

# CARBON PROFILING ANALYSIS

## Report for:

Central West NSW Forestry Hub

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## Executive summary

### Background

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The Central West NSW Forestry Hub (the Hub) are seeking to understand the carbon sequestration potential from Radiata pine plantations within the Hub region. The carbon estimates in this project were derived using the Full Carbon Accounting Model (FullCAM). FullCAM is used to calculate Australia's greenhouse gas emissions for the land sector.

### Regimes

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Three silvicultural regimes were used in the analysis:

1. Short rotation - clearfell at age 15, one year fallow, replant and repeat.
2. Long rotation - one thinning event at age 15, clearfell at age 32, one year fallow, replant and repeat.
3. Long rotation - two thinning events at age 17 and 25 years, clearfell at 32, one year fallow, replant and repeat.

### Outcomes

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- The average carbon sequestration potential (i.e. claimable ACCUs) ranges from **218.5** to **412.2** tCO<sub>2</sub>-e/ha across the identified potential plantation areas of the Hub. This is based on a 25-year permanence period and the variation relates to the productivity classification and regime.
- Heat maps of carbon sequestration potential are provided for the three regimes across the Hub region.
- Carbon profiles over 100 years are provided for all regimes and across productivity classes.
- In addition to this report, a spreadsheet has been provided in a format required for the Landowner Plantation Assessment Tool. This spreadsheet contains annual ACCU estimates for each regime.

# 1. Introduction

## 1.1 Background

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The Central West NSW Forestry Hub (the Hub) are seeking to understand the carbon sequestration potential from Radiata pine plantations within the Hub region. To achieve this, the Hub required an estimate of the carbon sequestration potential for each of the five productivity classes which were determined in the Plantation Capability Mapping project (see the [Hub website](#)<sup>1</sup> for more information). The productivity classes are based on estimated Mean Annual Increment (MAI):

- 11 - 13 m<sup>3</sup>/ha/year
- 13 - 15 m<sup>3</sup>/ha/year
- 15 - 17 m<sup>3</sup>/ha/year
- 17 - 20 m<sup>3</sup>/ha/year
- 20+ m<sup>3</sup>/ha/year

## 1.2 Purpose

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The purpose of the project is to provide carbon accumulation profiles for three *Pinus radiata* plantation regimes that are typical for the Hub. The regimes are short rotation (clearfell at 15 years), long rotation with one thinning (thinning at 15, clearfell at 32), and long rotation with two thinnings (thinnings at 17 and 25, clearfell at 32).

## 1.3 Project deliverables

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The deliverables for this project are:

- A report that describes the project and methodology and presents the results.
- A spreadsheet that presents the annual ACCU estimates for the Landowner Plantation Assessment Tool which is currently under development for the Hub.
- A 'heat map' showing the variability of ACCU estimates across the Hub.

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<sup>1</sup> <https://cwfh.com.au/>

## 2. Methodology

### 2.1 Point locations for carbon estimates

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Using a spatial software package, a 3 km by 3 km grid was placed across the entire Hub Region. The location (latitude and longitude, Australian Albers map projection) of each grid intersection was recorded and used as the location input for carbon estimation runs using the Full Carbon Accounting Model (FullCAM). The total number of points across the Hub is 2,543. The total number of points that landed in potential productive areas for new plantations was 1,132.

It should be noted that the carbon estimates from this project cannot be relied on for a specific plantation project. Every project must have FullCAM carbon estimates produced that are specific to that site.

### 2.2 FullCAM and the calculation of ACCUs

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FullCAM is a freely available software package. It provides fully integrated estimates of carbon pools in forest and agricultural systems for Australia's land sector. In addition, it accounts for human-induced changes in emissions and sequestration of major greenhouse gases. 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. Under the Emissions Reduction Fund (ERF), all modelled vegetation methods require the application of FullCAM to calculate available Australian Carbon Credit Units (ACCUs).

The FullCAM output is a csv file that provides, along with other variables, a monthly estimate of carbon mass (tonnes of carbon per hectare) over a period of 100 years for the following elements:

- Trees - the carbon stored in the trees as they are growing.
- Debris - the carbon stored in woody debris on the forest floor.
- Products - the carbon stored in forest products following harvesting.

The carbon mass values need to be converted to the equivalent of carbon dioxide (CO<sub>2</sub>-e). This is done by multiplying carbon mass by 3.667. This factor is derived from the atomic weights of the two elements. The atomic weight of carbon (C) is 12 and the atomic weight of oxygen (O) is 16, so the total atomic weight of CO<sub>2</sub> is 44. Therefore CO<sub>2</sub>-e equals total carbon mass multiplied by 44/12 (3.667).

The number of carbon credits available are referred to as Australian Carbon Credit Units (ACCUs) and are measured in tonnes of CO<sub>2</sub>-e. ACCUs equal the sum of the carbon in trees, debris and products, less the fuel emissions from thinning and harvesting.

The predicted long-term average carbon stock for a specific plantation project is the sum of the carbon in trees, debris and products divided by 1200 (1200 being the number of months in 100 years). This long-term average, less the total fuel emissions from thinning and harvesting is the net carbon stock. **The net carbon stock determines the maximum amount of ACCUs that can be claimed for the plantation project.**

### **2.2.1 Discounts from the net carbon stock**

The Clean Energy Regulator (CER) retains five per cent of all ACCUs issued in order to self-insure events that cause unexpected emissions from sequestration projects. The risk of reversal buffer (5%) is the Government’s self-insurance for projects where carbon stores have been emitted and the project originator has no capacity to reinstate the carbon (e.g. has gone out of business).

The CER also imposes the following additional reductions on the total ACCUs issued if the project originator chooses the 25 year permanence obligation (rather than 100 years):

- short rotations: 25 %
- long rotations: 20 %

The total discounts applied for short and long rotations is shown in Table 1

Table 1 - Total discounts applied to ACCUs (25 year permanence)

	Risk of reversal buffer	Permanence discount	Total discount
Short rotation	5%	25%	30%
Long rotation	5%	20%	25%

### **2.3 FullCAM parameter settings**

For each of the 2,543 points within the Hub, three FullCAM carbon estimation runs were conducted using the 2016 version of FullCAM. Although there are more recent versions of FullCAM used for other methods, the 2016 version is the mandated one when using the Plantation Methodology.

The following three regimes were applied:

1. Radiata pine – Plantation, short rotation, clearfell at age 15, one year fallow, replant and repeat.
2. Radiata pine – Plantation, long rotation, one thinning event at age 15 (55% removal), clearfell at age 32, one year fallow, replant and repeat.
3. Radiata pine – Plantation, long rotation, two thinning events at age 17 (40% removal) and 25 years (50% removal), clearfell at 32, one year fallow, replant and repeat.

Site preparation and establishment settings were the same for each regime and consisted of:

- Ripping to 600mm.
- Pre-plant weed control.
- Seedlings planted at 1,100 stems per hectare.
- No fertiliser application.

## **2.4 FullCAM output analysis**

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The predicted long-term carbon stock for each regime was associated with the relevant point location and three heat maps were produced for the Hub Region.

The location of the carbon estimate points was overlaid on the productivity spatial layer and each carbon estimate point was associated with the relevant productivity class. This enabled analysis of total carbon estimates with productivity class.

Analysis was conducted to understand the variation of carbon predictions and derive an average long-term carbon stock for each productivity class and each regime. The point location that was the closest to the average long-term carbon stock for each productivity class and regime was identified for detailed analysis.

Detailed analysis involved accessing the relevant FullCAM output file and performing the following calculations:

1. For each monthly output:
  - a. Convert the carbon mass of trees, debris and products into CO<sub>2</sub>-e.
  - b. Calculate the timing and quantity of fuel emissions from each thinning and harvesting event.

2. For each productivity class and regime:
  - a. Calculate the net carbon stock.
  - b. Apply the discounts, 5% risk of reversal and reduction due to 25 year permanence (as requested by the Hub project manager).
  - c. Derive the total ACCUs that can be claimed.
  - d. Calculate the annual net carbon stock and determine the year that the cumulative carbon stock equals the total ACCUs that can be claimed.
  - e. Create a carbon profile chart.

## **3. Results**

### **3.1 Heat maps**

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The three heat maps are provided in Figure 1, Figure 2 and Figure 3. It is evident, particularly with the long rotation\_1 thinning regime that there are distinct lines where the carbon estimates change. There are two reasons for these differences:

1. FullCAM estimates for the Plantation Methodology can only be calculated within the National Plantation Inventory (NPI) regions. There is an area in the northeast of the Hub region that is outside a NPI region. To obtain carbon estimates for this area, a default method in FullCAM must be used. This method is called 'mixed-species environmental planting' and the carbon estimates are typically more conservative than the Plantation Methodology. The impact of this for the Hub is minimal because there are no known plantations in this area and the area is unlikely to have future plantations.
2. There are two NPI regions within the Hub - Central Tablelands and Southern Tablelands. The FullCAM model is calibrated against NPI data from these regions. It is evident that this calibration appears to have lowered the carbon estimates for the Southern Tablelands when compared to the neighbouring points of the Central Tablelands.

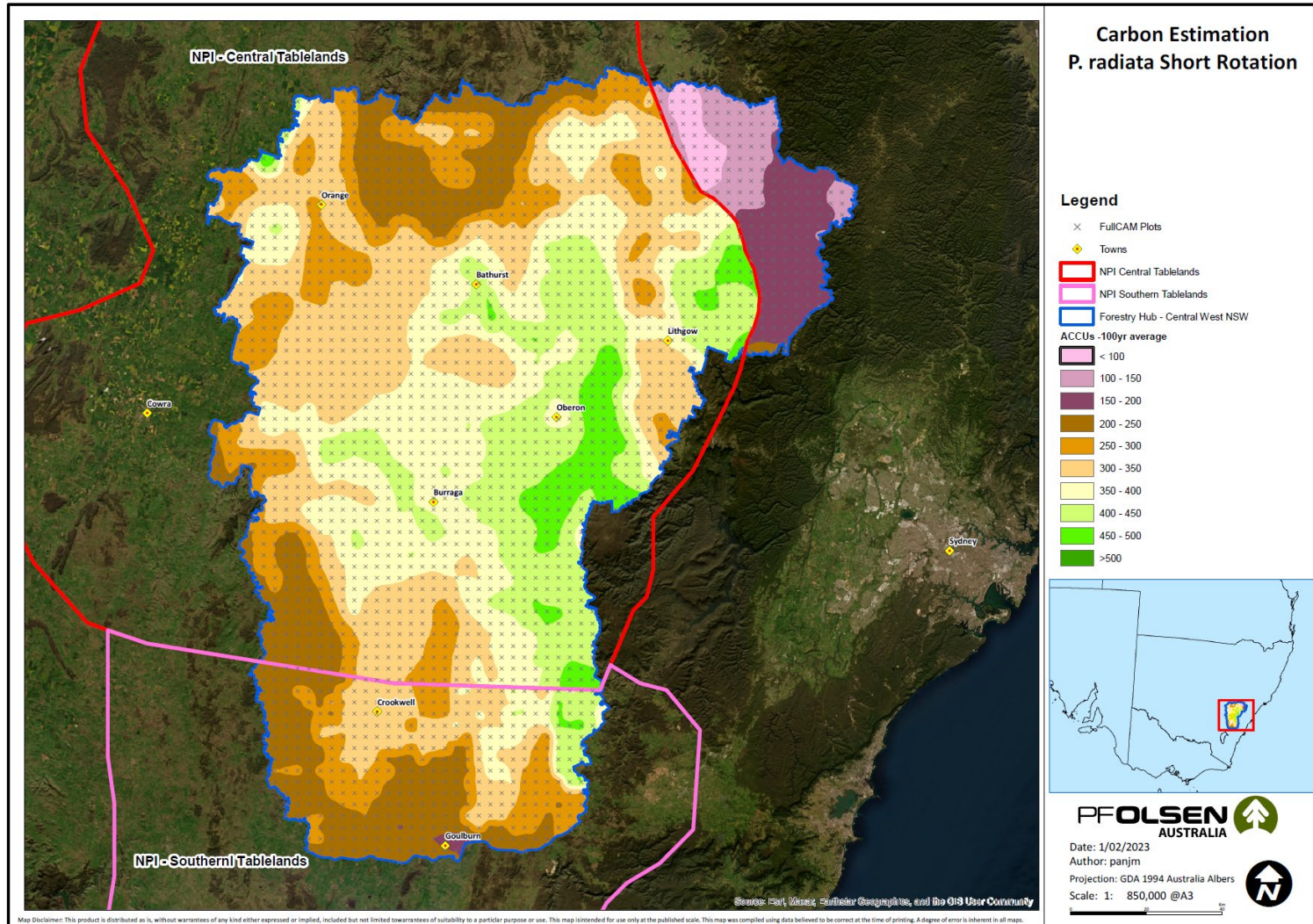


Figure 1: Heat map of predicted long-term carbon stock for Regime 1 - short rotation

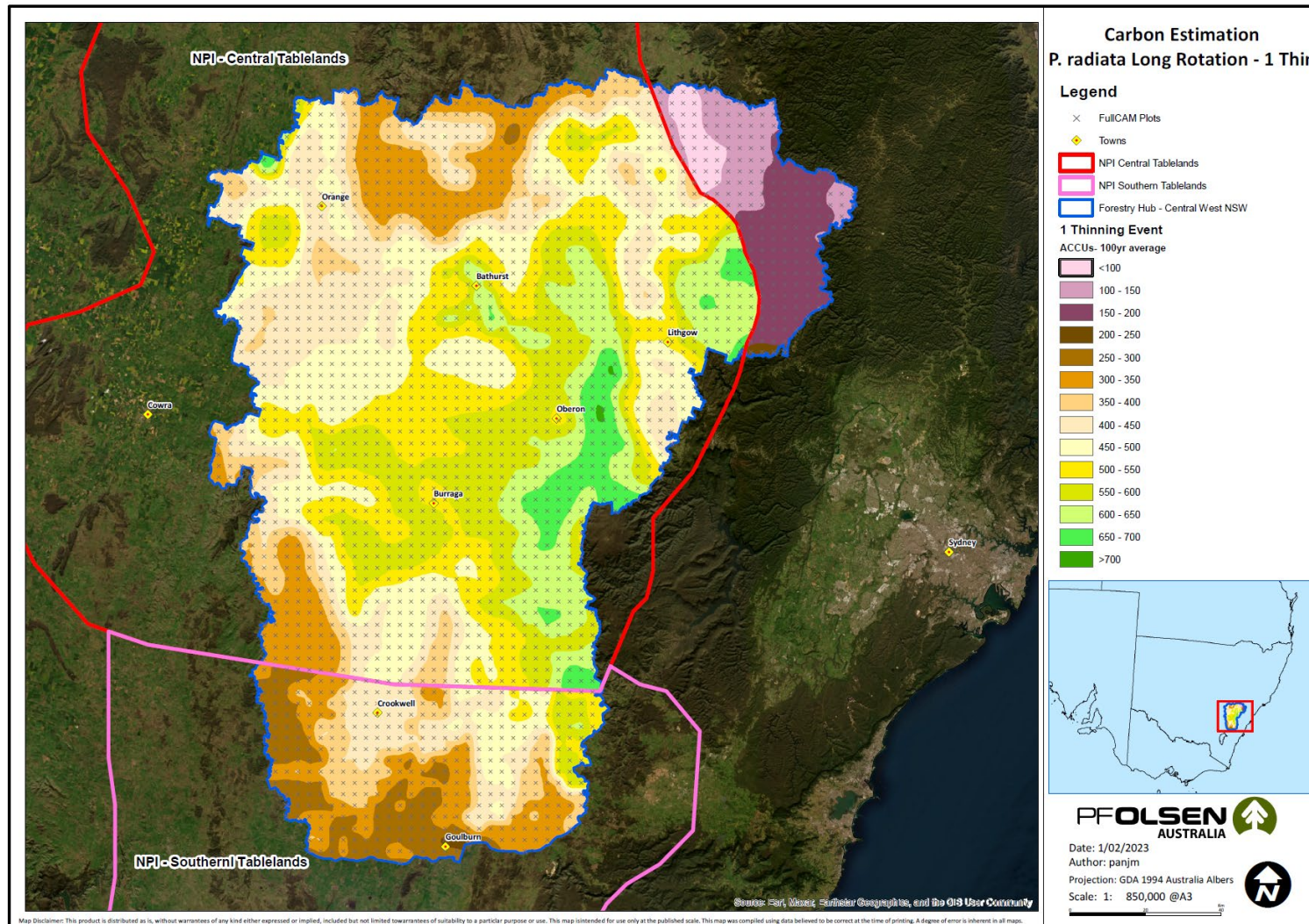


Figure 2: Heat map of predicted long-term carbon stock for Regime 2 – long rotation, 1 thinning

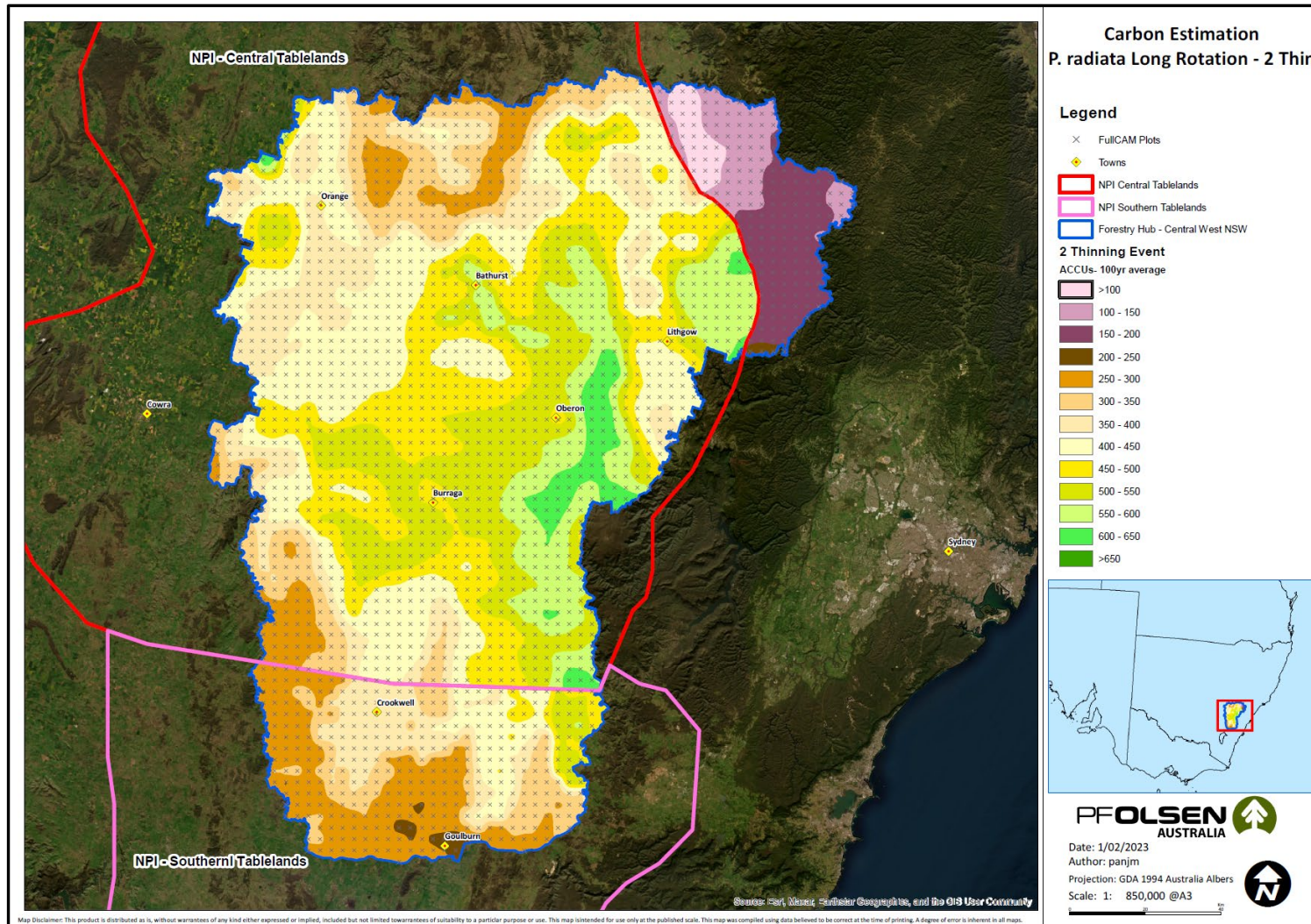


Figure 3: Heat map of predicted long-term carbon stock for Regime 3 – long rotation, 2 thinnings

### 3.2 Association of point locations with productivity classes

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Table 2 presents the number of carbon estimate points for each productivity class. The area of each productivity class is also provided. Given that the area of the lowest productivity class is the largest, there are a lot more carbon estimate points associated with this class.

Table 2: Number of carbon estimate points by productivity class for potential new pine plantations

Productivity class (MAI)	No. of points	Area (ha)
11-13	783	714,691
13-15	186	173,081
15-17	43	36,663
17-20	94	89,384
20+	26	25,357
<b>TOTAL</b>	<b>1,132</b>	<b>1,039,176</b>

Of the 2,543 points, 1,411 points were in locations that were identified in the Plantation Capability Mapping project as not available for plantation due to various constraints such as National Park or State Forest.

### 3.3 Analysis of carbon estimates with productivity classes

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We used carbon estimates relating to the short rotation regime for the following analysis. The same analysis could have been completed with either of the two long-rotation regimes, and there would have been the same outcome as that presented below.

Figure 4 presents a ‘box and whiskers’ plot of ACCUs by productivity class for the short rotation regime. Each box and whisker provide the following information:

- Mean - the ‘X’ within the box.
- Median - the line within the box.
- Bounds of the box - the bottom of the box is the median of the bottom half of the dataset (1<sup>st</sup> quartile) and the top of the box is the median of the top half of the dataset (3<sup>rd</sup> quartile).
- Whiskers - the minimum and maximum values of the dataset (ignoring outliers).
- Outliers - those values that are outside the interquartile range.

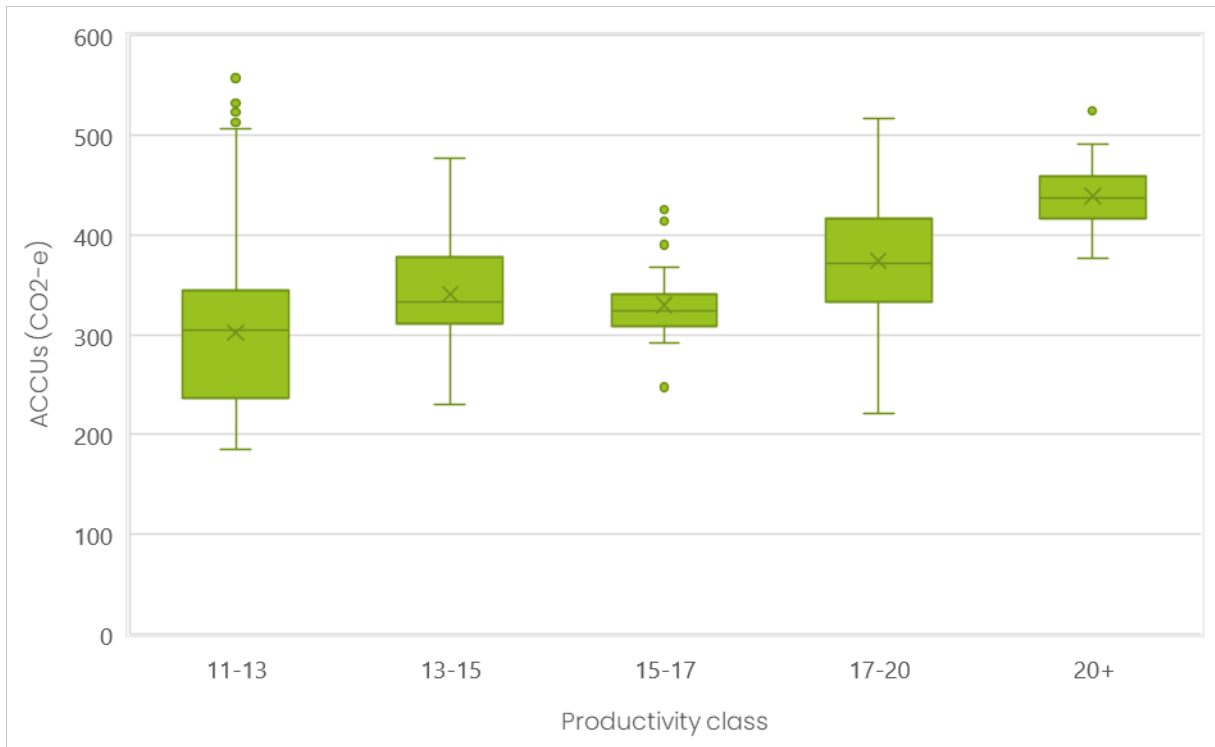


Figure 4: Total ACCUs by productivity class for the short rotation regime

It is clear from Figure 4 that there is a reasonable correlation between estimated carbon and productivity class; a low productivity class is generally associated with a lower carbon estimate and a high productivity class is generally associated with a higher carbon estimate. The only exception to this observation is the 15-17 productivity class. In this case, it is evident that there is no significant difference between this class and the 13-15 class. These two groups were then combined for all three regimes (short, long 1 thin, and long 2 thins) to enable further analysis (Figure 5).

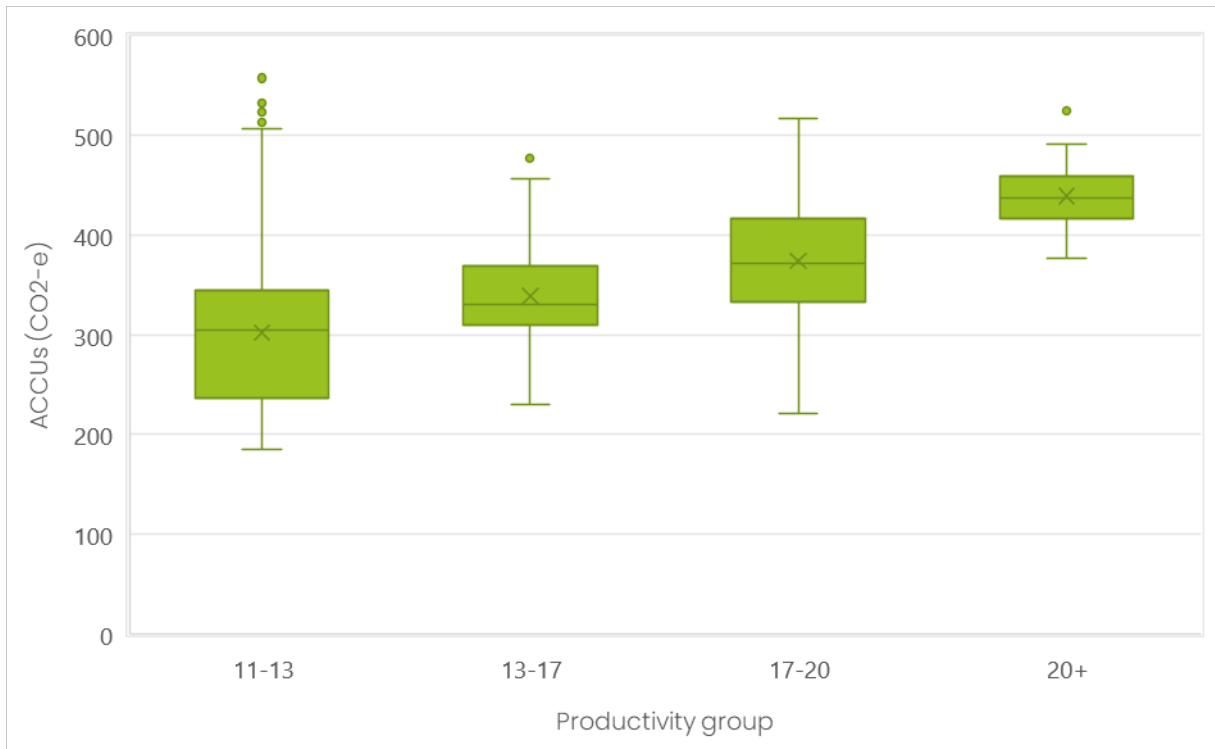


Figure 5: Total ACCUs by revised productivity class for the short rotation regime

The average net carbon stock and standard deviation for each productivity group are presented in Table 3. These average values are used to identify the point locations that are closest to the average for each regime and productivity class.

Table 3: Average and standard deviation net carbon stock for each regime by productivity class

Productivity class (MAI)	Regime		Short		Long 1 thin		Long 2 thins	
	No. of points	Average (CO <sub>2</sub> -e)	St dev (CO <sub>2</sub> -e)	Average (CO <sub>2</sub> -e)	St dev (CO <sub>2</sub> -e)	Average (CO <sub>2</sub> -e)	St dev (CO <sub>2</sub> -e)	
11-13	783	287	67	403	100	367	90	
13-17	229	322	46	453	70	414	63	
17-20	94	356	56	507	82	463	74	
20+	26	417	31	592	38	544	40	

### 3.4 Carbon profiles

As described in the methodology, the average values in Table 3 were used to identify specific carbon estimate points that were the closest to the average for the specific productivity class and regime. This value and the carbon profile over 100 years are provided in the following sub-sections.

#### 3.4.1 Short rotation

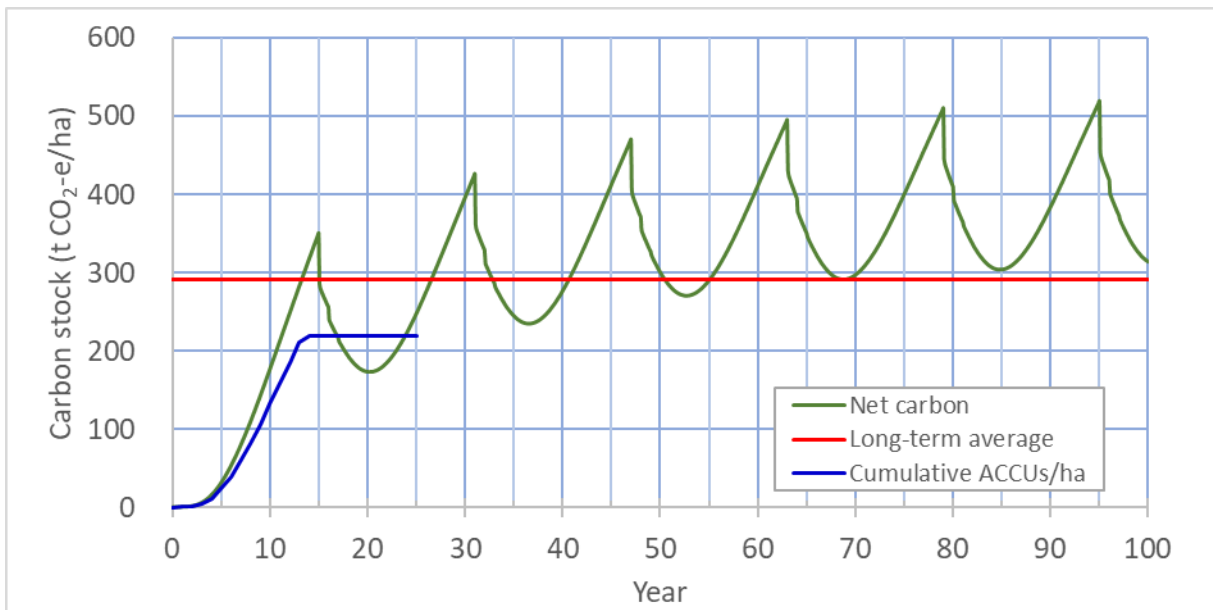


Figure 6: Carbon profile for 11-13, point ID 20, total claimable ACCUs = 218.5/ha

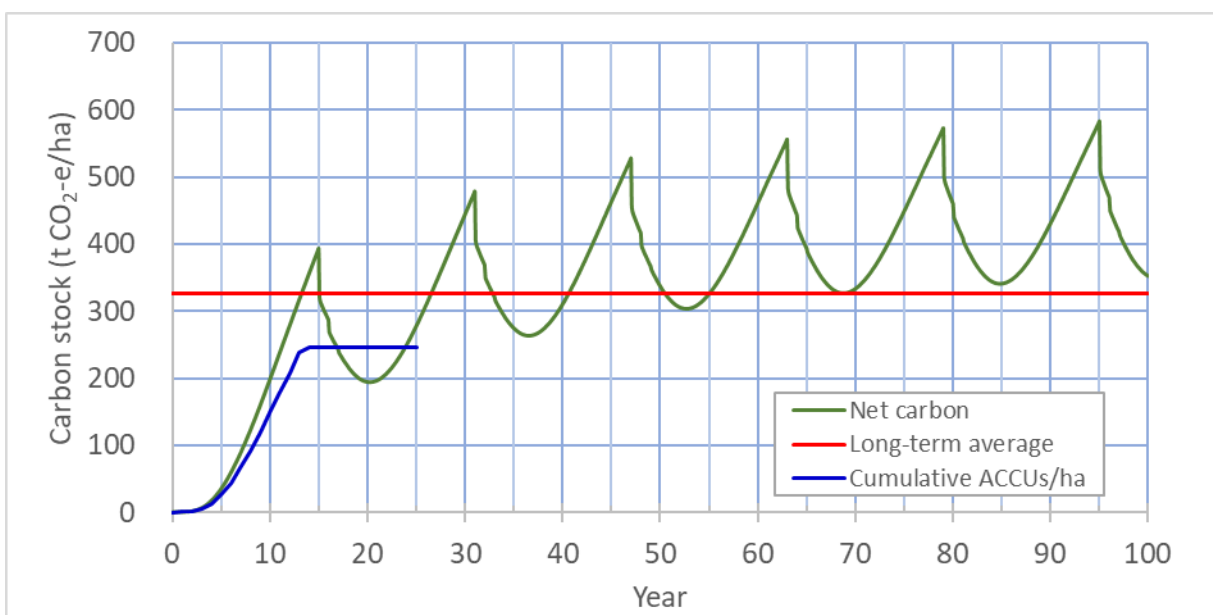


Figure 7: Carbon profile for 13-17, point ID 860, total claimable ACCUs = 245.4/ha

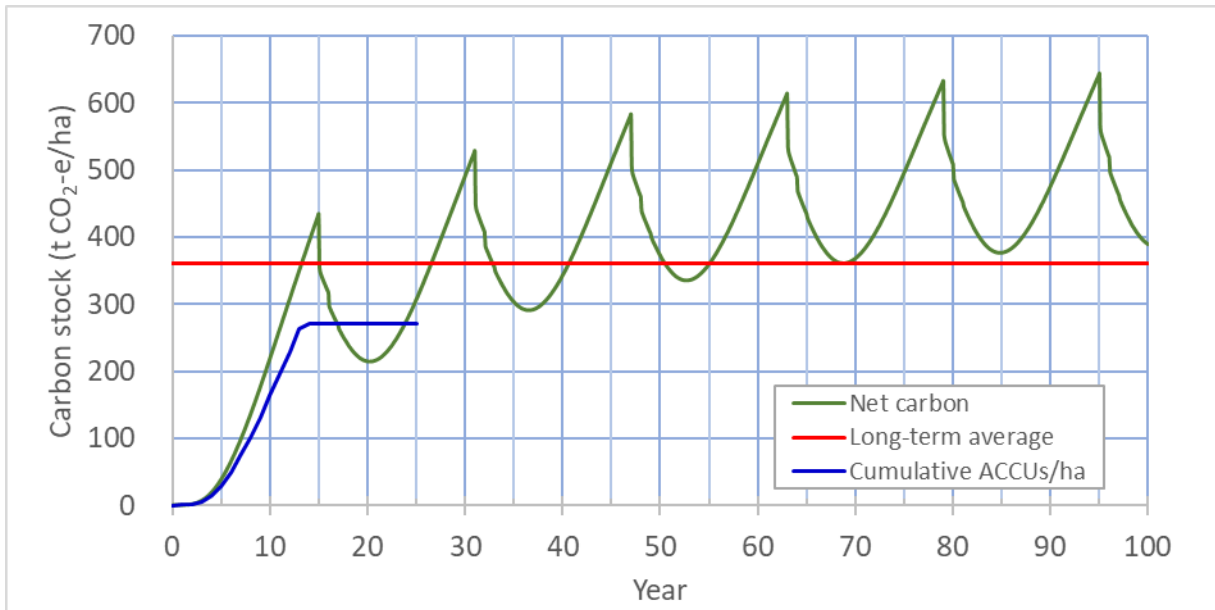


Figure 8: Carbon profile for 17-20, point ID 726, total claimable ACCUs = 271.0/ha

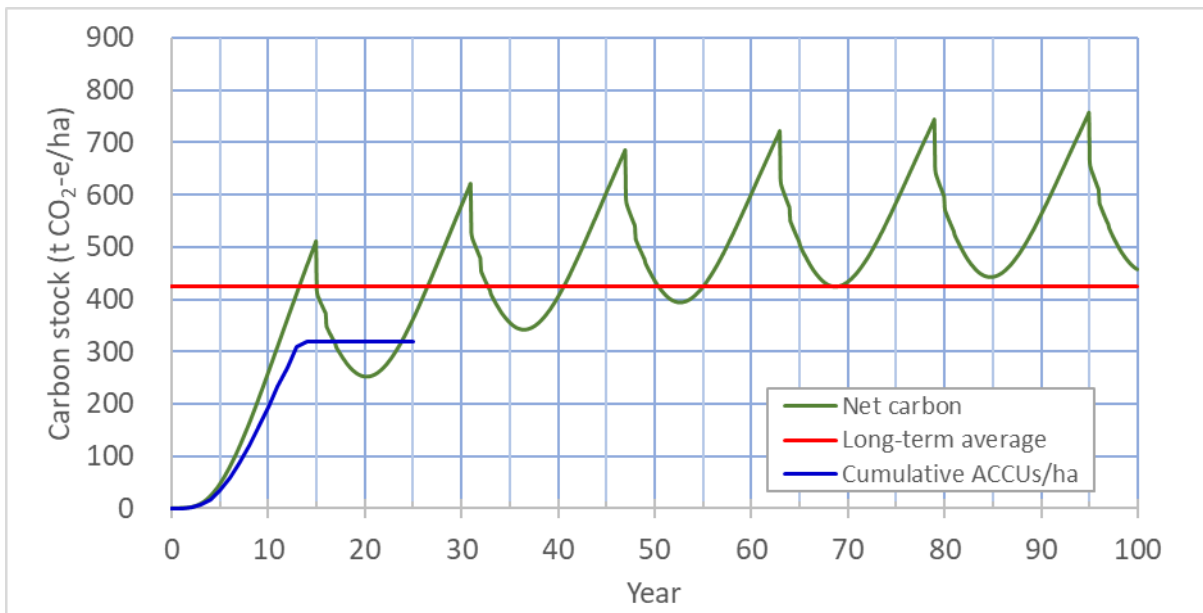


Figure 9: Carbon profile for 20+, point ID 2110, total claimable ACCUs = 319.0/ha

### 3.4.2 Long rotation 1 thin

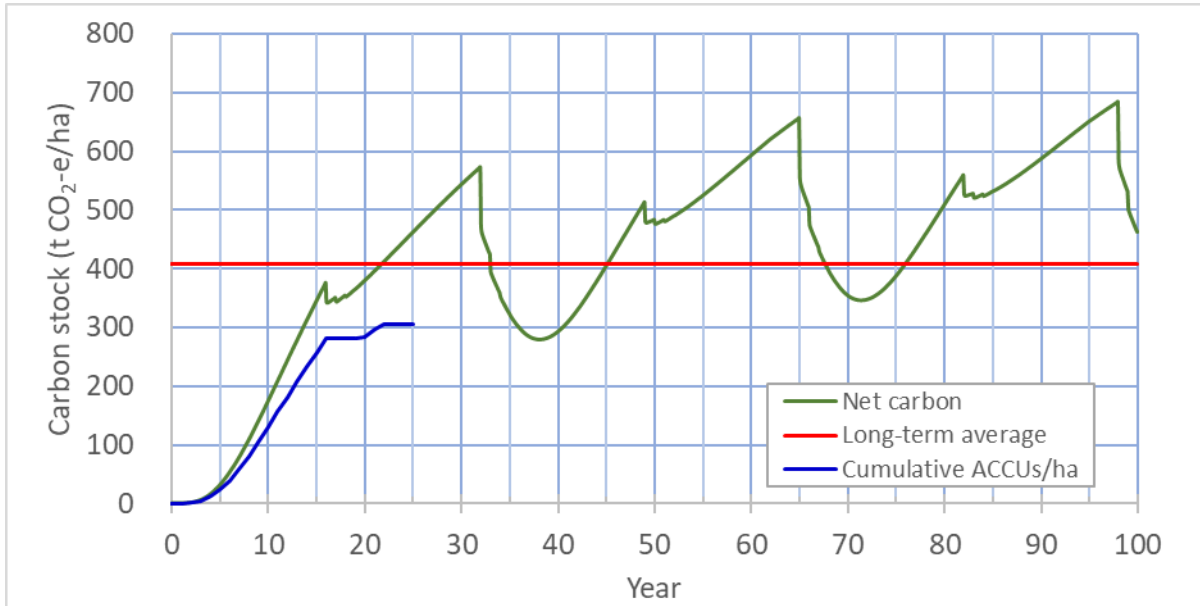


Figure 10: Carbon profile for 11-13, point ID 190, total claimable ACCUs = 305.7/ha

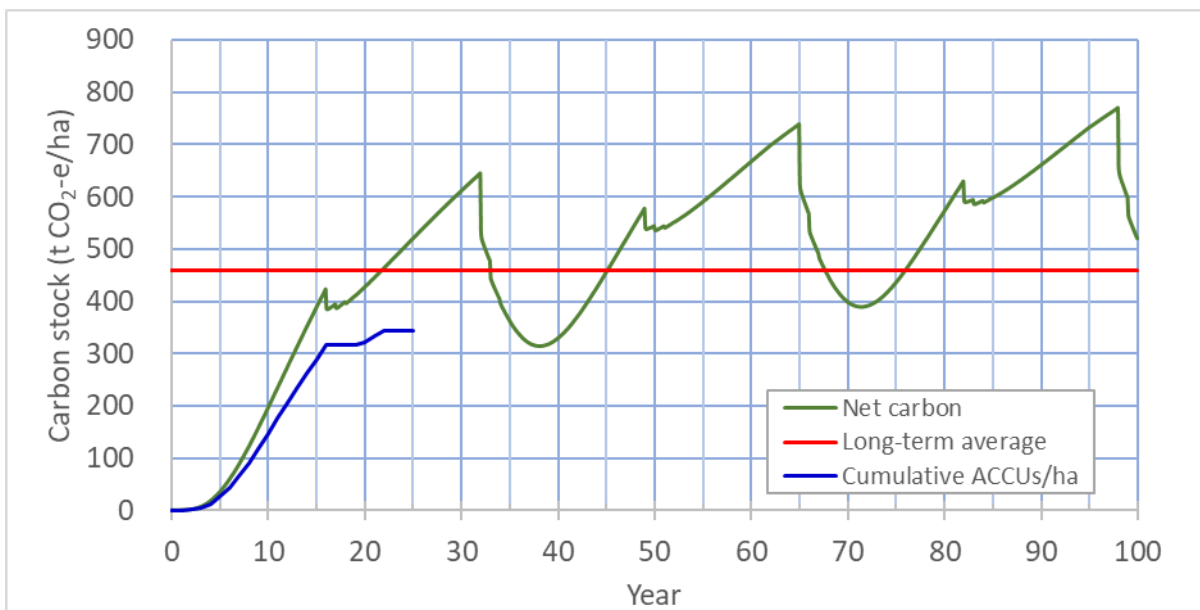


Figure 11: Carbon profile for 13-17, point ID 795, total claimable ACCUs = 344.7/ha

Note that a single thinning regime is not presented for 17-20 or 20+ because such a regime was not considered appropriate by the Hub project manager.

### 3.4.3 Long rotation 2 thins

Note that a two-thinning regime is not presented for 11-13 because such a regime was not considered appropriate by the Hub project manager.

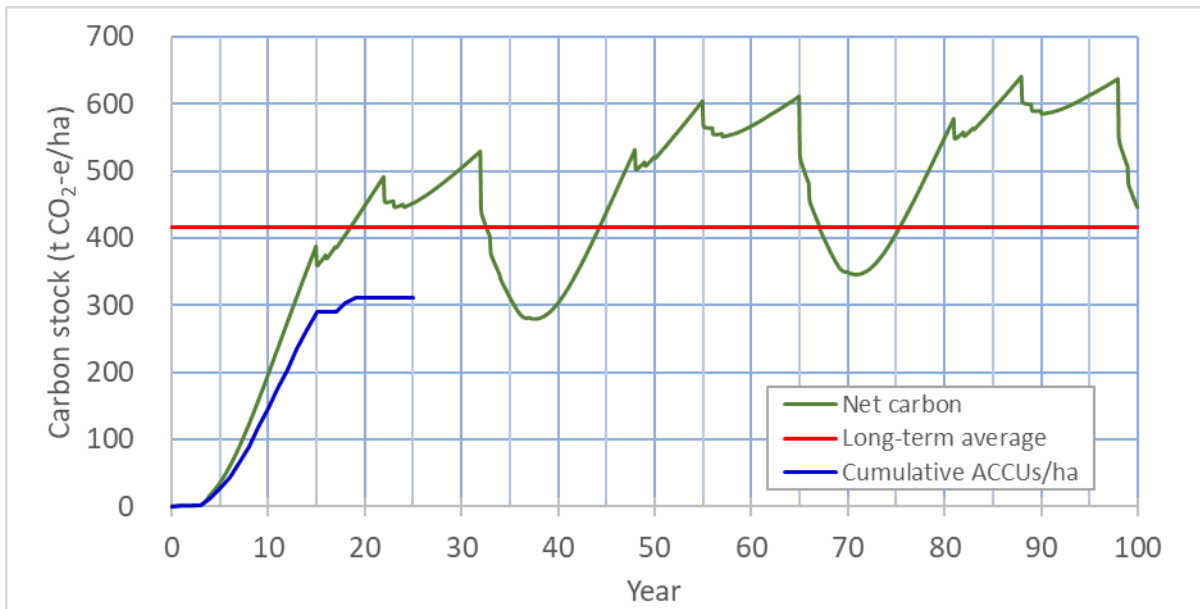


Figure 12: Carbon profile for 13-17, point ID 795, total claimable ACCUs = 312.1/ha

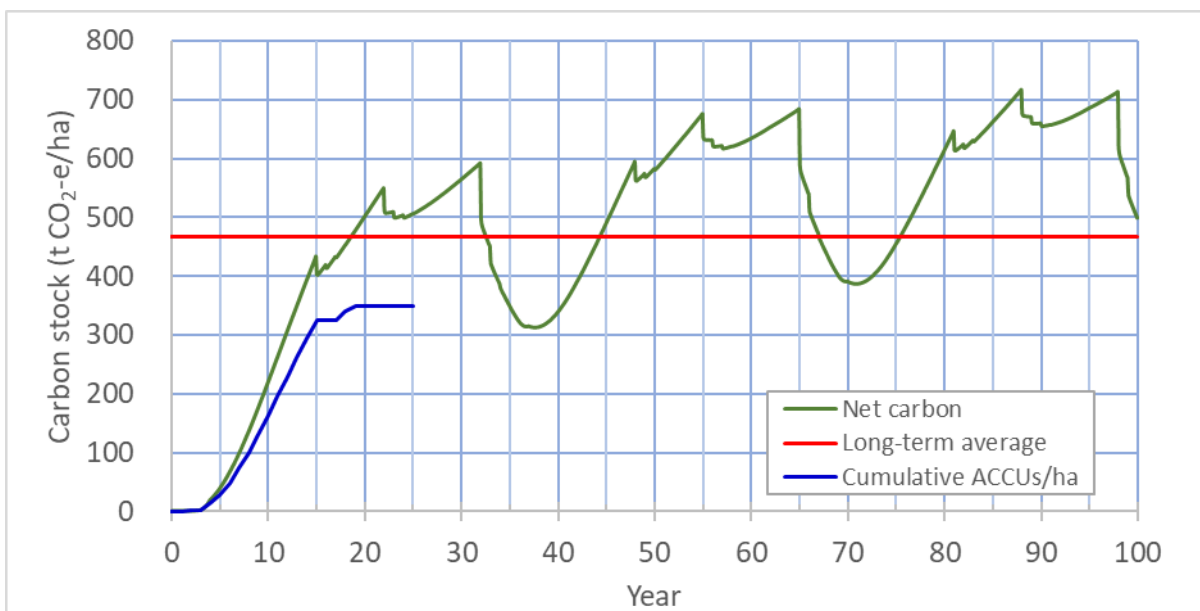


Figure 13: Carbon profile for 17-20, point ID 924, total claimable ACCUs = 349.8/ha

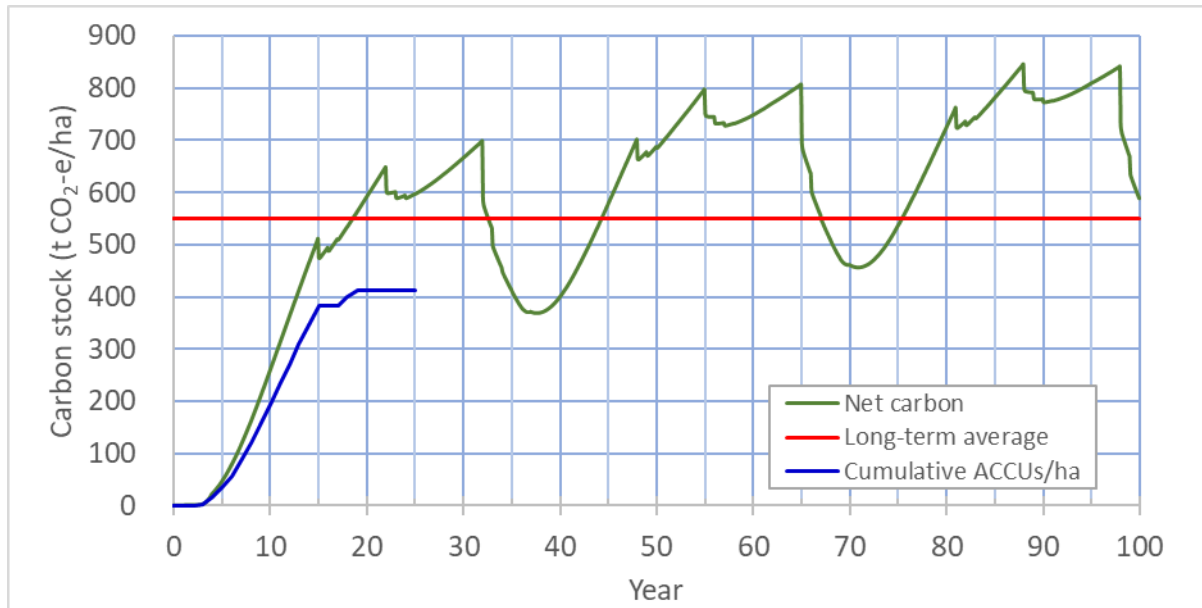


Figure 14: Carbon profile for 20+, point ID 2110, total claimable ACCUs = 412.2/ha

## 4. Conclusion

The output produced from this project will be utilised as the carbon estimate data in the Landowner Plantation Assessment Tool which, at the time of writing, is under development.

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