GRAZING PROPERTY CARBON BUDGET IN CENTRAL QUEENSLAND

- *The Lake* -

Property Carbon Budgeting in Central Queensland
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The lead Commonwealth agency on greenhouse matters

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THE LAKE - CARBON BUDGET

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Introduction

The information in this report is presented in two sections. The first section provides a general overview of carbon credits and carbon trading. Information has been gathered from two government publications, *Growing trees as greenhouse sinks. An overview for landholders (*The Australian Greenhouse Office) and *Carbon credits from forestry: questions and answers for rural landholders* (Queensland Government). The second section outlines details of the carbon budget estimated for "The Lake", a cattle property near Aramac in the Desert Uplands region in Central Queensland.

It was estimated that approximately 629,696 tonnes of carbon are stored in the trees and bushes on the property. This represents an average of 38.8 tonnes/ha of carbon in vegetation (excluding cleared and naturally open areas). In the predominant vegetation types, the values range from an average 19.2 tonnes/ha of carbon in ironbark country to 53.2 tons/ha of carbon in box country. Approximately 76.4% of the carbon is in the above-ground part of the trees and scrubs, while 23.6% is below-ground in the roots.

SECTION 1. GENERAL INFORMATION

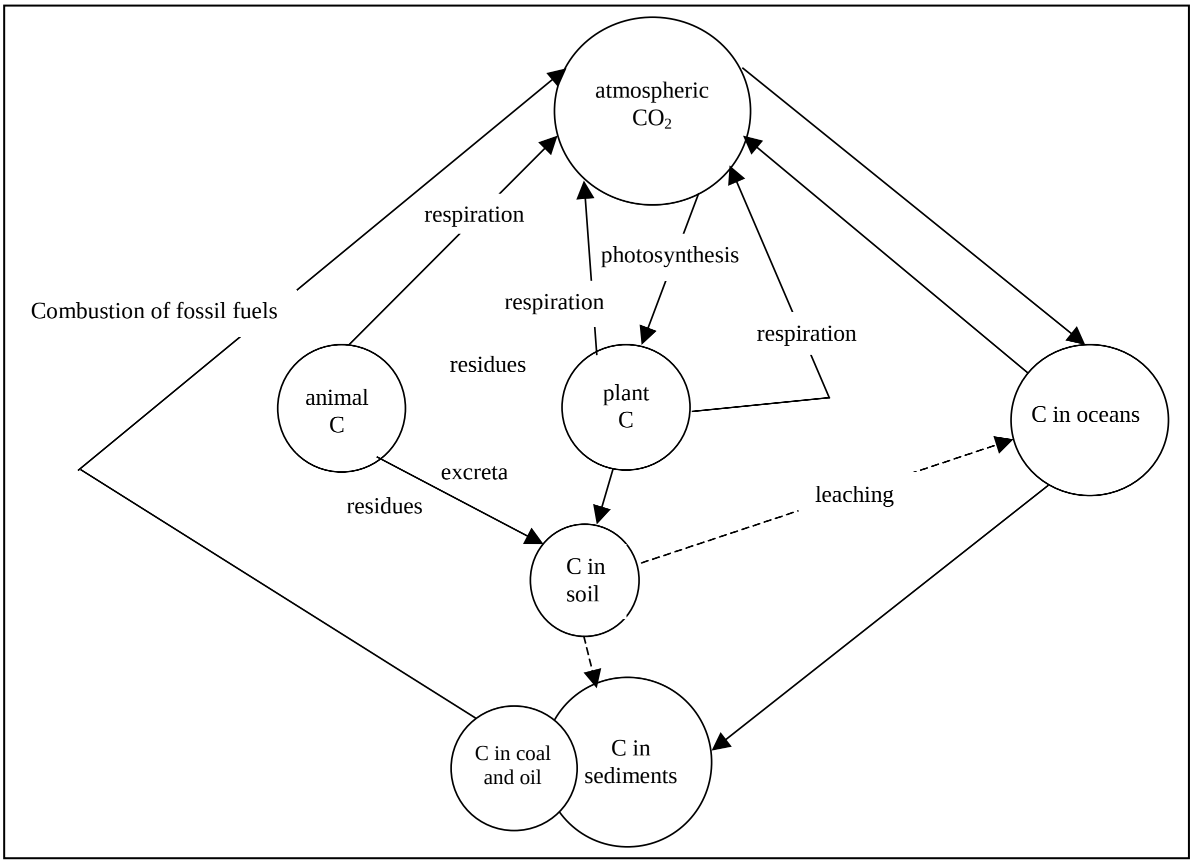
Greenhouse gas emissions

An increased level of certain gases in the atmosphere, known as the greenhouse effect, is believed by scientists to cause global warming and climate change. In 1998 Australia recorded its hottest year since quality records began, in line with a general increase in global temperatures. The increase in greenhouse gas emissions since the industrial revolution could be causing the increase in global temperatures. Carbon dioxide is the main greenhouse gas emitted by human activity, and is responsible for over half the increases in the greenhouse effect. The main source of carbon dioxide emissions comes from the burning of fossil fuels, principally from power generation and transport. Agriculture is also responsible for large emissions of carbon dioxide from vegetation and soils.

Trees and plants act as a carbon sink

Trees and plants use carbon dioxide from the atmosphere and store it as carbon in the leaves, branches, stem, bark and roots (Figure 1). The rate at which trees absorb carbon depends on the site where they are growing, and to a lesser extent on the species planted. It also varies during the different growth stages. While the plants are growing and carbon is absorbed and stored, they act as a carbon sink. When trees are harvested and some material is burnt or rots, carbon will be released back into the atmosphere. Mature forests act mostly as a store of carbon, because the amount of carbon taken up each year in new growth is balanced by losses from decay and fire. Forest products, such as timber and paper, also act as carbon stores until they are allowed to decay.

Figure 1. The Carbon Cycle



Carbon sinks and carbon trading.

The global community has viewed the prospect of the greenhouse effect to be serious enough to draft a planned commitment to cap greenhouse gas emissions. This planned commitment, known as the 1997 Kyoto Protocol, is an international treaty, agreed to in principle but not yet ratified by all countries. The United States of America and Australia have not ratified the agreement. The Protocol assigns each developed country a greenhouse gas target – Australia has a target of 108% of 1990 emissions, to be achieved, on average, during the period 2008 - 2012 (the first commitment period). While much emphasis is placed on the reduction of emissions, consideration is also given to practices that remove carbon dioxide from the atmosphere and lock up carbon in **carbon sinks**. This leads to the potential for **carbon trading**. Trading would work by people selling **carbon credits** (the amount of carbon locked up or stored) to a buyer who needed credits to offset their excessive level of emissions.

The Kyoto Protocol provides basic rules for using greenhouse sinks to reduce or offset emissions, and only internationally approved carbon sinks will be eligible to generate credits used for Kyoto purposes. However, formal decisions about the detailed rules, definitions and methodologies relating to sinks and the eligibility of additional sinks activities have yet to be agreed. It is also possible that some countries may establish their own internal carbon trading system that may differ from an international system. The Australian government has not yet decided on the introduction of a national emissions trading system for greenhouse gases.

Australia has made general commitments to controlling greenhouse gas emissions, even though it has not ratified the Kyoto Protocol. It is possible that the Australian Government will encourage some forms of carbon offsets even if it does not join any international trading programs.

Carbon sink activities

A major way of offsetting carbon dioxide emissions is to soak up carbon in growing forests. Forestry is likely to be the major source of carbon credits because large amounts of carbon are sequestered as the trees grow over a period of time. However, forestry will not be the only activity that may be recognised. A range of other land management practices, such as revegetation involving shrubs and other non-woody vegetation, minimum till cropping, crop rotation, and stock management, could become recognised sink activities.

Under carbon trading, major emitters (eg industry) may pay land managers to soak up carbon by growing forests or other activities. If a carbon trading system is established, there will need to be clear definitions of what constitutes a carbon sink. Most emphasis has been on growing forests. As yet, there are no exact definitions, but the forest plantings that meet the following definitions may be eligible as afforestation or reforestation sinks:

- a forest of trees with a potential height of at least two metres and crown cover of at least 20 per cent;
- in patches greater than one hectare in area;
- established since 1 January 1990;
- on land that was clear of forest at 1 January 1990 - not land that has been cleared since 1990, or land covered in woody weeds; and
- established by direct human induced methods, i.e. planting or direct seeding, or human induced promotion of regeneration from natural seed sources.

The following requirements may be proposed to meet eligibility criteria as revegetation activities:

- establishment of vegetation that is too small or sparse to qualify as afforestation or reforestation;
- a minimum area yet to be determined;
- established since 1 January 1990; and
- established by direct human induced methods only, i.e. planting or direct seeding.

Carbon trading examples

No national system of standards in relation to carbon sinks and carbon trading has yet been established in Australia, but some states are taking a proactive approach. In 1998

NSW enacted legislation that enabled the rights to carbon sequestered in planted forest to be separated as a legal entity from the land on which the planted forest grows and the timber rights attached to the planted trees themselves.

Tokyo Electric Power Company (TEPCO) signed a contract with State Forests of NSW to establish a planted forest for carbon sequestration and timber products over a ten-year period. TEPCO had been seeking an opportunity to invest in carbon sinks for greenhouse gas offsets, as part of its overall package of measures to deliver internal greenhouse gas emissions reduction targets. This type of investment can achieve a positive return from the commercial forestry aspect even assuming no value for carbon. The contract is for the planting of 1,000 hectares initially, with a target area of between 10,000 and 40,000 hectares. State Forests expects to lease the land from private landowners to establish the plantations, for which the landowner will receive an annual payment.

In June 2001, Australian Plantation Timber Ltd (APT) signed a deal with Cosmo Oil, one of Japan's biggest oil companies to supply carbon credits from 5,000 hectares of its Western Australian blue gum plantations. This deal is the first to come out of an agreement between APT and Japan's biggest bank, the Industrial Bank of Japan, to provide a suitable carbon trading vehicle for emitters. Investors in the blue gum plantations own the timber while APT owns the land and carbon rights.

What are the risks?

There are substantial risks and uncertainties associated with early carbon trading as there are no formally agreed rules. Recent estimates indicate that farming trees for carbon alone is not profitable, and assessing the potential for carbon credits should be considered as only one of a variety of benefits associated with tree planting on farms. The costs of developing a carbon sink activity need to be recognised, such as tree establishment, registration, insurance etc, and until an emissions trading system is introduced, it is hard to estimate the market price of carbon.

How does this relate to land managers in Central Queensland?

Many properties in Central Queensland are both sources and sinks for carbon. Emissions come from clearing vegetation (when it is burnt or rots), from cattle and sheep emitting methane, and from farming activities. Sinks come from growing trees, protecting trees from clearing or fire, and from improving soils. However, most sinks are not currently recognised as potential offsets because of issues about definition and measurement.

It is possible that land managers in the future will be asked to consider their sources and sinks of greenhouse gases. Better information is needed about the impacts of land management on greenhouse sources and sinks, at the property level.

SECTION 2. ON-FARM CARBON ASSESSMENT

Carbon stores on a property

There are three important pools of carbon to consider in a grazing property. The first is the carbon that is locked up in trees and bushes. This includes carbon in the trees and bushes above the ground, and carbon below the ground in the form of roots. The second pool to consider is carbon in grass, while the third is carbon in the soil. Carbon makes up about 50% of the dry matter weight of trees, bushes and grasses, and a smaller proportion of the soils.

Most of the discussion about carbon sinks has focused on trees. However, a full carbon budget for a grazing property should also include information on grasses and soils. In the example below, only estimates of the carbon in the trees and bushes have been made. It is estimated that approximately 629,696 tonnes of carbon are stored in these sources on the property.

An example from the Desert Uplands region in Central Queensland

The carbon estimates outlined below were taken from “The Lake” a cattle grazing property in the Desert Uplands region of Central Queensland. The property is located approximately 68 km north east of Aramac, and is located around a natural fresh water lake called Lake Dunn. The property has a total area of 18,455 hectares, of which about 2223 hectares (12%) has been cleared for grazing and established with improved pasture. The remainder 16,232 hectares (88%) is uncleared and classified as remnant vegetation by the Department of Natural Resources and Mines.

Different Types of Vegetation or Regional Ecosystems at “The Lake”

Queensland is divided into 13 bioregions based on broad landscape patterns that reflect the major underlying geology, climate patterns and broad groupings of plants and animals. Regional Ecosystems describe the vegetation communities within a bioregion. These Regional Ecosystems have been mapped by the Queensland Department of Natural Resources and Mines and the Queensland Herbarium. This is the mapping used for managing vegetation and the tree clearing permits.

The classification of the Regional Ecosystems (RE) follows a set pattern where there are three numbers that make up a classification. The first number refers to a biogeographical region. For the Desert Uplands, all Regional Ecosystem numbers start with 10. The second number refers to the land zone which is a simplified geology/substrate-landform classification for Queensland. Twelve different land zones are recognised. The third number relates to the vegetation.

“The Lake” is located within the Desert Uplands Bioregion, and includes vegetation categorised in 22 Regional Ecosystems. See Table 1 below for details.

Table 1: Regional Ecosystems (RE) and Area Represented on "The Lake"

RE	Major Tree Type	Scientific Name	RE Area (ha.)	%
10.3.1	Black Gidyea	*Acacia argyrodendron*	2069.3	12.8
10.3.3	Ghost Gum	*Eucalyptus papuana*	258.8	1.6
10.3.4	**Gidgee**	***Acacia cambegei***	**312.8**	**1.9**
10.3.6	**Reid's River Box**	***Eucalyptus brownii***	**745.7**	**4.6**
10.3.9	White's Ironbark	*Eucalyptus whitei*	170.1	1.1
10.3.12	Moreton Bay Ash	*Corymbia tessellaris*	494.8	3.1
10.3.13	Paperbark	*Melaleuca leucodendron*	120.7	0.7
10.3.14	River Coolibah	*Eucalyptus coolibah*	1130.4	7.0
10.3.15	River Coolibah	*Eucalyptus coolibah*	15.5	0.10
10.3.28	Silver Leaf Ironbark	*Eucalyptus melanophloia*	1621.9	10.0
10.4.1	Black Gidyea	*Acacia argyrodendron*	2058.8	12.7
10.4.5	Gidgee	*Acacia cambegei*	553.7	3.4
10.5.1	**Yellow Jacket**	***Eucalyptus similis***	**2975.6**	**18.3**
10.5.2	**Gum-topped Bloodwood**	***Corymbia brachycarpa***	**500.5**	**3.1**
10.5.5	**White's Ironbark**	***Eucalyptus whitei***	**1624.1**	**10.0**
10.5.8	Rough Leaf Bloodwood	*Corymbia setosa*	318.9	2.0
10.7.2	Napunyah	*Eucalyptus thoziana*	320.3	2.0
10.7.3	Lancewood	*Acacia shirleyi*	255.3	1.6
10.7.5	Napunyah	*Eucalyptus thoziana*	107.1	0.7
10.7.7	Tea Tree	*Melaleuca tamariscina*	14.3	0.1
10.10.1	Lancewood	*Acacia shirleyi*	532.7	3.3
10.10.5	Bloodwood.	*Corymbia spp.*	31.3	0.2
		Total area of uncleared vegetation	**16232.5**	100.0

Estimating the carbon in trees and bushes

As the property included such a wide range of Regional Ecosystems (REs) it was decided to sample only five of the REs, (marked in bold in Table 1) and to apply the information from these sites to the other REs.

At each RE one general area (site) was selected to be representative of the vegetation. Trees were measured in 200m^2 rectangular plots called transects. 30 transects were laid out at each site. Each transect was 50 metres long and 4 metres wide, and all were laid in a north-south direction. All trees were measured in the first three transects. Dead trees, if encountered were included in the measurements. In the remaining transects, trees were measured until thirty trees of each major tree type had been measured and then, only the number of trees was counted in each transect. All trees and bushes over 1.8 metres were measured. It was assumed that trees and bushes lower than this height would be susceptible to fire and may have perished in the landscape.

How the carbon budget was calculated

There are two components of the carbon stored in trees and bushes that need to be considered. The obvious component is the part of the tree that can be seen, ie tree trunk, bark, branches and leaves. This is known as the **above-ground tree biomass**. Carbon is also stored in the plant roots, known as the **below-ground tree biomass**, and this too needs to be considered.

The stem circumference of each tree selected was measured at a height of 30 cm above the ground. From this measurement, the tree biomass was calculated using previously developed equations, which relate stem circumference, or in some cases, stem diameter, to total above-ground biomass. A list of the available equations that were used is provided in Appendix 1. Although the carbon content varies between tree types, it is generally assumed that carbon constitutes 50% of the tree biomass. Consequently, once the tree biomass was calculated, an estimate of the carbon stored in the trees and bushes was readily assembled.

Estimating the carbon stored in the tree roots or below-ground biomass.

Estimates of carbon stored in the tree roots have to be calculated separately. Tree root biomass can be estimated by determining the root-shoot ratio or the proportion of the tree roots in relation to the above-ground tree biomass. It is known from the work of Burrows and others (see reference section), that below-ground biomass is 23%, 26% and 28% of the above-ground biomass of Narrow Leaf Ironbark, Silver Leaf Ironbark and Popular Box respectively The proportion for Poplar Box was applied to the other Eucalypt and Bloodwood trees on the property. A proportion of 43% was used for all other species, based on the assertion in Eamus, McGuinness and Burrows (see reference section) that approximately 30 - 50% of the total biomass in tropical Australian vegetation is located below ground. If 30% of the biomass is below ground, then the root/shoot ratio must be 30/70 which equals 0.43.

It was estimated that approximately 629,696 tonnes of carbon were stored in the trees and scrubs on the property, or approximately 38.8 tonnes carbon per hectare. Approximately 480,943 tonnes (76.4%) of carbon were stored in the above-ground vegetation, and 148,753 tonnes (23.6%) of carbon were stored in the below-ground stocks. A summary of the carbon in the different vegetation types is presented in Table 2 below; full details are presented in Appendix 2.

Table 2. Tonnes (t) of Carbon (C) Stores in Trees and Bushes at “The Lake”

RE	Main tree	Total below-ground tree C (t) /ha	Total above-ground tree C (t)/ha	Total Tree C (t)/ha	RE Area (ha.)	Total Tree Carbon (t)/RE
10.3.1	Black Gidyea	14.09	33.39	47.48	2069.25	98244.37
10.3.3	Ghost Gum	6.17	21.87	28.04	258.79	7257.20
10.3.4	Gidgee	14.09	33.39	47.48	312.79	14850.84
10.3.6	Reid's River Box	12.12	42.19	54.31	745.66	40496.14
10.3.9	White's Ironbark	4.10	15.14	19.24	170.07	3272.55
10.3.12	Moreton Bay Ash	5.36	16.55	21.91	494.83	10841.31
10.3.13	Paperbark	9.95	28.13	38.08	120.73	4597.92
10.3.14	River Coolibah	9.95	28.13	38.08	1130.44	43051.00
10.3.15	River Coolibah	9.95	28.13	38.08	15.46	588.84
10.3.28	Silver Leaf Ironbark	4.10	15.14	19.24	1621.87	31208.79
10.4.1	Black Gidyea	14.09	33.39	47.48	2058.81	97749.03
10.4.5	Gidgee	14.09	33.39	47.48	553.74	26290.47
10.5.1	Yellow Jacket	11.65	40.28	51.93	2975.62	154528.96
10.5.2	Gum-topped Bloodwood	5.36	16.55	21.91	500.45	10964.31
10.5.5	White's Ironbark	4.10	15.14	19.24	1624.10	31251.78
10.5.8	Rough Leaf Bloodwood	5.36	16.55	21.91	318.92	6987.16
10.7.2	Napunyah	9.95	28.13	38.08	320.29	12197.79
10.7.3	Lancewood	9.95	28.13	38.08	255.25	9720.70
10.7.5	Napunyah	9.95	28.13	38.08	107.09	4078.52
10.7.7	Tea Tree	9.95	28.13	38.08	14.30	544.69
10.10.1	Lancewood	9.95	28.13	38.08	532.69	20286.64
10.10.5	Bloodwood	5.36	16.55	21.91	31.33	686.51
				Total	**16323.49**	**629,695.50**

Carbon in individual Regional Ecosystems

10.3.1 and 10.4.1 Black Gidyea

The amount of carbon per hectare for these Black Gidyea ecosystems was not directly measured. The amount of carbon per hectare estimated for Gidgee RE 10.3.4 was used to represent these two ecosystems. The measurements for all tree types in RE 10.3.4 were included in the calculations.

Total above-ground carbon was estimated to be 33.39 tonnes/ha, with below-ground carbon estimated at 14.09 tonnes/ha. This gave a total amount of carbon in the trees and bushes of 47.48 tonnes/ha, for the 2069 hectares and 2059 hectares of REs 10.3.1 and 10.4.1 respectively, of this Black Gidyea country at “The Lake”.

10.3.3 Ghost Gum

The amount of carbon per hectare for this ecosystem was not directly measured and values were estimated by transferring the measurements for all trees of the RE 10.3.3 at another property named “Wololla” in the same Desert Uplands region.

Total above-ground carbon was estimated to be 21.87 tonnes/ha, with below-ground carbon estimated at 6.17 tonnes/ha. This gave a total amount of carbon in the trees and bushes of 28.04 tonnes/ha, for the 259 hectares of Ghost Gum country at “The Lake”.

10.3.4 Gidgee

This ecosystem was measured in detail and the amount of carbon per hectare estimated includes other trees as well as Gidgee (see Table 3 below). It was estimated that there were 442 trees/ha for Gidgee, 97 trees/ha for other Acacias, 25 tree/ha for False Sandalwood and 42 trees/ha for Eucalypts.

Table 3. Measurements for Gidgee Regional Ecosystem 10.3.4 at "The Lake"

Tree Types	Gidgee	Acacia	False Sandalwood	Eucalypts
Biomass (tonnes/tree)	0.143	0.001	0.007	0.078
Carbon/tree (tonnes)	0.072	0.001	0.003	0.039
Average number of trees/ha	442	97	25	42
Aboveground tree biomass (t/ha)	63.289	0.095	0.171	3.23
Belowground tree biomass (t/ha)	27.151	0.041	0.073	0.037
Belowground tree C (t/ha)	13.576	0.020	0.037	0.452
Aboveground tree C (t/ha)	31.645	0.048	0.085	1.616

The total above-ground carbon for this Gidgee ecosystem was estimated at 33.39 tonnes/ha, while the below-ground carbon was estimated to be 14.09 tonnes/ha. This gave a total amount of carbon of 47.48 tonnes/ha in the trees and bushes for this Regional Ecosystem, with 313 hectares at "The Lake".

10.3.6 Reid's River Box

This ecosystem was measured in detail and the amount of carbon per hectare estimated includes other trees as well as Reid's Box (see Table 4 below). It was estimated that there were 413 trees/ha for Reid's box, 156 trees/ha for False Sandalwood and Quinine Bush, 65 trees/ha for Acacias and Hop Bush, 8 trees/ha for Eucalypts, 2 trees/ha for Bloodwoods and 102 trees/ha for Others (Beefwood, Grevillea, Paperbark, Canthium, Wallaby Apple, Bauhinia, Tea Tree).

Table 4. Measurements for Reid's Box Regional Ecosystem 10.3.6 at "The Lake"

Tree Types	Reid's Box	FS'wood, Quinine B	Acacia + Hop Bush	Eucalypts	Bloodwd	Others
Biomass (tonnes/tree)	0.188	0.006	0.002	0.290	0.149	0.029
Carbon/tree (tonnes)	0.094	0.003	0.001	0.145	0.074	0.015
Average number of trees/ha	413	156	65	8	2	102
Aboveground tree biomass (t/ha)	77.593	0.945	0.111	2.416	0.565	3.001
Belowground tree biomass (t/ha)	21.726	0.405	0.048	0.677	0.087	1.290
Belowground tree C (t/ha)	10.863	0.203	0.024	0.338	0.043	0.645
Aboveground tree C (t/ha)	38.797	0.472	0.056	1.208	0.155	1.504

Total above-ground carbon for Reid 's Box was estimated at 42.19 tonnes/ha, while below-ground carbon was estimated to be 12.12 tonnes/ha. This gave a total amount of carbon of 54.31 tonnes/ha for the trees and bushes in this Regional Ecosystem (746 hectares at "The Lake").

10.3.9 White's Ironbark

The amount of carbon per hectare for this White's Ironbark ecosystem was not directly measured and values were used from those measured for Whites Ironbark (RE 10.5.5). Measurements of all tree types in RE 10.5.5 were included in the estimation.

Total above-ground carbon was estimated to be 15.14 tonnes/ha, with below-ground carbon estimated at 4.10 tonnes/ha. This gave a total of 19.24 tonnes/ha in the trees and bushes for the 170 hectares of White's Ironbark country at "The Lake".

10.3.12 Moreton Bay Ash

The amount of carbon per hectare for this Moreton Bay Ash ecosystem was not directly measured. As the main tree type of this RE is a Bloodwood, the values were transferred from the Bloodwood RE measured in detail on the property (RE 10.5.2).

Total above-ground carbon was estimated to be 16.55 tonnes/ha, with below-ground carbon estimated at 5.36 tonnes/ha. This gave a total amount of carbon of 21.91 tonnes/ha in the trees and bushes for the 495 hectares of Moreton Bay Ash country at "The Lake".

10.3.13 Paperbark

The amount of carbon per hectare for this ecosystem was not directly measured and values were estimated by averaging the total carbon/ha measurements of all trees in all sampled REs on the property. This gave a total amount of carbon in the trees and bushes of 38.08 tonnes/ha, for the 121 hectares of this Paperbark country at "The Lake".

10.3.14 and 10.3.15 River Coolibah

The amount of carbon per hectare for these ecosystems was not directly measured and values were estimated by averaging the measurements of the total carbon/ha measurements of all trees in all sampled REs on the property. This gave a total amount of carbon in the trees and bushes of 38.08 tonnes/ha, for the 1130 and 15 hectares of Coolibah country in the REs 10.3.14 and 10.3.15 respectively, at "The Lake".

10.3.28 Silver Leaf Ironbark

The amount of carbon per hectare for this Silver Leaf Ironbark ecosystem was not directly measured and values were transferred from those measured for Whites Ironbark (RE 10.5.5). Measurements of all tree types in RE 10.5.5 were included in the estimation.

Total above-ground carbon was estimated to be 15.14 tonnes/ha, with below-ground carbon estimated at 4.10 tonnes/ha. This gave a total amount of carbon in the trees and bushes of 19.24 tonnes/ha, for the 1622 hectares of Silver Leaf Ironbark country at "The Lake".

10.4.5 Gidgee

The amount of carbon per hectare for this Gidgee ecosystem was not directly measured and values were transferred from those measured for Gidgee (RE 10.3.4). All tree types occurring in RE 10.3.4 were included in the calculations.

Total above-ground carbon was estimated to be 33.39 tonnes/ha, with below-ground carbon estimated at 14.09 tonnes/ha. This gave a total amount of carbon in the trees and bushes of 47.48 tonnes/ha, for the 554 hectares of Gidgee country at “The Lake”.

10.5.1 Yellow Jacket

This ecosystem was measured in detail and the amount of carbon per hectare estimated includes other trees as well as Yellow Jacket (see Table 5 below). It was estimated that there were 286 trees/ha for Yellow Jacket, 322 trees/ha for Acacias, 75 tree/ha for Quinine Bush, 17 trees/ha for Ironbark, 58 trees/ha for Bloodwoods and 131 trees/ha for Others (Grevillea, Soap Bush and others)

Total above-ground carbon for Yellow Jacket was estimated at 40.28 tonnes/ha, while below-ground carbon was estimated to be 11.65 tonnes/ha. This gave a total amount of carbon of 51.93 tonnes/ha in the trees and bushes for this Regional Ecosystem (2976 hectares at “The Lake”).

Table 5. Measurements for Yellow Jacket Regional Ecosystem 10.5.1 at “The Lake”

Tree Types	Yellow Jacket	Acacia	Quinine Bush	Ironbark	Bloodwood	Others
Biomass (tonnes/tree)	0.139	0.011	0.006	0.029	0.604	0.007
Carbon/tree (tonnes)	0.069	0.006	0.003	0.015	0.302	0.004
Average number of trees/ha	286	322	75	17	58	131
Aboveground tree biomass (t/ha)	39.755	3.649	0.439	0.491	35.257	0.971
Belowground tree biomass (t/ha)	11.131	1.566	0.188	0.128	9.872	0.416
Belowground tree C (t/ha)	5.566	0.783	0.094	0.064	4.936	0.208
Aboveground tree C (t/ha)	19.878	1.825	0.219	0.245	17.629	0.485

10.5.2 Gum-topped Bloodwood

This ecosystem was measured in detail and the amount of carbon per hectare estimated includes other trees as well as Bloodwood (see Table 6 below). It was estimated that there were 117 trees/ha for Bloodwoods, 188 tree/ha for False Sandalwood and Quinine Bush, 248 trees/ha for Acacias, 19 trees/ha for Ironbark, 13 trees/ha for Yellow Jacket, 19 trees/ha for Eucalypts, 4 trees/ha for Box and 425 trees/ha for Others (Soap Bush, Maoli Orange, Tea tree, Hakea, Beefwood, Canthium)

Table 6. Measurements for Bloodwood Regional Ecosystem 10.5.2 at "The Lake"

Tree Types	Blood wood	F S'wood, Quinine B	Acacia	Ironbark	Yellow Jacket	Eucalypt	Box	Other
Biomass (tonnes/tree)	0.149	0.012	0.015	0.125	0.139	0.044	0.188	0.010
Carbon/tree (tonnes)	0.074	0.006	0.007	0.062	0.069	0.022	0.094	0.005
Average number of trees/ha	117	188	248	19	13	19	4	425
Aboveground tree biomass (t/ha)	17.382	2.201	3.598	2.339	1.737	0.816	0.784	4.243
Belowground tree biomass (t/ha)	4.867	0.944	1.543	0.608	0.486	0.229	0.219	1.820
Belowground tree C (t/ha)	2.434	0.472	0.772	0.304	0.243	0.114	0.110	0.910
Aboveground tree C (t/ha)	8.691	1.100	1.799	1.170	0.868	0.408	0.392	2.122

Total above-ground carbon for Bloodwood was estimated at 16.55 tonnes/ha, while below-ground carbon was estimated to be 5.36 tonnes/ha. This gave a total carbon amount of 21.91 tonnes/ha in the trees and bushes for this Regional Ecosystem (500 hectares at "The Lake").

10.5.5 White's Ironbark

This ecosystem was measured in detail and the amount of carbon per hectare estimated includes other trees as well as White's Ironbark (see Table 7 below). It was estimated that there were 450 trees/ha for White's Ironbark, 81 trees/ha for Quinine Bush, False Sandalwood and Turkey Bush, 186 trees/ha for Acacias and Hop Bush, 11 trees/ha for Eucalypts, 3 trees/ha for Reid's River Box, 8 trees/ha for Bloodwoods, and 125 trees/ha for Others (Euphorbiaceae, Beefwood, Soap Bush, Grevillea, Canthium, Wallaby Apple, Wilga)

Table 7. Measurements for White's Ironbark Ecosystem 10.5.5 at "The Lake"

Tree Types	White's Ironbark	Quinine B, F S'wood, Turkey B	Acacia, Hop Bush	Eucalypt	Reid's Box	Blood wood	Other
Biomass (tonnes/tree)	0.059	0.005	0.001	0.014	0.188	0.149	0.008
Carbon/tree (tonnes)	0.030	0.003	0.001	0.007	0.094	0.074	0.004
Average number of trees/ha	450	81	186	11	3	8	125
Aboveground tree biomass (t/ha)	26.664	0.416	0.249	0.155	0.523	1.242	1.038
Belowground tree biomass (t/ha)	6.933	0.178	0.107	0.043	0.146	0.348	0.445
Belowground tree C (t/ha)	3.466	0.089	0.053	0.022	0.073	0.174	0.223
Aboveground tree C (t/ha)	13.332	0.208	0.124	0.077	0.261	0.621	0.519

Total above-ground carbon for White's Ironbark was estimated at 15.14 tonnes/ha, while below-ground carbon was estimated to be 4.10 tonnes/ha. This gave a total carbon amount of 19.24 tonnes/ha in the trees and bushes for this Regional Ecosystem (1624.hectares at “The Lake”).

10.5.8 Rough Leaf Bloodwood and 10.10.5 Bloodwood.

The amount of carbon per hectare for these ecosystems was not directly measured and as with RE 10.3.12 Moreton Bay Ash, all values were transferred from the Bloodwood RE 10.5.2.

Total above-ground carbon was estimated to be 16.55 tonnes/ha, with below-ground carbon estimated at 5.36 tonnes/ha. This gave a total amount of carbon in the trees and bushes of 21.91 tonnes/ha, for the 319 hectares and 31 hectares of Bloodwood REs 10.5.8 and 10.10.5 respectively, at “The Lake”.

10.7.2 and 10.7.5 Napunyah

The amount of carbon per hectare for these ecosystems was not directly measured and values were estimated by averaging the measurements of the total carbon/ha measurements of all trees in all sampled REs on the property. This gave a total amount of carbon in the trees and bushes of 38.08 tonnes/ha, for the 320 and 107 hectares of Napunyah country in REs 10.7.2 and 10.7.5 respectively, at “The Lake”.

10.7.3 and 10.10.1 Lancewood

The amount of carbon per hectare for these ecosystems was not directly measured and values were estimated by averaging the measurements of the total carbon/ha measurements of all trees in all sampled REs on the property. This gave a total amount of carbon in the trees and bushes of 38.08 tonnes/ha, for the 255 and 533 hectares of Lancewood country in the REs 10.7.3 and 10.10.1 respectively, at “The Lake”.

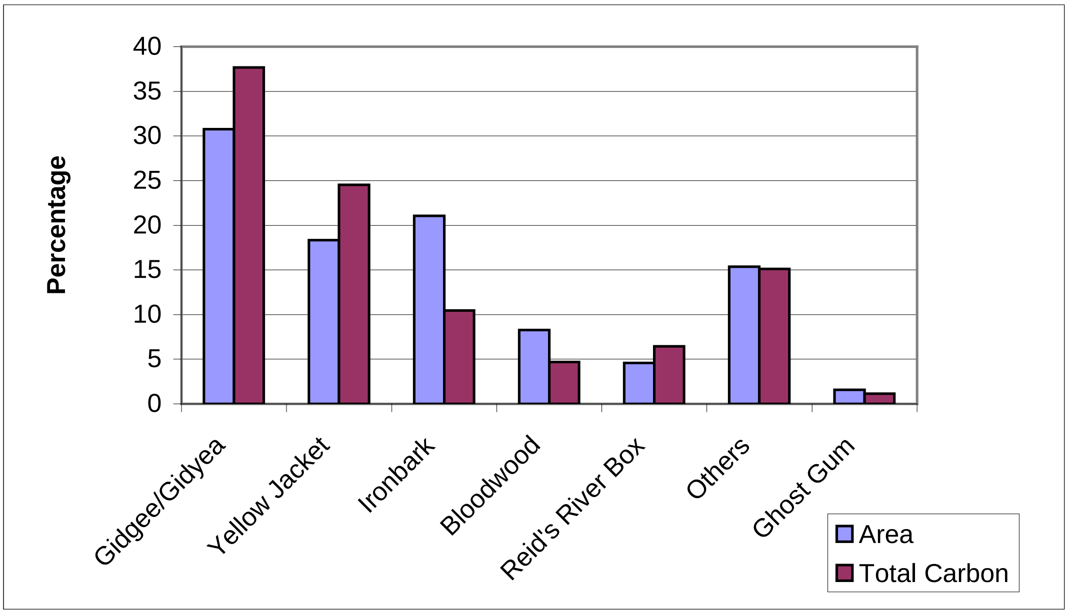
10.7.7 Tea Tree

The amount of carbon per hectare for this ecosystem was not directly measured and values were estimated by averaging the measurements of the total carbon/ha measurements of all trees in all sampled REs on the property. This gave a total amount of carbon in the trees and bushes of 38.08 tonnes/ha, for the 14 hectares of Tea Tree country in the RE 10.7.7, at “The Lake”.

Summary of the carbon stored in the trees and bushes at “The Lake”

There are five main tree type ecosystems that dominate the uncleared areas at “The Lake” and which were measured in detail. Measurements from these were then used as substitutes for similar ecosystems on the property. When the REs with the same measurements were grouped together, Gidgee/Gidyea REs accounted for 31% of the uncleared area and comprised 38% of the total carbon stored in the trees and bushes on the property (Figure 2). On the other hand Ironbark REs formed 21% of the total area, but only comprised 10% of the total carbon pool. The “Others” category in Figure 2 includes all the REs where average RE values were used in the absence of direct measurements. Ghost Gum measurements were not taken at "The Lake" and values were substituted from "Wololla", another property in the Desert Uplands.

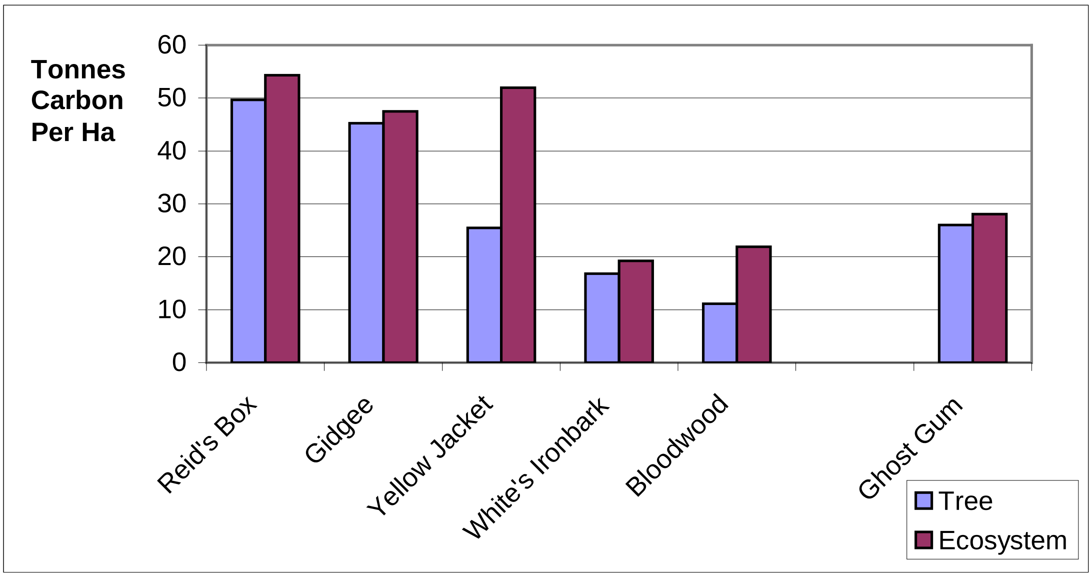
Figure 2. Contribution of Main Tree REs to Total Area and Total Carbon Stores



The largest difference between the proportion of the area and the proportion of carbon stores occurred in Ironbark ecosystems, and to a lesser extent in Bloodwood ecosystems (Figure 2). This is illustrative of the relatively low concentration of carbon in these ecosystems compared with the other ecosystems on the property.

The differences between the amounts of carbon stored in the individual tree types compared with that stored in the whole ecosystem, is illustrated in Figure 3.

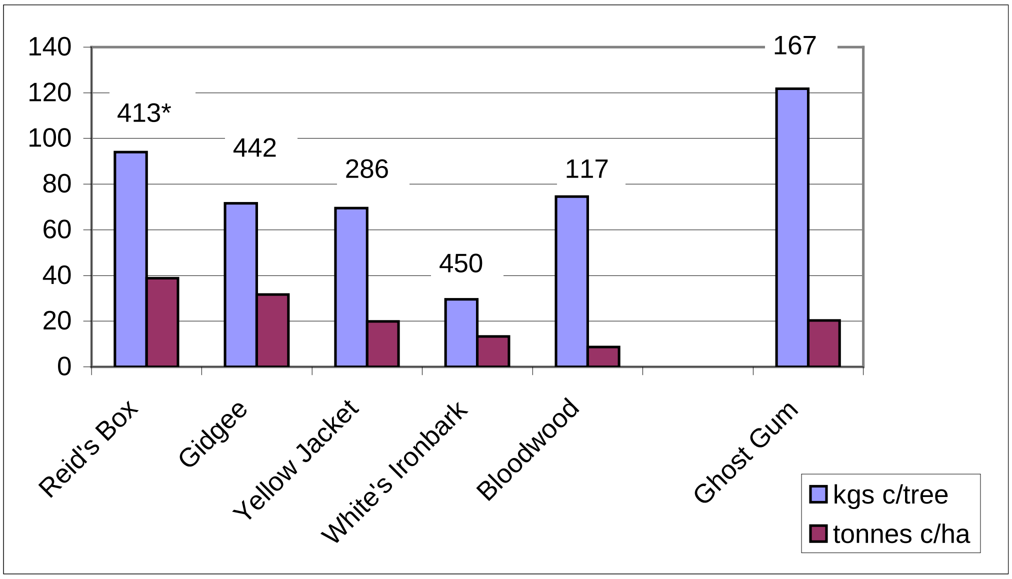
Figure 3. Tree and Ecosystem Carbon Stores for Measured REs at "The Lake"



Reid River Box had the highest value for total carbon per hectare, both in terms of the tree (50 t/ha) and the ecosystem (54 t/ha). Gidgee also had high carbon contents at both the tree and the ecosystem level. This was not the case for Yellow Jacket where the trees contributed less than half (49%) of the total carbon budget for the ecosystem. In this ecosystem, there were some large Bloodwood trees that contributed 43% to the total carbon value for the ecosystem. While the Bloodwood trees were an important component in the Yellow Jacket ecosystem, their influence on the total carbon budget for the property was less notable in the Bloodwood ecosystem. In this ecosystem, the Bloodwood trees only comprised half the carbon budget (11t/ha) for the ecosystem (22t/ha), and a variety of other trees formed the other half. The influence of a few very large trees can be substantial. The Bloodwood trees in the Yellow Jacket ecosystem had nearly double the carbon content (23 tonnes/ha) compared with the Bloodwood trees in the Bloodwood ecosystem (11 tonnes/ha).

The two main factors that affect the total carbon stores are the amount of carbon stored in a particular tree type, and the number of trees or tree density. A lot of trees, each with low amounts of carbon, may make the same contribution to the total carbon pool as a few trees each with a high carbon content. Another factor that influences the total carbon budget is the proportion used to calculate the below-ground tree biomass. In this case, a figure of 28% was used to calculate the below-ground biomass for Reid's Box, Yellow Jacket and Bloodwood trees and Ghost Gum (which was measured on a nearby property), and 26% was used for Ironbark. However, a much higher proportion (43%) was used to calculated below-ground tree biomass for Gidgee. Figure 4 illustrates the differences in above-ground carbon stores on the property, and while the relative carbon contribution from Gidgee, is reduced, it remains an important source.

Figure 4. Above-Ground Tree Carbon Stores and Tree Density at "The Lake"



***** The Figures above the columns are the number of trees per hectare

Ghost Gum had the highest above-ground carbon content per tree (122 kg), approximately four times higher than White's Ironbark (30 kg/tree). But, because of the relatively low tree density (167 trees per hectare), the carbon contribution from Ghost Gum on a per hectare basis (20 t/ha) was lower than both Reid's Box and Gidgee.

Conclusion

This report provides an example of how the amount of carbon stored in the trees and bushes may be estimated on a cattle property. Estimates have been made by measuring trees in different vegetation or Regional Ecosystem types.

The results demonstrate that there are substantial variations in carbon stocks across the different ecosystem types. The amount of carbon in trees and bushes varied from 19 tonnes/ha in Ironbark country to 54 tonnes/ha in Reid River Box country.

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Appendix 1: Common and Scientific Tree Names and Equations Used to Estimate Above-ground Tree Biomass

Category	Common Name	Scientific Name	*Function*	*Reference*
Silver Leaf Ironbark	Silver Leaf Ironbark, White's Ironbark	*Eucalyptus melanophloia, E. whitei*	$B = e^{(-6.553 + 2.726 \times \ln \mathbf{C})}$	Burrows et al. (2000)
Narrow Leaf Ironbark	Narrow Leaf Ironbark	*Eucalyptus crebra*	$B = e^{(-6.505 + 2.756 \times \ln \mathbf{C})}$	Burrows et al. (2000)
Box	Poplar Box, Reid River Box,	*Eucalyptus populnea, E. brownii,*	$B = e^{(-2.809 + 1.922 \times \ln \mathbf{C})}$	Burrows et al. (2000)
Other Eucalypts and Bloodwoods	Mountain Coolibah, River Coolibah, Red River Gum, Dawson River Gum, Ghost Gum, Queensland Yellow Jacket, Rough Leaf Bloodwood, Qld Peppermint, Napunyah, Moreton Bay Ash, Gum-topped Bloodwood, Bloodwood	*E. orgadophila, E. coolibah, E. camaldulensis, E. cambageana, E. papuana, E. similis, E. setosa, E. exserta, E. thozetiana, Corymbia tessellaris, C. brachycarpa, Corymbia spp.*	$B = e^{(-4.92+2.39 \times \ln \mathbf{C})}$	Burrows et al. (2000)
Acacias	Brigalow, Lancewood, Black Wattle, Sally Wattle, Ironwood, Gidgee, Black Gidyea, Desert Oak, other Acacias	*Acacia harpophylla, A. shirleyi, A. leiocalyx, A. salicina, A. excelsa, A. cambagei, A. argyrodendron, A. coriacea, Acacia spp.*	$b = e^{(-3.568 + 2.384 \times \ln \mathbf{c})} \times e^{0.031}$	Scanlan (1991)
Bushes	False Sandalwood, Turkey Bush, Quinine Bush	*Eremophila mitchellii, Erythroxylum australe, Petalostigma pubescens*	$B = e^{(-4.453 + 2.257 \times \ln (Dx1.15))} + e^{(-3.890 + 2.623 \times \ln (Dx1.15))}$	Harington (1979)
Others	Cattle Bush (Whitewood), Bitter Bark, Beefwood, Wilga, Soap Bush (Soapy Box), Wallaby Apple (Orange Thorn), Emu Apple, Monkey Vine, Canthium (Supple Jack), Bauhinia, Bulloak, Hakea, Black Cyprus Pine, Red Bottlebrush, Hop Bush, Prickly Pine, Paperbark, Tea-tree, Saltbush, Karajong, Maoli Orange	*Atalaya hemiglauca, Alistonia constricta, Grevillea striata, Geijera parviflora, Alphitonia excelsa, Citriobatus spinescens, Owenia acidula, Parsonsia eucalyptophylla, Canthium coprosmoides, Lysiphylum spp., Hakea lorea, Hakea sp, Callitris endlicheri, Callistemon viminalis, Dodonea spp., Bursaria incana, Melaleuca leucodendro, Melaluca spp, Holosarcia spp, Brachychiton spp, Capperacea spp*	$B = e^{(-2.156 + 1.614 \times \ln D)} + e^{(-2.028 + 2.119 \times \ln D)}$ B = above ground biomass (kg.) C = circumference at 0.3 mH (cm.) b = above ground biomass (g) c = circumference at 0.3mH (mm) D = diameter at 0.3mH (cm.)	Harington (1979)

Appendix 2: Above and Below Ground Tree Carbon for "The Lake"

RE	Main tree type	Estimate source	Carbon/ Tree (tonnes)	Trees/ha	Carbon/ ha (tonnes)			RE area (ha)	Total tree Carbon (tonnes/RE)
					Above ground	Below ground	Total Tree Carbon		
10.3.1	Black Gidyea	RE 10.3.4			33.39	14.09	47.48	2069.25	98244.37
10.3.3	Ghost Gum	"Wololla"	0.122	167	20.333	5.693	28.04	258.79	7257.19
	Silver Leaf Ironbark	RE 10.3.3	0.041	10	0.409	0.106			
	Chinee Tree, Quinine Bush		0.001	62	0.032	0.014			
	Bloodwood		0.048	15	0.721	0.202			
	Acacia		0.003	50	0.150	0.064			
	Others		0.007	30	0.221	0.095			
10.3.4	Gidgee	Measured	0.072	442	31.645	13.576	47.48	312.79	14850.84
	Acacia		0.001	97	0.048	0.020			
	False Sandalwood		0.003	25	0.085	0.037			
	Eucalypts		0.039	42	1.616	0.452			
10.3.6	Reid's Box	Measured	0.094	413	38.797	10.863	54.31	745.66	40496.14
	False S'wood, Quinine Bush		0.003	156	0.472	0.203			
	Acacia, Hop Hush		0.001	65	0.056	0.024			
	Eucalypts		0.145	8	1.208	0.338			
	Bloodwood		0.074	2	0.155	0.043			
	Others		0.015	102	1.504	0.645			
10.3.9	White's Ironbark	RE 10.5.5			15.14	4.10	19.24	170.07	3272.55
10.3.12	Moreton Bay Ash	RE 10.5.2			16.55	5.36	21.91	494.84	10841.31
10.3.13	Paperbark	Average all measured REs			28.13	9.95	38.08	120.73	4597.92
10.3.14	River Coolibah	Average all measured REs			28.13	9.95	38.08	1130.44	43051.00
10.3.15	River Coolibah	Average all measured REs			28.13	9.95	38.08	15.46	588.84
10.3.28	Silver Leaf Ironbark	RE 10.5.5			15.14	4.10	19.24	1621.87	31208.79

RE	Main tree type	Estimate source	Carbon/ Tree (tonnes)	Trees/ha	Carbon/ ha (tonnes)			RE area (ha)	Total tree Carbon (tonnes/RE)
					Above ground	Below ground	Total Tree Carbon		
10.4.1	Black Gidyea	RE 10.3.4			33.39	14.09	47.48	2058.81	97749.03
10.4.5	Gidgee	RE 10.3.4			33.39	14.09	47.48	553.74	26290.47
10.5.1	Yellow Jacket	Measured	0.069	286	19.878	5.566	51.93	2975.62	154528.96
	Acacia		0.006	322	1.825	0.783			
	Quinine Bush		0.003	75	0.219	0.094			
	Ironbark		0.015	17	0.245	0.064			
	Bloodwood		0.302	58	17.629	4.936			
	Others		0.004	131	0.485	0.208			
10.5.2	Gum-topped Bloodwood	Measured	0.074	117	8.691	2.434	21.91	500.45	10964.31
	F. Sandalwood, Quinine Bush		0.006	188	1.100	0.472			
	Acacia		0.007	248	1.799	0.772			
	Ironbark		0.062	19	1.170	0.304			
	Yellow Jacket		0.069	13	0.868	0.243			
	Eucalypt		0.022	19	0.408	0.114			
	Box		0.094	4	0.392	0.110			
	Others		0.005	425	2.122	0.910			
10.5.5	White's Ironbark	Measured	0.030	450	13.332	3.467	19.24	1624.10	31251.78
	F. S’wood, Quinine, Turkey B		0.003	81	0.208	0.089			
	Acacia, Hop Bush		0.001	186	0.124	0.053			
	Eucalypts		0.007	11	0.077	0.022			
	Reid’s Box		0.094	3	0.261	0.073			
	Bloodwood		0.074	8	0.621	0.174			
	Others		0.004	125	0.519	0.223			
10.5.8	Rough Leaf Bloodwood	RE 10.5.2			16.55	5.36	21.91	318.92	6987.16
10.7.2	Napunyah	Average all measured REs			28.13	9.95	38.08	320.29	12197.79
10.7.3	Lancewood	Average all measured REs			28.13	9.95	38.08	255.25	9720.70
10.7.5	Napunyah	Average all measured REs			28.13	9.95	38.08	107.09	4078.52

RE	Main tree type	Estimate source	Carbon/ Tree (tonnes)	Trees/ha	Carbon/ ha (tonnes)			RE area (ha)	Total tree Carbon (tonnes/RE)
					Above ground	Below ground	Total Tree Carbon		
10.7.7	Tea Tree	Average all measured REs			28.13	9.95	38.08	14.30	544.69
10.10.1	Lancewood	Average all measured REs			28.13	9.95	38.08	532.69	20286.64
10.10.5	Bloodwood.	RE 10.5.2			16.55	5.36	21.91	31.33	686.51
						Total		**16232.49**	**629695.50**