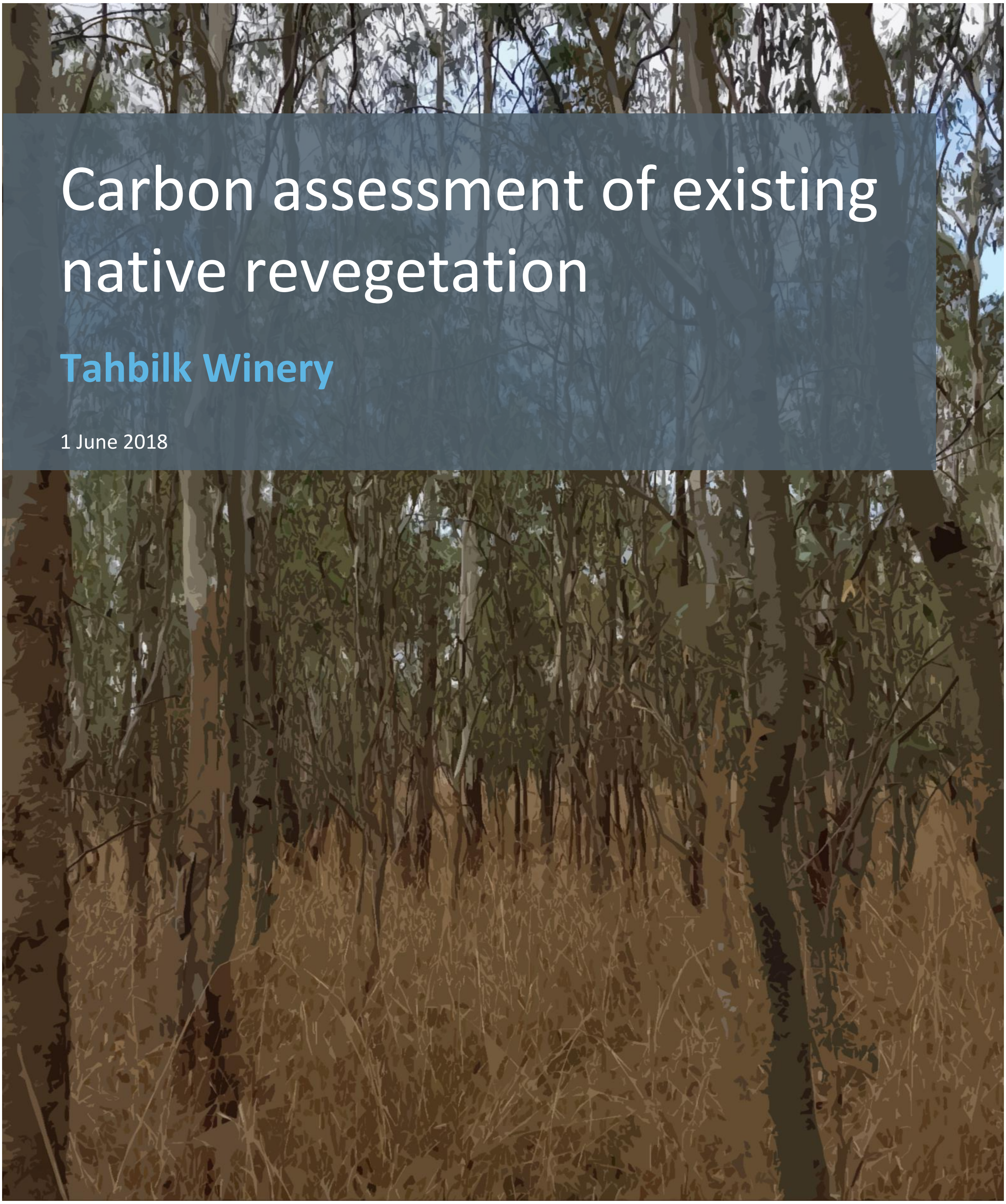
Carbon assessment of existing native revegetation

Tahbilk Winery

1 June 2018



APPROVALS

Rev	Date	Description
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1 INTRODUCTION

CO2 Australia has been engaged by Tahbilk to conduct a carbon assessment of existing plantings and natural regeneration (from hereon in referred to collectively as 'existing revegetation') on the Tahbilk estate near Nagambie, Victoria, in order to provide an estimate of current carbon stocks and carbon sequestration potential.

The purpose of this report is to provide:

- the results of the field-based assessment
- commentary about the likely impact of any management actions
- advice on whether the plantings are likely to be eligible as a project under the Emissions Reduction Fund (ERF), and if not, recommendations for aligning them with a relevant ERF method
- advice on voluntary carbon offsets that are available for purchase with a particular focus on revegetation and/or forest protection.

2 BACKGROUND

Tahbilk's revegetation program commenced in 1995 and the final set of plantings was established in 2014. The revegetation program comprised a mix of naturally regenerating forest and direct seeding or planting. In 2011, Tahbilk engaged Australian Carbon Traders to assess the carbon sequestration potential of 89 hectares of revegetation. Modelling of carbon sequestration potential was conducted using the Full Carbon Accounting Model (FullCAM), which estimated that a total of 17,355 tonnes of carbon dioxide equivalent (tCO2-e) could potentially be sequestered over a period of 40 years. This equates to an average of 195 tCO2e per hectare.

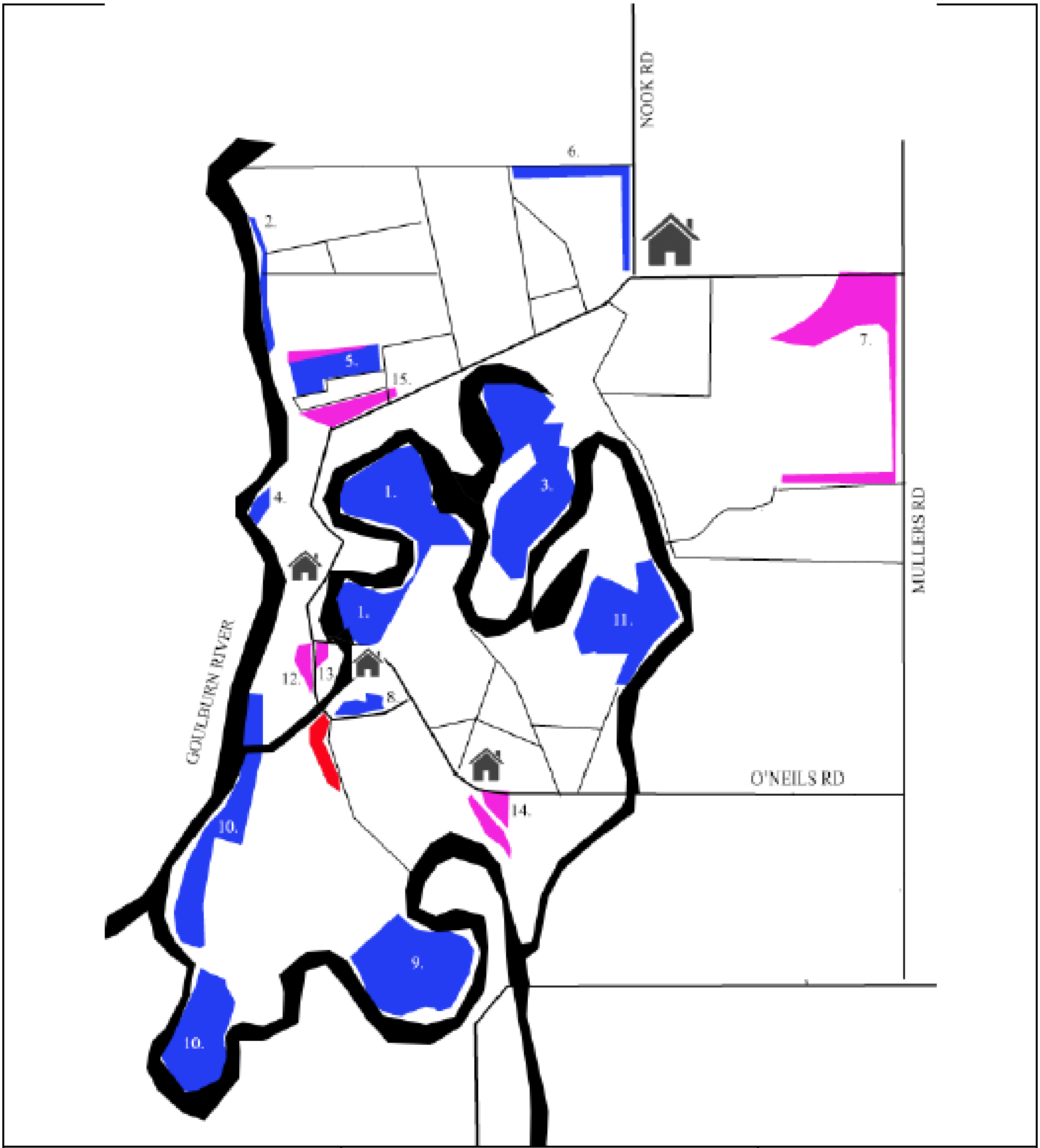
In 2012, Tahbilk engaged CO2 Australia to undertake a carbon assessment of 104.5 hectares of existing revegetation, plus an additional 55.9 hectares of potential future areas of revegetation. This assessment used a field-based measurement technique to estimate current carbon stocks, and the 3PG tree growth model to forecast future potential carbon sequestration. The results of the assessment showed that the carbon stock of existing revegetation areas in 2012 was estimated to be 20,670 tCO2-e. The future potential sequestration was estimated to be 121,580 tCO2-e by 2045 (comprising 91,779 tCO2-e from the 104.5 hectares of existing revegetation, and 29,801 tCO2-e from the 55.9 hectares of potential new revegetation), which equates to an average of 1,163 tCO2-e per hectare.

3 METHOD

3.1 CURRENT CARBON STOCKS

3.1.1 Overview

The carbon sequestered or stored in trees is commonly referred to as the biomass of the tree. Estimates of a forest's total biomass can then be converted in a measurement of a forest's current carbon stocks through the application of allometric equations. Our assessment of current carbon stocks involved undertaking field-based plot inventories of species, stem diameter and height. We then applied a range of species-specific (selected to reflect the species present on Tahbilk's estate) and general mixed plantings allometric equations taken from scientific literature to convert inventory data of tree dimensions to biomass. Various conversion factors were then used to convert biomass into the amount of carbon sequestered, measure in tCO2-e.



1. Wetlands	6. Bears Swamp	11. Guggers
2. Riverbank north	7. Plains (Wetland, Corridor & Gully)	12. Horse West
3. Mud flat	8. Seedbank	13. Horse East
4. Riverbank corridor	9. Bells Point	14. Howards
5. Woolshed	10. Bells Paddock	15. Tip & Mini Bears

Figure 1 Map of revegetation sites provided by Tahbilk.

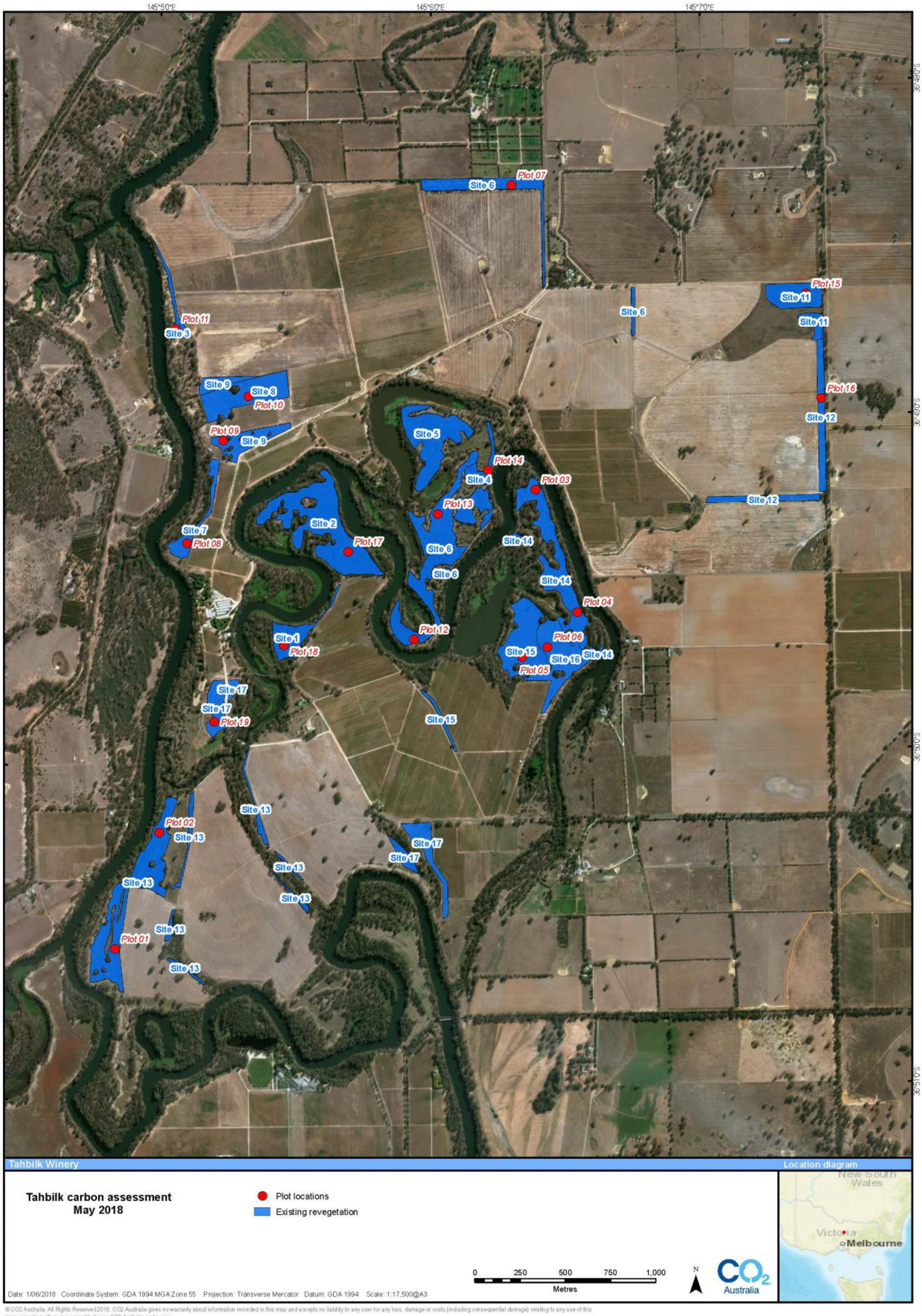


Figure 2 Patches assessed by CO2 Australia

3.1.2 Desktop assessment

A desktop assessment of the Tahbilk estate's existing revegetation was undertaken to determine each area to be assessed as part of the field-based assessment, including new areas of revegetation that have been established since the 2012 assessment. This involved reviewing information provided by Tahbilk, including a map of 'revegetation sites' (Figure 1), mapping and analysis undertaken during the previous assessment, and publically available imagery to determine areas of revegetation established since the last visit. Based on this assessment, areas of existing revegetation were stratified into 'patches', based on areas of similar revegetation treatment (i.e. direct seeding, tubestock, natural regeneration etc) and age (see Figure 2). Plots were then located within each patch in vegetation deemed representative of the range of vegetation types and biomass within the patch.

3.1.3 Field-based assessment

CO2 Australia undertook a site visit on 3 and 4 May 2018 to collect the necessary biomass data for estimating the current carbon stock in the existing revegetation. Data was collected in varying sized plots (25 – 400 m^2) and within each plot the following data was collected:

- stem diameter of each stem greater than or equal to 1 cm in diameter at 30 cm and 1.3 m above the ground (i.e. diameter at breast height)
- species
- height.

A total of 409 trees in 19 plots across 17 patches were measured in order to estimate the current carbon stock in the existing revegetation.

The site visit identified that the following revegetation areas had insufficient woody biomass to measure and therefore were not assessed:

- Seedbank (trial site) and Bells Point
- Bells Swamp Extension and New SE Planting (identified in the 2012 report as areas of future revegetation).

The boundary of each area of existing revegetation was remapped to afford greater accuracy of calculation.

For ease of reference, Table 1 provides an overview of how each patch assessed as part of this report corresponds to areas referred to in the 2012 report and in the map provided by Tahbilk on 5 February 2018. Please note that the actual ground-truthed area of each patch does not necessarily align exactly with these other areas, and may overlap in some instances.

Table 1 Relationship between each patch assessed and areas referred to in the 2012 report and in the map provided by Tahbilk on 5 February 2018

2018 assessment			Map emailed by Tahbilk 5/2/18		2012 report	
Patch	Plot	Area (ha)	Corresponding 'revegetation site'	Area (ha)	Corresponding 'patch'	Area (ha)
1	17	15.2	1. Wetlands	18.9	6. Wetland and Wildlife Reserve	18.9
2	18	2.1	1. Wetlands		6. Wetland and Wildlife Reserve	
3	11	1.3	2. Riverbank north	1.3	1. Riverbank Corridor - North	1.3
4	14	1.5	3. Mud flat	29.2	7. Mudflat	29.2
5	12	11.5	3. Mud flat		7. Mudflat	
6	13	11.5	3. Mud flat		7. Mudflat	

2018 assessment			Map emailed by Tahbilk 5/2/18		2012 report	
Patch	**Plot**	**Area (ha)**	**Corresponding 'revegetation site'**	**Area (ha)**	**Corresponding 'patch'**	**Area (ha)**
7	8	2.4	4. Riverbank corridor	2.3	5. Riverbank Corridor - Border Leister	2.3
8	10	6.8	5. Woolshed	2.9	4. Woolshed Oats	2.9
9	9	4.9	15. Tip & Mini Bears	6	n/a	
10	7	5.5	6. Bears Swamp	3.8	2. Bear's Swamp, 3. Plain 2	4.4
11	15	5.1	7. Plains (Wetland, Corridor & Gully)	27.2	13. New NE Planting	41.8
12	16	5.2	7. Plains (Wetland, Corridor & Gully)		n/a	
13	1, 2	15.3	10. Bells Paddock	15.1	10. Bells Paddock	15.1
14	3, 4	9.6	11. Guggers	27	8. Guggers	24.7
15	5	7.8	11. Guggers		8. Guggers	
16	6	6.9	11. Guggers		8. Guggers	
17	19	7.03	14. Howards, 12. Horse West, 13. Horse East	16	n/a	
Total		**119.6**		**149.7**		**140.6**

3.1.4 Comparison using FullCAM

We also calculated current carbon stocks in accordance with the *Carbon Credits (Carbon Farming Initiative) (Reforestation by Environmental or Mallee Plantings – FullCAM) Methodology Determination 2015* (the Environmental Plantings Methodology), including a back-dated calculation to 2012, which allows for a comparison between the years. This provides a way of illustrating the impact of using FullCAM (rather than field-based measurements) to estimate carbon stocks.

3.2 CARBON SEQUESTRATION POTENTIAL

3.2.1 Overview

In order to provide an assessment of the carbon sequestration potential of the existing revegetation, we re-forecast the future growth of the plantings using best available computer models parameterised as far as possible to accurately represent the Tahbilk plantings in terms of species composition, vegetation density, and local soil and climate. A variety of forest growth models were screened to confirm their suitability and availability for this task, noting that some forest growth models are proprietary and not necessarily publicly available. Much of this screening was done during the previous assessment.

Models considered included 3PG, CABALA, FullCAM and the Farm Forestry Toolbox. Of these, 3PG was chosen as the primary model since parameters were available for the key species (*E. camadulensis*) and it does not require detailed soils information. The 3PG modelling was supplemented by empirical modelling of other tree and shrub species using available relevant data from the published scientific literature. Patches dominated by shrub species were modelled with the FullCAM 'temperate' setting using stocking rates calculated from field measurements in an effort to avoid providing unrealistic estimates of future carbon stocks.

Since the previous assessment the Commonwealth has undertaken major upgrade of FullCAM. In particular FullCAM now includes an 'Environmental Plantings – Temperate' setting which is a significant improvement on the previous parameters of the model. This allows for stocking to be considered in estimates. This is an important as the more information that is able to be provided into a model, the better the model can estimate future growth. The result of this is a model that is more aligned to the specific site.

The 3PG growth models were used to forecast biomass production in each site over the period 1995-2045 (see Appendix A). The nominal start date of 1995 was chosen since it coincides with some of the first restoration activities. In some patches activities were not undertaken until the mid-2000s, and in others work may not have yet commenced. For simplicity, revegetation across the patches is assumed to have be established in three cohorts:

- Cohort 1: 1995 - natural regeneration of *E.camaldulensis* in riparian areas after cessation of cropping and removal of livestock. (patches 1, 3, 4, and 8)
- Cohort 2: 2005 - direct seeding and/or planting of native species on riparian areas, with associated stimulation of *E.camaldulensis* regeneration in riparian zones. (patch 1)
- Cohort 3: 2015 - direct seeding and/or planting of native species on plains and riparian areas that has occurred since the 2012 assessment. (patch 12 and 13)

We have also made the following assumptions:

- Woody biomass is not lost through harvest or fire. Normal senescence of shrubs (aged 15-45 yrs) occurs and biomass decomposes over 10 years. Shrubs are not replaced.
- Woody biomass is not lost through a disturbance event (e.g. fire, flood or harvesting).

4 RESULTS AND DISCUSSION

4.1 CURRENT CARBON STOCKS

The current carbon stocks of the existing 119.6 ha revegetation is estimated to be 39,168 tCO2-e (see Table 2 and Table 3), which represents an additional 18,498 tCO2-e compared to the results of 2012 assessment (20,670 tCO2-e). Current carbon sequestration is driven by the River Red Gum (*E. camaldulensis*) in riparian areas, with Box and other eucalypts on the plains. The shrubs (predominantly *Acacia* spp), while dominant in some patches, only make a relatively small contribution to current carbon.

It is important to note that whilst the results presented provide an estimate of the *current* carbon stock in each patch, it cannot be assumed that sequestration will continue at the same rate. Typically, carbon sequestration rates will slow down as each area of revegetation approaches its maximum carrying capacity. In areas where stocking rates are particularly high, without natural or managed thinning these patches may become 'locked up' and significantly slow their growth rate. Furthermore, some patches appear to be dominated by *Acacia* sp., many of which have a short life span. This will affect the long term sequestration and storage of these patches.

Table 2 Total estimated carbon stocks using field-based measurements

Patch	Year Established	Area (ha)	Corresponding Plot	Estimated carbon stock per hectare in each patch (tCO2-e/ha)	Total estimated carbon stock in each patch (tCO2-e/patch)
1	1990	15.2	17	915.7	13,919.1
2	2003	2.1	18	338.0	699.6
3	2005	1.3	11	293.0	383.1
4	1990	1.5	14	378.2	577.9
5	1990	11.5	12	597.1	6,881.8

Patch	Year Established	Area (ha)	Corresponding Plot	Estimated carbon stock per hectare in each patch (tCO2-e/ha)	Total estimated carbon stock in each patch (tCO2-e/patch)
6	1990	11.5	13	375.9	4,332.4
7	2012	2.4	8	70.1	166.4
8	2005	6.8	10	152.7	1,032.2
9	2005	4.9	9	107.8	530.8
10	1992	5.5	7	705.1	3,867.5
11	2012	5.1	15	333.8	1,705.1
12	2012	5.2	16	48.1	251.3
13	2010	15.3	1, 2	170.6	2,617.0
14	2012	9.6	3, 4	85.6	819.2
15	2013	7.8	5	61.6	478.2
16	2013	6.9	6	55.4	380.8
17	2012	7.0	19	74.8	525.9
				Total	**39,168.4**

Table 3 Annual estimated carbon stocks using field-based measurements

Year	Area (ha)	Estimated carbon stock per hectare (tCO2-e/ha)	Total estimated carbon stock (tCO2-e)
1990	39.8	0.0	0.0
1991	39.8	23.1	918.3
1992	45.3	20.3	918.3
1993	45.3	23.6	1,067.0
1994	45.3	23.6	1,067.0
1995	45.3	23.6	1,067.0
1996	45.3	23.6	1,067.0
1997	45.3	23.6	1,067.0
1998	45.3	23.6	1,067.0
1999	45.3	23.6	1,067.0
2000	45.3	23.6	1,067.0
2001	45.3	23.6	1,067.0
2002	45.3	23.6	1,067.0
2003	45.3	22.5	1,067.0
2004	45.3	23.5	1,113.6
2005	60.3	18.5	1,113.6
2006	60.3	20.9	1,263.4
2007	60.3	20.9	1,263.4
2008	60.3	20.9	1,263.4
2009	60.3	20.9	1,263.4
2010	60.3	16.7	1,263.4

Year	Area (ha)	Estimated carbon stock per hectare (tCO2-e/ha)	Total estimated carbon stock (tCO2-e)
2011	60.3	21.0	1,590.5
2012	60.3	15.2	1,590.5
2013	60.3	17.4	2,080.8
2014	60.3	18.8	2,252.6
2015	119.6	19.9	2,384.1
2016	119.6	19.9	2,384.1
2017	119.6	19.9	2,384.1
2018	119.6	19.9	2,384.1
		Total	**39,168.4**

4.2 FULLCAM RESULTS

The results of calculating current carbon stocks in accordance with the Environmental Plantings Methodology using FullCAM are provided in Table 2. Calculating estimated carbon stocks using FullCAM shows an estimated 21,848 tCO2-e in standing carbon stocks. When compared to the estimate of 39,168 tCO2-e provided by the field-based measurements, it's clear that FullCAM provides an arguably over-conservative estimate of carbon stocks in this situation.

Table 4 Estimated carbon stocks using FullCAM

Year	Area (ha)	Estimated carbon stock per hectare (tCO2-e/ha)	Total estimated carbon stock (tCO2-e)
1996	45.3	2.6	117.4
1997	45.3	11.2	504.8
1998	45.3	22.4	1,015.2
1999	45.3	28.4	1,284.1
2000	45.3	33.6	1,521.7
2001	45.3	28.4	1,286.1
2002	45.3	21.2	959.5
2003	45.3	25.9	1,170.6
2004	45.3	21.1	954.0
2005	60.3	20.8	943.0
2006	60.3	19.8	852.7
2007	60.3	24.8	819.2
2008	60.3	33.7	964.3
2009	60.3	35.5	938.9
2010	60.3	48.4	1,026.9
2011	60.3	43.2	986.2
2012	60.3	40.1	985.8
2013	60.3	29.7	711.1
2014	60.3	31.2	738.9
2015	119.6	24.0	507.0
2016	119.6	24.9	624.7

Year	Area (ha)	Estimated carbon stock per hectare (tCO2-e/ha)	Total estimated carbon stock (tCO2-e)
2017	119.6	33.5	1,210.0
2018	119.6	40.9	1,726.1
		Total	**21,848.0**

4.3 CARBON SEQUESTRATION POTENTIAL

Based on the biomass forecasts in Appendix A and the assumptions detailed below, the modelling estimated a potential yield of 114,172 t CO2-e by 2045 from the 119.6 hectares of existing revegetation on the Tahbilk estate (see Table 5). Figure 3 provides an overview of the total amount of carbon sequestered by each patch over the period 1996 to 2045 and Figure 4 provides the rate of sequestration per hectare.

The results compare very favourably with the 2012 figure of 121,580 tCO2-e by 2045, particularly given that the modelled area was more than 40 hectares larger. Furthermore, we have taken a more conservative approach this time by using FullCAM for patches dominated by shrubs. In the 2012 report, *E.camaldulensis* dominated patches (patches 1, 3, 4, 12, and 13) were assumed to be managed into the future with a proportion of shrubs included in the mix, however this has not occurred. *E.camaldulensis* continues to dominate and having assessed the patches a second time we believe this will continue. Large trees such as *E.camaldulensis* are able to store significantly more carbon in comparison to shrub species.

The gap between the two results is even further minimised if the previous modelling results are adjusted to partly account for the fact that several patches assessed as part of the 2012 report do not currently contain sufficient woody vegetation. By doing so, the 2012 results are reduced to 111,576 tCO2-e. Even though the revised 2012 modelled area remains more than 20 hectares larger, the weighted average carbon potential per hectare is only 749 tCO2-e compared to the 2018 result of 960 tCO2-e.

As can be seen from Table 5, the potential amount of carbon sequestered by 2045 varies significantly for each patch. This is to be expected given the varying ages, species and treatment types for each patch. Although there is very limited data available about the carbon sequestration potential of *E.camaldulensis* in the region to compare these results against, there has been some research that indicates that dry temperate forests have living carbon stocks of 1,019 tCO2-e per hectare (e.g. Keith *et al.* 2009).

Table 5: Potential carbon sequestration by 2045

Patch	Year Established	Area (ha)	Corresponding Plot	Total potential sequestration per hectare (tCO2-e/patch)	Total potential sequestration per patch (tCO2-e/patch)
1	1990	15.2	17	1,660	25,239
2	2003	2.1	18	1,094	2,265
3	2005	1.3	11	407	532
4	1990	1.5	14	1,730	2,643
5	1990	11.5	12	1,730	19,934
6	1990	11.5	13	1,730	19,934
7	2012	2.4	8	384	912
8	2005	6.8	10	407	2,748
9	2005	4.9	9	407	2,002
10	1992	5.5	7	1,328	6,622
11	2012	5.1	15	384	1,961

Patch	Year Established	Area (ha)	Corresponding Plot	Total potential sequestration per hectare (tCO2-e/patch)	Total potential sequestration per patch (tCO2-e/patch)
12	2012	5.2	16	384	2,006
13	2010	15.3	1, 2	382	5,867
14	2012	9.6	3, 4	934	8,934
15	2013	7.8	5	934	7,252
16	2013	6.9	6	382	2,625
17	2012	7.0	19	384	2,698
				Total	**114,172**

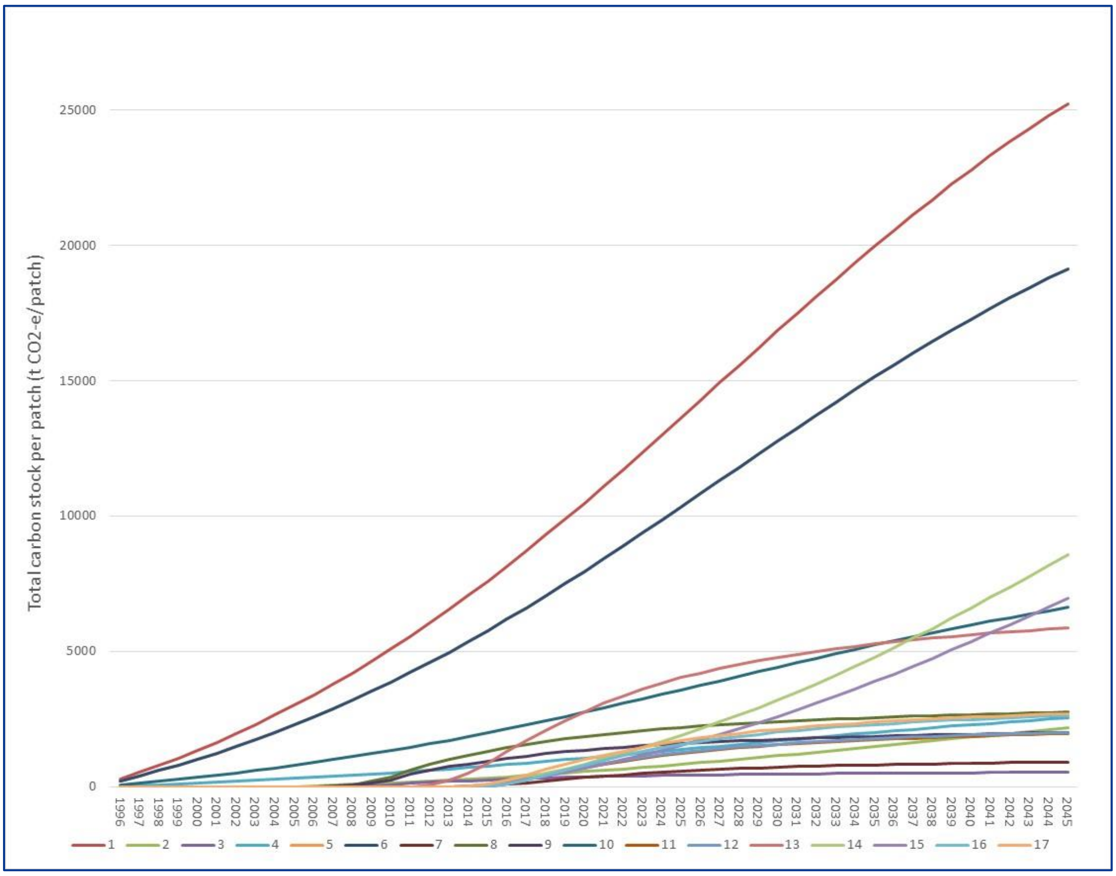


Figure 3 Total potential carbon stock for each patch from 1996 to 2045

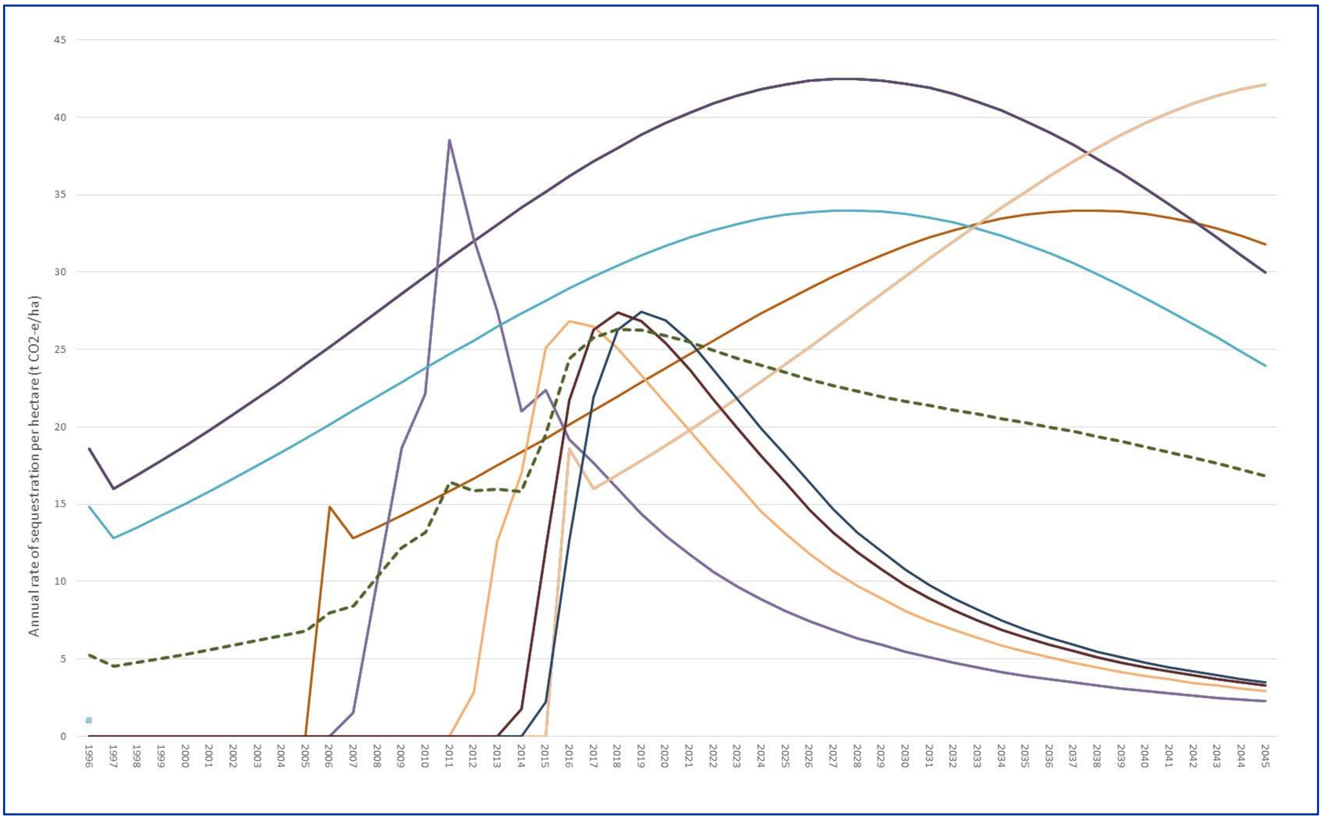


Figure 4 Annual rate of potential sequestration per hectare for each patch from 1996 to 2045

5 RECOMMENDATIONS

There are limited management actions that will increase the carbon sequestration of the established revegetation. Factors that should be considered are:

- Understory planting of shrub species in patches dominated by *E.camaldulensis*. This would allow for an additional structural layer within the patch. However, the practicalities of this would be very challenging and likely change what is the natural ecological structure of *E.camaldulensis* forests – generally single species dominated.
- Re-planting of failed patches and infill planting of patches dominated by shrubs with a strong focus on long lived species such as *Eucalyptus* and *Allocasuarina* species. These species are generally best established through tube stock planting.
- Consider mechanical thinning of heavily stocked *E.camaldulensis* patches. Research by *Horner et al 2010* suggested that thinning had a pronounced effect on above ground biomass in *E.camaldulensis* stands along the Murray River. This created more large trees which are more resilient to disturbance events and support a higher diversity of biodiversity.

Other recommendations relating to community/Indigenous engagement as well as recommendations to enhance carbon sequestration opportunities and future-proofing, include:

- Enhance reliability of forecast modelling by establishment of permanent plots – The methodologies and models employed to calculate a static, point-in-time measure of carbon storage across the Tahbilk estate draws on a number of assumptions including survey accuracy, sampling representativeness and survey effort reflecting the variability both within and across patches. These limitations have the potential to impart more significant variability in future modelling of carbon sequestration, as small 'errors' (e.g. measuring tree DBH 0.25 m instead of 0.27 m) have the potential to widen the range of future estimated carbon sequestration forecasts. An approach to counter this and enable collection of more reliable estimates of carbon sequestration would be to establish a network of permanent plots across the patches. This would allow for repeatable, direct comparisons between years to more precisely calculate current carbon stocks and more accurately model annual sequestration and likely future forecasts.

- Fostering community/Indigenous engagement opportunities – If permanent monitoring plots are established for calculating carbon sequestration, measurements could be taken annually to continually track current and future forecast carbon sequestration. To further Tahbilk's community engagement, measurements could be taken by the local community/Indigenous community group. CO2 Australia would be happy to assist Tahbilk with developing a 'Carbon Assessment tool' to be installed on an electronic tablet, along with 'Carbon Measurement Procedure' documentation to allow these measurements to be collected by engaged community volunteers. CO2 Australia would also be happy to assist Tahbilk by undertaking the carbon sequestration analysis and preparing necessary reporting. This would provide Tahbilk an opportunity to understand carbon stocks at a current point in time, allowing for more reliable forecasting of carbon sequestration.
- Additional revegetation opportunities to increase carbon sequestration
- As noted in the 2012 carbon assessment report, a number of future planting areas were identified, and utilised for future forecasting of carbon sequestration. It was noted at the time that these areas where scheduled to be planted on or about 2014. As part of the 2018 survey, it was noted that a number of these proposed planting areas did not support any measurable carbon on account of either planting not going ahead, or establishment of plantings were unsuccessfully. While land is understood to be in short supply on Tahbilk for future revegetation works, there is the opportunity to undertake a stocktake of land suitable for revegetation on the Tahbilk estate to identify additional areas, including investigating soils and other edaphic factors likely to have resulted in previously unsuccessful planting efforts.
- In concert with considering on-site revegetation opportunities that may still exist on Tahbilk, the extent of cleared land within the local Nagambie and regional Strathbogie districts affords opportunities for Tahbilk to foster a program that supported local landholders to revegetate areas of their land – "Trees for Tahbilk." CO2 Australia would be happy to assist in the design of a program like this.
- Future-proofing carbon sequestration ambitions – Our experience with some of the types of plantings established at Tahbilk suggests that some will start to slow in their annual sequestration rates as a consequence of either their age, or by virtue of some revegetation areas attaining their maximum carbon carrying capacity (e.g. *Acacia*-dominated plantations). It is therefore recommended that if it is Tahbilk's intention to offset their carbon emissions is to rely on carbon sequestration through revegetation, new plantings will need to be established. In concert with new plantings, there is the opportunity to facilitate sequestration through numerous silvicultural treatments that enhance carbon storage. In particular, there is the opportunity to consider thinning of revegetated areas. While reducing point-in-time carbon storage in the short term, thinning has the potential to 'release' the carbon sequestration potential of otherwise stunted trees currently in dense stands.

6 ELIGIBILITY UNDER THE ERF

Based on our existing knowledge of Tahbilk's revegetation program, it appears that the existing plantings are largely in alignment with the Environmental Plantings Methodology, with the exception of the 'The Plains', which includes a number of Western Australian species. The Environmental Plantings Methodology only applies to trees that are planted within their natural range.

However, any revegetation that has already been commenced by Tahbilk is unlikely to meet the 'newness requirement' of the ERF, which would preclude registering it as a project. Whilst it may be possible that any new plantings at Tahbilk could meet the ERF eligibility requirements – so long as there has been no final investment decision made, which would mean that they have already 'started' – it's likely that insufficient scaled could be achieved in order to offset the significant administrative and compliance costs associated with ERF participation. Coupled with the issue of having to use FullCAM under the Environmental Plantings Methodology (i.e. significantly less carbon sequestration is likely to be recognised), there is little advantage to be gained by registering an ERF project.

7 OPTIONS FOR CARBON OFFSETS

The following provides some samples and indicative costings regarding carbon offsets that are available for purchase with a particular focus on revegetation and/or forest protection. Please note that pricing is indicative based on availability 1 June 2018 and is subject to change. Minimum purchasing volume is 500 for international credits and 100 for Australian credits.

Table 6: Example carbon projects and indicative credit prices ($/credit GST-ex)

Project Description	Location	Project Type	Standard	Price ($)
1. CO2 Australia Creating a Better Climate	Australia (NSW/WA)	Reforestation (tree planting)	ERF	$17.00
2. Savannah burning	Australia (QLD/NT/WA)	Savannah fire management	ERF	$16.50
3. Human Induced Regeneration of native forest	Australia (QLD/NSW)	Regeneration of forest	ERF	$16.50
4. Kasigau Corridor REDD Project - Phase II The Community Ranches	Kenya	Avoided deforestation	VCS/CCB	$8.00
5. Rimba Raya Biodiversity Reserve	Indonesia	Avoided deforestation	VCS/CCB	$6.75
6. Isangi REDD+	Democratic Republic Congo	Avoided deforestation	VCS/CCB	$4.50
7. Solar power generation	India / China	Solar energy	VCS	$0.80
8. Wind power generation	India / China	Wind energy	VCS	$0.80

VCS: Verified Carbon Standard **CCB**: Climate, Community and Biodiversity Standard **ERF**: Emissions Reduction Fund

CO2 AUSTRALIA CREATING A BETTER CLIMATE PROGRAM – REFORESTATION IN HISTORICALLY CLEARED FARMLANDS

Standard/verification program: Emissions Reduction Fund

Location: New South Wales, Australia

Description: Extensive plantings of native eucalypt tree species have progressively been established by CO2 Australia through central New South Wales across the past decade. Plantings include tree belts integrated into existing farming operations, and larger consolidated plantings delivering larger scale abatement outcomes. Species have been selected for drought, disease and fire tolerance, with mallee eucalypts favoured for many project locations. For some projects, revenue share arrangements have been negotiated with landholders, so that proceeds from carbon sales flow back to landholders. Revegetation in what are otherwise heavily cleared landscapes delivers a number of biodiversity and environmental co-benefits, as well as helping to promote the uptake of carbon projects and tree planting by local landholders.

Co-benefits: Improved cover of native woodland in a location subject to extensive clearing historically, increased biodiversity and habitat value, reduced risk of soil erosion, increased diversification of land use and promotion of improved land management practices.

ARNHEM LAND SAVANNAH FIRE MANAGEMENT

Activity type: Savannah fire management

Standard/verification program: Carbon Farming Initiative / Emissions Reduction Fund

Location: Northern Territory (Arnhem Land), Australia

Description: Through this project, strategic fire management activities are conducted across the project area to reduce fire-generated greenhouse emissions. Historically, the west and central Arnhem Land region has been experiencing severe late dry season wildfires covering many thousands of square kilometres. By conducting strategic early dry season burning activities, this project is reducing the total area burnt each year and the intensity of fire events, through shifting the seasonality of burning from late, to early, dry season. The project is being carried out by three Indigenous ranger groups: the Djelk Rangers (Bawinanga Aboriginal Corporation) based at Maningrida, the Mimal Rangers (Mimal Land Management Aboriginal Corporation) based in Bulman and the Arafura Swamp Rangers (Arafura Swamp Rangers Aboriginal Corporation) who operate out of Ramingining.

Co-benefits: The project developer is a not-for-profit company owned by Aboriginal people with custodial responsibility for the land included in the project. Funding generated through sale of carbon credits from the project supports indigenous business and helps Aboriginal people in returning to, remaining on and managing their country. The project also protects biodiversity and is helping transfer traditional knowledge and maintain Aboriginal languages.

HUMAN INDUCED REGENERATION OF NATIVE FOREST (VARIOUS PROJECTS)

Activity type: Human-induced native forest regeneration

Standard/verification program: Emissions Reduction Fund

Project identifiers: Various

Location: Australia (QLD and NSW)

Description: Under these projects, land management practices have been altered within a series of large rural landholdings in New South Wales and Queensland, so as to promote the regeneration of native forest. Properties have typically had a long history of use for agricultural purposes and, historically, were subject to extensive clearing and ongoing vegetation suppression through a variety of mechanisms. Through actively managing grazing pressure and the landholder committing to the cessation of further clearing activity, the conditions have been created for substantial parts of these properties to return to a cover of native woodland and shrub-land consistent with the lands pre-cleared state. With the change in management practice, substantial areas of native trees and shrubs are now returning.

Co-benefits: Improved cover of native woodland and shrub-land in a location subject to extensive clearing historically, increased biodiversity and habitat value, reduced risk of soil erosion, increased diversification of land use and promotion of improved land management practices.

KASIGAU REDD PROJECTS

Activity type: Avoided deforestation (REDD)

Standard/verification program: Verified Carbon Standard/ Climate, Community and Biodiversity Standard

Location: Kenya

Description: This series of projects has been protecting forests, flora and fauna since 2006. The aim is to bring the benefits of direct carbon financing to local communities, while simultaneously addressing alternative livelihoods and protecting vital flora and fauna. These are large avoided deforestation projects, estimated to reduce emissions by over 1 million tonnes of CO2-e per year through providing the local community with financial incentives to retain natural forest. Eighty rangers from the local community, who help protect the forest from clearing. The rangers also help protect the local fauna. Tree planting is being undertaken as part of the project, so as to provide the local community with a sustainable, renewable source of wood for fuel and charcoal. The positive socio-economic and biodiversity impact the project is having is recognised through its dual verification under the VCS and Climate, Community and Biodiversity Standard.

Co-benefits: Avoids loss of biodiversity through reducing deforestation, diversification revenue opportunities for local people, creates jobs including through directly employing 80 local rangers, protects local native food sources (hunting) and protects traditional cultural practices.

RIMBA RAYA BIODIVERSITY RESERVE

Activity type: Avoided deforestation (REDD)

Standard/verification program: Verified Carbon Standard/ Climate, Community and Biodiversity Standard

Location: Indonesia

Description: One of the most significant avoided deforestation projects in the world, with 65,000 hectares of peat swamp forest protected in what is now the Rimba Raya Biodiversity Reserve. The reserve, which was formerly threatened from conversion to palm oil plantations, is helping preserve High Conservation Value lowland peat swamp forests, one of the most highly endangered ecosystems in the world. The reserve provides habitat for a wide range of species, including the endangered Bornean orangutan, Clouded Leopard, Gibbon, Proboscis Monkey and Asian Sun Bear. Carbon offset sales revenues have been used to fund environmental education programs, improve access to clean water, introduce efficient cook stoves and improve health care. The positive socio-economic and biodiversity impact the project is having is recognised through its dual verification under the VCS and Climate, Community and Biodiversity Standard.

Co-benefits: Avoids loss of biodiversity through reducing deforestation, provides communities a sustainable revenue source from valuing and retaining natural forest assets, protects local native food sources (fishing and hunting), protects traditional cultural practices, reduces sedimentation of water-ways, improved agriculture and food production without impacting forests.

ISANGE REDD+

Activity type: Avoided deforestation (REDD)

Standard/verification program: Verified Carbon Standard / Climate, Community and Biodiversity Standard

Location: Democratic Republic of Congo

Description: This project is located in a 334,000 hectare (825,332 acre) area of tropical forest in the heart of the Congo River basin, at the confluence of the Congo and the Lomami Rivers. In place of deforestation, forests are being conserved and sustainable social development is being promoted. The project has been approved by the Climate, Community and Biodiversity Alliance (CCBA) and the Verified Carbon Standard (VCS), earning a “double gold” rating that is reserved for only the highest quality REDD+ projects. Under the project, a former logging concession has now been converted to a very large carbon and forest protection project, saving approximately 10 million t CO2e of emissions entering the atmosphere as compared with large-scale clearing of the entire area. There are 21 villages located in the project area, with a combined population of 20,000 people. The project area is listed as High Conservation Value and supports fauna species of global importance, such as the black leopard, forest elephant, red river hog and 14 species of primate most notably the Bonobo chimpanzee. Community benefits from the project include school construction, job creation and improved agricultural practices.

Co-benefits: Avoids loss of biodiversity through reducing deforestation, provides communities a sustainable revenue source from valuing and retaining natural forest assets, protects local native food sources (fishing and hunting), protects traditional cultural practices, reduces sedimentation of water-ways.

SOLAR POWER GENERATION

Activity type: Avoiding emissions through displacing coal fired power with a mix of renewable solar and wind energy sources

Standard/verification program: Verified Carbon Standard

Location: India / China

Description: Under these projects, greenhouse emissions are reduced through displacing coal-fired power sources with renewable and reliable solar energy sources. The solar energy that is captured through large-scale solar power installations is fed into the power grid.

Co-benefits: Improved availability of reliable energy sources, diversification of local economy, increased local employment, increased awareness and uptake of renewable energy opportunities, increased awareness of environmental issues and options for addressing these, improved human health and reduction of air pollution.

WIND POWER GENERATION

Activity type: Avoiding emissions through displacing coal fired power with a renewable wind energy source

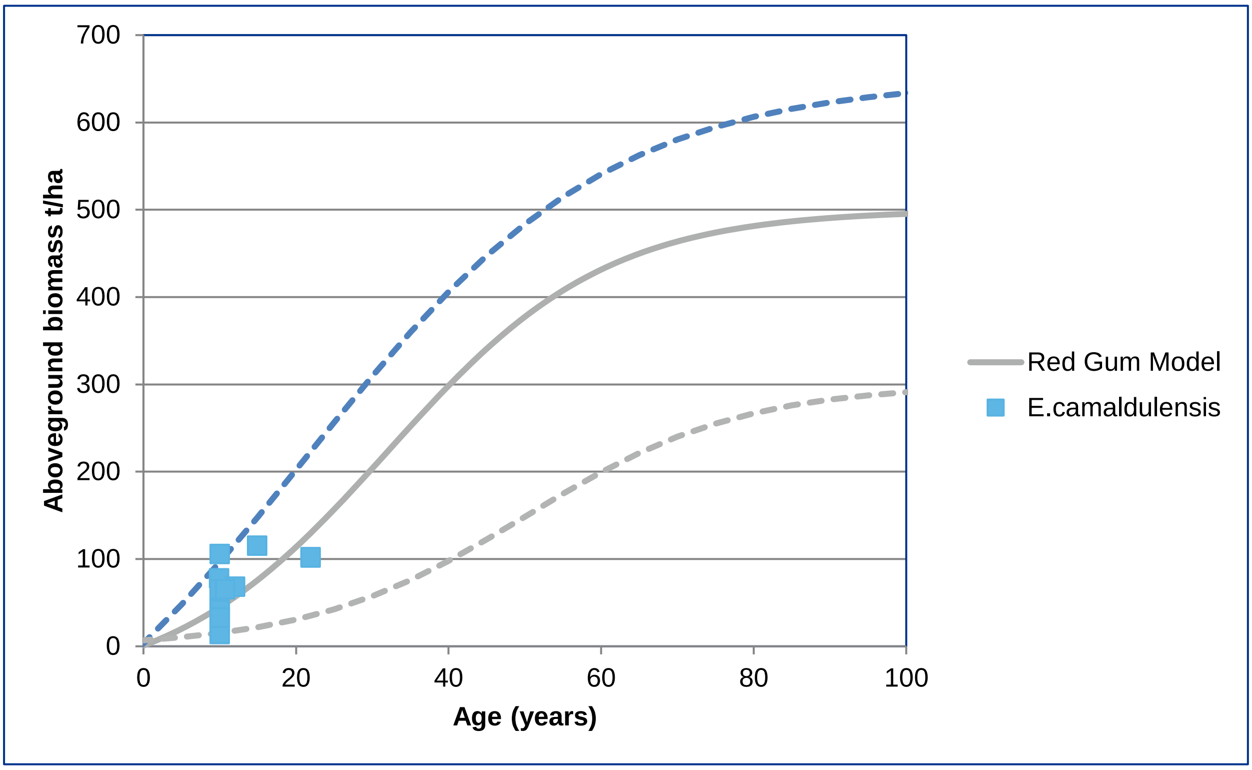
Standard/verification program: Verified Carbon Standard

Location: India / China

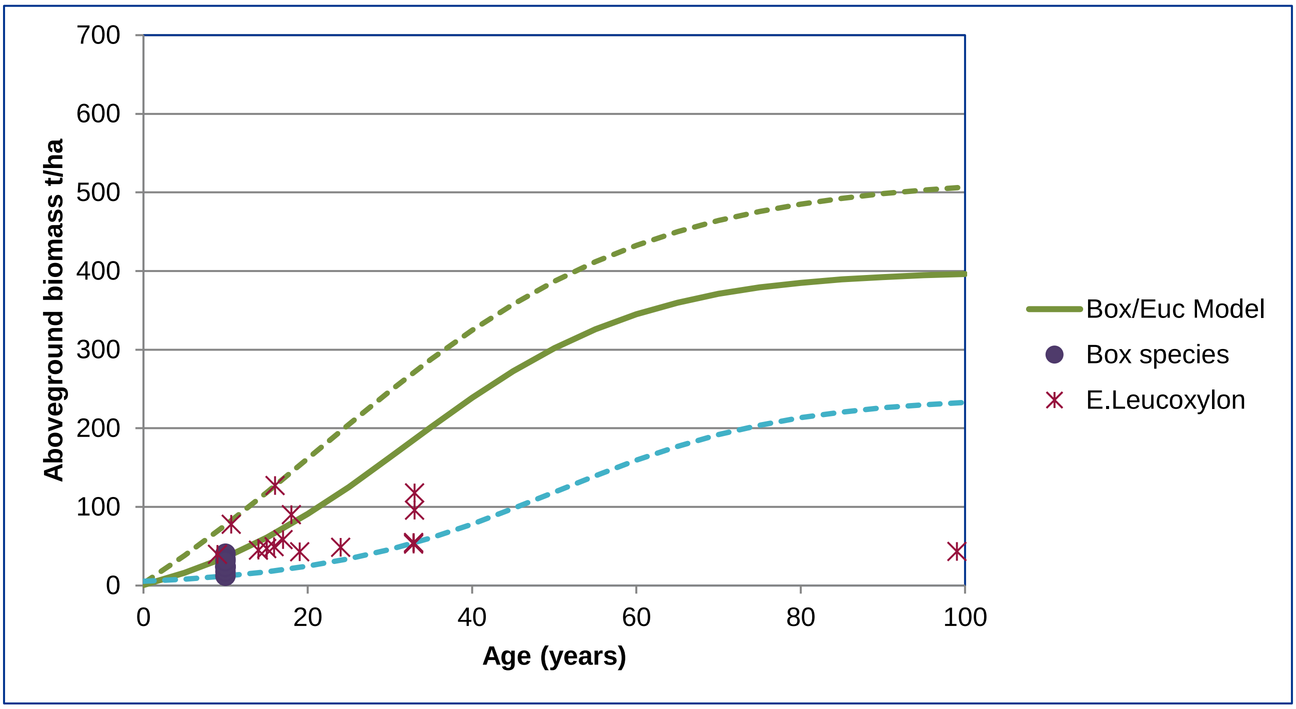
Description: Under these projects, greenhouse emissions are reduced through displacing coal-fired power sources with clean, renewable and reliable wind energy. Electricity generated by wind turbines is fed into the power grid, both reducing greenhouse emissions and improving reliability of electricity availability as compared with out-dated coal-fired power sources.

Co-benefits: Improved availability of reliable energy sources, diversification of local economy, increased local employment, increased awareness and uptake of renewable energy opportunities, increased awareness of environmental issues and options for addressing these, improved human health and reduction of air pollution.

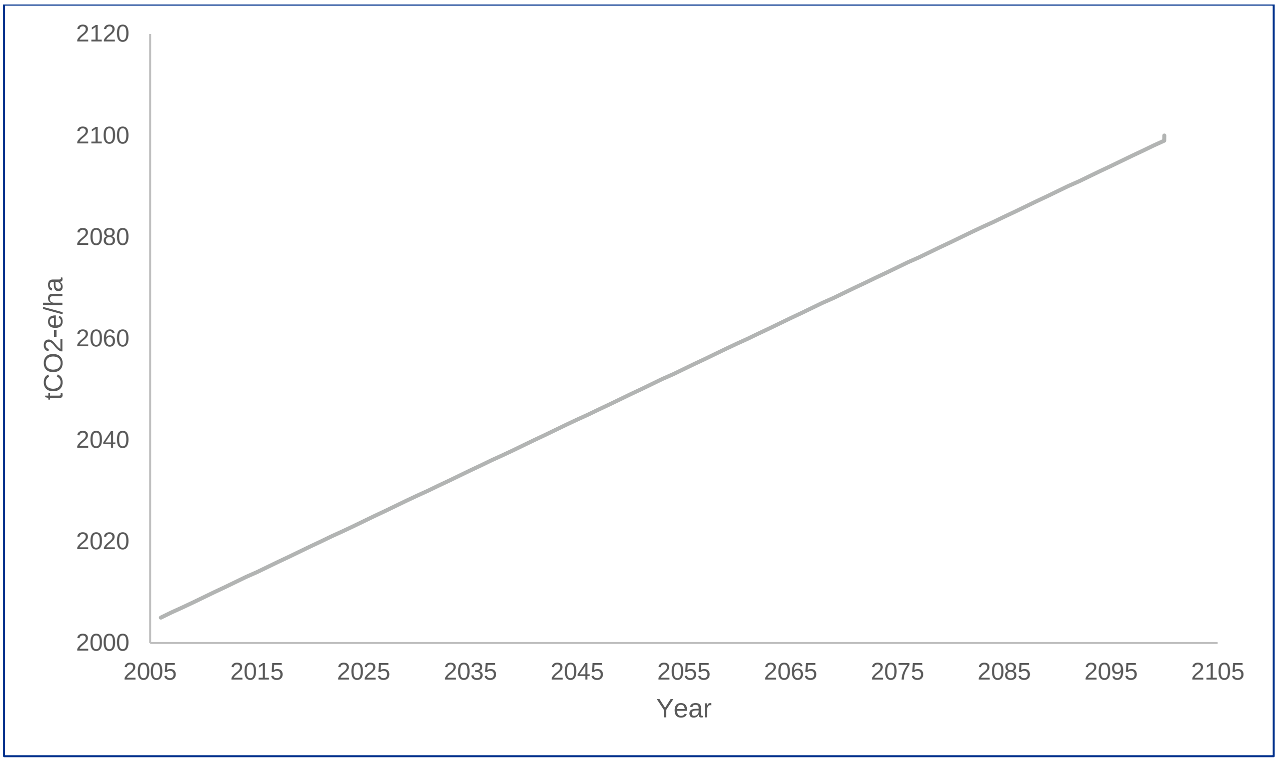
APPENDIX A BIOMASS FORECASTS



Appendix Figure A-1: Forecast of above ground biomass for pure stands River Red Gum (*E. camadulensis*) growing in riparian zones of the Tahbilk estate. Dashed lines show upper and lower limits. Solid line is the yield used in forecasts. Points are data from relevant sites used to calibrate the model.



Appendix Figure A-2: Forecast of above ground biomass for mixed stands of Box and other Eucalypt species (E. polyanthemus, E. microcarpa, E.albans, E. meliodora, E. leucoxylon) growing on the plains of the Tahbilk estate. Dashed lines show upper and lower limits. Solid line is the yield used in forecasts. Points are data from relevant sites used to calibrate the model.



Appendix Figure A-3: Forecast of above ground biomass for shrubs using the Environmental Plantings – Temperate setting in FullCAM.