Forests Alive

FORESTS ALIVE PTY LTD

Carbon Stocks in the Strathbogie Ranges

An assessment of carbon stocks in the Strathbogie Ranges and the potential carbon emissions as a result of harvesting trees in the area for wood products

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1 Contents

2 Acronyms

3PG: Tree Growth Model in FullCAM

CAMAg: Carbon Accounting Model, Agriculture

CAMFor: Carbon Accounting Model, Forest

CER: Clean Energy Regulator

CFI: Carbon Farming Initiative

CO_2e: Carbon Dioxide Equivalents

ERF: Emissions Reduction Fund

EVC: Ecological Vegetation Class

FullCAM: Full Carbon Accounting Model

GENDEC: Litter Decomposition Model in FullCAM

GIS: Geographical Information Systems

NCAS: National Carbon Accounting System

NFP: National Forest Policy

RothC: Soil carbon turnover model in FullCAM

SA2: Statistical Area Level 2 (from the Australian Statistical Geography Standard)[1]

3 Definitions

Aboveground biomass: All live material in a tree above the level of mineral earth and includes the stem and crown.

Belowground biomass: All live material in a tree below the level of mineral earth and includes the tap root or lignotuber, and the lateral roots.

Biodiversity: Variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Carbon Carrying Capacity: The amount of carbon terrestrial ecosystems can store when averaged over an appropriate time scale and area.

[1] Australian Bureau of Statistics, 2011. Australian Statistical Geography Standard (ASGS): Volume 1 – Main Structure and Greater Capital City Statistical Areas, July 2011. http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/88F6A0EDEB8879C0CA257801000C64D9

Carbon Farming Initiative: The Australian Federal Government initiative to allow farmers and land managers to earn carbon credits by storing carbon or reducing greenhouse gas emissions on the land. The Carbon Farming Initiative is a legislated carbon offsets scheme.[2]

Carbon Pool: Above ground biomass, below ground biomass, debris, soil or wood products where carbon could be stored.

Carbon Stock: The quantity of carbon held within the area at that time within each carbon pool.

Clean Energy Regulator: The regulatory body overseeing the implementation of the Emissions Reduction Fund.

CO_2 Equivalents: A measurement to describe how much global warming a given type and amount of greenhouse gas may cause, using the functionally equivalent amount or concentration of carbon dioxide (CO_2) as a reference. For example, 1 tonne of carbon has the CO_2 equivalent of 44/12, or 3.6667 tonnes of CO_2.

Deforestation: The direct human-induced conversion of forested land to non-forested land.

Direct Action: The overarching Australian Government policy to "efficiently and effectively source low carbon emissions reductions and improve Australia's environment.[3]

Emissions Reduction Fund: A framework to provide incentives for emissions reduction activities across the Australian economy.[4]

Forest (as a technical definition under the ERF): Land of a minimum area of 0.2 of a hectare on which trees:

(a) have attained, or have the potential to attain, a crown cover of at least 20% across the area of land; and
(b) have reached, or have the potential to reach, a height of at least 2 metres.

Forest Degradation: The reduction in forest canopy, but not the conversion of forest to another land use.

FullCAM: The latest publicly released version on the Department's website of the Full Carbon Accounting Model used to model forest carbon stocks associated with land use and management for Australia's National Greenhouse Gas Inventory, and includes related databases and spatial inputs used by FullCAM for its calculations.

Land Clearing: In this report shares the same definition as *deforestation*.

On-site Carbon (also C mass on site): The sum of the carbon stock within each carbon pool that is included in the FullCAM assessment

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[2] Australian Government, Comlaw, 2011. Carbon Credits (Carbon Farming Initiative) Act 2011. https://www.comlaw.gov.au/Series/C2011A00101/Amendments

[3] Australian Government, Department of the Environment, 2015. Clean Air. https://www.environment.gov.au/clean-air

[4] Australian Government, Department of the Environment, 2015. Emissions Reduction Fund. https://www.environment.gov.au/climate-change/emissions-reduction-fund

Reforestation: The direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989

Regeneration: The re-growing of native vegetation and tree stems from in situ seed, rootstock or lignotuber sources in a carbon estimation area.

Revegetation: a direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares and does not meet the definitions of afforestation and reforestation.

Thinning: the selective killing of trees for ecological purposes, including to maintain species diversity or ground cover.

Tree: a perennial plant that has primary supporting structures consisting of secondary xylem.

Tree Harvesting: The removal of trees for the creation of wood products.

4 Summary

An emissions assessment has been conducted for planned harvest and burning activities in the Strathbogie Ranges. A summary of emissions is presented in Table 1. The analysis includes an assessment of emissions from decaying debris and wood products created as a direct result of the harvest. This summary assumes only one harvest occurs. A comparative scenario has been presented in section 7.3 to model harvest events every 40 years.

An analysis of vegetation regrowth after a harvest event is also included. Although models indicate significant carbon gains from tree growth over 100 years, successful regeneration is not a given, as explained in section 7.1.1 of this report.

When a harvest emission occurs and when the carbon can sequestered back in to the vegetation is also an important factor to consider. This is explored in section 7.3.

Table 1. Summary of emissions from burning and harvesting activities in the Strathbogie Ranges

Cause of emissions	Emissions in 2016 tCO_2e	Emissions between 2017 and 2116 tCO_2e	
Burning vegetation	42,838	76,537*	
Immediate vegetation loss due to harvest	53,339	0	
Decay of debris as a result of harvest	0	88,081	
Decay of wood products created from harvesting	0	70,616	
Carbon decay in soil	0	11,033	
Sub total	**96,177**	**246,267**	
TOTAL		**342,444**	**Equivalent to the annual emissions of 177,433 cars**[+]
Sequestration from vegetation regrowth re-seeding [$]		**287,749**	

* Burning activities expected to be conducted in 2017 and 2018.

[$] Assuming no future harvest events and no natural disturbances

[+] Based on average Australian car use.

5 Introduction

Forests Alive used a combination of GIS files provided by the Euroa Environmental Group and FullCAM to assess the carbon stock of trees in the Strathbogie Ranges. Four GIS layers were provided, two showing the extent of vegetation for 1970 and 2005, one showing the extent of planned logging activities in the area and one showing the extent of planned prescription burns.

Through the linking of Ecological Vegetation Class (EVC) Group Names (provided in the GIS layers) and FullCAM forest types, Forests Alive was able to use FullCAM to estimate the total carbon stock in 1970, and also estimate the loss of carbon stock by 2005 due to the loss of vegetation extent.

The carbon stock of trees in the area set aside for logging has been calculated to determine the loss of carbon in that area if logging were to take place. The carbon stock here is presented as two values, the first where the carbon stock is at carrying capacity, and the second where the vegetation is 40 years old, or 60% of the carrying capacity. This was due to information being found which indicates the area has been logged previously 30-50 years ago.

A full carbon accounting assessment has been conducted to demonstrate the carbon flow and emissions for 100 years from the point of harvest. For this assessment it was assumed the vegetation was 40 years old before harvesting.

Similar assessments have been conducted for the area where planned prescription burns are to take place. For this assessment the carbon stock is assumed to be at carrying capacity which may lead to an over-estimation of the emissions from these activities.

From these assessments the social and financial value of the carbon stocks can be calculated. Values can also be assigned to the emissions from logging and fire management. The social cost of carbon is the result of academic work by Stanford University in the USA, where by the effect of one ton of CO_2 emitted to the atmosphere can be equated to the cost climate change will have on livelihoods. The financial value of emissions is the current price the Australian Government is paying to offset emissions to meet emission reduction targets.

A common argument used to support the harvesting of trees is that carbon will be locked up in the wood products and with the additional carbon sequestered in newly planted trees more carbon will be stored in carbon pools than emitted into the atmosphere. Though carbon is held in wood products, current accepted rates of wood product decay demonstrate the pools are not infinite stores of carbon. Waste from the harvesting and milling processes also contributes to a loss of carbon immediately after the harvesting event and debris created by the process decays slowly over time. Section 7 provides useful diagrams to help demonstrate the differences in carbon stocks and emissions in a 100 year period.

A final point to consider is when the atmosphere will "see" the emissions from a harvest event. On average the atmosphere will see 7 years of emissions as a result of the harvest taking place before the regrowth of vegetation leads to annual carbon sequestration surpassing annual emissions. The emissions will be certain, yet the regrowth of vegetation will not be. The increase in drier weather conditions in Australia will mean increased likelihood of drought and fire which will hamper vegetation recovery.

6 Estimation of potential tree carbon stocks in Strathbogie Ranges

6.1 Estimated Carbon Stocks of 1970

The GIS layer provided by Euroa Environment Group has been used to determine the potential tree carbon stock in the Strathbogie Ranges in 1970. To calculate the carbon stock it is assumed that the vegetation was at maximum carrying capacity.

EVC Group names were matched with Forest Types within FullCAM (shown in Table 2) to provide reasonable estimations of carbon stocks within the Strathbogie Ranges.

Table 2. EVC Group names and their pairing with FullCAM Forest Types.

EVC Group Name	FullCAM Forest Type
Box Ironbark Forests or dry/lower fertility Woodlands	Eucalyptus open forests
Dry Forests	Eucalyptus open forests
Lower Slopes or Hills Woodlands	Eucalyptus Woodland
Plains Woodlands or Forests	Eucalyptus Woodland
Riparian Scrubs or Swampy Scrubs and Woodlands	Melaleuca Forest and Woodland
Riverine Grassy Woodlands or Forests	Eucalyptus Woodland
Rocky Outcrop or Escarpment Scrubs	Heath
Wet or Damp Forests	Eucalyptus Tall Open Forest

For this assessment a focus area has been defined as the most contiguous vegetation cover in the Strathbogie Ranges, and the area most at risk from logging and burning activities (a map of this area is provided in Figure 1). It is estimated that the native vegetation extent within the focus area in 1970 covered 33,682 ha. If the vegetation was at carrying capacity the total tree carbon stock is estimated to have been 4,402,110 tC. This is an average carbon stock of 131 tC/ha, as shown in Table 3.

Table 3. Estimated tree carbon stocks in the Strathbogie Ranges in 1970

FullCAM Forest Types	Area (ha)	Tree Carbon Stock (tC)	Carbon Stock (tC/ha)
Eucalyptus Open Forests	31,973	4,212,234	131.7
Eucalyptus Tall Open Forest	1,108	109,178	98.5
Eucalyptus Woodland	73	6,897	94.1
Heath	168	30,350	180.2
Melaleuca Forest and Woodland	360	43,451	120.8
TOTAL	**33,682**	**4,402,110**	**130.7**

6.2 Estimated Carbon Stocks of 2005

An assessment of vegetation extent in 2005 indicates 20% of the area vegetated in 1970 has been converted to softwood plantation. This is an estimated loss of 1,014,500 tonnes of carbon from native vegetation. The results of the carbon stock assessment for native vegetation extent in 2005 are presented in Table 4.

The assessment assumed that the vegetation was at carrying capacity in 2005, as it was in 1970. Information on past logging would suggest some areas will have vegetation between 30 and 50 years old, and will therefore not be at carbon carrying capacity.

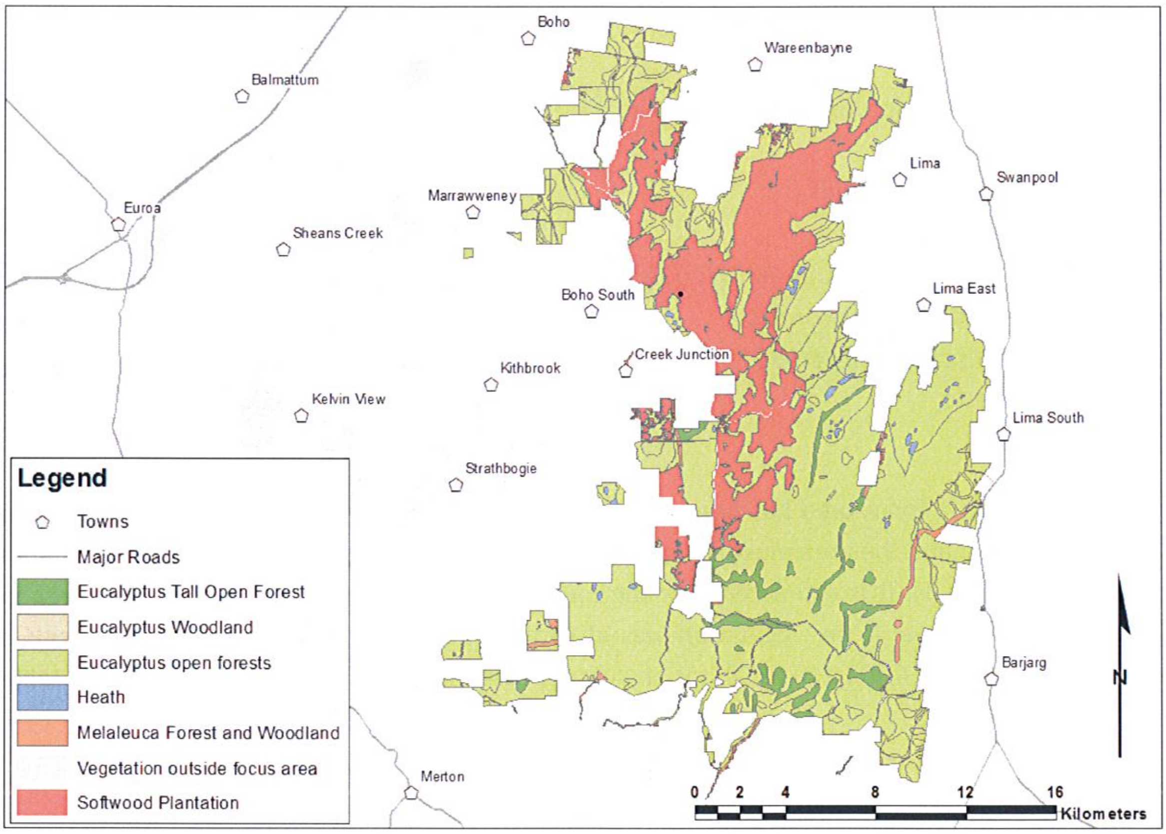

Figure 1. FullCAM Forest Types in 2005 in the project focus area. Red areas indicate where native vegetation has previously been logged and replaced with softwood plantation.

Table 4. Estimated tree carbon stocks in the Strathbogie Ranges in 2005.

	Area (ha)	Tree Carbon Stock (tC)
Eucalyptus open forests	24,710	3,206,459
Eucalyptus Tall Open Forest	1,085	106,917
Eucalyptus Woodland	39	3,847
Heath	168	30,292
Melaleuca Forest and Woodland	328	40,135
TOTAL	**26,331**	**3,387,560**

7 Estimated emissions from planned logging activities in Strathbogie Ranges

To calculate the carbon emissions from planned logging activities in the Strathbogie Ranges, the model has assumed that logging events take place in 2016, and projected the carbon flow through wood products, forest debris and regrowth vegetation over 100 years. 100 years is the default model period for all the land based methods under the Emissions Reductions Fund (despite projects lasting for 25 or 100 years).

This timeframe allows for a reasonable length of time to account for decay in wood products and the regrowth of any seeded vegetation after a harvest event.

The Strathbogie Ranges Conservation Management Network's website[5] states that the planned logging is taking place on coups logged previously, and that the vegetation is 30, 40 and in some cases 50 years old. It is therefore assumed the vegetation is 40 years old by 2016. An initial harvesting event is modelled in 1976 to determine the likely volumes in 2016. When harvesting events were modelled, it was assumed that the area was clear-felled and re-seeded. Victoria Forests have indicated they are moving towards the harvesting practice of single tree selection. If figures can be obtained to understand the percentage of site mass removed from this type of practice, this percentage can be applied to the numbers presented below to get a more accurate picture of carbon stock losses and gains.

As Table 5 shows, according to FullCAM 40 year old vegetation has a tree carbon stock 60% of the carrying capacity.

Table 5. A comparison of tree carbon stocks of vegetation at carrying capacity and at 40 years old within the planned logging coupes.

	Carrying Capacity	40 year old vegetation
Total carbon stock of trees (tC)	100,121	59,088
Total area to be harvested (ha)	726	726
Carbon stock of trees (tC/ha)	137	81

The map provided in Figure 2 shows the location of proposed logging coupes with relation to the expected carbon stocks at carrying capacity in the Strathbogie Ranges.

[5] Strathbogie Ranges Conservation Management Network, http://www.strathbogierangescmn.com/projects/logging-strathbogie-forests/

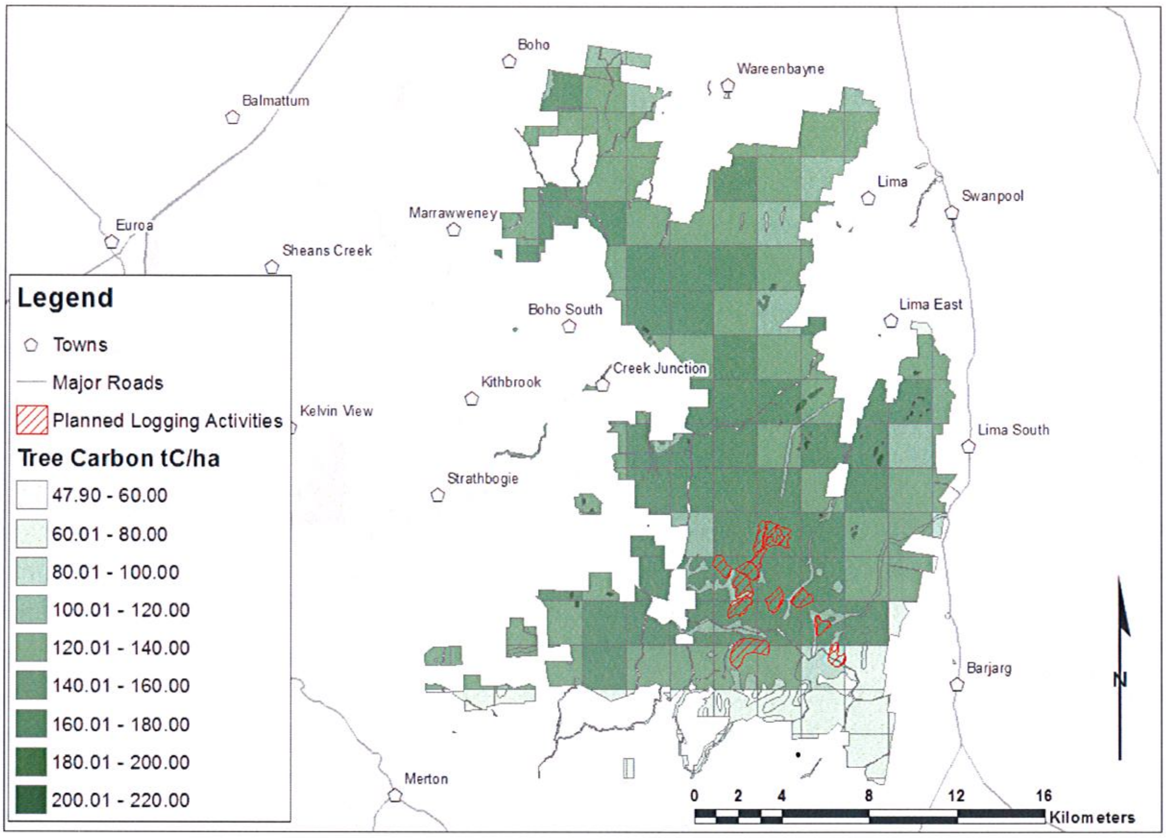

Figure 2. A map of the proposed logging area and the estimated potential carbon stocks (at carrying capacity) of native vegetation in the Strathbogie Ranges.

7.1 Carbon stocks volumes as a result of harvesting vegetation

For the purposes of the initial assessment, only one event is modelled in the harvest scenario. Without future protection, or if a business as usual scenario remains for the next 100 years, it is reasonable to expect harvesting to have occurred every 40 years.

7.1.1 Carbon in Trees

The model indicated that by 2016 the total carbon stock of trees in the area was 59,088 tC. This carbon stock is lost from the tree carbon pool in a harvest event. If no regeneration occurs, this is the total carbon stock loss once all wood product pools have decayed.

Due to the re-seeding event in the model, the vegetation is shown to regenerate after the harvest and quickly accumulates carbon back in the tree carbon pool. Successful regeneration shouldn't be a given, as many factors could impede the establishment and growth of trees. Logically, in the best case scenario, it would take roughly 40 years to accumulate what is lost if 40 year old trees are harvested, provided no disturbances occur whilst the trees are young. Over 100 years, the carbon in vegetation will increase to 78,477 tC provided there are no major disturbances.

7.1.2 Carbon in Debris

Once harvested, 23,721 tC transfers to the debris carbon pool that will decay over 100 years. By 2116 only 2,373 tC remains in this pool, meaning 90% of carbon in this pool will be emitted to the atmosphere over 100 years.

7.1.3 Carbon in Wood Products

From harvesting, 20,622 tC would be transitioned to a wood product pool. FullCAM has 7 wood product carbon pools which 90% of harvested biomass transitions to (Table 6). The remaining 10% of harvested biomass transitions to a deadwood pool. Each pool decays at a different rate.

Of the 20,622 tC transitioned into a wood product pool, 1,363 tC will remain by 2116. The carbon remaining would predominantly be in sawlog products used in construction. It is unlikely that 20% of the wood products extracted from the Strathbogie logging coupes will be suitable for construction purposes as the FullCAM default values suggest. By using the default values in FullCAM, wood product decay is conservative.

Table 6. Default FullCAM wood product pools and their decay rates.

Wood Product Pool	Percentage of harvested biomass	Decay rate (% per year)
Deadwood	10	10
Biofuel	0	100% burnt in year of harvest
Paper and pulp	30	29.29
Packing wood	30	2.73
Furniture	0	2.73
Fiberboard	5	2.73
Construction	20	1.96
Mill Residue	5	100

7.1.4 Total carbon stock change

The total carbon stock at the end of the harvest scenario is 94,466 tC, which is a total sequestration of 18,177 tC over 100 years.

The volume of the carbon pools in the harvest scenario is shown in Figure 3.

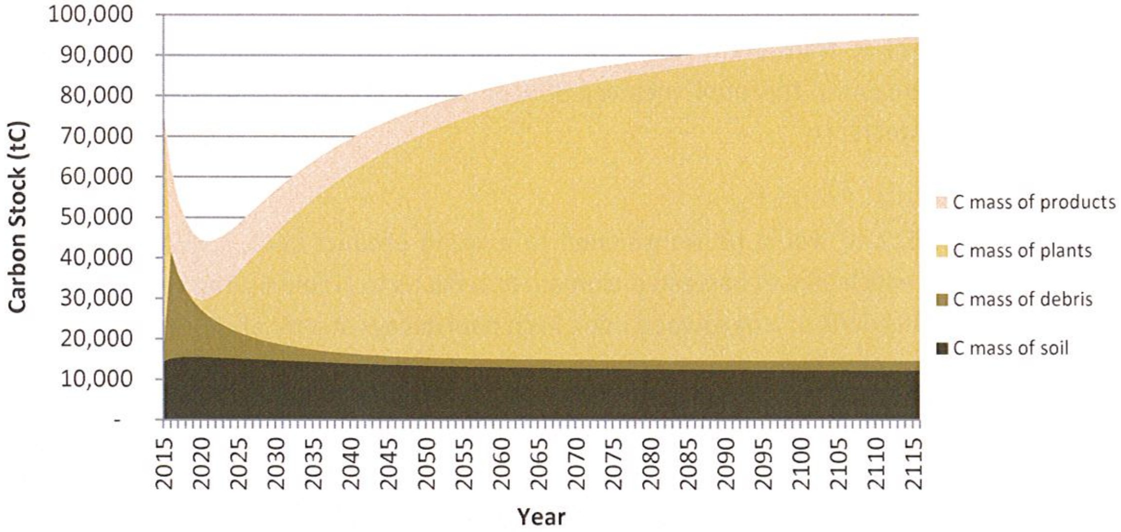

Figure 3. The volume of the carbon pools over 100 years if the vegetation is harvested in 2016.

7.2 Carbon stocks volumes as a result of protecting vegetation

Without any harvest, the vegetation will continue to accumulate carbon over time. In this scenario, debris and soil carbon pools remain fairly constant. Provided there are no disturbances, the total carbon stock will increase to 97,367 tC, a total carbon sequestration of 21,078 tC over 100 years.

The volume of the carbon pools in the harvest scenario is shown in Figure 4.

It is assumed no natural disturbance such as fire occurs in the protection and harvest scenarios.

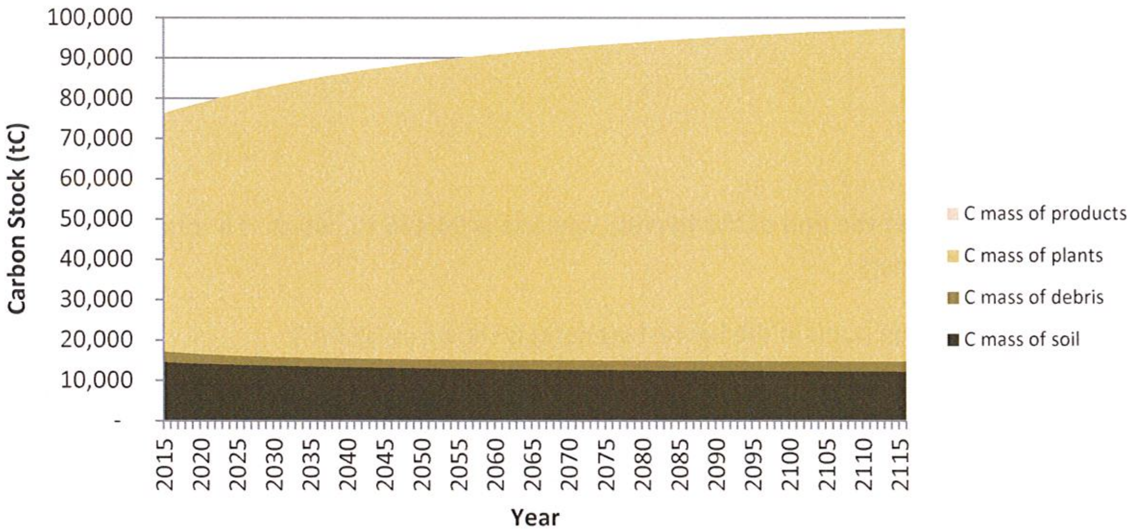

Figure 4. The volume of the carbon pools over 100 years if the vegetation is protected.

7.3 Calculating Carbon emissions from the logging of vegetation

FullCAM shows that the total carbon stock (the total carbon in vegetation, debris and wood product pools) in the harvest scenario will always be lower than the carbon stock in the protection scenario. The carbon lost from logging is the difference in carbon stock between the two scenarios over time. This is shown in Figure 5.

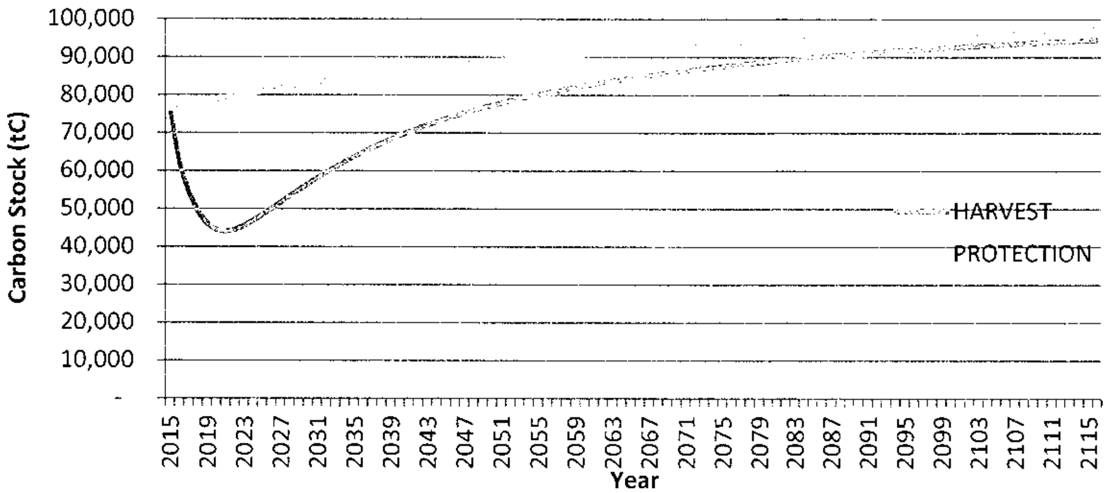

Figure 5. Total carbon stock volumes for both the harvest and protection scenarios.

The carbon emissions over time are calculated from the difference of the losses or gains of carbon each year between the harvest and protection scenarios. Carbon emissions are displayed in CO_2 equivalents (or CO_2e) to represent the quantity of CO_2 emitted from the loss of carbon. This is done by multiplying the carbon stock by 44/12 (3.6667).

Over 100 years, the net carbon emissions from the harvest would be 10,593 tCO_2e. Although this is a small volume, it doesn't describe what the atmosphere sees each year. In the first 7 years after harvest, the atmosphere will see emissions of roughly 53,000 tCO_2e. After 7 years, the carbon sequestered in tree growth annually will surpass any of the carbon emissions from the decay of wood products or debris each year (shown in Figure 6).

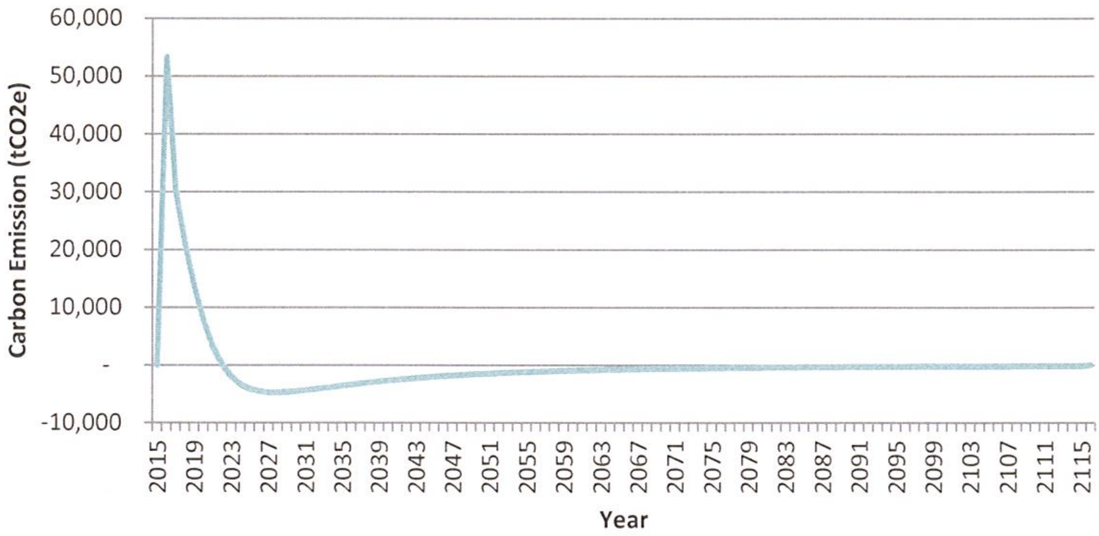

Figure 6. Total carbon emissions, as seen by the environment from a 2016 harvest event, note the negative values from 2024 onwards.

The upfront emissions are important when considering the cost of carbon emissions. This is demonstrated by applying the social cost of carbon to the emissions over time. Stanford University describes the social cost of carbon as follows: "If climate change affects not only a county's economic output but also its growth, then that has a permanent effect that accumulates over time, leading to a much higher social cost of carbon". They found the value to be $220 per ton (in US dollars). By applying US$220 per ton to the emissions from the logging event, and including a 5% discount rate over time, the social cost of emissions from this logging event is just under US$15.7 million. If no discount value is used, the social cost is US$2.1 million. Figure 7 is provided to show the effect of different discount rates to the social cost.

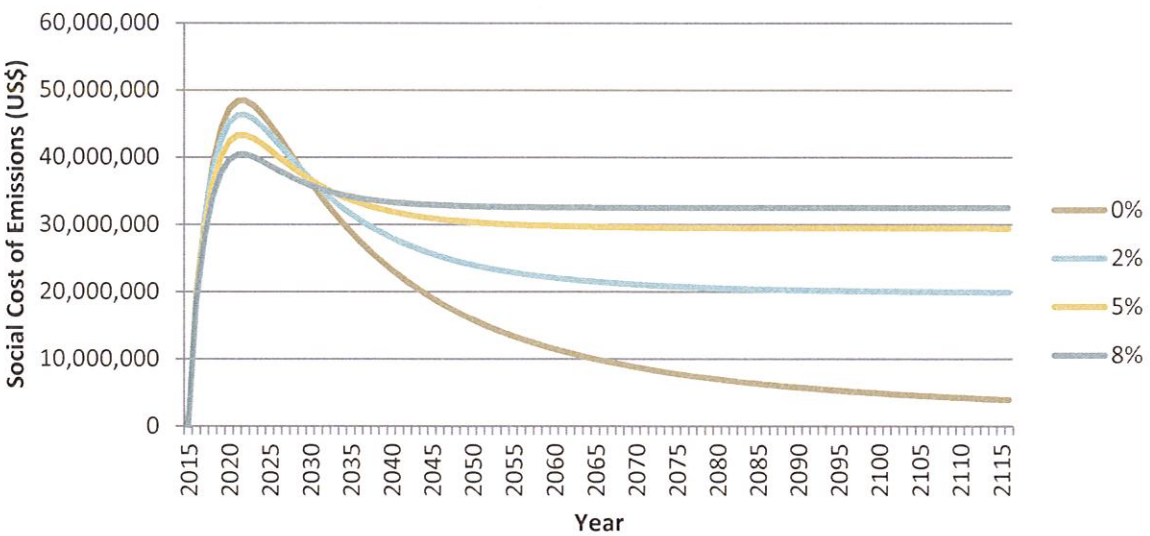

Figure 7. The cumulative present values for emissions over time when the cost of carbon emissions is US$220 per ton. Different discount rates (0, 2, 5 and 8%) have been used for comparison.

Other values for the carbon emissions could be applied, for example of price of carbon as determined by the ERF auctions. In the first ERF auction the government purchased carbon for AU$13.95 per tCO_2e, decreasing to AU$12.25 in the second auction. This is a value of AU$147,775 and AU$129,767 respectively when no discount rates are applied.

If harvesting was to occur every 40 years, three harvesting events would be avoided over a 100 year span from the first harvesting event. This creates a carbon emission, not a sequestration, over the 100 year period, emitting a total of 110,371 tCO_2e. At the value of the last ERF auction, AU$12.25 per tonne, avoiding these carbon emissions would have a value of AU$1,352,045 (with no discounting applied). Figure 8 shows the carbon stocks in each of the pools over 100 years in this scenario and Figure 9 shows the emissions created as a result.

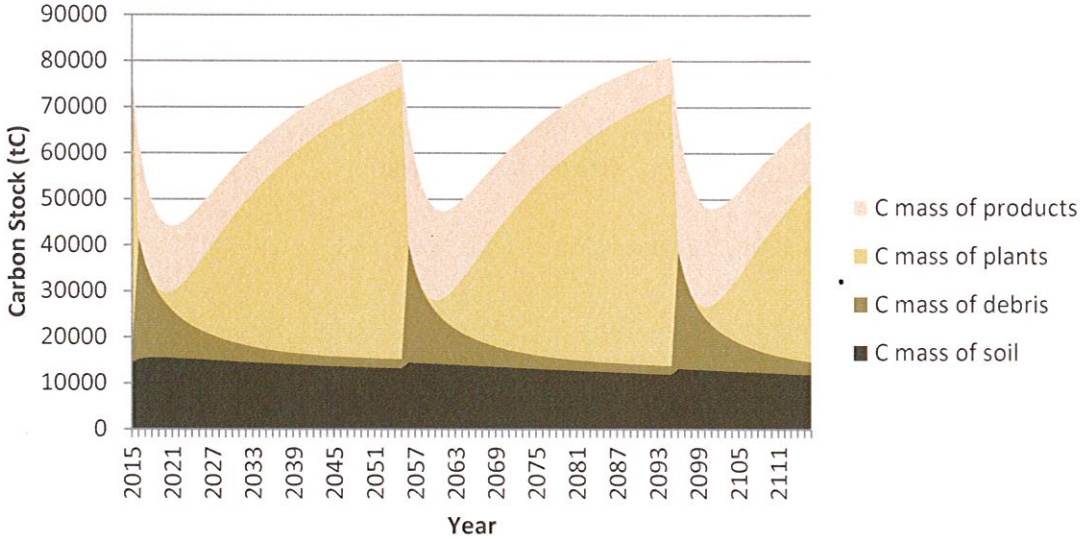

Figure 8. The volume of the carbon pools over 100 years if the vegetation is harvested in 2016, 2056 and 2096.

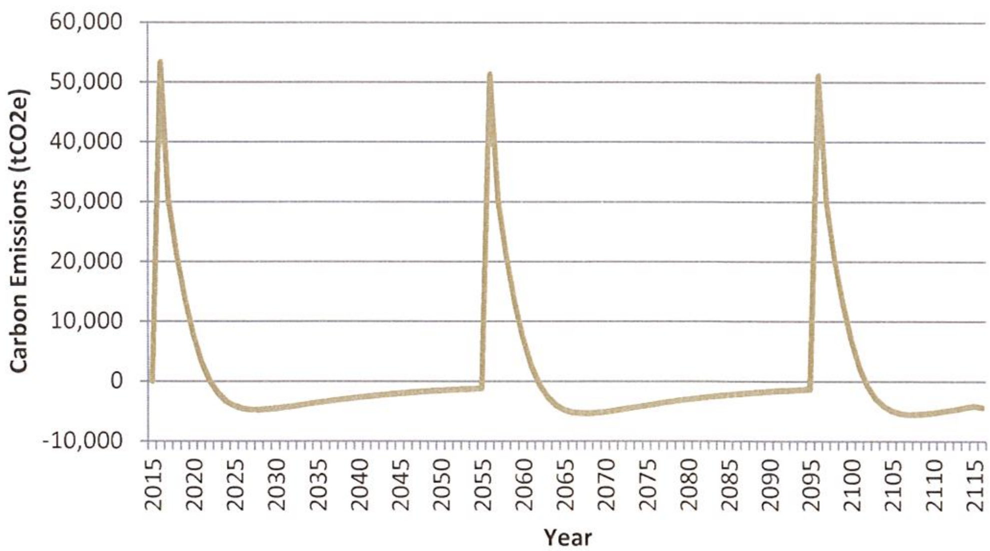

Figure 9. Total carbon emissions, as seen by the environment from one tree harvest in 2016, 2056 and 2096.

A comparison of average carbon stocks in the three scenarios (40 year logging rotations, one off harvest event in 2016 and protection) has been provided in Figure 10.

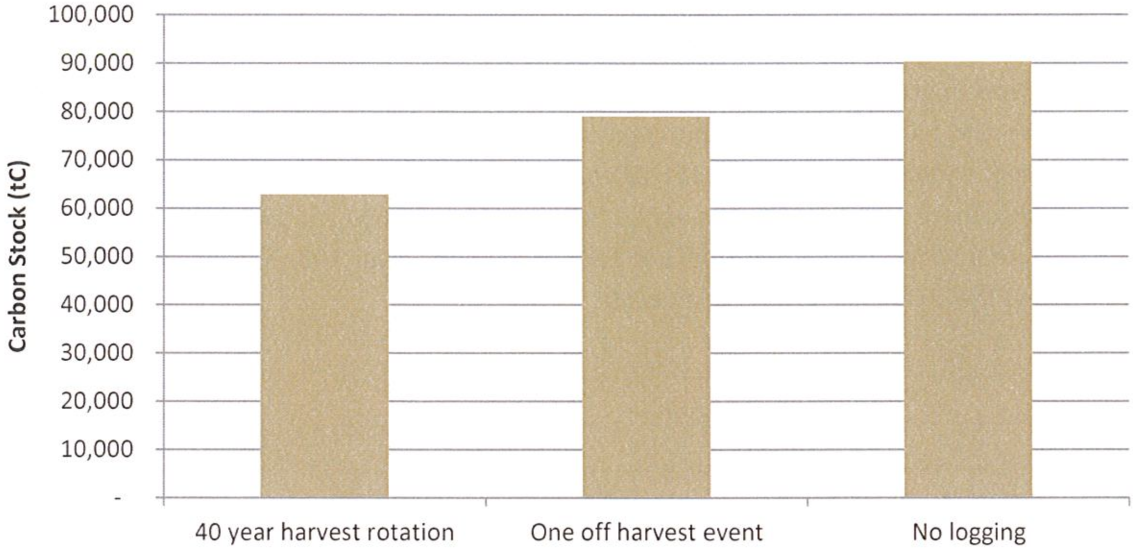

Figure 10. Average carbon stock (tC) of three different scenarios for a 100 year period.

8 Estimated emissions from planned burning activities in Strathbogie Ranges

Forests Alive has assessed the areas set aside for prescribed burning. The total carbon stock of trees in the 8,346 ha of forest inside the burning area is 0.685 million tC (shown in Figure 11). This is assuming the vegetation is at 40 years of age. FullCAM has been used to determine the emissions that would be created if the planned burning were to take place. Prescribed burning in FullCAM only affects the carbon in bark and leaf pools (decreasing the carbon in these pools by roughly 10%). This is a loss of about 0.5% from the total carbon in the total tree carbon pool.

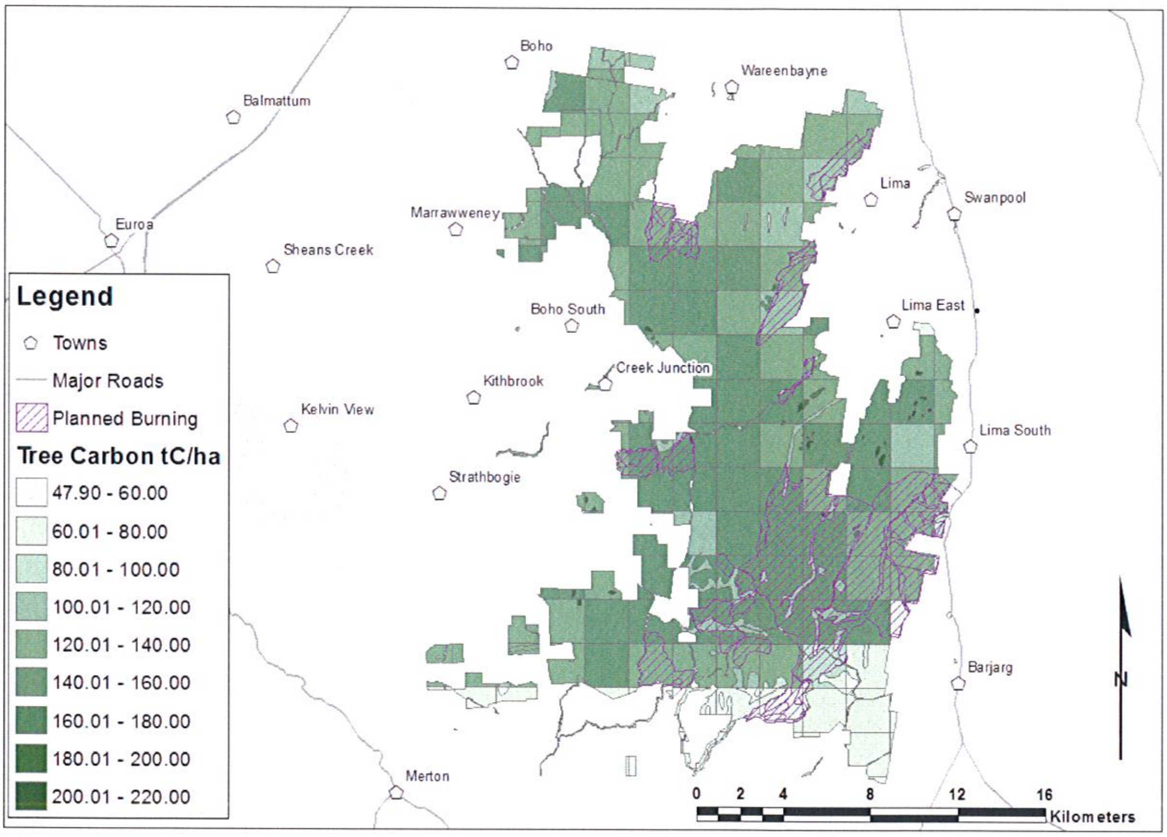

Figure 11. A map of the proposed burning area and the estimated carbon stocks (at carrying capacity) in the Strathbogie Ranges.

When vegetation is burnt, methane (CH_4) and Nitrous Oxide (N_2O) are created which are greenhouse gasses in addition to CO_2. FullCAM has provided figures for the total tons per hectare of carbon, methane and nitrous oxide that would be emitted from prescribed burning. The gasses have different global warming potentials (for example 1 tonne of N_2O has greater warming potential when emitted to the atmosphere than CO_2). These figures are therefore standardised by being converted to CO_2 equivalents using global warming potential figures for methane and nitrous oxide. The carbon was converted to CO_2 using the 44/12 ratio as in previous sections. Table 7 provides the results of this assessment.

Table 7. Total emissions from the prescribed burning in the Strathbogie Ranges.

	Carbon (C)	Methane (CH_4)	Nitrous Oxide (N_2O)
Total Tonnes	2,644	19	353
Global Warming Potential factor	44/12	21	310
Total Emissions (CO_2 equivalents)	9,694	398	109,283

The total emissions from the burning of this area is 119,375 tCO_2e. This is an average of 15 tCO_2e per hectare. That is the equivalent of driving a new car (manufactured in 2014) over 967 million kilometres[6]. This is the rough equivalent of fuel emissions from 62,000 cars in one year.[7]

[6] Based on a figure of 123.4 g CO_2/km as calculated by the Climate Action department of the European Commission (http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm).

[7] Based on the average kilometres driven per annum for Australian drivers from Roy Morgan Research (http://www.roymorgan.com/findings/australian-moterists-drive-average-15530km-201305090702)

9 The FullCAM model

9.1 FullCAM Background

FullCAM[8] is the chosen model to assess carbon stock in forest biomass. This model has been chosen based on its prevalence in land sector carbon accounting for the National Inventory, and subsequently the Emissions Reduction Fund (ERF) (part of the Federal Government's Direct Action policy). This model is required for the implementation of several ERF methods under the Vegetation Management sector.

FullCAM models the carbon and nitrogen flows in forest systems (including activities associated with their management such as afforestation, reforestation, deforestation and agroforestry) and agricultural systems. There are several component models that make up FullCAM. These are:

- CAMFor – for forest systems;
- CAMAg – for cropping and grazing systems;
- 3PG – for forest growth;
- GENDEC – for microbial decomposition; and
- RothC – for agricultural soil carbon.

For the assessment of the carbon stocks in the Strathbogie Ranges, the selected model type is "Forest System". FullCAM recommends that this system should be used to model plantation transitioning to improved rotation plantations, native forests transitioning to plantation, or plantation transitioning to native forest or plantings[9]. A model type called "Multilayer mixed systems" should be used for agricultural systems transitioning to plantations or native forest.

There are a few justifications for the use of the "Forest System" model type over the "Multilayer mixed systems" type:

- The ERF methods for managed native forest regrowth and avoided clearing of regrowth require this model type to be used.
- It is assumed that the land has always been native forest for the purposes of this exercise; and
- There is no additional data to identify whether the land was cleared and used for agriculture before the forests were re-established.

It is important to note that FullCAM has been criticised due its reliance on site data derived from regrowth forests and plantations, and thereby under-estimating the longer term carbon carrying capacity of modelled sites[10]. Despite this, FullCAM is considered appropriate for younger age classes

[8] Australian Government, Department of the Environment, 2015. FullCAM; http://www.environment.gov.au/climate-change/greenhouse-gas-measurement/land-sector

[9] Australian Government, Department of the Environment, 2015. FullCAM Help; http://www.fullcam.com/FullCAMServer/Help/6_Configure%20the%20Plot.htm

[10] Keith, H., Mackey, B., Berry, S., Lindenmayer, D., & Gibbons, P., 2010. "Estimating carbon carrying capacity in natural forest ecosystems across heterogeneous landscapes: addressing sources of error". Global Change Biology. 16, 2971-2989.

of vegetation[11]. The application of this model is likely to provide conservative estimations of carbon stocks in covenants and properties. On site field data collection would provide better estimates of carbon stocks but gathering this type of data is a costly exercise.

The current application of the FullCAM model has been limited due to the data available in the GIS layers provided. For example, an assumption has been made about the age of the forest in 2016 (the year of planned harvest) based on information found on Strathbogie Ranges Conservation Management Network's website[12]. FullCAM default values are used for calculating the carbon stock of wood product pools after harvest due to this information being unavailable at the time of assessment. Other information such as past fire disturbances in the area were also not available.

9.2 FullCAM Carbon Pools included in this assessment

Using the "Forest System" type model, the following FullCAM carbon pools have been used:

- Carbon mass of tree components, with the following sub-sections:
  - Carbon mass of tree stems; and
  - Carbon mass of remaining tree components (carbon mass of tree components less the carbon mass of tree stems).
- Carbon mass of debris, used to calculate the emissions from decay of debris after harvesting;
- Carbon mass of soil;
- Carbon mass of products, with the following sub-sections;
  - Carbon mass of paper and pulp;
  - Carbon mass of packing wood;
  - Carbon mass of Fiberboard;
  - Carbon mass of Construction (wood); and
- Carbon mass of mill residue.

9.3 FullCAM default values for tree harvesting

When harvested, 10% of tree stem mass becomes deadwood, decaying at 10% per year after the harvest. 5% of tree stem mass becomes mill residue, a waste from the processing of wood products. The remaining 85% of tree stem mass become the wood products "Paper and Pulp" (30%), "Packing wood" (30%), "fibreboard" (5%) and "Construction" (20%).

These figures are default assumptions and are likely to vary depending on harvested tree species, quality of wood, mills in the vicinity and market. For example, the logging of the Tolmie forests produced a ratio of 4:1 woodchips to sawlog. Woodchip products do decay faster over time and are the vast majority of products are not expected to last for 100 years, unlike sawlog products which have a longer product life.

[11] Mackey, B., Keith, H., Berry, S., & Lindenmayer, D., 2003. "Green Carbon: the role of natural forests in carbon storage". ANU Press.

[12] Strathbogie Ranges Conservation Management Network, http://www.strathbogierangescmn.com/projects/logging-strathbogie-forests/

9.4 Sampling Strategy for using the FullCAM model

FullCAM uses location specific data, with a resolution of 25 by 25 meters, to determine biological productivity rates. The most influential driver of biological productivity is rainfall.

To sample the vegetation present in the Strathbogie Ranges GIS file, two grid overlays have been created at two different resolutions. The first grid overlay is at a resolution of 400 ha and covers the main area where logging and burning is expected to take place. The second grid overlay is at a resolution of 1,600 ha and covers the remaining vegetation area. Table 8 provides a summary of the two grid overlays. A map has been provided in Figure 12 to show the geographical extent of the sampling grids.

A model point is created for each FullCAM forest type in each square.

Table 8. Summary of two grid overlays for sampling vegetation in the Strathbogie Ranges.

Grid	Resolution	No. of squares	No. of model points
Primary	400 Ha	162	259
Secondary	1,600 Ha	192	266

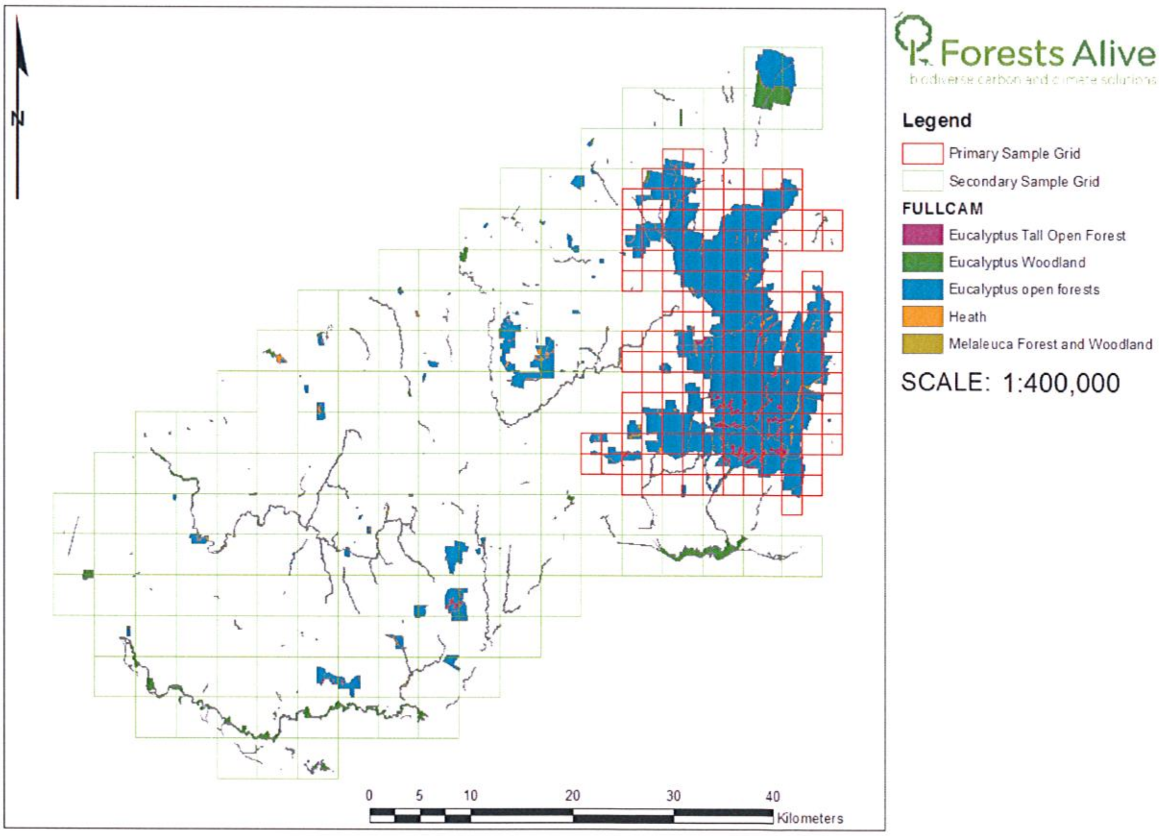

Figure 12. Geographical extent of the sampling grids.