GRAZING PROPERTY CARBON BUDGET IN CENTRAL QUEENSLAND

- *Berrigurra* -

Property Carbon Budgeting in Central Queensland
Report No. 6

Central Queensland University, Emerald
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AUSTRALIAN Greenhouse Office
The lead Commonwealth agency on greenhouse matters

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BERRIGURRA 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 “Berigurra”, a cattle property near Blackwater in the Central Highlands region of Central Queensland. The property is part of the Emerald Agricultural College.

It was estimated that approximately 92,011 tonnes of carbon were stored in the trees and bushes on the property. This represents an average of 58.05 tonnes/ha of carbon in vegetation (excluding cleared and naturally open areas). In the predominant vegetation types, the values range from an average 25.5 tons/ha of carbon in narrow-leafed ironbark country to 69.0 tonnes/ha of carbon in brigalow country. Approximately 72% of the carbon is in the above-ground part of the trees and scrubs, while 28% is below-ground in the roots.

SECTION 1. GENERAL INFORMATION

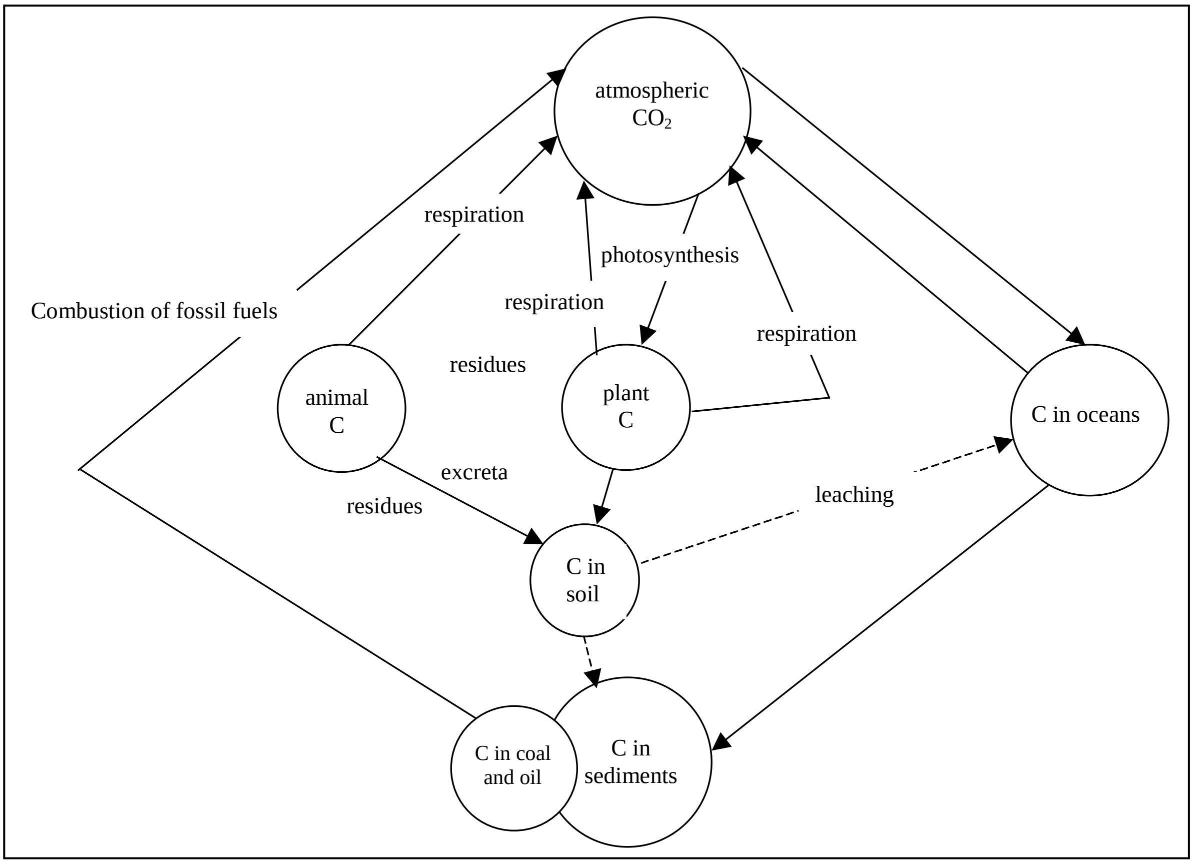
Greenhouse gas emissions

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 92,011 tonnes of carbon are stored in these sources on the property.

An example from the Central Highlands region in Central Queensland

The carbon estimates outlined below were taken from “Berrigurra” a cattle grazing property located approximately 27 km west of Blackwater. The property has a total area of 9323.45 hectares, of which about 7756 hectares (83%) has been cleared for grazing and established with improved pasture. The remaining 1567.80 hectares (17%) is uncleared and classified as remnant vegetation by the Department of Natural Resources and Mines.

Different Types of Vegetation or Regional Ecosystems at “Berrigurra”

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. All Regional Ecosystem numbers starting with 11 are classified as part of the Brigalow Belt. 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.

“Berrigurra” is located within the Brigalow Belt Bioregion and includes vegetation categorised in 13 Regional Ecosystems. See Table 1 below for details.

Table 1. Regional Ecosystems (RE) and Area Represented on "Berrigurra"

RE	Major Tree	Scientific Name	RE Area (ha.)	RE Area %
11.3.1	**Brigalow**	***Acacia harpophylla***	**157.06**	**10.02**
11.3.2	Poplar Box	*Eucalyptus populnea*	61.95	3.95
11.3.3	River Coolibah	*E. coolibah*	34.42	2.20
11.3.25	Red River Gum	*E. camaldulensis*	51.19	3.27
11.4.2	**Clarkson's Bloodwood**	***Corymbia clarksoniana***	**4.54**	**0.29**
11.4.3	**Brigalow**	***Acacia harpophylla***	**69.22**	**4.42**
11.4.8	Brigalow	*Acacia harpophylla*	14.96	0.95
11.5.9	**Narrow Leaf Ironbark**	***Eucalyptus crebra***	**86.92**	**5.54**
11.7.1	Brigalow	*Acacia harpophylla*	80.76	5.15
11.7.2	**Lancewood**	***Acacia shierlyi***	**724.50**	**46.21**
11.9.1	Brigalow	*Acacia harpophylla*	11.88	0.76
11.9.5	Brigalow	*Acacia harpophylla*	11.20	0.71
11.10.12	**Poplar Box**	***Eucalyptus populnea***	**259.20**	**16.53**
		Total area of uncleared vegetation	**1567.80**	**100**

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 six of the REs, (marked in bold in Table 1) and to apply the measurements 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 92,011 tonnes of carbon were stored in the trees and bushes on the property, or approximately 59 tonnes carbon per hectare. Approximately 66,606 tonnes (72.2%) of carbon were stored in the aboveground vegetation, and 25,405 tonnes (27.8%) of carbon were stored in the belowground 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 on “Berrigurra”

RE	Major 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
11.3.1	Brigalow	16.96	42.04	59.00	157.06	9266.01
11.3.2	Poplar Box	12.30	39.65	51.95	61.95	3218.73
11.3.3	River Coolibah	13.71	38.06	51.77	34.42	1781.88
11.3.25	Red River Gum	13.71	38.06	51.77	51.19	2650.04
11.4.2	Clarkson’s Bloodwood	9.73	29.91	39.64	4.54	179.98
11.4.3	Brigalow	18.53	50.42	68.95	69.22	4772.85
11.4.8	Brigalow	18.53	50.42	68.95	14.96	1031.52
11.5.9	Narrow Leaf Ironbark	5.55	19.96	25.51	86.92	2217.34
11.7.1	Brigalow	17.74	46.23	63.97	80.76	5166.56
11.7.2	Lancewood	19.15	46.40	65.55	724.50	47494.16
11.9.1	Brigalow	9.65	23.48	33.13	11.88	393.62
11.9.5	Brigalow	9.65	23.48	33.13	11.20	371.09
11.10.12	Poplar Box	12.30	39.65	51.95	259.20	13467.22
				Total	**1567.80**	**92011.00**

Carbon in individual Regional Ecosystems

11.3.1 Brigalow

This regional ecosystem was sampled in detail at "Berrigurra". While the dominant tree type in the sampled area was Brigalow, other tree types were also found (see Table 3). For example, it was estimated that there were 1198 trees/ha for Brigalow, 35 trees/ha for False Sandalwood, 32 trees/ha for Eucalypt species, and 110 trees/ha for Others (Soap Bush, Bahunia, Canthium, Whitewood, others).

The equations used to estimate the biomass for each tree type are summarised in Appendix 1. The average biomass for each tree was calculated by averaging the estimates from all the trees of that type measured in the transects.

Table 3. Measurements for Brigalow Regional Ecosystem 11.3.1 at "Berrigurra"

	Brigalow	False Sandalwood	Eucalypts	Others
Biomass (tonnes/tree)	0.040	0.023	0.456	0.186
Carbon/tree (tonnes)	0.020	0.011	0.228	0.093
Average number of trees/ha	1198	35	32	110
Aboveground tree biomass (t/ha)	48.375	0.801	14.433	20.466
Belowground tree biomass (t/ha)	20.753	0.344	4.041	8.780
Belowground tree C (t/ha)	10.377	0.172	2.021	4.390
Aboveground tree C (t/ha)	24.188	0.401	7.217	10.233

Total above-ground carbon was estimated to be 42.04 tonnes/ha, with below ground estimated at 16.96 tonnes/ha. This gave a total of 59 tonnes/ha for trees and bushes, in the 157 hectares of this Brigalow country at "Berrigurra".

11.3.2 Poplar Box

This Poplar Box ecosystem was not measured in detail. Measurements were transferred from another Poplar Box community (RE 11.10.12) that was measured in detail on the property.

Total above-ground carbon was estimated at 39.65 tonnes/ha, while below-ground carbon was estimated to be 12.30 tonnes/ha. This gave a total of 51.95 tonnes/ha for the trees and bushes in this Poplar Box Regional Ecosystem (62 hectares at "Berrigurra").

11.3.3 River Coolibah

This River Coolibah ecosystem was not measured in detail on the property and values were estimated by averaging the measurements of the total carbon/ha measurements of all trees in all sampled REs on the property. Total above-ground carbon was estimated at 38.06 tonnes/ha, while below-ground carbon was estimated to be 13.71 tonnes/ha. This gave an average amount of carbon in the trees and bushes of 51.77 tonnes/ha, for the 34 hectares of this River Coolibah country (RE 11.3.3) at "Berrigurra".

11.3.25 Red River Gum

This Red River Gum ecosystem was not measured in detail on the property and values were estimated by averaging the measurements of the total carbon/ha measurements of all trees in all sampled REs on the property. Total above-ground carbon was estimated at 38.06 tonnes/ha, while below-ground carbon was estimated to be 13.71 tonnes/ha. This gave an average amount of carbon in the trees and bushes of 51.77 tonnes/ha for the 51 hectares of this River Gum country (RE 11.3.25) at "Berrigurra".

11.4.2 Clarkson's Bloodwood

This Bloodwood regional ecosystem was sampled in detail at "Berrigurra". While the dominant tree type in the sampled area was Bloodwood, other tree types were also found (see Table 4). For example, it was estimated that there were 57 trees/ha for Clarkson's Bloodwood, 57 trees/ha for other Bloodwoods, 22 trees/ha for Poplar Box, 8 tree/ha for Narrow Leaf Ironbark, 167 trees/ha for other Acacias, 65 trees/ha for False Sandalwood and Quinine Bush, 18 trees /ha for Moreton Bay Ash, 157 trees/ha for Others (Bitter Bark, Canthium, Whitewood, Bauhinia, Wallaby Apple, others).

The average biomass for each tree was calculated from the transect data, and then averaged. The equations used to estimate biomass for each tree type are summarised in Appendix 1.

Table 4. Measurements for Clarkson's Bloodwood RE 11.4.2 at "Berrigurra"

	Clarks' Blood wood	Other Blood woods	Poplar Box	N Leaf Ironbark	Other Acacia	F' Swood Quinine Bush	Moreton Bay Ash	Others
Biomass (tonnes/tree)	0.293	0.259	0.394	0.027	0.095	0.014	0.063	0.010
Carbon/tree (tonnes)	0.147	0.130	0.197	0.013	0.047	0.007	0.032	0.005
Average number of trees/ha	57	57	22	8	167	65	18	157
Aboveground tree biomass (t/ha)	16.720	14.765	8.675	0.216	15.826	0.912	1.134	1.571
Belowground tree biomass (t/ha)	4.682	4.134	2.429	0.050	6.789	0.391	0.318	0.674
Belowground tree C (t/ha)	2.341	2.067	1.215	0.025	3.395	0.196	0.318	0.337
Aboveground tree C (t/ha)	8.360	7.382	4.338	0.108	7.913	0.456	0.159	0.786

Total above-ground carbon was estimated to be 29.91 tonnes/ha, with below ground estimated at 9.73 tonnes/ha. This gave an average amount of carbon in the trees and bushes of 39.64 tonnes/ha, for the 5 hectares of this Clarkson's Bloodwood country at "Berrigurra".

11.4.3 Brigalow

This Brigalow ecosystem was sampled in detail at "Berrigurra". While the dominant tree type in the sampled area was Brigalow, other tree types were also found (see Table 5). It was estimated that there were 1463 trees/ha for Brigalow, 242 trees/ha for False Sandalwood, 117 trees/ha for Dawson River Gum, 47 trees/ha for Poplar Box, 2 trees/ha for Acacia, and 85 trees/ha for Others (Canthium, Whitewood, Bitter Bark, Emu Apple).

Table 5. Measurements for Brigalow RE 11.4.3 at "Berrigurra"

	Brigalow	F'Sandal wood	Dawson River Gum	Poplar Box	Acacia	Others
Biomass (tonnes/tree)	0.037	0.010	0.302	0.137	0.105	0.028
Carbon/tree (tonnes)	0.019	0.005	0.151	0.068	0.052	0.014
Average number of trees/ha	1463	242	117	47	2	85
Aboveground tree biomass (t/ha)	54.367	2.354	35.226	6.371	0.175	2.348
Belowground tree biomass (t/ha)	23.323	1.010	9.863	1.784	0.075	1.007
Belowground tree C (t/ha)	11.662	0.505	4.932	0.892	0.037	0.504
Aboveground tree C (t/ha)	27.183	1.177	17.613	3.185	0.087	1.174

The equations used to estimate the biomass for each tree type are summarised in Appendix 1. The average biomass for each tree was calculated by averaging the estimates from all the trees of that type measured in the transects.

Total above-ground carbon for this Brigalow RE was estimated at 50.42 tonnes/ha, while below-ground carbon was estimated to be 18.53 tonnes/ha. This gave a total of 68.95 tonnes/ha for vegetation in this Brigalow Regional Ecosystem (69 hectares at “Berrigurra”).

11.4.8 Brigalow

This Brigalow ecosystem was not measured in detail and values were transferred from a similar Brigalow community RE 11.4.3. Total above-ground carbon was estimated at 50.42 tonnes/ha, while below-ground carbon was estimated to be 18.53 tonnes/ha. This gave a total of 68.95 tonnes/ha for trees and bushes in this Brigalow Regional Ecosystem (15 hectares at “Berrigurra”).

11.5.9 Narrow Leaf Ironbark

This Narrow Leaf Ironbark ecosystem was measured in detail. Both Narrow Leaf Ironbark and Black Wattle were dominant trees in the ecosystem. It was estimated that there were 170 trees/ha for Narrow Leaf Ironbark, 402 trees/ha for Black Wattle, 37 trees/ha for other Acacias, 12 trees/ha for Eucalypts, 28 trees/ha for False Sandalwood, Quinine and Turkey Bush, and 40 trees/ha for Others (Bauhinia, Soap Bush, Bitter Bark, Canthium).

The equations used to estimate the biomass for each tree type are summarised in Appendix 1. The average biomass for each tree was calculated by averaging the estimates from all the trees of that type measured in the transects.

Table 6. Measurements for Narrow Leaf Iron Bark RE 11.5.9 at “Berrigurra”

	N Leaf Ironbark	Black Wattle	Acacia	Eucalypt	F' Swood, Quin +Tky B	Others
Biomass (tonnes/tree)	0.173	0.012	0.069	0.093	0.017	0.036
Carbon/tree (tonnes)	0.087	0.006	0.034	0.046	0.009	0.018
Average number of trees/ha	170	402	37	12	28	40
Aboveground tree biomass (t/ha)	29.419	4.961	2.514	1.083	0.485	1.451
Belowground tree biomass (t/ha)	6.766	2.128	1.078	0.303	0.208	0.623

Belowground tree C (t/ha)	3.383	1.064	0.539	0.152	0.104	0.311
Aboveground tree C (t/ha)	14.710	2.480	1.257	0.541	0.243	0.726

Total above-ground carbon was estimated at 19.96 tonnes/ha, while below-ground carbon was estimated to be 5.55 tonnes/ha. This gave a total of 25.51 tonnes/ha in the trees and bushes of this Narrow Leaf Ironbark Regional Ecosystem (87 hectares at “Berrigurra”).

11.7.1 Brigalow

This Ecosystem was not sampled in detail. The measurements taken at Brigalow REs 11.3.1 and 11.4.3 were averaged and used to represent this ecosystem.

Total above-ground carbon was estimated at 46.23 tonnes/ha, while below-ground carbon was estimated to be 17.74 tonnes/ha. This gave a total of 63.97 tonnes/ha in the trees and bushes of this Brigalow Ecosystem (81 hectares at “Berrigurra”).

11.7.2 Lancewood

This ecosystem was measured in detail and apart from Lancewood, the dominant tree, other tree types were also found (see Table 7). It was estimated that there were 1492 trees/ha for Lancewood, 58 trees/ha for Acacias, 43 trees/ha for Eucalypts, 13 trees/ha for False Sandalwood and Turkey Bush, and 68 trees/ha for Others (Beefwood, Soap Bush, Bitter Bark, Hakea, other bushes).

The equations used to estimate the biomass for each tree type are summarised in Appendix 1. The average biomass for each tree was calculated by averaging the estimates from all the trees of that type measured in the transects.

Table 7. Measurements for Lancewood Regional Ecosystem 11.7.2 at “Berrigurra”

	Lancewood	Acacia	Eucalypt	F’ Sandal wood	Others
Biomass (tonnes/tree)	0.053	0.045	0.235	0.003	0.019
Carbon/tree (tonnes)	0.026	0.022	0.117	0.002	0.010
Average number of trees/ha	1492	58	43	13	68
Aboveground tree biomass (t/ha)	78.663	2.617	10.175	0.042	1.313
Belowground tree biomass (t/ha)	33.746	1.123	2.849	0.018	0.563
Belowground tree C (t/ha)	16.873	0.561	1.425	0.009	0.282
Aboveground tree C (t/ha)	39.332	1.308	5.088	0.021	0.657

Total above-ground carbon for this RE was estimated at 46.40 tonnes/ha, while below-ground carbon was estimated to be 19.15 tonnes/ha. This gave a total of 65.55 tonnes/ha for the trees and bushes in this Lancewood Regional Ecosystem 11.7.2 (725 hectares at “Berrigurra”).

11.9.1 Brigalow and 11.95 Brigalow

These RE was not sampled at Berrigurra but the values of carbon were transferred from a Brigalow ecosystem (RE 11.9.1) sampled in detail at Avocet (another property in the Central highlands region).

Total above-ground carbon for these RE was estimated at 23.48 tonnes/ha, while below-ground carbon was estimated to be 9.65 tonnes/ha. This gave a total of 33.13 tonnes/ha in the trees and bushes for the 12 and 11 hectares of Brigalow REs 11.9.1 and 11.9.5 respectively.

11.10 .12 Poplar Box

This Poplar Box ecosystem was sampled in detail at "Berrigurra". While the dominant tree type was Poplar Box, other tree types were also found (see Table 8). It was estimated that there were 208 trees/ha for Poplar Box, 163 trees/ha for False Sandalwood, Quinine and Turkey Bush, 215 trees/ha for Acacias, 12 trees/ha for Eucalypts, and 93 trees/ha for Others (Hakea, Beefwood, Wilga, Whitewood, Emu Apple, Bauhinia, Canthium, Bitter Bark, other bushes).

The equations used to estimate the biomass for each tree type are summarised in Appendix 1. The average biomass for each tree was calculated by averaging the estimates from all the trees of that type measured in the transects.

Table 8. Measurements for Poplar Box RE 11.10.12 at "Berrigurra"

	Poplar Box	F.Swood, etc	Acacias	Eucalypts	Others
Biomass (tonnes/tree)	0.292	0.020	0.055	0.206	0.011
Carbon/tree (tonnes)	0.146	0.010	0.027	0.103	0.006
Average number of trees/ha	208	163	215	12	93
Aboveground tree biomass (t/ha)	60.788	3.241	11.813	2.401	1.063
Belowground tree biomass (t/ha)	17.021	1.390	5.068	0.672	0.456
Belowground tree C (t/ha)	8.510	0.695	2.534	0.336	0.228
Aboveground tree C (t/ha)	30.394	1.620	5.907	1.201	0.532

Total above-ground carbon for Poplar Box was estimated at 39.65 tonnes/ha, while below-ground carbon was estimated to be 12.30 tonnes/ha. This gave a total of 51.95 tonnes/ha for the trees and bushes in this Poplar Box Regional Ecosystem (259 hectares at "Berrigurra").

Summary of the carbon stored in trees and bushes at "Berrigurra"

Three main tree type ecosystems (Lancewood, Brigalow, and Poplar Box), dominated the carbon pool at "Berrigurra", and were measured in detail. In addition, Narrow Leaf Ironbark and Clarkson's Bloodwood ecosystems were also measured on the property. Lancewood was the major vegetation community in terms of area as well as carbon stores followed by Brigalow and Poplar Box (Figure 2).

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

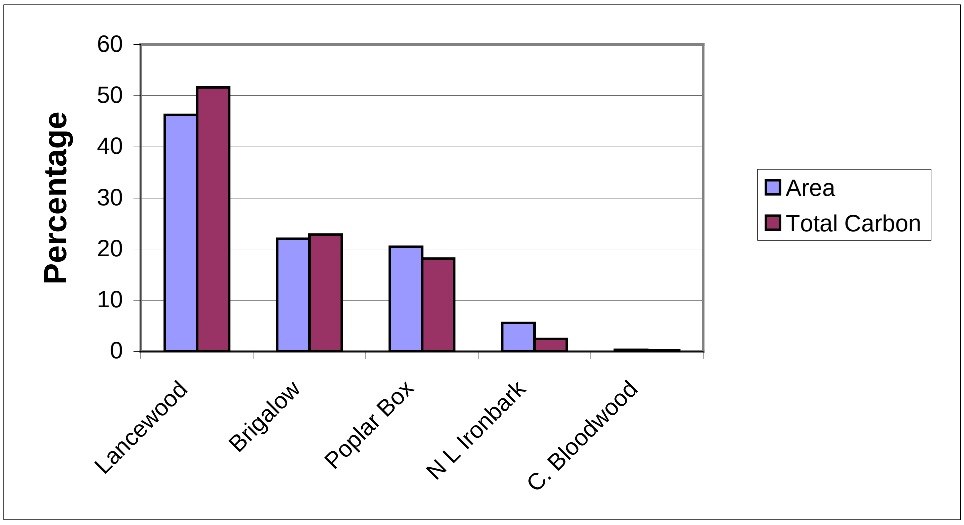
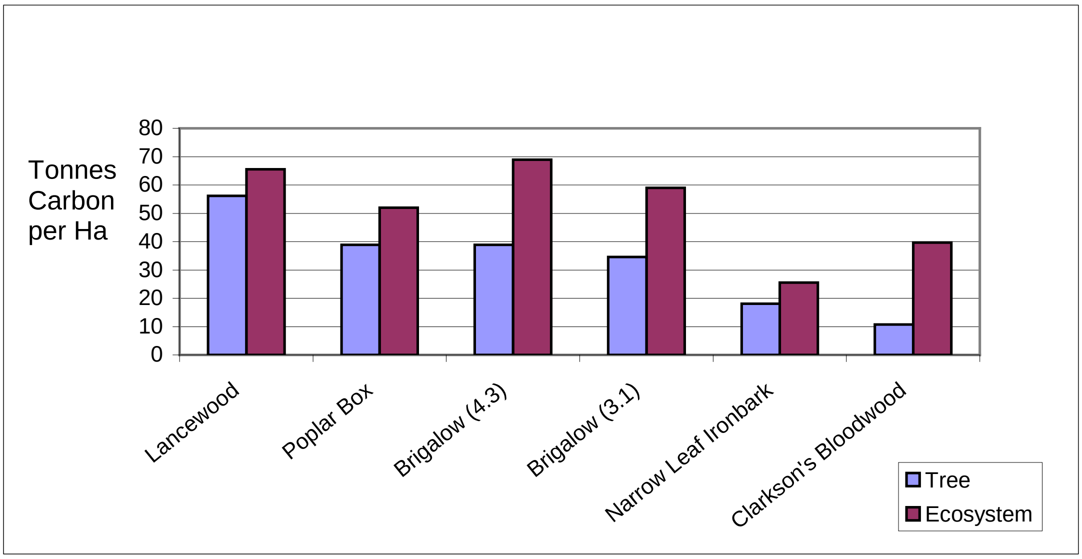


Figure 2 illustrates the differences in the proportions of carbon sources, but a different picture emerges in terms of the amounts of carbon stored per hectare, in the total ecosystem compared with that stored in main tree type within the ecosystem. Lancewood was the main tree type that had the highest amount of carbon per hectare (56 t/ha) stored in the actual trees, whereas one of the Brigalow communities (RE 11.4.3) had the highest amounts of carbon (69 t/ha) stored in the ecosystem (Figure 3).

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



In both the Brigalow and the Bloodwood communities there is a large gap between the carbon values for the main tree type and that for the whole ecosystem. This is an indication that other tree types may also be important in the ecosystem.

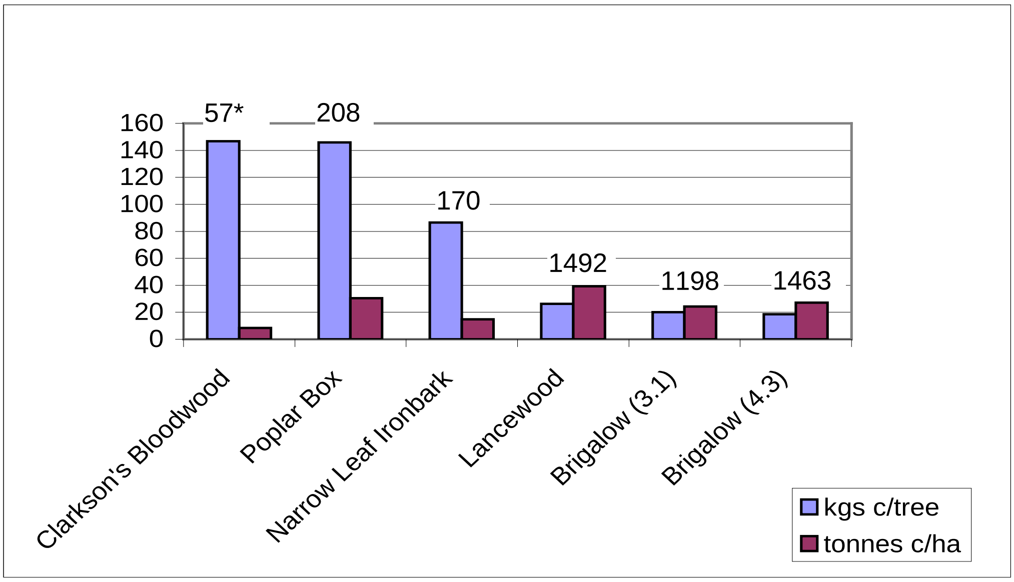
In Brigalow (RE 11.4.3) the main tree, Brigalow, contributed over half (56%) of the carbon stored in the ecosystem. However, Dawson River Gum also made an important contribution (33%) to the total amount. In the other Brigalow ecosystem (RE 11.3.1), Brigalow again contributed over half of the total stores (59%), while Other Trees (Soap

Bush, Bahunia, Canthium, Whitewood, others) contributed 25% and Eucalypts (principally Poplar Box), contributed 16%. In the case of Clarkson's Bloodwood ecosystem, the main tree type did not make the largest contribution to the total carbon pool. While Clarkson's Bloodwood contributed 27%, Acacias (mainly Gidgee, with some Lancewood and other acacia species) contributed 29%. However, other Bloodwoods contributed 24%, and the combined contribution of Bloodwoods was 51%. (See Appendix 2 for details).

Another factor that potentially could influence the total carbon content per hectare was the proportions used to calculate the below-ground portion. In this case, Lancewood, Brigalow and other Acacias were calculated at 43%, whereas Poplar Box, other Eucalypts and Bloodwoods were calculated at 28%, while Narrow Leaf Ironbark was calculated at 23%.

There are two aspects of the vegetation that affect the total carbon stores. First is the density of trees and the second is the amount of carbon stored in a particular tree type. A lot of trees each with low amounts of carbon may make the same contribution to the total pool as a few trees, each with a high carbon content. Figure 4 illustrates the differences in the amount of above-ground carbon stored in each main tree type and the density of these trees.

Figure 4. Above-ground Tree Carbon Stores and Tree Density at "Berrigurra"



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

When the amount of carbon stored in the above-ground tree biomass is considered, the importance of the Eucalypts and Bloodwoods becomes prominent, and without the high proportion of below-ground carbon, the importance of the Acacias declines. For example Clarkson's Bloodwood has a carbon content of 147kgs per tree compared with only 20 and 19 kgs per tree for the two Brigalows. The density of trees follows a reverse pattern, with the Acacias having a much higher tree density than the Eucalypts and Bloodwoods (1463 trees per hectare for Brigalow compared with 57 trees per hectare for Clarkson's Bloodwood.)

When the amount of carbon stored in the trees (above-ground biomass) is considered on a per hectare basis, the smaller, more densely distributed trees contribute more to the carbon budget that than larger, more sparsely populated trees. The one exception being Poplar Box which has the second highest carbon content per hectare (30 tonnes) compared with 39 tonnes for Lancewood and 27and 24 tonnes for the two Brigalows (Figure 4).

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 an average of 26 tonnes/ha in Ironbark country to 69 tonnes/ha in Brigalow country.

References

The Australian Greenhouse Office (AGO) 2001 *Growing trees as greenhouse sinks. An overview for landholders*, A Bush for Greenhouse Project, Commonwealth of Australia, Canberra.

Burrows, W.H., Hoffman, M.B., Compton, J.F., Black, P.V. and Tait, L.J. 2000, "Allometric relationships and community biomass estimates for some dominant eucalypts in Central Queensland woodlands", *Australian Journal of Botany*, 48: 707-714.

Eamus, D., McGuiness, K., and Burrows, W. 2000 *Review of allometric relationships for estimating woody biomass for Queensland, the Northern Territory and Western Australia,* National Carbon Accounting System Technical Report No. 5A, Australian Greenhouse Office, Commonwealth of Australia, Canberra.

Harrington, G. 1979 "Estimation of above ground biomass of trees and shrubs in a *Eucalyptus populnea* F. Muell. woodland by regression of mass on trunk diameter and plant height", *Australian Journal of Botany*, 27: 135-143.

Queensland Government 2001 *Carbon credits from forestry: questions and answers for rural landholders*, A discussion paper prepared by Queensland Government agencies, Queensland Government, Brisbane.

Scanlan, J.C. 1991 "Woody over storey and herbaceous understorey biomass in *Acacia harpophylla* (Brigalow) woodlands", Australian Journal of Ecology 16: 521-529.

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, Peppermint (Queensland 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)
Wattles	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, Hopbush, Prickly Pine, Paperbark, Tea-tree, Saltbush, Karajong	*Atalaya hemiglauca, Alistonia constricta, Grevilea 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 sp*	$B = e^{(-2.156 + 1.614 \times \ln D)} + e^{(-2.028 + 2.119 \times \ln D)}$ 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 "Berrigurra"

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		
11.3.1	Brigalow	Measured	0.020	1198	24.188	10.377	59.00	157.06	9266.01
	False Sandalwood		0.011	35	0.401	0.172			
	Eucalypts		0.228	32	7.217	2.021			
	Other Trees		0.093	110	10.233	4.390			
11.3.2	Poplar Box	RE 11.10.12			39.65	12.30	51.95	61.95	3218.73
11.3.3	River Coolibah	Average all measured REs			38.06	13.71	51.77	34.42	1781.88
11.3.25	River Red Gum	Average all measured REs			38.06	13.71	51.77	51.19	2650.04
11.4.2	Clarkson's Bloodwood	Measured	0.147	57	8.360	2.341	39.64	4.54	179.98
	Other Bloodwoods		0.130	57	7.382	2.067			
	Poplar Box		0.197	22	4.338	1.214			
	Narrow Leaf Ironbark		0.013	8	0.108	0.025			
	Acacia		0.047	167	7.913	3.395			
	F. S'wood, Quinine Bush		0.007	65	0.456	0.196			
	Moreton Bay Ash		0.032	18	0.567	0.159			
	Other Trees		0.005	157	0.786	0.337			
11.4.3	Brigalow	Measured	0.019	1463	27.184	11.662	68.95	69.22	4772.85
	False Sandalwood		0.005	242	1.177	0.505			
	Dawson River Gum		0.139	117	17.613	4.932			
	Poplar Box		0.068	47	3.185	0.892			
	Acacia		0.052	2	0.087	0.037			
	Other Trees		0.014	85	1.174	0.504			
11.4.8	Brigalow	RE 11.4.3			50.42	18.53	68.95	14.96	1031.52
11.5.9	Narrow Leaf Ironbark	Measured	0.087	170	14.710	3.383	25.51	86.92	2217.34
	Black Wattle		0.006	402	2.480	1.064			

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		
	Acacias		0.034	37	1.257	0.539			
	Eucalypt		0.046	12	0.514	0.152			
	F Swood, Quin+Turkey B		0.009	28	0.243	0.104			
	Other Trees		0.018	40	0.726	0.311			
11.7.1	Brigalow	Average REs	0.019	1331	25.686	11.019	63.97	80.76	5166.56
	F' Sandalwood etc.	11.3.1+ 11.4.3	0.008	138	0.789	0.338			
	Other Eucalypts		0.228	16	3.608	1.010			
	Other Acacias		0.052	1	0.044	0.019			
	Poplar Box		0.068	23	1.593	0.446			
	Dawson River Gum		0.151	58	8.807	2.466			
	Other Trees		0.053	98	5.703	2.447			
11.7.2	Lancewood	Measured	0.026	1492	39.332	16.873	65.55	724.5	47494.16
	Acacias		0.022	58	1.308	0.561			
	Eucalypts		0.117	43	5.088	1.425			
	F. S'wood, Turkey Bush		0.002	13	0.021	0.009			
	Other Trees		0.010	68	0.657	0.282			
11.9.1	Brigalow	"Avocet"	0.021	928	19.60	8.41	33.13	11.88	393.62
	False Sandalwood	RE 11.9.1	0.003	359	1.05	0.45			
	Poplar Box		0.056	51	2.82	0.79			
11.9.5	Brigalow	"Avocet " RE 11.9.1			23.48	9.65	33.13	11.20	371.09
11.10.12	Poplar Box	Measured	0.146	208	30.394	8.510	51.95	259.2	13467.22
	All Acacias		0.027	215	5.907	2.534			
	F Swood, Quin+Turkey B		0.010	163	1.620	0.695			
	Eucalypts		0.103	12	1.201	0.336			
	Other Trees		0.006	93	0.532	0.228			
							Total	**1567.80**	**92011.00**