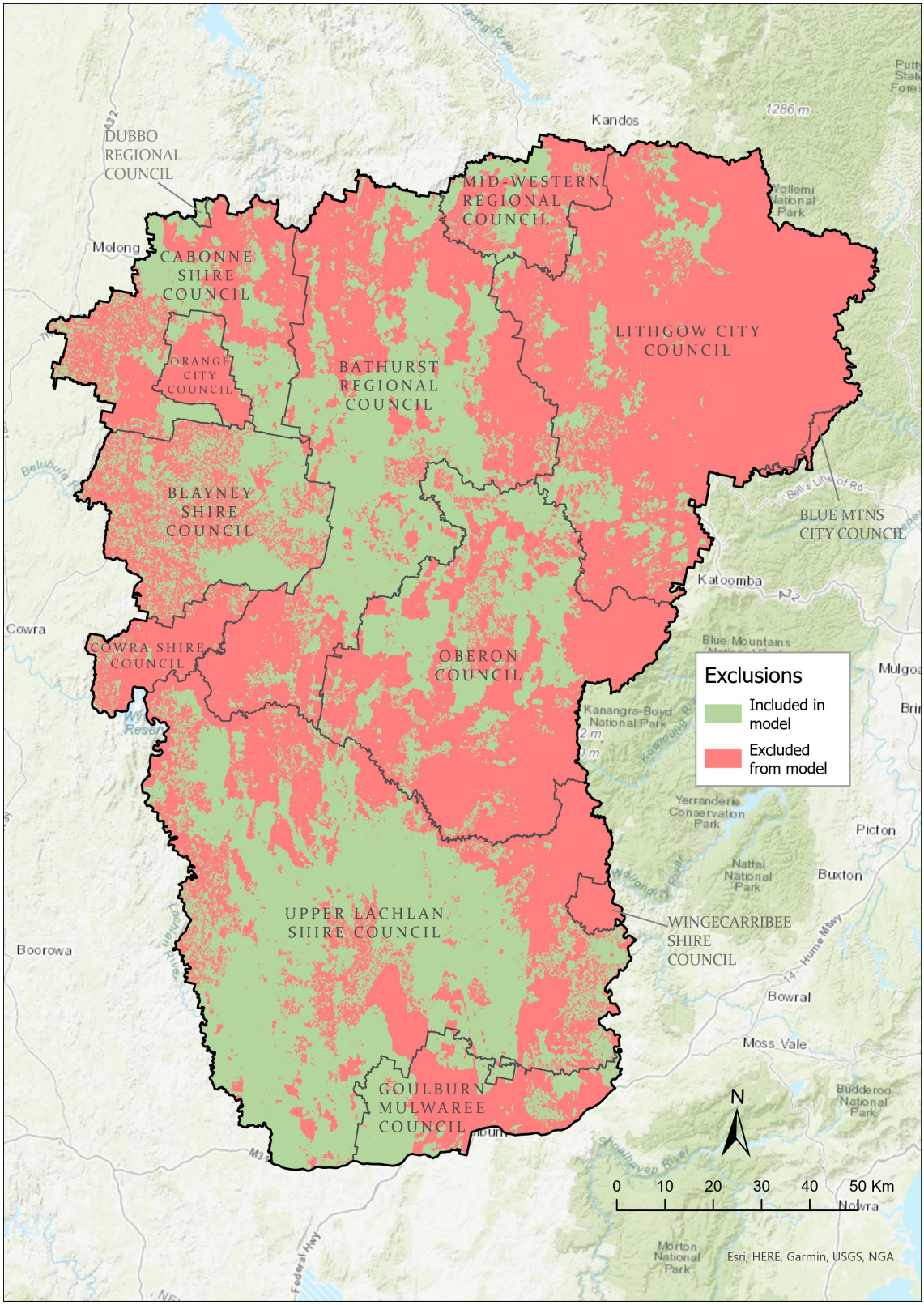

Figure 3: Spatial arrangement of modelled excluded and potential land for P. radiata plantations in the Hub region

Step 3: Potential land capability for commercial plantations

Land capability for plantation establishment was modelled by intersecting suitability and availability layers (described above). That is modelled suitability classification applicable to land modelled as potentially available for plantation expansion (1.04 million ha) was assessed into an equivalent capability classification. For modelled available land, there were 0 ha modelled as highly capable, 0.248 million ha as capable, 0.792 million ha as moderately capable and very small area (108 ha) was modelled as incapable and excluded (refer Table 16 and Figure 4).

Table 16: Modelled land capability for plantation expansion on available land in the Hub

Local Government Authority	Capable (ha)	Moderately capable (ha)	Total (ha)
Bathurst Regional Council	33,303	161,409	194,712
Blayney Shire Council	63,730	60,835	124,565
Blue Mountains Shire Council	-	-	-
Cabonne Shire Council	28,446	56,408	84,854
Cowra Shire Council	4,434	9,476	13,910
Dubbo Regional Council	-	1,131	1,131
Goulburn-Mulwaree Shire Council	820	35,569	36,389
Lithgow City Council	6,779	78,122	84,901
Mid-western Regional Council	9,060	18,456	27,516
Oberon Shire Council	28,211	90,640	118,861
Orange City Council	1,415	3,063	4,478
Upper Lachlan Shire Council	71,344	276,522	347,866
Wingecarribee Shire Council	-	2	2
Total	247,542	791,633	1,039,175

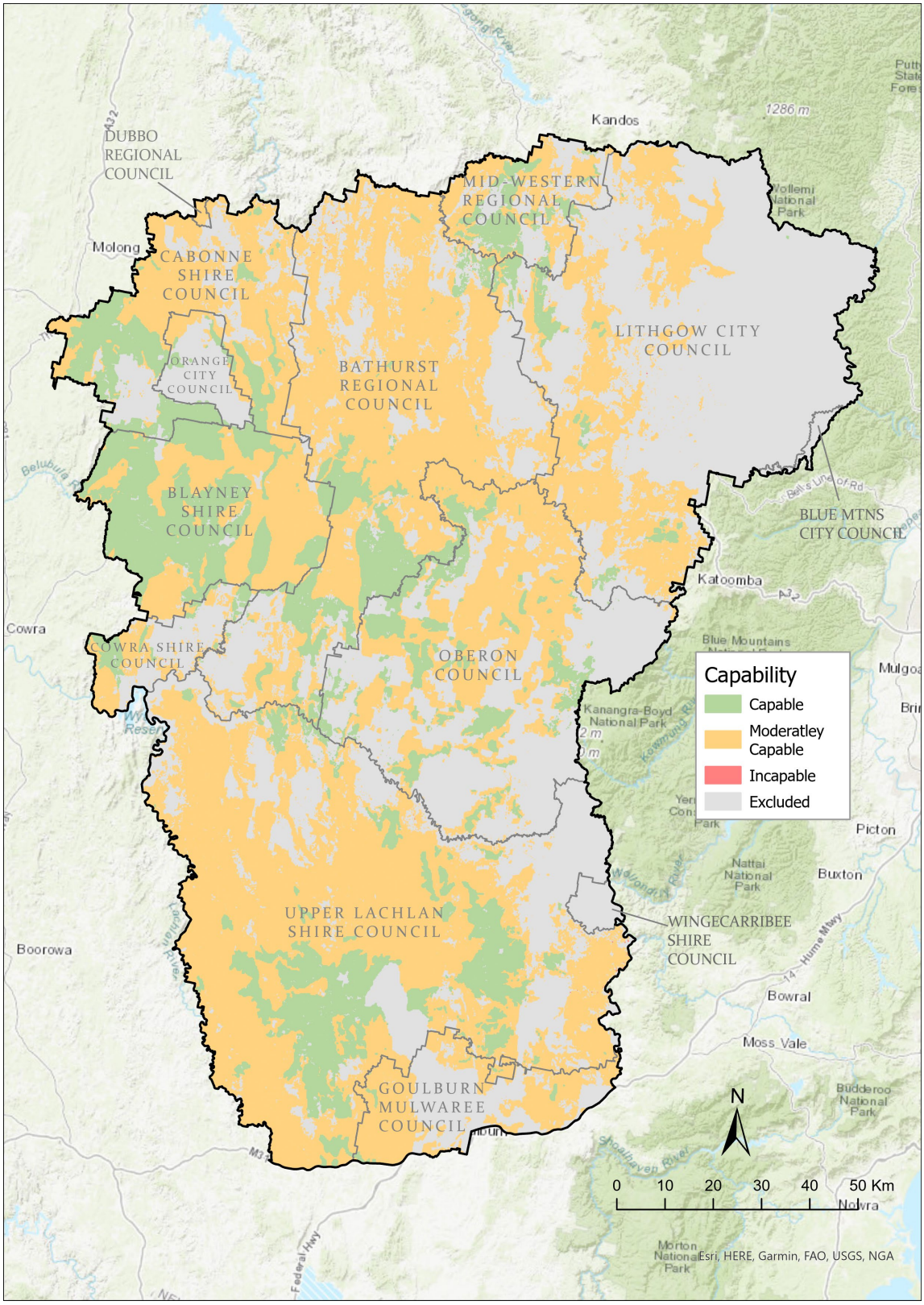

Figure 4: Spatial arrangement of modelled plantation capability on available land; importantly, this figure presents land modelled as unavailable.

Step 4: Potential land productivity for commercial plantations

Available and capable land within the Hub was modelled as highly capable, capable or moderately capable for plantation expansion using a productivity (MAI) rating matrix based on productivity/rainfall/elevation. Table 17 presents modelled outcomes by MAI classes across the Hub. The analysis indicates 86% (0.888 million ha) of potentially available land is capable of growing *P. radiata* plantations at up to 14 m^3/ha/y. A further 14% of potentially available land (151,404 ha) is capable of productivity from 15 to 20 m^3/ha/y.

Table 17: Distribution of modelled productivity classes (MAI) by area (ha) for land available and capable of supporting plantations

	MAI class (m^3/ha/y)					
Local Government Authority	11-13	13-14	15-16	17-19	≥20	Total
Bathurst Regional Council	149,436	30,306	2,947	10,792	1,232	194,712
Blayney Shire Council	64,765	33,563	8,538	17,696	3	124,565
Cabonne Shire Council	56,147	5,507	14,878	8,266	56	84,854
Cowra Shire Council	11,347		1,646	916		13,910
Dubbo Regional Council	770	1	359	1		1,131
Goulburn-Mulwaree Shire Council	36,385	3				36,388
Lithgow City Council	51,639	13,961	5,542	9,907	3,852	84,902
Mid-western Regional Council	21,722	4,996		551	247	27,516
Oberon Shire Council	30,245	31,436	77	37,126	19,967	118,852
Orange City Council	415	375	2,528	1,159	0	4,478
Upper Lachlan Shire Council	291,816	52,934	147	2,970		347,866
Wingecarribee Shire Council	2					2
Total	714,691	173,081	36,663	89,384	25,357	1,039,175
Percentage	69%	17%	3%	9%	2%	100%

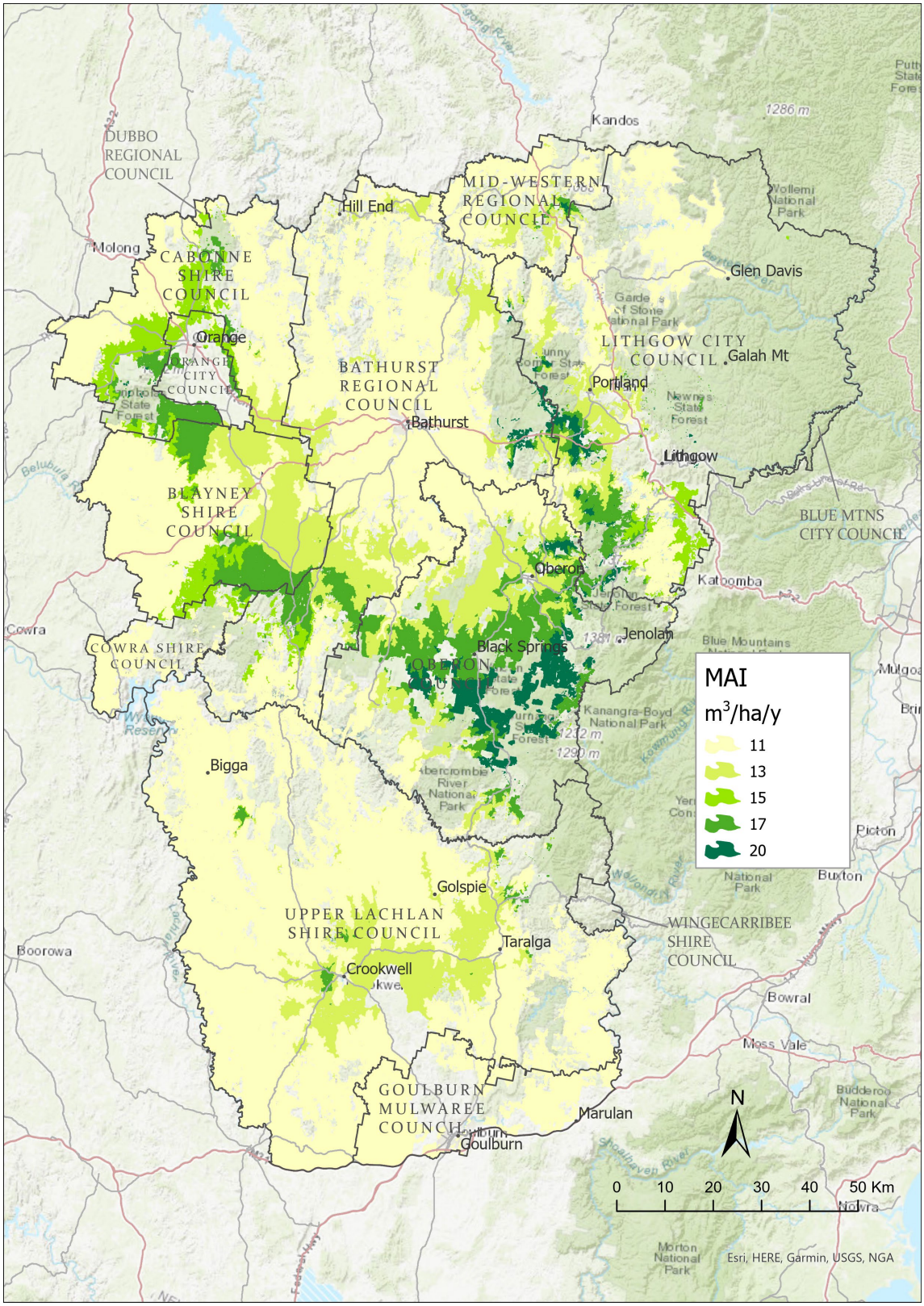

Figure 5: Spatial arrangement of modelled plantation productivity (MAI) classes for available and capable land

DISCUSSION

Model outputs

Plantation capability and productivity modelling has identified approximately 1.04 million ha of land which is capable of supporting establishment of viable *P. radiata* plantations with potential productivity between 11 to 20 m^3/ha/y. Importantly, this includes approximately 0.11 million ha modelled as being able to support plantation growth of ≥17m^3/ha/y.

Application of plantation capability mapping

Intended use

The specific intent of plantation capability mapping is to provide evidence (analysis and outputs) to support identifying focus areas (nodes) for potential plantation expansion. It is a high level, strategic tool intended to be used, combined with other modelling and information, to provide guidance for a wide range of stakeholders; forest and wood products industry in the region, potential plantation investors and landowners who may have an interest in plantation establishment in agricultural settings.

Availability

The outputs from this modelled plantation capability mapping project will be made publicly available as a layer in the Spatial Database developed for Project CWFH001.

Limitations

Modelling limitations

There are limitations associated with the capability and productivity modelling methods which are important to recognise. First, while significant effort was applied to attempt to identify and incorporate data on soil fertility into the productivity model, requisite soil fertility data were not available with sufficient granularity or in appropriate formats. Consequently, the correlation between capability and productivity modelling is compromised. Second, as with capability modelling, there is robust anecdotal evidence to support the productivity classifications north of the Abercrombie River but results south of the Abercrombie River are likely to be less reliable and could be an underestimate. Finally, actual productivity data from the existing plantation estate would provide a basis on which to inform and confirm productivity modelling outputs. However, due to understandable commercial sensitivities, these data were not able from larger forest growers in the region. It is likely that these limitations can be addressed in a practical way to improve the veracity of productivity modelling outputs in future.

Comparison with the existing estate

A first logical step in undertaking a plantation capability mapping exercise for a specified region is to apply data from existing plantations to correlate (calibrate)

capability and productivity against known physical and environmental characteristics. Due to commercial sensitivities, plantation growers in the region were unable to provide productivity data for the existing estate to support further enhancement of the capability and productivity mapping.

Historic plantation capability mapping

The second logical step is to determine whether previous work has been undertaken which can inform further enhancement of model outputs. In the Hub region, capability and suitability projects have been undertaken since at least the 1990s. However, availability of outputs from such projects is generally limited, as is underlying input data. Therefore, this project was able to make use of some historic works to support assumptions in relation to input factors contributing to capability and productivity of *P. radiata* plantations in the region; but not to provide direct data inputs. This highlights an important limitation. There is anecdotal and reported information which supports the assumptions used to populate the model for higher elevation areas north of the Abercrombie River (the Central Tablelands portion of the Hub). This is based on a long history of plantation development in that part of the region and a current extensive plantation estate. The area south of the Abercrombie River (in the Southern Tablelands portion of the Hub) is quite different with respect to geology, soil types, elevation and rainfall. Although a number of small plantations have been successfully established, this area does not have a strong history of plantation development. It is feasible that modelled outputs for south of the Abercrombie River are an under-estimate of plantation capability.

Limiting factor model

Application of a limiting factor modelling approach to plantation capability mapping means that modelled outputs tend to be conservative.

Output format

The model outputs are presented in raster format on a 50 m X 50 m grid. Model inputs vary in granularity and consequently, overall modelled outputs must be considered as strategic rather than site specific. It will be possible for a user to identify modelled capability and productivity outputs modelled for that site. It is important that appropriate caveats are made on publicly available information to ensure that users are aware of the strategic nature of the model. Hence, a party must rely on their own specific inquiries and site specific characteristics in order to determine actual plantation capability for that site.

Potential improvements and future enhancements

Financial models

The Hub has identified a potential project to develop simple financial models to guide to landowners in regard to potential returns from plantation establishment in the Hub region. It is possible that these models could be linked to plantation capability mapping outputs in the Spatial Database such that landowners can

identify their location and access this financial guidance material. However, the same caveats would need to apply with respect to parties must relying on their own specific inquiries and site specific characteristics in order to determine actual plantation capability for a site.

Refinement with existing plantation data

An important future enhancement of plantation capability modelled and mapping would be to utilise actual productivity data from the existing plantation estate to refine productivity classifications utilised by this project. This would require current plantation owners and managers to provide information (data) about current estates which may present challenges due to commercial sensitivities.

Understanding potential impacts of climate change

The likely impacts of climate change on plantation productivity and viability in Australia are still not well understood. It has been forecasted that different regions are likely to experience either positive or negative outcomes as a consequence of increased or decreased rainfall, temperature and changes in seasonality. For example, Pinkard *et al* (2014) identified that across key Victorian and NSW plantation regions, median likely plantation productivity for *P. radiata* will improve in the Central Tablelands of NSW (refer to Figure 5). There is value in the Hub considering a more in-depth analysis of potential implications (positive and negative) of climate change for *P. radiata* plantations across the Hub region. This should include consideration of alternative plantation species.

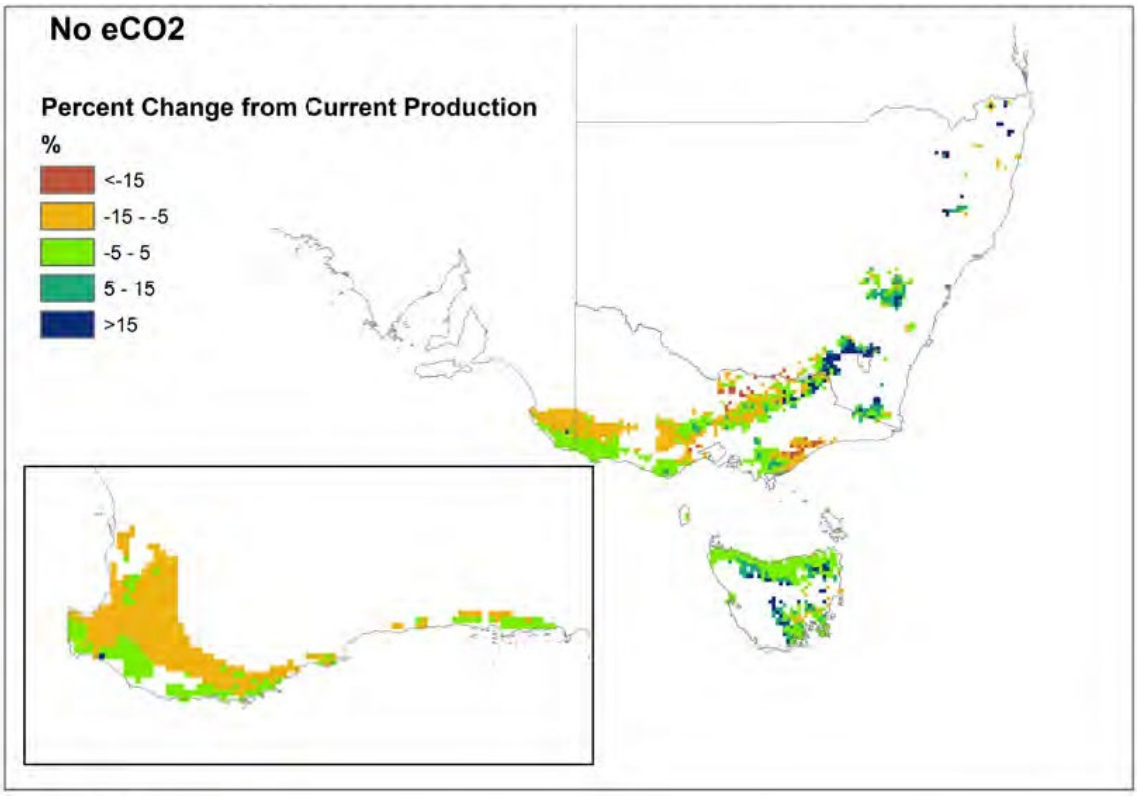

Figure 6: An example of modelled percent production change from current for P. radiata in south-eastern Australia (Pinkard et al, 2014)

REFERENCES

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Charman, P.E.V. 1978 (ed.), Soils of New South Wales: Their Characterisation, Classification and Conservation, Tech. Handbook No. 1, Soil Conservation Service of NSW, Sydney.

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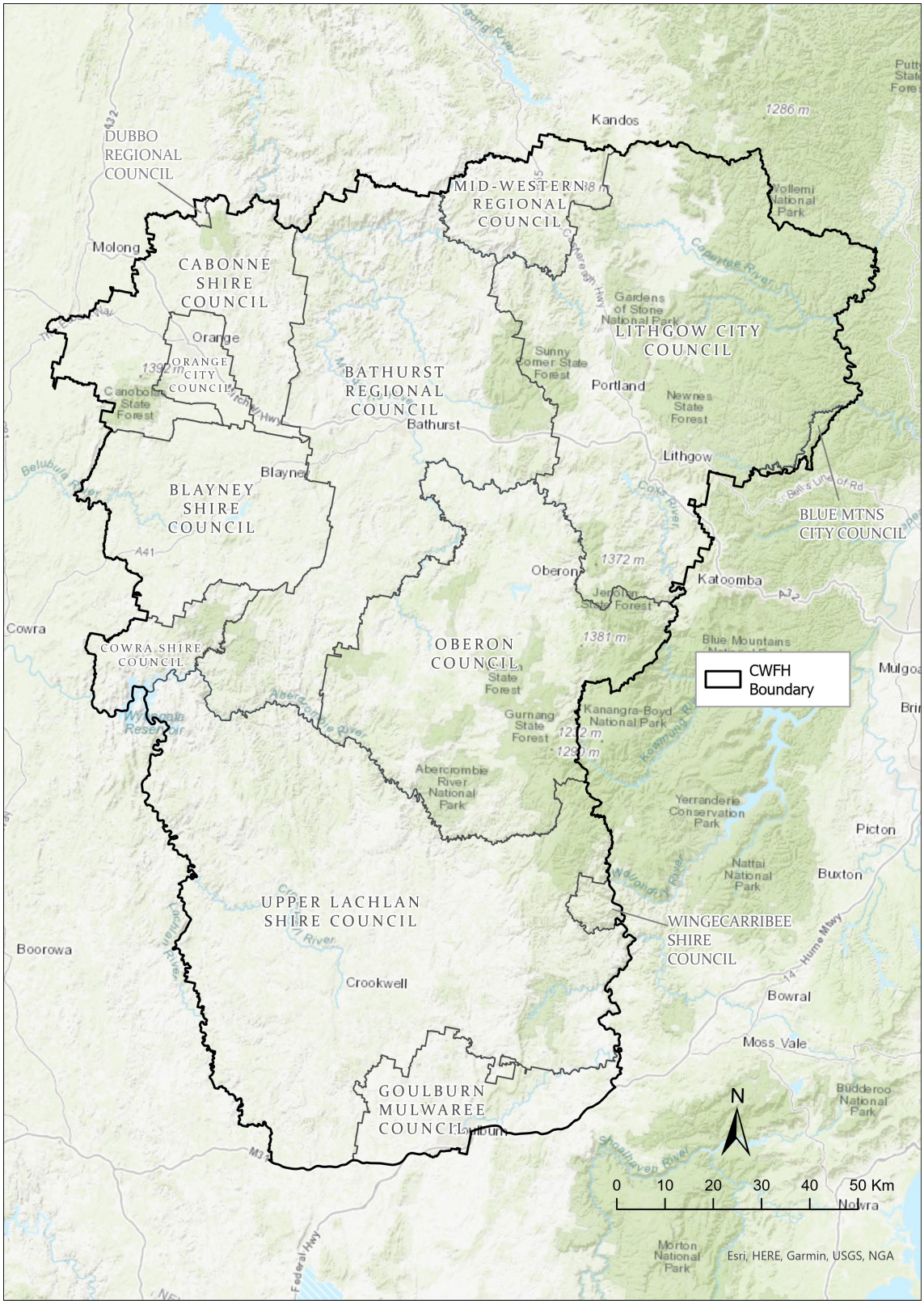
Department of Planning, Industry and Environment, 2020, *Estimated Inherent Soil Fertility of NSW, Version 4*, NSW Department of Planning, Industry and Environment.

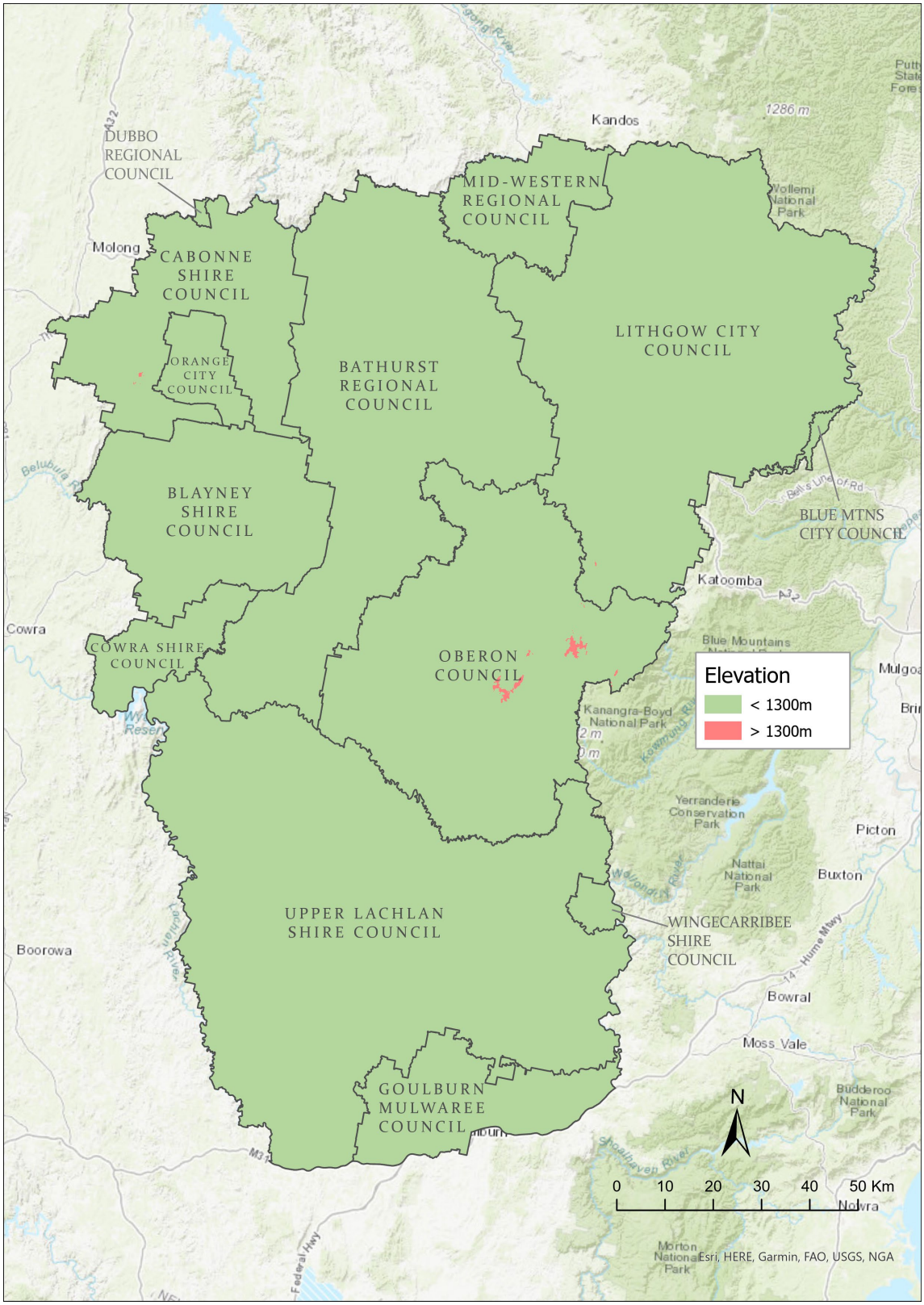
Pinkard. L., J. Bruce, M. Battaglia, S. Matthews, D. Drew, G. Downes, D. Crawford and M. Ottenschlaeger (2014) *Adaptation strategies to manage risk in Australia's plantations* Project No: PNC228-1011, Forest & Wood Products Australia.

APPENDICES

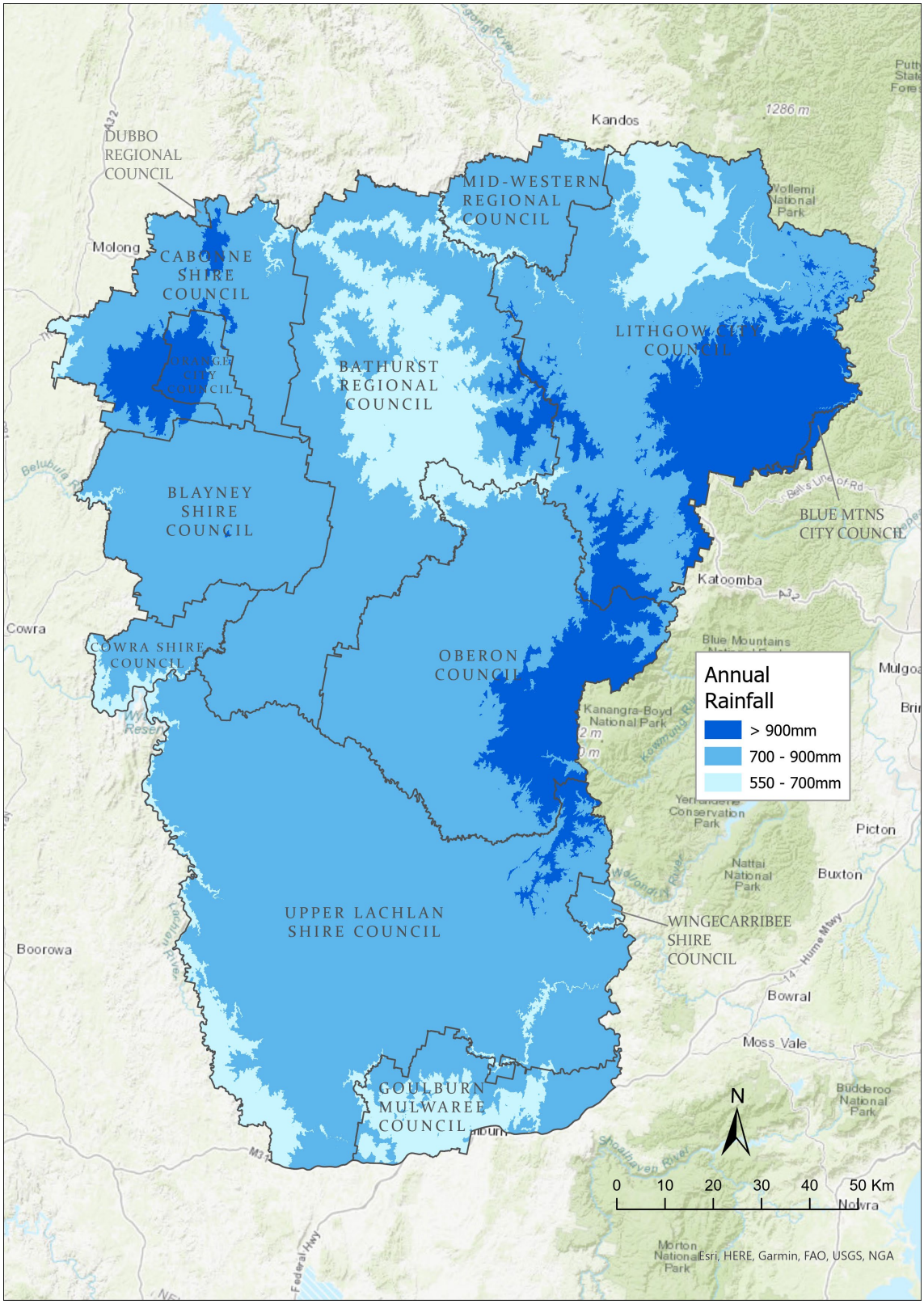
Appendix 1: Input – The Hub boundary



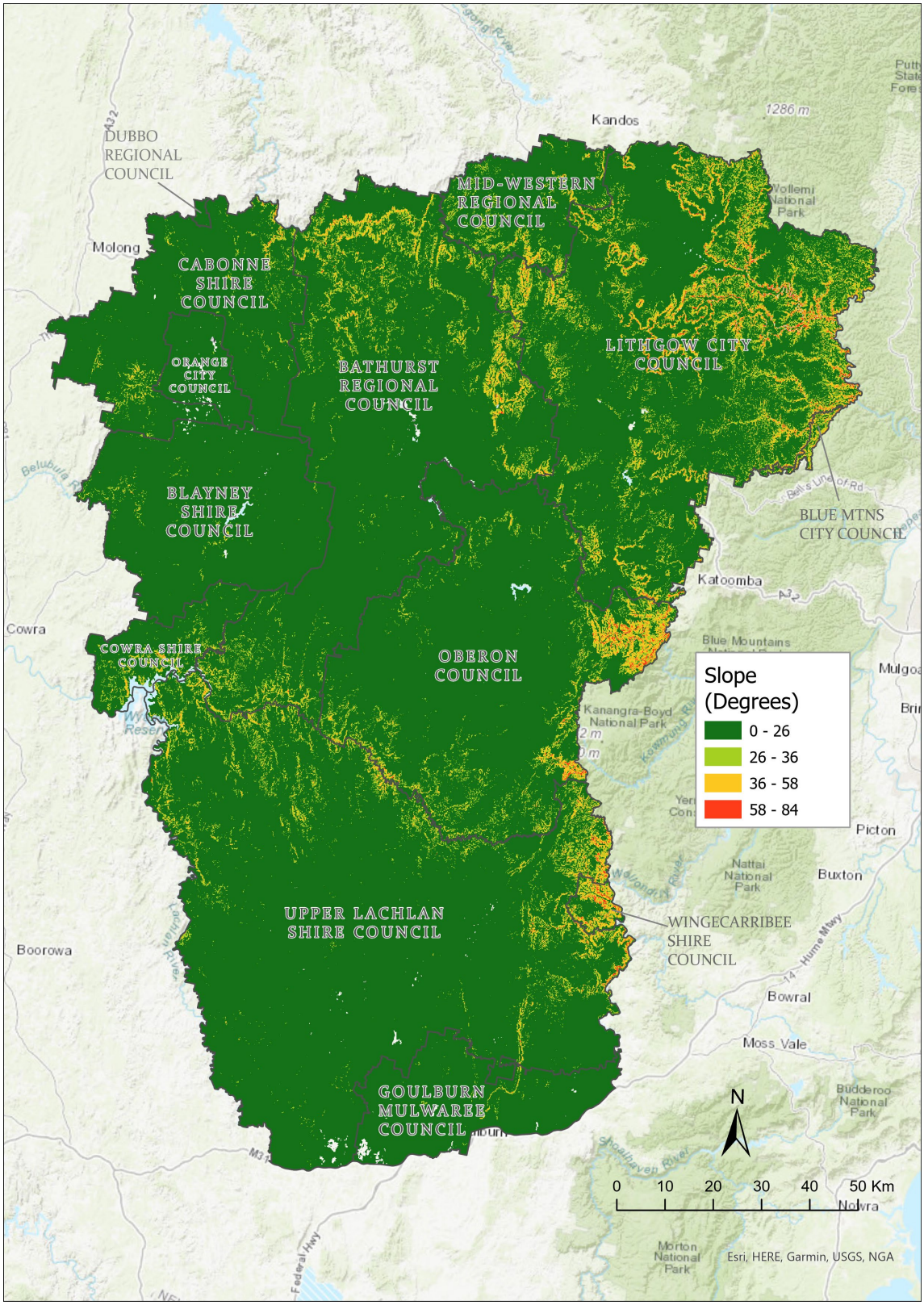
Appendix 2: Input – Elevation



Appendix 3: Input – Rainfall



Appendix 4: Input – Slope



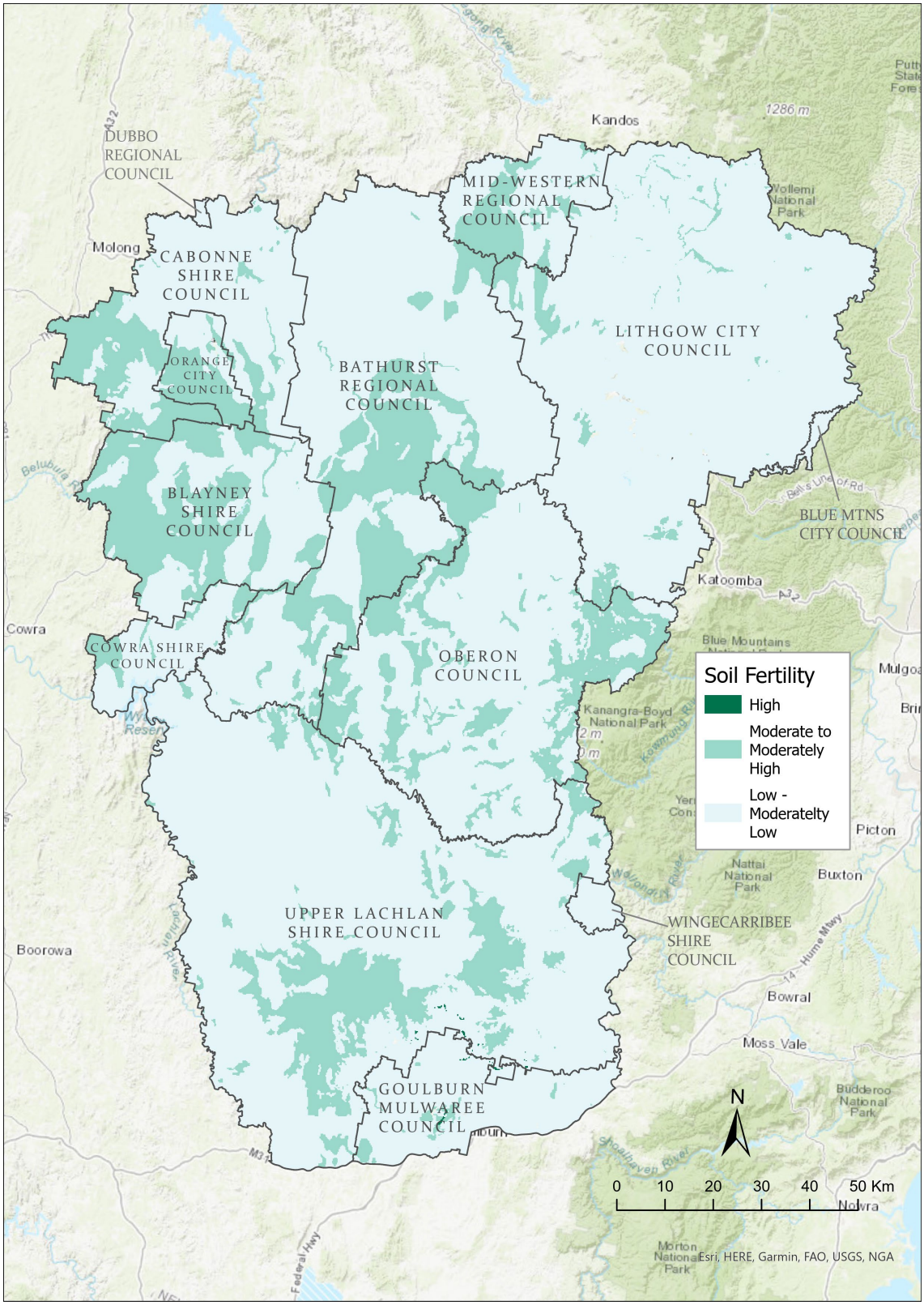
Appendix 5: Soil fertility classification

Inherent Soil Fertility classes of Great Soil Groups; Source: Department of Planning, Industry and Environment (2020); Modified from Charman (1978).

Soil Type (Great Soil Group)	Inherent Fertility class	Fertility
Acid Peats	Low	1
Alluvial Soils - light sandy textured	Moderately low	2
Alluvial Soils - medium to heavy textured	Moderately high	4
Alpine Humus Soils	Low	1
Black Earths	High	5
Brown Earths	Moderate	3
Brown Podzolic Soils	Moderate	3
Calcareous Red Earths	Moderately low	2
Calcareous Sands	Low	1
Chernozems	High	5
Chocolate Soils	Moderately high	4
Chocolate Soils – low iron	Moderately high	4
Desert Loams	Moderately low	2
Earthy Sands	Low	1
Euchrozems	Moderately high	4
Gleyed Podzolic Soils	Moderately low	2
Grey-brown and Red Calcareous Soils	Low	1
Grey-brown Podzolic Soils	Moderately low	2
Grey, Brown and Red Clays	Moderate	3
Grey, Brown and Red Clays - good surface condition	Moderately high	4
Humic Gleys	Moderately low	2
Humus Podzols	Low	1
Kraznozems	Moderately high	4
Lateritic Podzolic Soils	Moderately low	2
Lithosols	Low	1
Neutral to Alkaline Peats	Low	1
Non-calcic Brown Soils	Moderate	3
Peaty Podzols	Low	1
Podzols	Low	1

Prairie Soils	Moderately high	4
Red and Brown Hardpan Soils	Low	1
Red-brown Earths	Moderate	3
Red Earths - less fertile	Moderately low	2
Red Earths - more fertile	Moderately high	4
Red Podzolic Soils - less fertile	Moderate	3
Red Podzolic Soils - more fertile	Moderately high	4
Rendzinas	Moderate	3
Siliceous Sands	Low	1
Solodic Soils	Moderately low	2
Solodized Solonetz	Moderately low	2
Solonchaks	Low	1
Solonetz	Moderately low	2
Solonized Brown Soils	Moderately low	2
Soloths	Moderately low	2
Terra Rossa Soils	Moderate	3
Weisenboden	Moderate	3

Appendix 6: Input – Soil Fertility



Appendix 7: Snapshot image – MAI layer in Spatial Database