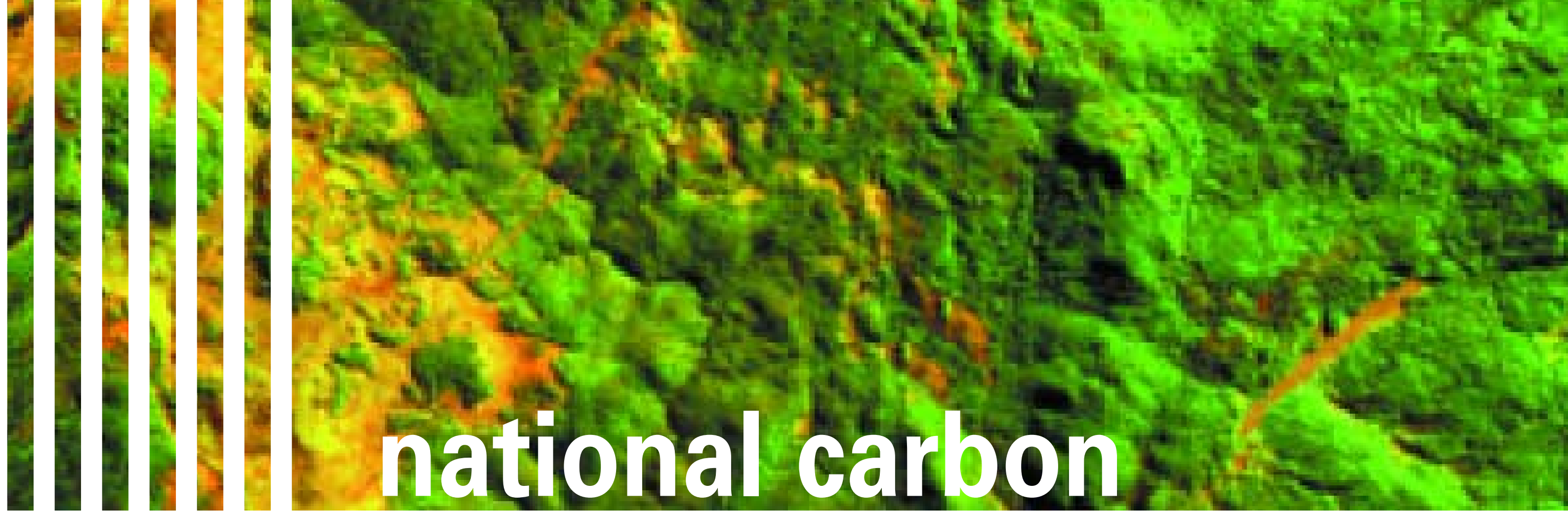

national carbon accounting system

technical report no. 44

Spatial Estimates of Biomass in 'Mature' Native Vegetation

John Raison, Heather Keith, Damian Barrett,
Bill Burrows and Pauline Grierson

Australian Government
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SPATIAL ESTIMATES OF BIOMASS IN 'MATURE' NATIVE VEGETATION

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TABLE OF CONTENTS

LIST OF TABLES

SUMMARY

About 200 biomass estimates for native vegetation are provided for contrasting locations throughout Australia based upon published and unpublished information. Discussion is provided in relation to 'maturity' of the vegetation (i.e. change due to prior disturbance), accuracy of spatial location, and the size of the area sampled (plot versus stand) and hence likely representativeness of local conditions. Much of the data do not meet the strict criteria specified by the Australian Greenhouse Office (AGO) in relation to these factors, and thus the data should be evaluated very carefully prior to their use to calibrate the modelled continental productivity surface produced by the AGO.

We recommend that additional robust verification data (derived from multiple inventory plots over several hectares) for a range of vegetation types along the biomass gradient, be collected to confirm the reliability of the calibration.

BACKGROUND

The biomass data contained in this report were assembled at the request of the Australian Greenhouse Office (AGO) for the purpose of calibrating a modelled continental productivity surface (Landsberg & Kesteven, 2002).

The criteria for inclusion of data were that:

1. Estimates were for 'mature' (or nearly mature) native vegetation;
2. Estimates were accurately spatially referenced (preferably by GPS) to ± 200 m;
3. Estimates were at the stand level (~1 ha) if possible;
4. An estimate of total biomass, split into above- and below-ground components was available; and
5. A wide range of forest types and productivities were represented.

It was often not possible to meet all these criteria, but an evaluation (discussion) in relation to the criteria was provided for each data set.

Four major sources of data were identified as relevant to the project that could be rapidly summarised. Time constraints did not make it feasible to generate new biomass estimates (e.g. by applying inventory data to existing allometric equations); but this is a cost-effective option for the future to fill identified gaps in existing data. The data sources were:

1. **Synthesis of published information.**
   Much work had already been done (Barrett 2001, Barrett *et al.* 2001) to evaluate existing information. A relevant sub-set of published data was assembled by Dr Damian Barrett of CSIRO.
2. **Unpublished forest data from South-East Australia.**
   Data were assembled for about 40 sites in sub-alpine eucalypt forest, and for *Eucalyptus obliqua* forest by Dr Heather Keith of CSIRO.
3. **Woodland data from Queensland.**
   Data were assembled for a wide range of woodland sites in central Queensland by Dr Bill Burrows from the Queensland Department of Primary Industries.
4. **Shrubland, woodland and forest data from Western Australia (WA).**
   About 30 unpublished biomass estimates, mostly for shrubland and woodland vegetation in WA, were assembled by Dr Pauline Grierson of the University of WA.

Section 1 provides a synthesis of the compiled information. The data tables and associated discussion follow in Sections 2-4 of this report.

REFERENCES

Barrett, D.J. 2001. NPP Multi-Biome: VAST Calibration Data 1965-98. [http://www.daac.ornl.gov/]

Barrett, D.J. Galbally, I.E. and Graetz, R.D. 2001. Quantifying uncertainty in estimates of C emissions from above-ground biomass due to historic land-use change to cropping in Australia. *Global Change Biology*, **7**, 883-902, 2001.

Landsberg, J. and Kesteven, J. 2002. Spatial estimation of plant productivity. In *Richards, G.P. 2002 (Editor) Biomass estimation: Approaches for assessment of stocks and stock change.* Australian Greenhouse Office. NCAS Technical Report 27. Chapter 2. 140pp

1. SYNTHESIS OF PUBLISHED DATA

Data were sourced from the VAST dataset (Barrett 2001) with compilation methods described in Barrett *et al.* (2001). Note the present version of the dataset is modified from that of Barrett *et al.* (2001) (it includes more data points and some data points not used in the earlier analysis are included here). The original purpose for developing the VAST data set was to generate a *representative* sample of observations over as much of the climatic domain of the continent as possible for developing model parameterization and uncertainty methods. The VAST dataset is not a *comprehensive* compilation of data, which would duplicate work being conducted elsewhere. Consequently, predictions made from model parameterizations using these data are likely to be unbiased but the prediction standard errors will be greater than if larger more comprehensive sample sets are used.

Quality control in the data set included stipulation that measurements had undergone scientific peer review prior to publication. The full VAST data set comprised above-ground fine tissue Net Primary Productivity (NPP), above-ground fine and coarse tissue biomass, fine tissue littermass, soil carbon (C) concentration profiles, and soil bulk density profiles. A total of 45 published papers are included in the biomass data set provided for this report and a full reference list of these studies is provided below.

Georeferencing of point observations used the latitude and longitude provided by authors or, where absent, were obtained from an identifiable topographic feature described in the study and locatable on 1:1,000,000 or 1:2,500,000 scale Australian Survey and Land Information Group (AUSLIG) maps. In studies where authors presented an age sequence of biomass, the oldest sites were used where possible because it was reasonable to assume that these sites were less disturbed than younger sites. Measurements were averaged for those studies where multiple sites were described by authors but listed under a single latitude and longitude. Various techniques were used by authors to sample biomass, which included direct harvesting, application of existing or new allometric equations, or visual methods made on a single date. Branch biomass and lignotuber (where present) were included with the stem component. In only a very few studies were data on below-ground biomass available (Table 1). These measures were stratified by AUSLIG vegetation classes (Growth Form of Tallest Stratum x Foliage Projected Cover) and expressed as the ratio of below-ground to total biomass, f_b.

Biomass data provided for this report were taken from the published literature 'as is' i.e. no expansion factors have been applied to stem + branch mass. This is because above-ground biomass included both fine and coarse tissues of the over- and under-storey where provided by authors. Where no-data are presented in the accompanying tables it indicates that only one biomass pool (either fine or coarse) was reported in the original study.

It is important to note that the data published in the scientific literature were collected for purposes other than estimating potential above-ground biomass. Therefore, not all details are provided for determining the level of disturbance or the coverage over all C-pools. In addition, the information in each publication must be interpreted which may itself introduce errors. Other interpretations may therefore generate different biomass values from the present data set (which is part of the total uncertainty of biomass prediction).

To establish whether biomass met the criteria of 'minimal disturbance', two indicators were used. First, details on disturbance, fire history or harvesting were noted from papers where provided (see detailed notes below), and secondly, the author's description of overstorey vegetation structure and species composition was compared with the AUSLIG digital Atlas of Australian Pre-European Vegetation (1770) at the same location. Where the vegetation classification matched between the contemporary study and the historical data set it was assumed that the vegetation type remained constant during this century. Thus, biomass data used here refer to a maximum potential biomass in the absence of major disturbance.

The total area sampled in each study was calculated by multiplying the individual area of each plot by the number of plots sampled. The total area sampled ranged from 0.00006 ha for quadrat sampling in herbaceous communities up to 17 ha in Tall Forests of south-east and south-west Australia. In one forest, the whole 33.2 ha was sampled by a random 'point-quadrant' method. The reliability of biomass measurements made by the authors of each study should be regarded as high given that each study was peer reviewed prior to publication. Reliability that all above-ground biomass pools were included is lower given that these studies didn't necessarily set out to achieve this aim. The reliability of latitude and longitude are probably reasonable given that it is likely authors obtained these from topographic maps in most cases (although in two cases the provided coordinates were obviously a typographic error in the published paper). The precision of each location was 1 minute latitude and longitude because authors never specified locations to any greater accuracy. This means that the locations provided by authors can only be accurate to within ~2 km at best. In two cases latitude and longitude were given to nearest 0.1° yielding a precision of only ~11 km. Where a location description was provided by authors, the precision varied from ~1 km up to 20 km.

The reporting of standard errors in different studies need to be interpreted with some care. Some standard errors referred to the error associated with predictions of biomass from allometric equations. Other reporting of standard errors referred to variation within a forest (i.e. between forest plots). Of the 45 papers available, 17 presented some measure of an error in estimated mean biomass. The coefficient of variance, CV (ratio of standard error to the mean) ranged between 10 and 44% (Table 2). As a measure of landscape heterogeneity, this is the measure of uncertainty in which we are interested. It is a measure of total variance in the estimated biomass. Note, that the prediction standard error of allometric equations will be less than the total variance. The range of CV reported in Table 2 is consistent with a minimum CV of ~25% suggested by Barrett *et al.* (2001) to be the practical minimum uncertainty achievable for large scale biomass estimation studies given financial and logistical constraints on sampling.

REFERENCES

Barrett, D.J. 2001, NPP Multi-Biome: VAST Calibration Data, 1965-1998. Available on-line [http://www.daac.ornl.gov/] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A, 2001.

Barrett, D.J., Galbally, I.E., and Graetz, R.D. 2002, Quantifying uncertainty in estimates of C emissions from above-ground biomass due to historic land-use change to cropping in Australia, *Global Change Biology*, **7**, 883-902, 2001.

Table 1. Fraction of total plant biomass below-ground, f_b, for Australian vegetation types (n = 20) from a range of literature studies. Dominant species were identified by the authors of each study. Data are grouped into vegetation classes based on the AUSLIG vegetation classification scheme.

°Latitude	°Longitude	Dominant species	f_b	Author	Year
Tall and Medium forests (T3, T4, M4)					
37.43	145.58	*Eucalyptus regnans*	0.08	Feller	1980
37.43	145.58	*E. obliqua / E. dives*	0.11	Feller	1980
34.45	116.03	*E. diversicolor*	0.04	Grove and Malajczuk	1985
33.55	150.37	*E. maculata* forest	0.15	Ash and Helman	1990
		Mean	0.10		
Medium and Low forests (M1, M2, M3, L3, L4)					
27.28	149.75	*Brigalow*	0.26	Moore *et al.*	1967
27.70	153.45	*E. signata / E.umbra*	0.42	Westman and Rogers	1977
25.47	153.07	*E. pilularis*	0.42	Applegate	1989
33.82	151.15	*Avicennia marina*	0.54	Briggs	1977
35.36	148.80	*E. pauciflora / E. dives*	0.19	Keith *et al.*	1997
		Mean	0.37		
Low shrubs (arid and semi-arid) (L1, L2, Z1)					
26.42	146.22	*Eremophila gilesii*	0.25	Burrows	1972
31.90	141.45	*Atriplex vesicaria*	0.29	Charley and Cowling	1968
23.55	133.60	*Eragrostis eriopoda / Acacia aneura*	0.57	Ross	1977
		Mean	0.37		
Tall shrubs (S1, S2, S3, Z2, Z3)					
38.13	145.13	*Leptospermum myrsinoides / Banksia marginata*	0.86	Jones	1968
38.13	145.13	*Leptospermum myrsinoides / Banksia marginata*	0.88	Jones	1968
33.96	151.22	*Banksia/Leptospermum / Acacia/Lepidosperma*	0.62	Maggs and Pearson	1977a
35.87	140.45	*Banksia, Casuarina, Xanthorrhoea, Melaleuca*	0.76	Specht *et al.*	1958
38.87	146.40	*Banksia* coastal heath	0.84	Groves	1965
39.033	146.32	*Leptospermum myrsinoides / Casuarina pusilla*	0.66	Groves and Specht	1965
38.87	146.40	*Leptospermum myrsinoides / Xanthorrhoea australis*	0.50	Groves and Specht	1965
29.87	115.25	*Banksia* sclerophyllous scrub	0.69	Low and Lamont	1990
		Mean	0.73		
Grasses, Sedges and Other Herbaceous (H,G,F)					
30.58	153.00	Coastal *Spinifex*	0.86	Maze and Whalley*	1990
35.28	149.12	*Phalaris* / Sub-clover pasture	0.74	D. Barrett unpub. data	

* K.M. Maze and R.D.B. Whalley (1990).
Aust. J. Ecol. ***15**, 145-153.*

Table 2. Approximate standard errors as a percentage of the mean (coefficient of variance, CV) for 17 of the 45 studies in the VAST data set, which reported a measure of uncertainty. 'Prediction' error refers to the standard error of the prediction of the least-squares linear regression by authors (allometric equation) and 'between plot' error refers to standard errors reported by authors for between plot variance.

	Approximate coefficient of variance, CV (%)			Comment
Ref No.	Prediction (allometric eqn.)	between plot	other	
6		25-30		
16		24		
23	1			
28		18		
29		10-44		
46		21		
51		16		
59			3-9	Based on stem circumference measurement
64		15-34		
66		21-27		
98	18			
102		30		
107		3-9		Based on weighing all harvested biomass
127			1-2	Based on root biomass measurement
128		20-30		
140				SED of means between treatment
192		14-22		

Sources for published studies used to construct dataset

Ref No.	Reference
6	Cook G.D. & Andrew, M.H. (1991) *Australian Journal of Ecology* **16**, 375-384.
7	Scanlan, J.C. (1991) *Australian Journal of Ecology* **16**, 521-529.
10	Turner, J., Lambert, M.J. & Kelly, J. (1989) *Annals of Botany* **63**, 635-642.
16	Turner, J., Lambert, M.J. & Holmes, G. (1992) *Forest Ecology and Management* **55**, 135-148.
21	Baker, T.G. & Attiwill, P.M. (1985) *Forest Ecology and Management* **13**, 41-52.
23	Attiwill, P. (1979) *Australian Journal of Botany* **27**, 439-458.
28	Ash, J. & Helman, C. (1990) *Cunninghamia* **2**, 167-182.
29	Turner, J. & Lambert, M.J. (1983) *Forest Ecology and Management* **6**, 155-168.
31	Turner, J. & Lambert, M.J. (1986) *Oecologia* **70**, 140-148.
33	Moore, A.W., Russell, J.S. & Coaldrake, J.E. (1967) *Australian Journal of Botany* **15**, 11-24.
34	Specht, R.L., Rayson, P. & Jackman, M.E. (1958) *Australian Journal of Botany* **6**, 59-88.
35	Specht, R. (1966) *Australian Journal of Botany* **14**, 361-371.
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Sources for published studies used to construct dataset continued

Ref No.	Reference
38	Westman, W. & Rogers, R. (1977) *Australian Journal of Botany* **25**, 171-191.
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46	Feller, M. (1980) *Australian Journal of Ecology* **5**, 309-333.
51	Bradstock, R. (1981) *Australian Forest Research* **11**, 111-127.
59	Pressland, A.J. (1975) *Australian Journal of Botany* **23**, 965-976.
60	Noble, I.R. (1977) *Australian Journal of Botany* **25**, 639-653.,
61	Stewart, H., Flinn, D. & Aeberli, B. (1979) *Australian Journal of Botany* **27**, 725-740.
64	Applegate, G.B. (1989) *Australian Forestry* **52**, 195-196.
66	Grove, T. & Malajczuk, N. (1985) *Forest Ecology and Management* **11**, 59-74.
72	Rixon, A.J. (1969) In 'The Biology of Atriplex' (Ed. R. Jones) CSIRO Divn. Plant Industry, 128 p.
84	Bridge, B.J., Mott, J.J. & Hartigan, R.J. (1983) *Australian Journal of Soil Research*, **21**, 91-104.
98	Harrington, G. (1979) *Australian Journal of Botany* **27**, 135-143.
102	Low, A. & Lamont, B. (1990) *Australian Journal of Botany* **38**, 351-359.
104	Friedel, M. (1981) *Australian Journal of Botany* **29**, 219-231.
107	Jones, R. (1968) *Australian Journal of Botany* **16**, 589-602.
115	Turner, J. (1980) *Australian Forest Research* **10**, 289-294.
122	Andrew, M.H. & Lange, R.T. (1986) *Australian Journal of Ecology.* **11**, 395-409.
126	Ross, M.A. (1977) *Australian Journal of Ecology* **2**, 257-268.
127	Briggs, S.V. (1977) *Australian Journal of Ecology* **2**, 369-373.
128	Ive, J.R. (1976) *Australian Journal of Ecology* **1**, 185-196.
131	Robertson, G. (1988) *Australian Journal of Ecology* **13**, 519-528.
138	Crane, W.J.B. & Raison, R.J. (1980) *Australian Forestry* **43**, 253-260.
140	Keith, H., Raison, R.J. & Jacobsen, K.L. (1997) *Plant and Soil* **196**, 81-99.
143	Walker, B.H. & Langridge, J.L. (1997) *Journal of Biogeography* **24**, 813-825.
147	Maggs, J. & Pearson, C. (1977) *Oecologia* **31**, 239-250.
154	Leigh, J.H. & Mulham, W.E. (1966) *Australian Journal of Experimental Agriculture and Animal Husbandry* **6**, 460-467.
159	Roshier, D.A. & Nicol, H.I. (1998) *Rangelands Journal* **20**, 3-25.
167	Groves, R.H. (1965) *Australian Journal of Botany* **13**, 281-289.
168	Groves, R.H. & Specht, R.L. (1965) *Australian Journal of Botany* **13**, 261-280.
192	Burrows, W.H., Hoffmann, M.B., Compton, J.F., Back, P.V. & Tait, L.J. (2000) *Australian Journal of Botany*, **48**, 707-714.

Detailed notes on published papers used to generate the VAST Biomass dataset: 'Ref' relates to the reference number in the above list of published papers.

Ref. No.	Notes:
6	Understorey of Tallgrass Savanna including grasses, shrubs, forbs and litter (*Sorghum intrans* dominant). No soil details provided. Biomass reported in Table refers to 'unburnt' site only. Latitude and longitude published to nearest minute ('Thorak' site). 3 x 0.25 m^2 quadrats measured by clipping, bulking, drying at 80°C and weighing sub-samples. Sampled 1979/1980. No root biomass. No standard errors given for biomass (standard errors of nitrogen measurements varied between CV = ~25 – 30%; Figure 1 of paper).
7	*Acacia harpophyla* woodland community from 2 years old to mature trees. Duplex soil with sandy-clay loam surface (Db1.13). Vegetation previously cleared at different times. Biomass applies to 'mature' vegetation only [data sourced from Moore *et al.* (1967); Ref No. 33]. Latitude and longitude published to nearest minute. Biomass determined on 50 x 2 m plot. Biomass sampled 1982 on 29 trees selected across a range of sizes. Above-ground biomass harvested, separated into trunks, branches, leaves, and bark, oven dried and weighed and allometric equations developed. Allometric equations applied to measurements of basal circumference and height for all trees on plot. No root biomass. No errors reported.
10	Subtropical rainforest in northern New South Wales (NSW). Soils were deep basalts red clay loam with clay sub-soils (Clay >50% in surface and 70-90% in subsoils). Measurements made on 'undisturbed' forest plots. Latitude and longitude published to nearest minute. Plots were 0.36 ha in diameter. Understorey biomass measured using 10 x 1 m^2 quadrats. Eight overstorey trees sampled to establish allometric relationships. All understorey vegetation <2 m harvested. On two other plots, diameter measured on all trees and mass estimated using allometric equations. Mass was estimated on plots in three years: 1965, 1973 and 1981 (reported in the Table). No root biomass. No errors reported.
16	Dry sclerophyll forest of indeterminate but probably mixed age dominated by *Eucalyptus sieberi* with *Acacia* understorey. Soils are red and yellow podzolics. The authors reported fire disturbance in 1980, which was severe in other catchments but which disturbed only fine litter in the study catchment (no tree mortality). Latitude and longitude not published but taken as middle of Yambulla State Forest from AUSLIG maps. Two stage sampling of trees occurred: 1000 m^2 circular plot in which all trees were measured, diameter at breast height (DBHOB) and (DBH) then 2000 m^2 circular plot on which all trees >40 cm were measured DBHOB. Five 'Strata' sampled each with 1 to 5 'plots' in the State Forest. Biomass reported in Table as mean over all strata. Mass estimated 1981. Allometric equations developed elsewhere (Turner *et al.* 1992; Forest Commission Research Paper) were used to predict mass. Understorey biomass estimated by allometric equations measured on adjacent vegetation. Standard deviation of overstorey + understorey vegetation was 53.8 + 18.79 t_{DW} ha^{-1} (CV = 24%). No root biomass.
21	Vegetation is *Eucalyptus obliqua* forest of age between 70 and 90 years. Soils were described as 'clay-loam' and 'loam'. Two *E. obliqua* sites were measured near upper and lower end of productivity for the Gippsland area. Latitude and longitude given to nearest minute. Sample plots were

0.1 ha. Allometric equations of Attiwill (1962; *Aust. J Bot*. **28**, 199-222) used to estimate the mass of the 'average' trees in 5 or 6 classes on each plot. No understorey component measured. Plot descriptions were done in 1980 (Table 1 of paper). No date given for measurements. No root biomass.
No error given.

23 'Open eucalypt (*Eucalyptus obliqua*) forest with well developed understorey', Victoria. Soils are highly weathered red-brown friable clay loams uniform to 1 m. Biomass in Table applies to 66 year old forest. Latitude and longitude not supplied but given in another study to nearest minute. All measurements were made on a 0.1 ha square plot in each stand (Polglase *et al.* 1992 *Plant and Soil*, **142**, 167 – 176). Allometric relationships established previously (Attiwill, 1962; *Aust. J Bot.* **28**, 199-222) with a further 10 trees felled for this study. Allometric relationships were applied to measurements of DBHOB. Overstorey components only were measured. No standard errors given for 66 year old (y.o.) forest. For 50 y.o. forest, reported biomass was 298 tDM ha^{-1} with standard error of 2 (CV = 1%); although Attiwill cautioned on using these precision estimates as they apply only to the regression models not the plot and they were developed for a different location at a different time. Allometric measurements were made in 1962 and 66 year old DBHOB measurements were made in 1977. No root biomass.

28 Vegetation comprises both eucalypt sclerophyll forest and subtropical rainforest. Soils are grey leached sands overlying a yellow-grey B horizon of high clay content on weathered sandstone. Forest has been selectively logged since 1880s with an intense period between 1910 and 1926. Latitude and longitude given to nearest minute. Measurements were made in 1981 and 1984. 'Point-centred quarter survey method' was used where points are located randomly throughout the forest and nearest trees >5 cm DBH in each compass quadrant are measured. Forest area sampled 33.2 ha. Allometric relationships were determined for fallen trees in and around the catchment using separate wood density estimates. Root biomass of uprooted trees was also determined. Thirty 0.1 m^2 pits 40 to 90 cm deep were excavated and root biomass <5 cm measured in each. Standard errors for biomass density are given for eucalypts, rainforest trees, shrubs and herbs (CV ~ 18%).

29 Tall wet sclerophyll forests dominated by flooded gum (*Eucalyptus grandis*). Soils are 'moderate to high fertility'. Forest was destroyed by fire in 1951 and replanted to *E. grandis* in 1962. Forests 27 years old. Approximate location only given in Coffs Harbour Forestry Region. Destructive sampling conducted in 1978 on adjacent plots to establish allometric equations. Biomass measured on plots using DBHOB. No root biomass measurements. Plot areas not given. No errors given for biomass (standard errors of nitrogen measurements are between CV = 10 and 44%).

31 Tall eucalypt forests of mixed species composition (dominant species *E. seiberi, E. muellerana, E. obliqua, E. consideniana, E. agglomerata*). Soils are red-yellow podzolics with poor structure and low nutrient status, rooting depths from 40 to 100 cm. Forest has been logged for sawlog and pulpwood and regenerates from existing seed bed. Stands selected for measurement were 'fully stocked to represent an upper level of accumulation' of biomass. Unknown date of measurements. Approximate location only in 'Eden Forestry Region' south-east

NSW. Biomass was estimated for trees on plots using existing allometric equations for the area. Plots of unknown size. No root biomass measurements. No standard errors given for biomass.

33 Monospecific stand of *Acacia harpophyla* (Brigalow) woodland. Soils are gilgaied deep clays. Drought conditions prevailed at time of measurement; consequently no understorey was present. No comment on disturbance; however, a photograph depicted 'virgin Brigalow forest on gilgai soil'. Latitude and longitude given to nearest minute. Sampling was carried out between 1964 and 1965. Above-ground biomass was estimated by felling trees on 10 x 0.04 ha plots and fresh weights determined. Plot biomass was calculated by sub-sampling plant tissues for dry weight measurements. Root material was sampled from 1 square yard quadrats (0.84 m^2) randomly placed on the same plot. Roots were sampled using soil cores and soil blocks. No errors given for biomass.

34 Heath community in south-east South Australia dominated by *Banksia*, *Casuarina, Xanthorrhoea, Eucalyptus, Melaleuca* and *Leptospermum*. Soils are sand as described in Ref No. 35 below. Heath vegetation is regularly disturbed by fire; biomass values are for a 25 year old stand where biomass dynamics have approximated steady state. No date given for measurements. Location given by latitude and longitude from other papers to an accuracy of 1 minute. Biomass estimated using six randomly placed 5 x 10 yard quadrats (~42 m^2) and all above-ground material harvested dried and weighed. Quadrat size was increased in some measurements to better represent vegetation. Root biomass reported but no details given as to methods. No errors given for biomass.

35 Heath community as described in Ref No. 34 above. Soils are sandy comprising between 29 and 55% coarse sand component in 0 – 10 cm layer. Fire had completely removed vegetation in 1954 and the study reports on biomass 12 years after fire. Latitude and longitude given in other papers to 1 minute accuracy. Six quadrats of 5 yards square and all above-ground material harvested, weighed and subsampled. Subsamples were dried and back-estimates of total dry weight were made. No date given for measurements, but it was assumed to be 1966. No root biomass measurements were made. No errors of biomass.

36 Monospecific *Eremophila gilesii* xeric shrub community. Soil is a lateritic red earth containing ~40% coarse sand and ~15% clay. Plots on which measurements were made were fenced to exclude grazing animals. Final harvest was made in 1971. Latitude and longitude given to 1 minute accuracy. Plot area was 30 x 30 m. Harvests of above-ground material were made, plant material dried and weighed. Root biomass estimated by applying root:shoot ratios developed by Burrows (1971) MSc Thesis, Univ. Qld. No errors given.

37 Xeric saltbush (*Atriplex vesicaria*) community. Soil is deep and fine-textured. The case study applies to 'a stable' saltbush community by which is interpreted to be minimally disturbed. Location in Broken Hill area but assumed to be Fowlers Gap with latitude and longitude obtained from AUSLIG maps. No sampling details are provided other than that root biomass was excavated to 45 cm depth. It was assumed cut quadrats and oven drying methods were used. No plot area specified. No dates of sampling given other than to state biomass measurements were made in winter. Root biomass estimated. No errors are given for biomass.

38 Low sclerophyll forest to 15 m on Stradbroke Island, Queensland (*Eucalyptus, Tristania, Angophora, and Banksia*) with a well developed understorey of herbs, grasses and forbs. No details of disturbance are given but field site part of a long term study of production and nutrient cycling. Forests grow on a sand dune substrate of very low nutrient status. Latitude and longitude were published to nearest minute; although longitude is in error. A correction was made based on the longitude of Stradbroke Is. Plot area was 0.25 ha (50 x 50 m) and established in 1973. Biomass censused on the plot by harvesting 31 study trees and excavating root systems. Sub-sampling was used to determine dry weight of tree material. Understorey biomass determined by harvesting ten 1 x 1 m quadrats, drying and weighing material. Allometric equations were developed from the mass of tree components. No standard errors reported.

41 Dry sclerophyll eucalypt forest (*Eucalyptus marginata* and *E. calophylla*) with understorey trees, shrubs and herbs (*Banksia, Persoonia, Macrozamia, Xanthorrhoea, Hakea* and *Acacia*). The site was logged before 1920, thinned in 1963 and subject to hazard reduction burns on 5 to 7 year intervals. Latitude and longitude obtained from Figure 1 of publication. Soils are lateritic sandy gravels often containing large amounts of gravel and low nutrients. Measurements were made on a single 0.36 ha plot in 1977. Ten representative trees of each overstorey species were felled and measured for above-ground biomass. Allometric equations were used to estimate total above-ground biomass in trees from measurements of DBHOB. Understorey trees, shrubs and plants >1.5 m high were also sampled to generate allometric equations and biomass estimated by measurement of DBH. Ground-cover plants were harvested from 48 x 1 m^2 quadrats. No standard error given. No root biomass given.

44 Two examples of sclerophyll forest were sampled at the one location; wet sclerophyll forest (dominated by *E. regnans*) with understorey of small trees (*Acacia*) and shrubs; dry Sclerophyll forest (*E. sieberi* and *E. obliqua*) with more open understorey. Soils in wet sclerophyll forest are coarsely textured brown loams to 60 cm depth grading to red-brown clay loams to 1.6 m then weathered clays to 5.5 m. Soil in the dry sclerophyll forests are fine structured brown to dark-grey-brown soil up to 25 – 75 cm grading to yellowish brown compact clay loams to 1.5 – 2.2 m overlaying weathered clays to <3.0 m. Forest was severely burnt in 1939 fires and the dry sclerophyll forests have been repeatedly burnt in the meantime (although it is interpreted that these disturbed sites were avoided in biomass estimation). Geographic description of the location given, from which latitude and longitude were obtained from AUSLIG topographic map. Forest was 27 years old at time of sampling (in 1967). A representative set of trees was felled and subsamples collected for dry mass determination and allometric equations were generated. Forest biomass was estimated over an undisclosed area using measurements of DBHOB and allometric equations. Understorey biomass was cut from 'several' 10 x 10 m quadrats. Root mass (interpreted as fine root mass) was estimated from 20 soil blocks, 25 x 25 cm in area and 12.5 cm deep. No standard errors reported.

46 Two forest plots were sampled at the one location. Vegetation was wet and dry sclerophyll tall forests in Victoria. The wet sclerophyll forest was dominated by *E. regnans* with and understorey of *Acacia* and shrubs.

The dry sclerophyll forest was dominated by *E. obliqua* and *E. dives* with an *Acacia* and shrub understorey. Plots were burnt in the 1939 bushfires but not burnt since. Measurements were done in 1978 (Forest was 39 years old). Latitude and longitude given to nearest minute. Allometric equations were developed for 6 *E. regnans*, 5 *Acacias*, 6 *E. obliqua* and 5 *E. dives* trees over a wide range of sizes. Subsamples were taken from each component for dry mass determination. Stand level biomass density estimates were made by measuring diameter and height of all trees on a 20 x 20 m plot within each forest type. Understorey biomass was calculated by sampling above-ground biomass in five 2 x 2 m plots per forest type and subsamples taken for dry mass determination. Root biomass was sampled from 3 x 1 m^2 plots per forest type at two depths 0 – 20 and 20 – 50 cm. Standard errors of predicted biomass were calculated from allometric equations. It was assumed that plot level standard errors were estimated by multiplying tree level standard errors of predicted biomass by number of trees (see Table 4 of paper). CV of above-ground biomass was 21% and for roots CV was 22%.

51 Vegetation type is a 27 year old *Eucalyptus grandis* plantation near Coffs Harbour NSW, planted from tube-stock immediately after a wildfire with no site preparation. Soils were derived from 'Lower Permian sediments'. Location was given as 'Boyds Deviation' 8 km from coast in Coffs Harbour Forestry Region and an approximate latitude and longitude were derived from AUSLIG and NSW State Forest maps. It was assumed that measurements were made in 1978. Biomass was estimated by developing allometric equations for representative range of trees on subsidiary forest plots (of 20 x 20 m) adjacent to a main undisturbed plot (of 20 m width and a length which enclosed ~100 trees in the plantation) on which DBHOB measurements were made on all trees. Felled trees were subsampled for dry mass determination. Mean values and standard deviations were estimated from data on all three plots. Standard deviations for above-ground tree biomass are supplied (CV = 16%). No root biomass was given.

59 Mulga (*Acacia aneura*) vegetation of south-western Queensland. No soils information was available. Allometric relationships were developed for representative trees from a range of sizes at 8 sites in the Charleville district, Queensland. Three of these sites could be located on AUSLIG maps to obtain latitude and longitude. It appeared that measurements were made in 1972 and 1975. No information was available on disturbance although only 'healthy trees with no broken main branches were used' in an 'open forest situation'. 33 trees were felled, subsampled and dry mass determined. Root biomass was estimated using 20 soil cores 3.6 cm diameter and 120 cm deep in concentric circles up to 4.0 m from the tree bole. Roots were washed from soil and dry mass determined. Tree densities were determined for all sites and a mean circumference reported. Biomass was estimated using mean forest circumference and allometric equations. Standard errors of mean tree circumference were between 3 and 9% of the mean. No area estimates were given over which measurements were made.

60 Vegetation is an arid saltbush and chenopod shrubland and mixed grassland of central north South Australia (SA) dominated by *Atriplex vesicaria* and *Maireana sedifolia*. No soils data supplied. Study site located on TGB Osborne Vegetation Reserve at Koonamore, SA on which sheep and rabbits were fenced out since 1925. Latitude and longitude were given to nearest minute. Photographic records from fixed photo-

points were begun in 1926 and conducted at 3 month intervals until 1931. Since 1950 photographs have been taken at irregular intervals. Final record was 1972 in the study. Photographs were used to develop a ranking of biomass dynamics of vegetation. Biomass calibration of the photographs was achieved by developing correlation coefficients with leaf dry weights of more than 50 bushes each for the two major shrub species. A maximum biomass ('carrying capacity') of the shrubland over the 46 years of record was used as the maximum biomass of the site. No root biomass was recorded. No standard errors are given.

61 Vegetation is an uneven-aged sclerophyll forest up to 40 m high dominated by *Eucalyptus agglomerata*, *E. muellerana*, and *E. sieberi*. Understorey consists of trees, shrubs and herbs (*Acacia, Casuarina, Banksia*, and other shrubs). Soils are duplex with a hard-setting loamy surface over mottled yellow clay subsoils ranging in depth from 50 cm to 200 cm. Latitude and longitude are supplied to nearest minute. Measurements were made in 1976. Age of forest not supplied. Natural fires caused by lightning and fuel control burns have left fire scars on trees. The DBHOB of all trees on 17 x 0.1 ha plots was measured and then 31 trees were selected from a range of species and size classes. Trees were felled subsampled, dry mass determined and allometric equations were developed. Equations were applied to all other trees to determine plot biomass. Understorey vegetation was measured by harvesting vegetation in 15 x 0.04 ha plots. No root biomass sampled. No standard errors are given.

64 Vegetation is blackbutt forests on Fraser Island Qld (*Eucalyptus pilularis*) growing on nutrient poor siliceous sands. No further soil details are given. Measurements are from an old growth forest of about 500 years age. Location was described as 'Deep' on Fraser Is. No plot area was given. No year of measurement available. Above and below-ground biomass was estimated by a 'harvest technique' which appeared to comprise felling trees, excavating roots and weighing plant parts. Mean biomass and standard error as a percentage of the mean is given (Trees: 34%, Understorey: 15%). No allometric equations were available.

66 Tall open forest of WA dominated by *Eucalyptus diversicolor* with dense understorey. Soils are described by soil group as 'Red Earth'. Location given as 'Big Brook Forest' 6 km north-west of Pemberton, WA (latitude and longitude obtained from AUSLIG maps). Forests are managed for sawlog and pulp production. Stand was 36 years old with last control burn 9 years prior to measurement. Overstorey was measured 3 years prior by Hingston *et al.* (1979) (Ref No. 41) which makes year of measurement in present study 1980. On younger sites (4, 8 and 11 years old) 11 individual trees across the range of sizes were harvested for dry mass determinations and allometric relationships developed between mass and DBHOB. Fine root biomass was measured in a previous study. Plots for overstorey biomass determination were 50 x 50 m. Understorey biomass was measured on ten plots each 2 x 2 m by developing allometric equations for small trees and shrubs. Standard errors are available for understorey biomass estimation (CV~21–27%) and for overstorey components in younger forests.

72 Vegetation is arid saltbush community dominated by *Atriplex vesicaria* and *Kochia aphylla*, intermixed with annual grasses and perennial herbs. No soils description is provided. Location is given by description

of study site in Ref No. 154 and latitude and longitude determined from AUSLIG maps. Biomass was sampled in 1969. Plant material was harvested and a mean of five replicates is presented. No plot area given. Biomass density determined as weighted average of beneath and between vegetation clumps based on Figure 1 of paper and assumption that figure is to scale. No root biomass. No standard errors available.

84 Vegetation is open woodland dominated by *Eucalyptus foelscheana* with a grass understorey. Soil was described as 'representative of the widespread Tippera family of the Katherine-Darwin area'. Soil respiration measurement was the primary aim of the study but root biomass was measured at the completion of respiration measurements on soil cores removed from the site. Latitude and longitude were published to nearest 0.1º. Root biomass only was reported for 'natural grassland' (i.e. unburnt). No above-ground data were available. Measurements were made in 1979. Biomass was sampled in a 7 x 7 m plot within three 30 x 30 m sites free of overgrazing effects within an area of 'protected natural grassland'. No standard errors were available.

98 Vegetation was poplar box open woodland of central-west NSW (*Eucalyptus populnea*) with extensive shrub understorey comprising *Eremophila, Cassia, Myoporum* and *Acacia*. No soils information supplied; although reference is made to Moore *et al.* (1970) in 'Australian Grasslands' for general soil-shrub associations. Latitude and longitude supplied by authors to nearest 1 minute. No year of measurement supplied. Overstorey allometric equations were developed from measured DBH and harvesting of above-ground biomass on 20 trees. Shrub allometric equations were developed using DBH measurements and felling shrubs at ground level and weighing plant parts. Biomass estimates were made from 85 quadrats each of 40 x 50 m from application of allometric equations to DBH measurements. Standard errors are supplied based on regression equations applied to sample plots (an overall CV of 18% is quoted as accuracy of predicted biomass based on the regression equations. The author states that between-plot errors have been ignored because they 'would dominate the final estimation of biomass per hectare'. Hence the true error would be larger than 18%). No root biomass available.

102 Overstorey vegetation was a sclerophyllous scrub-heath in south-west WA dominated by *Banksia* with a shrub and herb understorey. Soils were deep freely drained sands to at least 10m depth. Vegetation was disturbed 12 years prior to measurement by fire but not since. Sampling was conducted in 1984. Latitude and longitude supplied to nearest minute. Biomass was harvested from six 4 x 2 m plots located randomly in the *Banksia* stand separated into tissues, dried and mass determined. Roots were excavated from one plot at 15 cm intervals to 180 cm depth and then bulked from 180 to 250 cm. Other root mass measurements were made by backhoe. Standard deviations are given for above-ground biomass (CV ~30%). Root mass was reported for one plot only (no standard errors).

104 Three vegetation communities were sampled; *Astrebla* grasslands, Open woodlands and *Acacia* shrublands. Data collected pertain to understorey only. Soils are red, coarse-structured clays. Latitude and longitude supplied to nearest minute. Site was enclosed in 1976 to reduce grazing pressure (data reported in Table refer to 'excellent' range condition class only). Samples were collected at 10 week intervals

between 1976 and 1977. The site area was 100 x 100 and samples were obtained from eight 4 x 0.25 m quadrats. No root biomass. No standard errors.

107 Vegetation is a sclerophyllous heath dominated by *Leptospermum*, *Casuarina* and *Banksia* with a secondary layer of shrubs. Soils are described as deep sands of very low fertility. The stand had been burnt in 1960 and final measurements were made in 1966 (biomass values appeared to fluctuate around a constant mean by 4.5 years of growth). Latitude and longitude to nearest minute was supplied by Specht and Jones (1971; *Aust. J. Bot*, **19**, 311 – 326). Biomass was sampled using 12 x 1 m^2 quadrats randomly placed at the site. All biomass was harvested from within the vertical projection of each quadrat and dry mass determined. A range of standard errors for total above-ground biomass of 3 – 9% of mean value were supplied. No details of below-ground harvesting are supplied but root biomass values are given.

115 Vegetation overstorey is a sclerophyll forest dominated by *Eucalyptus radiata* and *E. dalrympleana* and an *Acacia* dominated understorey. Soils are described as 'red, permeable soils derived from Ordovician granite'. Latitude and longitude are supplied to nearest 0.1^o. The forest was cleared in 1927 and plots were located in areas of naturally regenerated forest. The adjacent Douglas-fir forest was 50 years old (assume same age as naturally regenerated eucalypt forest). This would make the year of measurement 1977. Tree biomass was determined using previously established allometric equations. Tree DBH was measured for all trees on 6 x 20 m circular plots. No root data available. No standard errors available.

122 Vegetation is arid chenopod shrubland in mid-north SA dominated by *Acacia aneura* overstorey, *Atriplex vesicaria* and *Maireana sedifolia* shrubs and various grasses. Soils are a brown calcareous earth containing carbonate nodules at about 20 cm depth. (Vegetation and soil descriptions given in Andrew and Lange (1986) *Aust. J. Ecol.* **11**, 395 – 409.) Latitude and longitude provided to nearest minute. Measurements were made in 1975, 1976 and 1977. The site was in 'near pristine condition' at the commencement of the study and grazing animals were excluded by fencing. Shrub biomass was estimated by the 'Adelaide Technique'; a visual method of rapidly estimating biomass. Biomass was estimated in 6 plots of 30 x 1.5 m area. Biomass reported in the Table represents average biomass over 15 months of shrubs and grass for the fenced (ungrazed) plots obtained from Figure 2 and Figure 7 of the paper. No standard errors were supplied by authors. No root biomass was supplied.

126 Arid grassland community in central Australia dominated by the perennial grass *Eragrostis eriopoda*. Soil was a gradational red-earth and sandy loam surface. Latitude and longitude were supplied to nearest minute. Five fixed quadrats 2 x 2 m in area was established in grass communities. Biomass was estimated by a non-destructive visual method using regressions of clipped weights against visual weights to calibrate the technique. On additional plots, soil cores 5 cm in diameter to 50 cm depth were taken and roots washed from soil. No details of pasture condition were provided but biomass fluctuated about a constant mean for last 12 months of the study (from which biomass was obtained). Latitude and longitude were supplied to nearest minute. Above-ground measurements were made between 1973 and 1975 and root biomass

measurements between 1974 and 1975 (biomass reported in Table refers to 12 month period 1974 – 1975). No standard errors given for individual biomass measurements.

127 Vegetation was a temperate mangrove community dominated by *Avicennia marina*. No soil information provided. Latitude and longitude supplied to nearest minute. No disturbance information provided. Two 30 x 30 m plots were marked off. Measurements were made in 1972. Above-ground tree biomass on plots was estimated for trunks only from estimated volume (radius and height measurements) and measured woody density. Seedling biomass from harvesting selected seedlings in a 50 x 50 cm quadrat dried and weighed. Dry mass was calculated by multiplying mass per seedling by seedling abundance. Below-ground mass was determined from five soil cores 8 cm diameter and 40 cm deep. Roots were washed and dried. Biomass reported in Table is mean of the 2 sites. Standard errors are supplied for measured root biomass only (~1 – 3% of mean).

128 A Townsville Stylo perennial pasture system. Soils were a 'Tippera' clay loam. Latitude and longitude were supplied to nearest minute. Site was cleared in 1951, cropped until 1967 when it was converted to pasture and grazed. Phosphate fertilizer had been applied at variable rates for 20 years prior to experiment. Measurements were made in 1971. Three plots were used 10 x 10 m in area. Vegetation was harvested in one 0.5 x 0.5 m quadrat in each plot, subsampled, dried and weighed. No root biomass was supplied. Standard errors are supplied on graphs of biomass dynamics. Biomass reported in Table was taken from final biomass measurements in 1971.

131 Vegetation is pasture in an arid grazing system dominated by black box (*Eucalyptus largiflorens*) and chenopod shrubs. Soils are a mix of heavy-textured grey clay soils and light-textured red sand soils. Site is located inside the Kinchega National Park and fenced since 1967 to exclude grazing animals. Latitude and longitude are provided to nearest minute. Measurements were made between 1980 and 1984. Three 0.25 m^2 circular plots were positioned at random within each site. Photographic standards were generated for plots of known biomass and plot biomass was estimated visually as it changed over time. A linear model of pasture biomass as a function of previous 12 months rainfall was developed. The biomass reported in Table is the pasture biomass from the linear model at mean annual rainfall. No standard errors were provided although the residual standard deviation of the linear model was provided. No root biomass was provided.

138 Vegetation was two almost pure stands of *Eucalyptus delegatensis* tall forest. Soils were deep red-earths. Two sites were studied 49 and 25 years old, but only the older forest was used to obtain data used in Table 1. Location provided from which latitude and longitude was obtained from AUSLIG maps. No year of measurement was supplied but must be pre-1980. Five 0.1 ha plots were located randomly in the 49 y.o. forest and DBHOB of all trees was measured. Three trees of 'about the mean cross-sectional area' were felled and sampled for wood density. Plot biomass was estimated from wood volume and wood density. The paper reports on dry matter of wood and bark in stem only. No standard errors were provided. No root mass was provided.

140 Vegetation was a mature stand of *Eucalyptus pauciflora* in the Brindabella Range, near Canberra. Soil details provided in Keith *et al.* (1997; *Plant and Soil*, **190**, 127 – 141). The stand regenerated naturally from wildfire in 1939 which killed most of the overstorey. The site was last burnt by a fuel reduction burn in 1980. Measurements were made in 1993–1994. Plots were 0.04 ha in size and replicated three times. Biomass data reported in Table refer to unfertilized plots. The location of the field site was described and latitude and longitude obtained from AUSLIG maps. Allometric equations were established from 12 harvested trees and 18 fallen branches and foliage biomass estimated by adding up branch units. Diameter measurements of all trees on each plot were combined with allometric equations to estimate above-ground biomass. Root biomass was estimated from existing literature sources for root allometric equations and measurements of above-ground biomass. Standard errors of difference of means between unfertilized and fertilized plots are reported.

143 Vegetation data obtained for a diverse range of sites located throughout savanna woodlands of Australia ranging from Mitchell Grasslands, semi-arid mulga savannah to semi-arid woodlands. Soils at these sites range from cracking clays through duplex to sandy loams. Of the 21 sites available 9 were selected based on opinion of the authors that these were low disturbance sites. Latitude and longitude were obtained from AUSLIG maps based on location details provided by authors. No year of measurement was provided. Biomass was obtained from measurements on 50 x 50 m plots of height and diameter using existing allometric equations. No root biomass was provided. No standard errors were supplied; although 95% confidence intervals of regression models for leaf biomass are provided.

147 Vegetation is a dry sclerophyll scrub system dominated by *Banksia*. No soil descriptions were provided other than to state that vegetation was growing on 'windblown north-south sand ridges'. Latitude and longitude were derived from AUSLIG maps based on details provided in the paper. Vegetation is situated inside a golf course and (based on leaf whorl scars of the *Banksia*) was 28 years old. The shorter vegetation was 13 years old but most plots were located in the tall, older scrub. Measurements were made in 1975 and 1976. Overstorey biomass was determined by estimating volume of stem components and converting this to biomass using a constant wood density. Understorey vegetation biomass was harvested from 8 x 1 m^2 quadrats. Below-ground biomass was estimated by sieving soil from eight 50 x 75 x 70 cm deep pits. All biomass was oven dried and weighed. No standard errors are provided.

154 Vegetation is an arid saltbush plant community dominated by *Atriplex*. Soil details are not provided. The site had been subjected to normal grazing practice, and it was representative of surrounding area. Location details were provided and latitude and longitude obtained from AUSLIG maps. The experimental plot was 5 acres (~2 ha) in area. Measurements were made in 1962, 1963 and 1964. Biomass was estimated using a visual technique comprising three observers and calibrated using harvested biomass from 20 x 1 m^2 quadrats. In the experimental plot, 50 quadrats were sampled for biomass determination. No root biomass was provided. No standard errors were provided.

159 Vegetation was arid chenopod shrubland dominated by *Atriplex* and *Maireana* in the far west of NSW. Soils were desert loams or brown gibbers. The study was performed between 1990 and 1993 in which a severe drought occurred from 1991 until 1992 when rains restored biomass maximal levels observed over the three year study. Latitude and longitude were provided to nearest minute. The study was conducted over five properties, two paddocks per property and six sites per paddock. Each site comprised four permanent 4 x 4 m plots on which pasture measurements were made. The method used to estimate pasture biomass was the 'comparative yield technique' calibrated against three quadrats of harvested biomass. Biomass measures were obtained from 180 x 0.56 m^2 quadrats in each paddock measured four times per year. Biomass values used in the Table were measured in 1992 after drought breaking rain and comprised an average over five properties and two paddocks per property. No standard errors were provided for biomass dynamics in the paper. No root biomass was provided.

167 Heath vegetation dominated by *Banksia*, Victoria. Soils are described as sandy. Vegetation was 5 years old and was selected to be as uniform as possible. Latitude and longitude were obtained from other studies by the authors. Measurements were made on 6 x 18 m^2 quadrats per harvest. All vegetation was cut and weighed. Subsamples dried and weighed. Two soil cores (4.2 cm diameter and 27 cm depth) were taken in each quadrat, roots were wet sieved and dry weight determined. Harvests for biomass were made on six occasions between 1962 and 1963. Biomass reported in Table is the average over six harvests for unfertilized control plots. No standard errors were provided.

168 Heath vegetation on sandy soils of low nutrient status at three sites (two in Victoria and one in SA). Time dynamics of biomass presented from which upper limits were obtained (i.e. approximate steady state values). A location diagram was provided from which latitude and longitude was determined using AUSLIG maps. No year of measurement was provided. Above-ground biomass was harvested from quadrats of various sizes (required because of differences in vegetation structure) from ~ 1 m^2 up to 50 m^2. Numbers of quadrats ranged from 6 to 20. Biomass was immediately weighed after harvesting, sub-sampled and dry weights determined. Soil coring was performed on the same quadrats as above (4.2 cm in diameter and up to 150 cm depth) and roots were wet sieved prior to dry weight determinations. No standard errors were provided.

192 Vegetation was semi-arid woodlands throughout Queensland dominated by *Eucalyptus crebra*, *E. melanophloia* and *E. populnea*. No soils information was provided for sites in the paper. All sites used in developing allometric equations were 'intact woodlands' defined as sites not subject to mechanical or chemical tree clearing for 30 years prior to sampling. Latitude and longitude were provided by the authors to nearest minute. Permanent sites consist of 5 x 100m long transects. Plots comprise the 100 m transect and are 4 m wide. Allometric equations were developed for 'average trees with respect to vigour and foliage cover for a particular size class'. Sites were last measured between 1983 and 1998 (see Table). Between 20 and 22 stems were felled in each woodland type adjacent to permanent sites. Plant tissues were sorted, weighed, sub-sampled and dry weights determined. Root biomass was estimated by excavating lignotubers and also by soil

coring (4.35 cm diameter to 100 cm depth). Allometric equations were applied to a selection of permanent plots deemed not disturbed in last 30 years. Component biomass values for sites were obtained from authors and, as reported in the Table, lignotuber data were grouped with stem mass and root data comprise only fine roots. Standard errors are given in the paper for all biomass components and total biomass (CV between ~14 and 22%).

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Dry sclerophyll eucalypt forest (*Eucalyptus sieberi*) with *Acacia* understorey. Red and yellow podzolic soils.	Dr2.21	-37.27	149.40	298.57		1981	Previously developed allometric equations applied.	1 ha, plot		Ref No. 16 Turner, Lambert and Holmes, Forest Ecology and Management, 1992		
	Subtropical rainforest. Basalt red clay-loam surface soils with clay sub-soils.	Gn4.4	-28.50	153.00	383.30		1965	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	0.36 ha, plot		Ref No. 10 Turner, Lambert and Kelly, Annals of Botany, 1989		
	Subtropical rainforest. Basalt red clay-loam surface soils with clay sub-soils.	Gn4.4	-28.50	153.00	372.12		1973	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	0.36 ha, plot		Ref No. 10 Turner, Lambert and Kelly, Annals of Botany, 1989		
	Subtropical rainforest. Basalt red clay-loam surface soils with clay sub-soils.	Gn4.4	-28.50	153.00	385.04		1981	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	0.36 ha, plot		Ref No. 10 Turner, Lambert and Kelly, Annals of Botany, 1989		
	Eucalyptus obliqua forest. Clay-loam and loam soils.	Dy3.41	-38.33	146.25	328.00		Unknown	Previously developed allometric equations applied.	0.2 ha, plot		Ref No. 21 Baker and Attiwill, Forest Ecology and Management, 1985		
	Eucalyptus obliqua forest with well developed understorey. Highly weathered brown friable clay-loams uniform to 1 m.	Gn4.14	-37.43	145.13	374.50		1977	Previously developed allometric equations applied.	0.1 ha, plot		Ref No. 23 Attiwill, Australian Journal of Botany, 1979		
	Tall wet sclerophyll forest (*Eucalyptus grandis*) on 'moderate to high fertility' soils.	Dr2.21	-30.20	153.13	436.06		1978	Trees harvested, allometric equations developed and applied to forest plots.	Unknown		Ref No. 29 Turner and Lambert, Forest Ecology and Management, 1983		

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Tall eucalypt forest of mixed species. Soils are red-yellow podzolics with poor structure and low nutrient status.	Dr2.21	-37.00	149.50	435.50		Unknown	Previously developed allometric equations applied.	Unknown		Ref No. 31 Turner and Lambert, Oecologia, 1986		
	Wet sclerophyll forest (*Eucalyptus regnans*) with shrub understorey. Coarse textured brown loams to 60 cm grading to red-brown clay loams to 1.6 m.	Gn4.14	-37.42	145.13	831.10		1967	Trees harvested, allometric equations developed and applied to forest plots.	Unknown		Ref No. 44 Ashton, Journal of Ecology, 1976		
	Dry sclerophyll forest (*Eucalyptus sieberi* and *E. obliqua*). Fine structured brown to dark-grey clays, grading to yellow-brown clays to 1.5 - 2.2 m.	Gn4.14	-37.42	145.13	928.50		1967	Trees harvested, allometric equations developed and applied to forest plots.	Unknown		Ref No. 44 Ashton, Journal of Ecology, 1976		
	Wet sclerophyll forest (*Eucalyptus regnans*) with shrub understorey. Well structured dark-brown soil grading to yellow-brown clays at depth.	Dy3.4	-37.43	145.58	654.30	63.20	1978	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	0.08 ha, plot	0.09	Ref No. 46 Feller, Australian Journal of Ecology, 1980		
	Dry sclerophyll forest (*Eucalyptus obliqua* and *E. dives*). Soils were well structured with grey surface grading to orange-brown clays at depth.	Dy3.4	-37.43	145.58	373.40	45.40	1978	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	0.08 ha, plot	0.11	Ref No. 46 Feller, Australian Journal of Ecology, 1980		
	Plantation forest (*Eucalyptus grandis*). Soils were derived form Lower Permian sediments.	Dy3.41	-30.42	153.00	436.06		1978	Trees harvested, allometric equations developed and applied to forest plots.	Unknown		Ref No. 51 Bradstock, Australian Forest Research, 1981		

Uneven-aged sclerophyll forest (*Eucalyptus agglomerata, E. muellerana, E. sieberi*) with developed understorey on Duplex soils of loams on mottled yellow clays).	Dr2.21	-37.42	149.55	327.30		1976	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	1.7 ha, plot		Ref No. 61 Stewart, Flinn and Aeberli, Australian Journal of Botany, 1979
Tall open sclerophyll forest (*Eucalyptus diversicolor*) with dense understorey. 'Red Earth' soils.	Dy3.62	-34.45	116.03	249.59	10.52	1980	Trees harvested, allometric equations developed and applied to forest plots. Understorey clipped quadrats.	0.25 ha, plot	0.04	Ref No. 66 Grove and Malajczuk , Forest Ecology and Management, 1985a & b
Semi-arid woodlands (*Eucalyptus crebra*). (1997). No soils information provided.	Ug5.1	-22.98	150.27	184.74		1997	Trees harvested, allometric equations developed and applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus crebra*). (1992). No soils information provided.	Gn3.12	-23.07	150.20	158.24		1992	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1994). No soils information provided.	Ug5.2	-22.45	148.72	99.70		1994	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Tallgrass Savanna. No soils details provided.	Dy3.43	-12.67	132.92	3.10		1980	Clipped quadrats.	0.0075 ha, quadrat		Ref No. 6 Cook and Andrew, Australian Journal of Ecology, 1991
Tallgrass Savanna. No soils details provided.	Dy3.43	-12.67	132.92	3.00		1980	Clipped quadrats.	0.0075 ha, quadrat		Ref No. 6 Cook and Andrew, Australian Journal of Ecology, 1991
Acacia harpophylla woodland. Duplex soil with sandy clay-loam surface layer.	Ug5.2	-24.50	149.80	118.80		1982	Trees harvested, allometric equations developed and applied to forest plots.	0.01 ha, plot		Ref No. 7 Scanlan, Australian Journal of Ecology, 1991

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Eucalypt and subtropical rainforest. Soils are grey leached sands overlying a yellow-grey clay B horizon.	Gn2.74	-33.55	150.37	500.75	91.80	1981 & 1984	Allometric equations developed from fallen trees in adjacent forest.	33.2 ha, point-sampling	0.15	Ref No. 28 Ash and Helman, Cunninghamia, 1990		
	Woodland (*Acacia harpophylla*) on gilgaied clay soils.	Gn2.12	-27.28	149.75	118.80	40.70	1964/1965	Biomass harvested on plots.	0.4 ha, plot	0.26	Ref No. 33 Moore, Russell and Coaldrake, Australian Journal of Botany, 1967		
	Xeric shrub community (*Eremophila gilesii*) on lateritic red earth soils.	Uc1.2	-26.42	146.22		0.78	1971	Biomass harvested on plots.	0.09 ha, plot		Ref No. 36 Burrows, Australian Journal of Botany, 1972		
	Xeric shrub community (*Atriplex vesicaria*). Soils are deep and fine textured.	Um5.41	-31.90	141.45		0.91	Unknown	Clipped quadrats.	Unknown		Ref No. 37 Charley and Cowling, Proceedings of the Ecological Society of Australia, 1968		
	Low sclerophyll forest (*Eucalyptus*) with a well developed understorey of shrubs, grasses and herbs. Sandy soils.	Uc1.21	-27.70	153.45	103.63	76.49	1973	Biomass harvested on plots.	0.025 ha, plot	0.42	Ref No. 38 Westman and Rogers, Australian Journal of Botany, 1977		
	Dry sclerophyll forest (*Eucalyptus marginata* and *E. calophylla*) with understorey of shrubs and herbs. Soils are lateritic sandy gravels.	KS-Uc4.2	-32.67	116.08	266.20		1977	Trees harvested, allometric equations developed and applied to forest plots.	0.36 ha, plot		Ref No. 41 Hingston, Dimmock and Turton, Forest Ecology and Management, 1980/81		
	Mulga vegetation in south-west Queensland (*Acacia aneura*). No soils information provided.	Gn2.12	-26.68	146.17	48.37		1972/ 1975	Biomass harvested on plots.	Unknown		Ref No. 59 Pressland, Australian Journal of Botany, 1975		
	Mulga vegetation in south-west Queensland (*Acacia aneura*). No soils information provided.	Dr1.33	-26.33	146.27	46.64		1972/ 1975	Biomass harvested on plots.	Unknown		Ref No. 59 Pressland, Australian Journal of Botany, 1975		

Mulga vegetation in south-west Queensland (*Acacia aneura*). No soils information provided.	Ug5.2	-26.38	146.25	41.89		1972/ 1975 on plots.	Biomass harvested.	Unknown		Ref No. 59 Pressland, Australian Journal of Botany, 1975
Arid saltbush and chenopod shrubland (*Atriplex vesicaria* and *Maireana sedifolia*). No soils information provided.	Um5.11	-32.12	139.37	1.34		1972	Visual method using photo-points calibrated by clipped quadrats.	Unknown, point-sampling		Ref No. 60 Noble , Australian Journal of Botany, 1977
Sclerophyll forest on Fraser Is. (*Eucalyptus pilularis*) growing on nutrient poor siliceous sands.	Uc1.21	-25.47	153.07	267.40	193.00	Unknown	Biomass harvested on plots.	Unknown	0.42	Ref No. 64 Applegate, Australian Forestry, 1989
Arid saltbush shrubland (*Atriplex vesicaria* and *Kochia aphylla*), grasses and herbs. No soils information provided.	Ug5.2	-35.03	144.97	3.54		1969	Clipped quadrats.	Unknown		Ref No. 72 Rixon, In 'The Biology of Atriplex', 1969
Open woodland (*Eucalyptus foelscheana*) with grass understorey. Soils 'representative of the widespread Tippera family of the Katherine-Darwin area'.	Gn2.12	-14.60	132.20		19.60	1979	Soil cores and root extraction.	0.0147 ha, plot		Ref No. 84 Bridge, Mott and Hartigan, Australian Journal of Soil Research, 1983
Open woodland (*Eucalyptus populnea*) with shrub understorey (*Eremophila, Cassia, Myoporum* & *Acacia*). No soils information supplied.	Gn2.13	-30.92	146.50	54.72		Unknown	Allometric equations developed for small trees and shrubs and applied to woodland plots.	17 ha, plot		Ref No. 98 Harrington, Australian Journal of Botany, 1979
Astrebla grasslands on red, coarse-structured clays.	Uc5.21	-23.70	133.88	4.0		1976/ 1977	Clipped quadrats.	0.0008 ha, quadrat		Ref No. 104 Friedel Part I, Australian Journal of Botany, 1981
Open woodland on red, coarse-structured clays.	Uc5.21	-23.70	133.88	2.6		1976/ 1977	Clipped quadrats.	0.0008 ha, quadrat		Ref No. 104 Friedel Part I, Australian Journal of Botany, 1981
Acacia shrublands on red, coarse-structured clays.	Uc5.21	-23.70	133.88	1.3		1976/ 1977	Clipped quadrats.	0.0008 ha, quadrat		Ref No. 104 Friedel Part I, Australian Journal of Botany, 1981

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Sclerophyll forest (*Eucalyptus radiata* & *E. dalrympleana*) with *Acacia* understorey on red, permeable soils derived from Ordovician granite.	Gn2.14	-35.60	148.10	133.62		1977	Previously developed allometric equations applied.	0.754 ha, plot		Ref No. 115 Turner, Australian Forest Research, 1980		
	Arid chenopod shrubland (*Acacia aneura, Atriplex vesicaria* & *Maireana sedifolia*). Soils are a brown *calcareous* earth containing carbonate nodules at about 20 cm depth.	Gc1.12	-32.88	137.38	0.5		1975/ 1976/ 1977	Visual method calibrated by clipped quadrats.	0.027 ha, plot		Ref No. 122 Andrew and Lange, Australian Journal of Ecology, 1986		
	Arid chenopod shrubland (*Acacia aneura, Atriplex vesicaria* & *Maireana sedifolia*). Soils are a brown *calcareous* earth containing carbonate nodules at about 20 cm depth.	Gc1.12	-32.88	137.38	0.5		1975/ 1976/ 1977	Visual method calibrated by clipped quadrats.	0.027 ha, plot		Ref No. 122 Andrew and Lange, Australian Journal of Ecology, 1986		
	Temperate mangrove community (*Avicennia marina*). No soils information provided.	Dy3.41	-33.82	151.15	128.50	153.80	1972	Previously developed allometric equations applied.	0.18 ha, plot	0.54	Ref No. 127 Briggs, Australian Journal of Ecology, 1977		
	Townsville-Stylo perennial pasture. Soils were a 'Tippera' clay loam.	Gn2.12	-14.47	132.32	2.0		1971	Clipped quadrats.	0.03 ha, plot		Ref No. 128 Ive, Australian Journal of Ecology, 1976		
	Pasture in an arid grazing system dominated by *Eucalyptus largiflorens* and chenopod shrubs. Soils are a mix of heavy texture grey clays and light textured red sands.	Ug5.2	-32.42	142.42	0.4		1980 & 1984	Visual method using photo-points calibrated by clipped quadrats.	0.00006 ha, quadrat		Ref No. 131 Robertson, Australian Journal of Ecology, 1988		

Tall forests of almost pure stands of *Eucalyptus delegatensis* on deep red-earth soils.	Um5.51	-35.42	148.80	313.3		Unknown	Tree DBH measured on plots, then a tree of 'about mean cross section area' harvested for dimensions and density measurements.	0.5 ha, plot		Ref No. 138 Crane and Raison, Australian Forestry' 1980
Mature stands of *Eucalyptus pauciflora*. Soil details not provided in paper (see notes).	Um5.51	-35.36	148.80	261.56	60.40	1993/ 1994	Allometric equations developed from fallen trees and applied to forest plots. Understorey clipped quadrats.	0.12 ha, plot	0.19	Ref No. 140 Keith, Raison and Jacobsen, Plant and Soil, 1997
Open Savannah woodland, Lake Mere. Sandy Loam.	Gn2.13	-30.28	145.90	2.27		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Arabella. Sandy loam.	Gn2.12	-26.48	146.47	3.61		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Hilgrove. Loamy Clay.	Ug5.12	-19.67	145.75	29.11		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Cardigan. Sandy loam.	Dr2.12	-20.18	146.72	11.16		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Redlands-red. Deep red earth.	Gn2.22	-20.23	145.87	16.97		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Redlands-yellow. Deep red earth.	Gn2.22	-20.23	145.87	16.69		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Manbullo unburnt. Sandy loam.	Gn2.12	-14.52	132.27	31.46		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Katherine. Sandy loam.	Gn2.12	-14.80	131.80	44.40		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997
Open Savannah woodland, Kapalga. Sandy clay loam.	KS-Uc4.11	-12.67	132.42	57.48		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Arid saltbush dominated by *Atriplex vesicaria*. No soils information provided.	Ug5.2	-35.03	144.97	2.83		1962	Visual method calibrated by clipped quadrats.	0.002 ha, quadrat		Ref No. 154 Leigh and Mulham, Australian Journal of Experimental Agriculture and Animal Husbandry, 1966		
	Arid saltbush dominated by *Atriplex vesicaria*. No soils information provided.	Ug5.2	-35.03	144.97	2.71		1963	Visual method calibrated by clipped quadrats.	0.002 ha, quadrat		Ref No. 154 Leigh and Mulham, Australian Journal of Experimental Agriculture and Animal Husbandry, 1966		
	Arid saltbush dominated by *Atriplex vesicaria*. No soils information provided.	Ug5.2	-35.03	144.97	2.77		1964	Visual method calibrated by clipped quadrats.	0.002 ha, quadrat		Ref No. 154 Leigh and Mulham, Australian Journal of Experimental Agriculture and Animal Husbandry, 1966		
	Arid chenopod shrubland (*Atriplex veiscaria* & *Maireana sedifolia*). Soils were desert loams or brown gibbers.	Um5.41	-31.90	141.50	1.10		1992	Visual method calibrated by clipped quadrats.	0.0101 ha, quadrat		Ref No. 159 Roshier and Nicol, Rangeland Journal, 1998		
	Semi-arid woodlands (*Eucalyptus crebra*). (1997). No soils information provided.	Gn2.11	-23.08	149.33	68.91		1997	Trees harvested, allometric equations developed and applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus crebra*). (1994). No soils information provided.	Um1.43	-22.85	147.32	44.60		1994	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus crebra*). (1992). No soils information provided.	Db1.13	-24.95	149.80	78.64		1992	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		

Semi-arid woodlands (*Eucalyptus crebra*). (1992). No soils information provided.	Dy3.42	-22.57	149.53	184.06	1992	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus crebra*). (1992). No soils information provided.	Uf6.61	-23.58	150.90	44.91	1992	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus crebra*). (1992). No soils information provided.	Dy2.43	-23.82	149.90	98.42	1992	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus crebra*). (1995). No soils information provided.	Gn2.11	-23.68	149.52	142.20	1995	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus crebra*). (1998). No soils information provided.	Dr2.12	-20.30	147.35	37.82	1998	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus crebra*). (1998). No soils information provided.	Ug5.12	-21.32	148.35	8.15	1998	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus melanophloia*). (1995). No soils information provided.	Dr2.12	-24.18	150.13	46.39	1995	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus melanophloia*). (1995). No soils information provided.	Dr2.31	-24.92	148.35	126.92	1995	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus melanophloia*). (1986). No soils information provided.	Db1.13	-24.92	148.60	90.75	1986	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1987). No soils information provided.	Dy2.43	-22.90	147.03	33.41		1987	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1996). No soils information provided.	Gn2.12	-23.75	146.03	47.34		1996	Trees harvested, allometric equations developed and applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1995). No soils information provided.	Gn2.12	-23.68	146.52	110.15		1995	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1997). No soils information provided.	Gn2.12	-23.18	146.57	52.75		1997	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1997). No soils information provided.	Dy3.41	-25.67	150.97	44.43		1997	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1998). No soils information provided.	Gn2.12	-26.75	147.57	78.56		1998	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1997). No soils information provided.	Dy2.43	-20.97	145.85	27.01		1997	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		
	Semi-arid woodlands (*Eucalyptus melanophloia*). (1997). No soils information provided.	Dy3.22	-25.02	150.78	45.81		1997	Developed allometric equations applied to woodland plots.	1 ha, plot		Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000		

Semi-arid woodlands (*Eucalyptus populnea*). (1983). No soils information provided.	Dy2.43	-23.58	149.30	96.34	1983	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1992). No soils information provided.	Dy3.41	-23.17	150.55	99.23	1992	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1995). No soils information provided.	Gn2.11	-23.90	149.63	48.22	1995	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1992). No soils information provided.	Ug5.24	-23.63	150.63	100.43	1992	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1996). No soils information provided.	Dy2.43	-23.63	149.42	41.29	1996	Trees harvested, allometric equations developed and applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1996). No soils information provided.	Dy2.43	-23.62	149.42	79.88	1996	Trees harvested, allometric equations developed and applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1996). No soils information provided.	Dy2.43	-23.60	149.43	59.49	1996	Trees harvested, allometric equations developed and applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1997). No soils information provided.	Gn2.22	-23.00	145.83	66.33	1997	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus populnea*). (1997). No soils information provided.	Gn2.12	-27.63	148.87	108.98	1997	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000
Semi-arid woodlands (*Eucalyptus melanophloia*). (1997). No soils information provided.	Ug5.22	-24.67	145.93	105.58	1997	Developed allometric equations applied to woodland plots.	1 ha, plot	Ref No. 192 Burrows, Hoffmann, Compton, Back and Tait, Australian Journal of Botany, 2000

Site	Description (vegetation, soil)	Soil Type*	Location (Latitude)	Location (Longitude)	Above-ground Biomass (t/ha, variance)	Below-ground Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor etc)	Area Estimate and Basis (ha, plots etc)	Root:shoot (~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
	Heath community dominated by *Banksia, Casuarina, Xanthorrhoea, Eucalyptus* on very sandy soils.	Uc2.21	-35.87	140.45	26.44	81.50	Unknown	Clipped quadrats.	0.0252 ha, quadrat	0.76	Ref No. 34 Specht, Rayson, Jackman, Australian Journal of Botany, 1958		
	Heath community dominated by *Banksia, Casuarina, Xanthorrhoea, Eucalyptus* on very sandy soils.	Uc2.21	-35.87	140.45	9.15		1966	Clipped quadrats.	0.0125 ha, quadrat		Ref No. 35 Specht, Australian Journal of Botany, 1966		
	Sclerophyllous heath (*Banksia*) with shrub and herb understorey on deep draining sands.	Uc2.21	-29.87	115.25	13.98	30.74	1984	Clipped quadrats.	0.0048 ha, plot	0.69	Ref No. 102 Low and Lamont, Australian Journal of Botany, 1990		
	Sclerophyllous heath (*Leptospermum, Casuarina* and *Banksia*) with secondary shrub layer. Soils were deep sands of very low fertility.	Um2.12	-38.13	145.13	9.47	60.13	1966	Clipped quadrats.	0.0012 ha, quadrat	0.86	Ref No. 107 Jones, Australian Journal of Botany, 1968		
	Sclerophyllous heath (*Leptospermum, Casuarina* and *Banksia*) with secondary shrub layer. Soils were deep sands of very low fertility.	Um2.12	-38.13	145.13	10.12	74.49	1966	Clipped quadrats.	0.0012 ha, quadrat	0.88	Ref No. 107 Jones, Australian Journal of Botany, 1968		
	Arid perennial grassland community (*Eragrostis eriopoda*). Soils were a gradational red-earth with a sandy loam surface.	Gn2.12	-23.55	133.60	14.90	20.10	1973/ 1975	Visual method calibrated by clipped quadrats.	0.002 ha, quadrat	0.57	Ref No. 126 Ross, Australian Journal of Ecology, 1977		
	Open savannah woodland, Alice Springs-open woodland. Earth.	Gn2.12	-23.57	133.57	5.92		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997		
	Open Savannah woodland, Runnymead. Sandy loam.	Ug5.37	-20.35	142.63	10.09		Unknown	Previously developed allometric equations applied.	2.25 ha, plot		Ref No. 143 Walker and Langridge, Journal of Biogeography, 1997		

Dry sclerophyll scrub system dominated by *Banksia* growing on sand-ridges.	Uc2.3	-33.96	151.22	48.00	79.90	1975/ 1976	Volume estimates made and combined with wood density measurements.	0.0008 ha, quadrat	0.62	Ref No. 147 Maggs and Pearson, Oecologia, 1977a
Heath vegetation dominated by *Banksia* on sandy soils.	Uc2.3	-38.87	146.40	7.72	41.70	1962/ 1963	Clipped quadrats.	0.0108 ha, quadrat	0.84	Ref No. 167 Groves, Australian Journal of Botany, 1965
Heath vegetation on low nutrient, sandy soils.	Dy5.43	-36.03	140.50	28.00		Unknown	Clipped quadrats.	0.002 to 0.03 ha, quadrat		Ref No. 168 Groves and Specht, Australian Journal of Botany, 1965
Heath vegetation on low nutrient, sandy soils.	Uc1.11	-39.03	146.32	18.00	34.53	Unknown	Clipped quadrats.	0.002 to 0.03 ha, quadrat	0.66	Ref No. 168 Groves and Specht, Australian Journal of Botany, 1965
Heath vegetation on low nutrient, sandy soils.	Uc2.3	-38.87	146.40	13.50	13.31	Unknown	Clipped quadrats.	0.002 to 0.03 ha, quadrat	0.50	Ref No. 168 Groves and Specht, Australian Journal of Botany, 1965

* Atlas of Australian Soils Principle Form

2. UNPUBLISHED FOREST DATA FROM SOUTH-EAST AUSTRALIA

Notes accompanying unpublished spatial biomass estimates.

2.1 GENERAL COMMENT

The reported estimates of biomass on a plot basis are considered to have a high level of accuracy where site and species specific allometric equations have been applied. Greater uncertainty exists where non-specific equations have been applied.

Spatial extrapolation of plot estimates of biomass to the stand level introduces the next level of uncertainty, which is related to forest heterogeneity. Extensive testing with inventory data is required to quantify this uncertainty.

2.2 COMMENT ON AGO CRITERIA

2.2.1 Maturity of the vegetation and changes due to disturbance

All stands are considered 'mature' native vegetation. Notes are provided about known disturbance history.

The Brindabella sites (Sites 1 – 4) represent stands regenerated after the 1939 wildfire, but include some survivors and trees aged by dendrochronology at >100 years old. Sites 1 and 3 have had some prescribed burning that has damaged some trees and killed a few small trees. These stands all consist of multi-ages and sizes of trees.

The stands in Bago State Forest are all fully - stocked with a range of tree age and size classes. Regeneration has occurred following selective harvesting and some wildfires. Inventory plots that had been recently logged or had low stocking due to poor regeneration have not been included.

The *E. obliqua* sites in Tasmania and NSW were specifically selected to represent mature stands. They are fully-stocked, multi-aged stands that have regenerated following selective harvesting or wildfire.

Further information could be obtained about disturbance history from forest compartment records.

2.2.2 Accuracy of spatial location

All sites are permanently marked in the field and can be located. Geo-referencing of plots used latitude and longitude from 1:25 000 scale AUSLIG maps. Plots were carefully located in relation to topographic features while in the field and accuracy would be within 25 m. GPS locations could be obtained by returning to each plot, for Sites 1–4 and 35–39. Sites 5–34 have been located by GPS.

2.2.3 Size of the area sampled (plot versus stand) and representativeness of local conditions (~1 ha for stand level)

Sites 1–4 , 21–34 and 35–39 were selected to be representative of the surrounding forest stand of >1 ha. Sites 5–20 were selected from a grid-based inventory design across the State Forest. However, based on knowledge of the surrounding forest, these plots are considered representative of >1 ha stand. Notes on actual sizes of inventory plots at each site are given in the following table.

Although these plots are considered 'representative' of a 1 ha stand, great heterogeneity exists in forests due to topography, environmental conditions and disturbance history (even within a 'mature' forest). This heterogeneity is exemplified by the variance among 6 plots within several ha at Site 1, and the range in values for sites 5 to 26 that occur in Bago State Forest with the same species and soil type.

2.2.4 Biomass divided into above – and below-ground components

There are no estimates of below-ground biomass at these sites. A root / shoot ratio cannot be applied because there is inadequate information about soil type, species and environmental controls on allocation to apply a ratio from another site.

Quality control can be assessed because CSIRO Forestry and Forest Products staff were involved in the collection, processing and measurements. Notes are provided for each site about the quality of allometric equations and inventory data.

The accuracy of biomass estimates depends on:

1. Representativeness of harvested trees and components;
2. Methods of sampling biomass components;
3. Derivation of allometric equations; and
4. Application of equations to inventory data.

Sites 1–4: Trees and components were sampled opportunistically from material available and to cover a size range of trees within the study area. Samples of components were weighed, multiplied by volume and converted by ratios of fresh mass:dry mass. Logarithmic allometric equations were calculated and applied to inventory data for the plots.

Sites 5–28: Species specific allometric equations from the Brindabellas were applied to inventory data from Bago State Forest. Structure of the trees is similar but the errors associated with site differences have not been tested.

Sites 29–34: The closest possible allometric equation was selected from those available in south-east Australia (NCAS Technical Report 5b, Australian Greenhouse Office, 2000), in terms of species and environmental conditions. Errors associated with species and site differences have not been tested.

Sites 35–39: Trees were sampled systematically at a site to cover the range in sizes and structures. Samples were selected by random branch sampling and importance sampling to ensure an unbiased sample with the greatest accuracy for the amount of material harvested. Logarithmic allometric equations were calculated, and these species and site specific equations were applied to inventory data for the same site.

All data presented were calculated for the purpose of estimating standing above-ground biomass of trees. Inventory data includes trees only >10 cm diameter, and does not include biomass of small trees, understorey, groundcover, dead trees or litter.

Estimation of errors –

The error associated in estimating biomass at a site consists of four components:

1. Error involved in the derivation of the allometric equation;
2. Error involved in any application of the allometric equation to trees beyond the size range from which it was derived;
3. Error due to prediction using an allometric equation for individual trees within a plot; and
4. The variance among replicate plots within a site.

Information exists for the current sites on errors of type (3) at Sites 5–20 and type (4) at Site 1. Additional information about errors could be calculated for some of these sites.

The total error in the estimation of biomass is the sum of all these types of errors. It is important that each type of error is not confused, and that an individual type of error is not taken as the total error.

Site	Description (vegetation, soil)	Location	Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor, etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
1 PS	*E. pauciflora* - 60 year-old regeneration. Montane cool temperate eucalypt forest. Mature stand of mixed age / size classes, mainly regeneration from the 1939 wildfire with some large residual trees. Soil type is a Red Earth with high organic matter content.	Piccadilly catchment, Brindabella Range, ACT. 35 21' 49"S 148 48' 11"E Elevation 1200 m 50 km W of Canberra.	210.9 (mean) 188.1 (variance 1)	Biomass samples collected in approx. 1980. Allometric equation derived and stand biomass calculated in 1995. Inventory data is long term and on-going.	Allometric equation (site specific)	6 x 0.04 ha plots within an area of several ha		Keith H., Raison R. J. and Jacobsen K.L. 1997. Allocation of carbon in a mature eucalypt forest and some effects of soil phosphorus availability. Plant and Soil 196:81-99.	1) Location: Position of plots is accurately located on 1:25000 topographic map, permanently located in the field, and could be located by GPS. 2) Area estimate: Plots cover forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with trees approx. 60 years old and a range of ages. Disturbance history includes regeneration after the 1939 wildfire and regular prescribed burning.	Other data available at the site: 1) Detailed soil analyses, 2) Inventory data for an additional 21 plots, long-term and on-going, 3) Growth data in terms of annual DBH increment, 4) Budgets of C, N and P in the ecosystem and 5) Species lists.
2 FS	*E. pauciflora* - unburnt forest. (as above)	Ferny catchment, Brindabella Range, ACT. 35 22' 35" S 148 48' 11" E	145.7 t/ha	Inventory data from 1984. (as above)	Allometric equation (site specific)	1 x 0.25 ha plot		unpublished	1) Location: Position of plots is accurately located on 1:25000 topographic map, permanently located in the field, and could be located by GPS. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with trees >100 years old and a range of ages. No fires within known history.	Other data available at the site: 1) Some soil analyses 2) Growth data in terms of annual DBH increment of selected trees and 3) Species lists.

3	PD	*E. delegatensis* - 60 year-old regeneration. Montane cool temperate eucalypt forest. Mature stand of mixed age / size classes, mainly regeneration from the 1939 wildfire with some large residual trees. Soil type is a Red Earth with high organic matter content.	Piccadilly catchment, Brindabella Range, ACT. 35 21' 43" S 148 48' 23" E	287.8 t/ha	Inventory data from 1994. (as above)	Allometric equation (site specific)	1 x 0.25 ha plot	unpublished	1) Location: Position of plots is accurately located on 1:25000 topographic map, permanently located in the field, and could be located by GPS. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with trees 60 years old and a range of ages. Disturbance history includes regeneration after the 1939 wildfire and regular prescribed burning.	Other data available at the site: 1) Some soil analyses, 2) Growth data in terms of annual DBH increment of selected trees and 3) Species lists.
4	FD	*E. delegatensis* - unburnt forest. (as above)	Ferny catchment, Brindabella Range, ACT. 35 22' 28" S 148 49' 30" E	447.8 t/ha	Inventory data from 1994. (as above)	Allometric equation (site specific)	1 x 0.25 ha plot	unpublished of plots is accurately	1) Location: Position at the site: located on 1:25000 topographic map, permanently located in the field, and could be located by GPS. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with trees 60 years old and a range of ages. No fires in known history.	Other data available 1) Some soil analyses, 2) Growth data in terms of annual DBH increment of selected trees and 3) Species lists.
	PGP 1	*E. delegatensis.* Tall montane cool temperate eucalypt forest. Forest managed for selective timber production for >100 years. Mature stand of multiple age / size cohorts. Deep granodiorite soils.	Bago State Forest. Altitudinal range 800 to 1500 m. AMG zone 55 604130 E 6056246 N	563.0 149.5 (SD 2)	Inventory data from 1996.	Allometric equation (derived from Brindabella data)	1 x 0.1 ha plot	unpublished	1) Location: Position of plots is accurately located by GPS and mapped on the Bago GIS. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with a fully stocked, multiple-aged stand. Regeneration has occurred following selective harvesting and some wildfires.	Other data available at the site: 1) Detailed soil analyses 2) Growth data in terms of annual DBH increment and dendrochron-ological studies, 3) Species lists and 4) Historical records of management and disturbance events.

Site	Description (vegetation, soil)	Location	Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor, etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
6 PGP 2		AMG zone 55 604130 E 6056246 N	244.9 65.0 (SD 2)							
8 PGP 4		AMG zone 55 609177 E 6053686 N	495.5 122.0(SD 2)							
9 PGP 5		AMG zone 55 604139 E 6053727	241.6 64.1 (SD 2)							
10 PGP 6		AMG zone 55 606574 E 6053624 N	655.4 174.0 (SD 2)							
11 PGP 7		AMG zone 55 601568 E 6053619 N	283.9 75.4 (SD 2)							
13 PGP 9		AMG zone 55 601685 E 6051007 N	407.7 108.2 (SD 2)							
14 PGP 10		AMG zone 55 604373 E 6050916 N	152.3 40.4 (SD 2)							
15 PGP 11		AMG zone 55 609084 E 6051087 N	318.6 84.6 (SD 2)							
16 PGP 12		AMG zone 55 609180 E 6048615 N	244.1 64.8 (SD 2)							
18 PGP 14		AMG zone 55 599214 E 6046015 N	242.2 64.3 (SD 2)							
19 PGP 16		AMG zone 55 609114 E 6046175 N	222.7 59.1 (SD 2)							
20 PGP 18		AMG zone 55 611735 E 6043738 N	213.8 56.8 (SD 2)							

21 BMP 1	*E. delegatensis.* Tall montane cool temperate eucalypt forest. Forest managed for selective timber production for >100 years. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.62298 S 148.143043 E Easting 603510 Northing 6057252	475.0	Inventory data from 2001.	Allometric equation (derived from Brindabella data)	1 x 0.1 ha plot	unpublished	1) Location: Position of plots is accurately located by GPS and mapped on the Bago GIS. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with a fully stocked, multiple-aged stand. Regeneration has occurred following selective harvesting and some wildfires.	Other data available at the site: 1) Detailed soil and foliage analyses, 2) Growth data in terms of annual DBH increment, 3) Species lists, 4) Historical records of management and disturbance events and 5) remote sensing coverage.
22 BMP 3	as above	35.64250 S 148.179489 E Easting 606785 Northing 6055049	629.1	as above	as above	as above	as above	as above	as above
23 BMP 4	as above	35.61089 S 148.148658 E Easting 604034 Northing 6058587	384.5	as above	as above	as above	as above	as above	as above
24 BMP 8	as above	35.70121 S 148.125698 E Easting 601840 Northing 6048593	446	as above	as above	as above	as above	as above	as above
25 BMP 16	as above	35.65469 S 148.150438 E Easting 604139 Northing 6053727	414	as above	as above	as above	as above	as above	as above
26 BMP 118	as above	35.65962 S 148.156806 E Easting 604709 Northing 6053173	264	as above	as above	as above	as above	as above	as above
27 SG 1	*E. pauciflora / E. dalrympleana. Bago State Forest.* Low cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.66450 S 148.170750 E Easting 605964 Northing 6052621	331	as above	as above	as above	as above	as above	Other data available at the site: 1) Foliage analyses and 2) remote sensing coverage.
28 SG 2	*E. pauciflora / E. dalrympleana.* Low cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.68700 S 148.157300 E Easting 604718 Northing 6050140	275	as above	as above	as above	as above	as above	as above

Site	Description (vegetation, soil)	Location	Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor, etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
29 PM 1	*E. radiata / E. dalrympleana.* Low cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.57282 S 148.201117 E Easting 608837 Northing 6062753	358	as above	Allometric equation (derived from the closest data for the species)	as above		as above	as above	as above
30 PM 2	*E. radiata / E. dalrympleana.* Low cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.57662 S 148.211583 E Easting 609780 Northing 6062320	218	as above	Allometric equation (derived from the closest data for the species)	as above		as above	as above	as above
31 SB 1	*E. macrorhyncha / Acacia melanoxylon.* Low cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.87452 S 148.126517 E Easting 601693 Northing 6029369	228	as above	Allometric equation (derived from the closest data for the species)	as above		as above	as above	as above
32 SB 2	*E. macrorhyncha / Acacia melanoxylon.* Low cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.88223 S 148.109717 E Easting 600167 Northing 6028531	136	as above	Allometric equation (derived from the closest data for the species)	as above		as above	as above	as above
33 BL 1	*E. bicostata / E. radiata.* Tall cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.75838 S 148.110317 E Easting 600377 Northing 6042268	635	as above	Allometric equation (derived from the closest data for the species)	as above		as above	as above	as above
34 BL 2	*E. bicostata / E. radiata.* Tall cool temperate eucalypt forest. Mature stand of multiple age / size cohorts.	Bago State Forest. 35.75372 S 148.092933 E Easting 598811 Northing 6042803	446	as above	Allometric equation (derived from the closest data for the species)	as above		as above	as above	as above

35 Tas wet high	*E. obliqua.* Tall cool temperate eucalypt forest. Mature stands of multiple age / size cohorts. Fertile doleritic soils.	Picton valley in SW Tasmania. Easting 475940 Northing 5215940	876	Allometric equation and inventory data collected in 1998. Coupes harvested in 1998.	Allometric equation (site specific)	1 x 0.2 ha plot	Keith H. 1999 Generalised allometric equations for estimating the above-ground biomass of Australia's forests: Synthesis of results from destructive harvesting of *Eucalyptus obliqua* in NSW and Tasmania.	1) Location: Position of plots is accurately located on topographic and compartment maps. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with a fully stocked, multiple-aged stand. Regeneration has occurred following selective harvesting and some wildfires.	Other data available at the site: 1) Soil analyses and 2) Inventory data.
36 Tas wet high	*E. obliqua.* Tall cool temperate eucalypt forest. Mature stands of multiple age / size cohorts. Fertile doleritic soils.	Arve Valley in SW Tasmania. Easting 485290 Northing 5228290	883			1 x 0.2 ha plot		1) Location: Position of plots is accurately located on topographic and compartment maps. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is 'old growth', with a fully stocked, multiple-aged stand.	
37 Tas wet low	*E. obliqua.* Tall cool temperate eucalypt forest. Mature stands of multiple age / size cohorts. Soils of low fertility on sandstone.	Arve valley in SW Tasmania. Easting 486400 Northing 5224500	80	Allometric equation and inventory data collected in 1998.	Allometric equation (site specific)	1 x 0.1 ha plot	as above	1) Location: Position of plots is accurately located on topographic and compartment maps. 2) Area estimate: Plot covers forest representative of strips around the edge of swamps that may be <100 m wide. 3) Maturity: The forest stand is considered 'mature', with a fully stocked, multiple-aged stand.	as above

Site	Description (vegetation, soil)	Location	Biomass (t/ha, variance)	Year when biomass estimated	Method of Calculation (Allometric, expansion factor, etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref No., unpublished)	Reliability (AGO Criteria)	Comments
38 NSW dry high	*E. obliqua.* Medium temperate eucalypt forest. Mature stands of multiple age / size cohorts. Soils of moderate - high fertility on igneous parent material.	Tallaganda State Forest, NSW. 149 36' 21" E 35 30' 37" S	497	as above	as above	3 x 0.04 ha plots		as above	1) Location: Position of plots is accurately located on topographic and compartment maps. 2) Area estimate: Plot covers forest representative of >1 ha 3) Maturity: The forest stand is considered 'mature', with a fully stocked, multiple-aged stand. Regeneration has occurred following selective harvesting and some wildfires.	as above
39 NSW dry low	*E. obliqua.* Medium temperate eucalypt forest. Mature stands of multiple age / size cohorts. Soils of low fertility on sedimentary parent material.	Bendoura State Forest, NSW. 149 41' 07" E 35 37' 22" S	493	as above	as above	3 x 0.04 ha plots		as above	1) Location: Position of plots is accurately located on topographic maps. 2) Area estimate: Plot covers forest representative of >1 ha. 3) Maturity: The forest stand is considered 'mature', with a fully stocked, multiple-aged stand. Regeneration has occurred following some wildfires.	as above

Notes: 1) All sites could be located again in the field and are accurately located on topographic maps. GPS locations could be obtained.

2) Variance can be calculated for these biomass estimates in two ways: (1) replicated plots at a site, however, there are few examples where these data exist, or (2) the error due to prediction using an allometric equation for individual trees within a plot; this error term can be calculated for all sites.

3. WOODLAND DATA FROM QUEENSLAND

These notes have been extracted from: Growth and carbon stock change in eucalypt woodlands in north-east Australia: ecological and greenhouse sink implications, W.H. Burrows, B.K. Henry, P.V. Back, M.B. Hoffmann, L.J. Tait, E.R. Anderson, N. Menke, T. Danaher, J.O. Carter and G.M. M^c^Keon (2002). Global Change Biology **8**, 769-784.

3.1 MATERIALS AND METHODS

3.1.1 Permanent monitoring plots

Data on vegetation structure and growth in this study are from the Queensland Department of Primary Industries' network of permanent vegetation monitoring sites established within grazed woodland communities since 1982. A large number of different operators (>10) have been responsible for site selection over the years, avoiding areas close to obvious points of ongoing disturbance such as fences, yards and watering points. The sites were not randomly selected in a statistical sense, but have been progressively established on rural landholdings to provide a broad cover of vegetation community and prehistory, dominant species and geographical location across Queensland's grazed woodlands.

Woody plant composition and structure on these sites were determined using the **t**ransect **r**ecording **a**nd **p**rocessing **s**ystem (TRAPS) methodology (Back *et al.* 1997; 1999) for monitoring permanently positioned transect lines within representative stands of woodlands (Burrows *et al.* 2000). A standard site comprised five parallel belt transects 100 m long arranged along a north-south axis 25 m apart. Each transect set was contained within a minimum 300 m x 300 m buffer of similar vegetation. Stem circumference at 30 cm above-ground and height were measured for all live and dead woody plants (but see later) within a 2 m band either side of the transect line, at each successive recording.

3.1.2 Site representativeness

Fifty seven TRAPS sites dominated by *Eucalyptus* and/or *Corymbia* spp. were selected for analysis of woody vegetation growth and carbon stock change. Selection was based on field inspection and information supplied by landholders so as to exclude sites subject to tree clearing activity during the period of observation and sites regrowing from tree clearing within the previous 20 years.

The study area was delimited to the north by 17 degrees south latitude, and to the west by either 141 degrees longitude, or the 450 mm rainfall isohyet, whichever was further east. The extent of eucalypt woodlands within this area was defined by firstly determining the historic coverage of eucalypt dominant woodlands from the Carnahan (1976) map of subjectively estimated pre-European vegetation cover and then assessing the current area from the woody vegetation cover in 1997, as mapped from satellite imagery (Department of Natural Resources 1999).

The representativeness of the subset of 57 TRAPS sites in the present study was assessed in relation to a) rainfall; b) temperature; c) soils; and d) stand basal area based on the approach of Austin & Meyers (1996) for assessing the distribution of study plots in both environmental (defined by temperature, rainfall and lithology) and geographical space, for evidence of spatial bias in sampling. Environmental representativeness was assessed using an approach similar to common stratification techniques for vegetation resource surveys (for example, Thackway & Cresswell 1992) based on the attributes of rainfall and temperature of the wettest quarter, and soil texture classes. Temperature and rainfall data were also used to assess how well the 57 sites represented spatial variation in the interaction of these environmental parameters.

Climatic variables were derived from the ANUCLIM module which utilises topographic data to obtain climatic interpolations of high resolution (McMahon *et al*. 1996) and soil classification was from the Atlas of Australian Soils (Northcote *et al.* 1960-1968). Frequency distributions of average rainfall and temperature and of soil classes for the eucalypt woodlands of the study area, obtained by extracting the variable values at the intersections of a 5 km grid, were compared qualitatively and by χ^2 test with those for the TRAPS sites. To assess the representativeness of the interaction of temperature and rainfall, averaged data for the study area and TRAPS sites were classified into discrete classes of 1°C and 50 mm increments. All areas with environmental conditions represented by at least one TRAPS site were mapped and the proportion of eucalypt woodlands sampled was determined.

The representativeness in terms of tree basal area was assessed by comparing the stand basal area at the TRAPS sites with values measured using a combination of remote sensing and site data in the Statewide Landcover and Trees Study (SLATS) project (Danaher *et al.*, 1992). The tree (or woody) basal area frequency distribution had been calculated from a raster of woody vegetation cover (foliage projective cover) from Landsat TM (30 m resolution) data using a relationship derived by Kuhnell *et al.* (1998). This relationship applies only to mature stands of vegetation and therefore was not applied to areas mapped as young regrowth. Kuhnell *et al.* (1998) estimated stand basal area at breast height (approximately 130 cm above-ground) whereas basal area at the TRAPS sites was measured at 30 cm. To enable comparison of the two datasets a relationship between circumference (mm) at 30 cm and at 130 cm above-ground level was developed based on circumference (C) at the two heights measured on 54 eucalypt trees (3 species) harvested for biomass measurement (Burrows *et al.* 2000), $C_{130\ cm} = 0.789\ C_{30\ cm}$ (r^2 through the origin = 0.89).

3.1.3 Representativeness of the climate history

To determine how well the TRAPS measurement periods represented the available climate history, the rainfall for each observation period at each site was compared to the long-term rainfall records for that site. Rainfall for 1889 to 2000 (SILO database 2000 - see Jeffrey *et al.* 2001) for individual TRAPS sites was subdivided into observation records (moving windows) corresponding to the same calendar start day and duration of individual observation periods. This ensured the same sequence of seasons was compared throughout the climatic record. Rainfall during the TRAPS observation period, expressed as a percentile of rainfall in all moving windows (Kendall & Buckland 1971) gave the rainfall for each site ranked in relationship to all available observations. The frequency of ranked site percentiles thus summarises the relative dryness/wetness during the observation period, allowing comparison between sites.

3.1.4 Stand structure

Eucalyptus and/or *Corymbia* spp. plants alive at the initial and final recording of each site were grouped into 200 mm circumference classes (0 - 200, 200 - 400, …… 3600 - 3800 mm) to examine the size class distribution and interpret stand growth status. Basal area in each class was calculated and converted to carbon biomass as described below. There was a wide diversity of size class distributions amongst the 57 sites and statistical methods were used to select examples for illustration. Sites were firstly characterised using variables such as stand prehistory together with measures of standard deviation, skewness and kurtosis. Divisive Cluster analysis (Mathsoft, 1997) was used to group the sites and the stand structure of a representative individual site from each of the eight largest groups was subjectively selected for display.

3.1.5 Tree basal area

Tree basal area at each site was calculated from the circumference at 30 cm for the live and standing dead pools shown. The two major groups of woody plants, eucalypts and non-eucalypts, were recorded separately. Circumference measurements of all live woody plants at each observation enabled basal area to be calculated for those plants live at both initial and final recordings, plants live at the initial recording but which died during the observation period, and plants which established during the observation period (ingrowth). Standing dead woody plants were measured at the final recording enabling calculation of basal area for plants that died during the observation period and plants that were dead also at the initial observation (see later). The position of standing dead trees was recorded at the initial observation, but circumference was not measured. Coarse woody debris was not measured in this study. A small minority of plants that both established and died between the initial and final[1] recordings was ignored. The mean tree basal area increment ($m^2\ ha^{-1}\ y^{-1}$) for all live trees present at both initial and final recordings was determined as the average across all sites and observation periods. This increment was also expressed as the mean percentage of the original basal area of live trees in each stand.

3.1.6 Live above-ground biomass

The procedure for calculating live biomass from stem circumference used in this analysis is a further development of the procedure described by Burrows *et al.* (2000) and outlined here in points 1 to 4.

1. Woodland stands within the same area as used in the present study were selected to represent three dominant species (*Eucalyptus crebra, E. melanophloia, E. populnea*).

2. The above- and below-ground biomass of 20-40 plants of each species was measured and used to derive tree species allometric equations (Table 2, Burrows *et al.* 2000) and a generalised eucalypt equation (Fig. 1, Burrows *et al.* 2000).

3. Specific or generalised equations for above-ground biomass were applied to individual eucalypt trees for 33 TRAPS sites where eucalypts contributed >75% of stand basal area. If the basal area of any individual eucalypt was greater than that of the largest tree used in developing the above equations then the biomass was set to the maximum biomass of trees measured in developing the equations.

4. Total above-ground biomass of the eucalypt component of the stand was calculated and regressed on stand eucalypt live tree basal area (Fig. 3, Burrows *et al.* 2000) suggesting that stand biomass could be simply estimated from stand live tree basal area for the eucalypts.

The following additional steps were taken to extend this calculation procedure to other stands and other components of eucalypt stands:

5. Step 3 was repeated for an additional 24 TRAPS sites with eucalypt composition greater than 50% and a new relationship between stand live above-ground biomass and eucalypt basal area established.

6. The relationship derived in Step 5 was applied to total stand live tree basal area assuming that the biomass density (t dry matter per m^2 stand basal area) of eucalypt trees holds also for non-eucalypts. The appropriateness of this assumption is discussed later.

3.1.7 Above-ground biomass of standing dead trees

A decay function for standing dead *E. populnea* trees was derived in 1997 for a site in the Dingo region of central Queensland that had reliable records of individual trees ringbarked (girdled) or killed by chemical injection between 1933 and 1987 (Burrows, unpublished data). Standing dead trees (with no bark remaining) contributing to this function were harvested and weighed. Correction factors derived from harvesting tree fractions used to derive allometrics (Burrows *et al.* 2000) enabled over bark circumference at time of tree death, and hence final live weight, to be estimated. For decay periods less than 64 years, the biomass change can be derived from:

[1] The most recent observation is referred to as the 'final' observation for purposes of this paper.

$y = 24.4 + 75.6\ e^{-0.14x}$ ($r^2 = 0.99$, $p < 0.001$) (1),

where y = % of original live standing above-ground biomass remaining; x = time in years since tree death; n = 14.

The relationship was not extrapolated beyond the equivalent time range over which it was derived.

For trees that died during the observation period, the biomass at the initial recording was calculated from basal area using the generalised biomass to basal area conversion derived as above. Since the time of death within the observation period was not known, death was assumed to have occurred immediately following the first measurement and the decay function (1) used to estimate the proportion of the initial biomass remaining at the final observation. This assumption of maximum decay period, gave a conservative estimate of the final biomass.

3.1.8 Estimation of the biomass of trees dead at the initial recording

Standing trees that were dead at the initial recording were measured only at the final observation. These dead plants were mostly trunks with a few large lateral branches but with no small branches, leaves or bark remaining. We estimated that such dead trees on the TRAPS sites had been dead for an average of 20 years before the initial recording, based on our field observations of dead trees of known age. The same procedure used to derive the above decay function enabled conversion of stem circumferences of standing dead trunks, measured free of bark, to the original over bark circumference.

The generalised biomass to basal area relationship described previously was divided by the mean ratio of standing biomass to trunk mass for woodland eucalypt trees (Burrows *et al.* 2000) to give a conversion factor for the basal area (corrected to over bark) to biomass of trunk of standing dead. The derived trunk mass was assumed to approximate the standing dead tree mass at the final recording (t_2). The biomass of standing dead at the initial recording date (t_1) was estimated using the above decay function (1):

Biomass remaining at initial observation, t_1 (20 years since death),

$$B_{t_1} = \frac{B_0}{100}\left(24.4 + 75.6e^{-0.14t_1}\right)$$

Biomass at final observation, t_2

$$B_{t_2} = \frac{B_0}{100}\left(24.4 + 75.6e^{-0.14t_2}\right)$$

Thus, $$B_{t_1} = B_{t_2}\frac{24.4 + 75.6e^{-0.14t_1}}{24.4 + 75.6e^{-0.14t_2}}, \qquad (2)$$

where t_1 = 20 years; t_2 = 20 + (years between initial and final recording); B_0 = biomass at time of death; = standing dead biomass at t_1; = standing dead biomass at t_2. Maximum time (t_2) since estimated death for standing dead trees on the oldest established TRAPS site was 38 years – well within the time range of the derived decay function.

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Site	Description of Woodlands	Soil type	Location Latitude.	Location Longitude.	Eucalyptus Biomass (t/ha)	Eucalyptus Biomass (S.E.E.)	Method of Calculation	Biomass of Other spp. (t/ha)**	Total Dead Biomass (t/ha)***	Year when biomass estimated	Area Estimate and Basis*	Root biomass (euc) (t/ha, from R:S ratio of 0.26)	Data source	Reliability (AGO Criteria	Comments
1	*E. populnea*	Gn2.12	27°8'	146°59'	59.85	14.66	Allometric	39.45	33.16	2000	ha, plots	15.56[a]	Unpublished		
2	*E.fibrosa*	Ug5.1	22°58'	150°16'	189.93	26.06	Allometric	0.00	4.10	1999	ha, plots	49.38[a]	Unpublished		
3	*E. melanophloia*	Dy3.33	21°35'	145°42'	51.47	14.89	Allometric	2.86	0.15	1999	ha, plots	13.38[a]	Unpublished		
4	*E. brownii*	Um4.2	21°17'	147°17'	44.08	11.49	Allometric	8.11	30.62	2000	ha, plots	11.46[a]	Unpublished		
5	*E. melanophloia*	Gn2.12	23°10'	146°34'	48.66	16.52	Allometric	8.65	25.01	1999	ha, plots	12.65[a]	Unpublished		
6	*E. melanophloia*	Dr2.12	24°10'	150°6'	46.10	7.56	Allometric	0.45	1.34	1999	ha, plots	11.99[a]	Unpublished		
7	*E. melanophloia*	Dr2.12	25°40'	150°58'	41.98	10.51	Allometric	0.13	2.69	1999	ha, plots	10.92[a]	Unpublished		
8	*E. crebra*	Dy2.43	21°19'	148°21'	4.71	3.20	Allometric	0.06	25.17	2000	ha, plots	1.22[a]	Unpublished		
9	*E. crebra*	Gn2.21	24°57'	149°49'	68.98	16.63	Allometric	23.57	0.00	1992	ha, plots	17.94[a]	Unpublished		
10	*E. citriodora*	Dy3.41	25°41'	151°21'	155.41	56.06	Allometric	8.16	12.04	2000	ha, plots	40.41[a]	Unpublished		
11	*E. quadricostata*	Uc2.21	20°17'	145°31'	71.13	14.19	Allometric	1.84	3.52	1999	ha, plots	18.49[a]	Unpublished		
12	*E. crebra*	Dy3.42	22°34'	149°32'	140.99	27.14	Allometric	0.43	7.06	2000	ha, plots	36.66[a]	Unpublished		
13	*E. populnea*	Dy2.42	23°10'	150°33'	106.21	17.32	Allometric	0.48	4.81	1999	ha, plots	27.61[a]	Unpublished		
14	*E. platyphylla*	Dy3.43	20°36'	147°31'	29.50	7.48	Allometric	0.81	2.70	2000	ha, plots	7.67[a]	Unpublished		
15	*E. orgadophila*	Ug5.12	22°41'	148°2'	26.28	4.71	Allometric	2.03	1.29	1998	ha, plots	6.83[a]	Unpublished		
16	*E. melanophloia*	Gn2.12	23°34'	146°57'	67.38	20.23	Allometric	4.26	0.23	1999	ha, plots	17.52[a]	Unpublished		
17	*E. whitei*	Gn2.22	21°57'	144°50'	18.93	5.35	Allometric	2.40	3.19	1999	ha, plots	4.92[a]	Unpublished		
18	*E. similis*	Gn2.11	20°50'	145°5'	36.58	8.56	Allometric	9.95	1.01	1999	ha, plots	9.51[a]	Unpublished		
19	*E. melanophloia*	Gn2.12	26°45'	147°34'	72.36	17.32	Allometric	5.52	9.65	2000	ha, plots	18.81[a]	Unpublished		
20	*E. crebra*	Gn2.11	23°4'	149°20'	127.59	27.51	Allometric	8.40	2.59	1999	ha, plots	33.17[b]	Unpublished		
21	*E. xanthoclada*	Dr2.12	20°28'	146°43'	20.91	11.18	Allometric	0.92	5.57	1998	ha, plots	5.44[a]	Unpublished		
22	*E. xanthoclada*	Dr2.12	20°24'	146°43'	5.06	3.80	Allometric	0.45	17.59	1998	ha, plots	1.32[a]	Unpublished		
23	*E. crebra*	Gn2.11	23°56'	149°36'	73.52	11.04	Allometric	6.19	4.19	1999	ha, plots	19.12[a]	Unpublished		
24	*E. crebra*	Dr2.12	20°9'	146°28'	15.12	8.87	Allometric	1.62	0.86	1998	ha, plots	3.93[a]	Unpublished		
25	*E. melanophloia*	Gn2.94	20°58'	145°51'	25.94	12.48	Allometric	9.73	22.01	1999	ha, plots	6.74[a]	Unpublished		
26	*E. crebra*	Dy3.41	24°47'	151°38'	124.69	30.43	Allometric	23.49	5.76	1990	ha, plots	32.42[a]	Unpublished		
27	*E. populnea*	Ug5.24	23°38'	150°38'	93.34	9.06	Allometric	1.64	4.33	1999	ha, plots	24.27[a]	Unpublished		
28	*E. xanthoclada*	Dr2.12	19°50'	146°35'	27.66	7.07	Allometric	0.03	7.06	1998	ha, plots	7.19[a]	Unpublished		

29	*E. xanthoclada*	Dr2.12	19°50'	146°35'	14.09	5.15	Allometric	0.00	11.37	1998	ha, plots	3.66[a]	Unpublished
30	*E. tereticornis*	Db1.33	23°44'	147°19'	117.79	22.04	Allometric	0.01	1.31	2000	ha, plots	30.62[a]	Unpublished
31	*E. microneura*	Uc4.12	18°15'	143°32'	50.90	14.30	Allometric	6.67	0.05	1998	ha, plots	13.24[a]	Unpublished
32	*E. crebra*	Dy3.41	23°1'	150°12'	120.79	29.12	Allometric	3.93	8.05	1999	ha, plots	31.41[a]	Unpublished
33	*E. crebra*	Dr2.12	20°18'	147°53'	46.83	14.04	Allometric	8.58	5.62	2000	ha, plots	12.18[a]	Unpublished
34	*E. brownii*	Gn2.22	19°58'	145°46'	61.61	11.02	Allometric	0.29	10.68	1999	ha, plots	16.02[a]	Unpublished
35	*E. microneura*	Uc4.12	18°17'	143°24'	56.81	12.82	Allometric	16.34	2.53	1998	ha, plots	14.77[a]	Unpublished
36	*E. citriodora*	Dy3.41	24°12'	151°20'	96.98	12.99	Allometric	14.65	9.72	1999	ha, plots	25.21[a]	Unpublished
37	*E. crebra*	Gn3.12	18°33'	144°47'	70.34	14.59	Allometric	0.63	0.54	1998	ha, plots	18.29[a]	Unpublished
38	*E. melanophloia*	Dr2.31	24°54'	148°20'	109.66	27.54	Allometric	2.87	6.78	1999	ha, plots	28.51[a]	Unpublished
39	*E. melanophloia*	Dy3.22	25°1'	150°47'	52.26	14.71	Allometric	0.00	3.09	1999	ha, plots	13.59[a]	Unpublished
40	*E. moluccana*	Dy3.41	23°41'	151°1'	200.81	31.49	Allometric	0.00	11.08	1999	ha, plots	52.21[a]	Unpublished
41	*E. crebra*	Dy3.42	25°8'	150°45'	129.21	22.14	Allometric	0.18	9.75	1999	ha, plots	33.60[a]	Unpublished
42	*E. orgadophila*	Ug5.1	24°8'	148°7'	30.03	7.90	Allometric	21.45	4.92	2000	ha, plots	7.81[a]	Unpublished
43	*C. erythrophloia*	Dr2.12	20°19'	146°47'	21.71	5.26	Allometric	1.18	9.79	1998	ha, plots	5.64[a]	Unpublished
44	*C. erythrophloia*	Dr2.12	20°19'	146°47'	10.71	4.71	Allometric	0.50	4.85	1998	ha, plots	2.78[a]	Unpublished
45	*E. melanophloia*	Gn2.12	23°45'	146°2'	51.33	10.73	Allometric	1.99	4.48	1999	ha, plots	13.35[b]	Unpublished
46	*E. melanophloia*	Dy5.41	25°19'	148°01'	61.37	10.37	Allometric	25.44	2.26	2000	ha, plots	15.96[a]	Unpublished
47	*E similis*	Gn2.12	22°25'	145°31'	23.93	6.00	Allometric	5.26	4.44	1999	ha, plots	6.22[a]	Unpublished
48	*E. populnea*	Gn2.22	23°33'	145°50'	57.60	11.89	Allometric	10.60	4.04	1999	ha, plots	14.98[a]	Unpublished
49	*E. papuana*	Uc5.11	23°46'	145°14'	26.77	5.52	Allometric	4.18	1.63	1999	ha, plots	6.96[a]	Unpublished
50	*E. crebra*	Gn2.11	23°41'	149°31'	108.19	31.90	Allometric	21.92	5.29	1999	ha, plots	28.13[a]	Unpublished
51	*E. melanophloia*	Gn2.11	23°40'	149°30'	115.56	14.53	Allometric	1.81	4.99	1998	ha, plots	30.05[a]	Unpublished
52	*E. moluccana*	Gn2.11	23°41'	149°32'	85.90	31.07	Allometric	10.40	16.53	1999	ha, plots	22.33[a]	Unpublished
53	*E. brownii*	Dr2.12	22°22'	146°41'	48.33	17.10	Allometric	1.29	15.46	2000	ha, plots	12.56[a]	Unpublished
54	*E. populnea*	Dy2.43	23°38'	149°25'	38.37	10.28	Allometric	3.95	5.41	1998	ha, plots	9.98[a]	Unpublished
55	*E. populnea*	Dy2.43	23°37'	149°25'	70.81	10.22	Allometric	13.46	1.41	1998	ha, plots	18.41[b]	Unpublished
56	*E. populnea*	Dy2.43	23°36'	149°26'	55.61	11.67	Allometric	12.19	5.07	1998	ha, plots	14.46[a]	Unpublished
57	*E. populnea*	Gn2.12	27°38'	148°52'	90.22	14.72	Allometric	17.09	8.12	2000	ha, plots	23.46[a]	Unpublished

* Plot area 100 m x 100 m - sampled with 5 belt transects 100 m x 4 m.
** Calculated by stand allometrics
*** Total of dead Eucalyptus and Other spp.
a Data based on mean values as determined by Burrows *et al.* (2000).
b Data based on actual measurements (see Burrows *et al.* (2000).

4. SHRUBLAND, WOODLAND AND FOREST DATA FROM WESTERN AUSTRALIA

The following analysis of above-ground biomass and its C content for the shrubland and woodland communities in the Pilbara encompassed:

- Field work at 35 sites within an area covering more than 60,000 km^2.
- Dimensional analysis of >2300 trees and shrubs and >100 analyses of the physical dimensions of tussock and hummock grasses.
- Harvesting and destructive sampling (for dimensions and mass) of >200 trees and shrubs and >60 grass hummocks / tussocks.
- Gravimetric analysis of >5000 plant samples.
- Statistically rigorous (the number of sub-plots, *n*, varied between 3 and 11) measures of biomass and C content for 27 sites.

The projected area of the canopy of trees and shrubs, as well as the area occupied by the tussocks or hummocks of the major grasses, provided robust, independent variables for the estimation of biomass of individual plants (explaining up to 97% of the variation in mass). In many instances, canopy area provided a better estimation of mass than the more traditionally used DBHOB for trees or basal diameter for shrubs. This finding suggests potential to use remote sensing to estimate biomass and C content of vegetation.

The C content of above-ground biomass varied from as little as 0.5 t ha^{-1} to just over 25 t ha^{-1}. The majority of study sites contained less than 5 t ha^{-1}. Dense stands of Mulga (*Acacia aneura*) associated with the deepest soils (e.g. Mulga 'groves') and/or the major rivers (e.g. Fortescue - floodplains) contained the most biomass C in the Pilbara, followed by examples of Snappy gum (*Eucalyptus leucophloia*) tree-steppe (between 10 and 17 t ha^{-1}). However, even these vegetation 'types' showed high spatial variation with <2 t ha^{-1} recorded for several stands of Mulga.

Spinifex (*Triodia* spp.) contributed a high proportion of above-ground biomass at many sites containing up to 7 t C ha^{-1} but more typically around 2 t C ha^{-1}. Buffel grass (*Cenchrus* spp.), a major component of the vegetation on the floodplains at Ethel Creek Station, always contained <2 t C ha^{-1}.

The data collected suggest that for the Pilbara and elsewhere in Australia, arid and semi-arid communities contain considerably less C than has been estimated from 'international' models. The reasons for this are probably high temperatures and low rainfall coupled in many instances with soils having poor physical properties.

This study has highlighted several features of the Pilbara vegetation. First, above-ground biomass and its C content are generally far less than 'default' values ascribed by the Intergovernmental Panel on Climate Change (IPCC) and used in the past by the AGO. Secondly, the 'carbon density' varies strongly according to the vegetation type (e.g. grasslands with few trees or shrubs contain often <1 t C ha^{-1} whilst nearby groves of Mulga may contain ~15 t C ha^{-1}) and also to the availability of water to the vegetation. It should be noted that by far the largest areas of the Pilbara are dominated by spinifex with scattered shrubs, usually acacias. This vegetation 'type' will nearly always contain <5 t C ha^{-1} in the above-ground biomass.

Details for specific ecosystems are contained in the following table.

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Site	Description (vegetation, soil)	Location	Individual sites (t/ha)	Biomass (t/ha, SE) note: above-ground biomass factor ONLY	Year when biomass estimated	Method of Calculation (Allometric, expansion etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref, unpublished)	Reliability (AGO Criteria)	Comments	Area in the Pilbara region of this vegetation type (ha x 1000)
1	**“Perennial grasslands - tussock grass** (*Astrebla, Themeda, Eragrostis* species). Soil classification1 Ug 5.38 Ug 5.36 Ug 5.38 Soil descriptions: finely textured, cracking clays; uniform texture; non-calcareous finely textured, cracking clays; uniform texture; highly calcareous; underlying calcrete deposits finely textured, cracking clays; uniform texture; calcareous at depth”.		n=12	2.19 (.714)	1996/97	Allometrics derived for each species, including cover/biomass relationships and by destructive sampling.	Perennial and ephemeral plant biomass, as well as litterfall, were sampled from both ungrazed (1 ha, fenced to exclude cattle and kangaroos) and grazed (1 ha, open to grazing) plots for the perennial tussock grasses *A. pectinata, T. triandra* and *E. xerophila*	Mean root biomass across all sites, all species, all sampling periods 1.138, .363	Ingram, L.J. 2001. PhD thesis, UWA.			
	A. pectinata grazed	22° 17.58 S / 117° 41.20 E	1.665		1996/97							
	A. pectinata ungrazed	22° 17.58 S / 117° 41.20 E	1.85		1996/97							
	T. triandra grazed	22° 17.58 S / 117° 41.20 E	4.949		1996/97							
	T. triandra ungrazed	22° 17.58 S / 117° 41.20 E	5.378		1996/97							
	E. xerophila grazed	20° 53.09 S / 116° 40.05 E	1.782		1996/97							
	E. xerophila ungrazed	20° 53.09 S / 116° 40.05 E	1.855		1996/97							
2	**Perennial grasslands -hummock grass/spinifex communities (*Triodia* species).** North-facing slope and had rocky skeletal soil with some rock outcrops. Dominant species were *Triodia pungens* with scattered *Eucalyptus leucophloia*.	22° 57.437 S / 117° 09.529 E	1.06	4.49, 1.71 (SE)	2000	Allometrics derived for all species combined with site inventory data.	*E. leucophloia* was not quantified at this site because it was very sparse (greater than 100 m between trees). Spinifex plants in three 10 m x 10 m quadrats were measured for height and circumference. Nine hummocks of *Triodia pungens* were harvested at this site.	Insufficient data to predict with confidence.	Adams, M.A., Grierson, P.F., Bussau, A. & Dorling, K. (2001) Biomass and carbon in vegetation of the Pilbara region, Western Australia. Final report submitted to Hamersley Iron, BHP and Robe, July 2001. Ecosystems Research Group, The University of Western Australia, Crawley. 118 pp.			4082

	Flat sandplain adjacent to the Fortescue flood plain. Small patches of mixed shrubs (*Acacia* spp.) among a spinifex-dominated landscape.	2° 51.184 S / 2120° 07.835 E	6.03		2000	Allometrics derived for all species combined with site inventory data.	The cover of spinifex was measured using seven 10 m x 10 m quadrats located every 50 m along a 350 m transect. Spinifex species included *Triodia pungens* and at least one species of "hard" Spinifex.	Adams, M.A. *et al.* (2001)	
	Low rolling hills with stony soil. *Acacia pyrifolia* grew as a sparse overstorey over dense *Triodia* sp. (Kanji over spinifex).	21° 41.218 S / 116° 19.598 E	6.38		2000	Allometrics derived for all species combined with site inventory data.	Shrub density was assessed using the plot-less method along a 250 m transect, with sampling points at every 50 m. Percent cover was estimated along a 300 m transect with sampling points every 50 m. Cover of *Triodia* in 10 x 10 m plots was estimated independently by five people and the average estimate recorded.	Adams, M.A. *et al.* (2001)	
3	***Acacia* shrublands (including shrub steppe).** Undulating hills, with frequent rocky outcrops and skeletal soils. Vegetation was dominated by a low shrub layer, almost exclusively *Acacia maitlandii*, with patchy occurrence of perennial tussock grasses and *Triodia* (probably *T. wiseana*).	22° 43.328 S / 117° 49.932 E	2.81	2.61, .39	2000	Allometrics derived for all species combined with site inventory data.	Vegetation was assessed using a 100 m transect with one 15 m x 15 m quadrat and two 10 m x 10 m quadrats. Eight *A. maitlandii* were harvested.	Adams, M.A. *et al.* (2001)	29089
	Floodplain of the Fortescue River, where soil profiles included deep silts, sands and clays. The plant community consisted of sparse trees (*Eucalyptus aspera, E. deserticola, Hakea suberea* and *Acacia citrinoviridis*), shrubs (*Acacia victoriae, A. farnesiana, Cullen leucanthum*) and mixed tussock grass dominated by *Cenchrus ciliaris* (Buffel grass).	22° 53.276 S / 120° 09.538 E	2.46		2000	Allometrics derived for all species combined with site inventory data.	A plot-less method was used to assess vegetation frequency and cover with 4 sampling points separated by 50 m. Cover of *Cenchrus ciliaris* was assessed independently in 10m x 10m plots adjacent to each of the sampling points.	Adams, M.A. *et al.* (2001)	

Site	Description (vegetation, soil)	Location	Individual sites (t/ha)	Biomass (t/ha, SE) note: above-ground biomass factor ONLY	Year when biomass estimated	Method of Calculation (Allometric, expansion etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref, unpublished)	Reliability (AGO Criteria)	Comments	Area in the Pilbara region of this vegetation type (ha x 1000)
	Floodplain of the Fortescue River, soils were deep sandy loams and sandy-clay loams. Vegetation was mixed shrubs and grasses. *Senna artemisioides* spp. *oligophlla* and *Acacia victoriae* were the dominant shrubs, with a sparse groundcover of grasses (possibly *Aristida* sp) and forbs.	22° 55.360 S / 120° 13.334 E	1.46		2000	Allometrics derived for all species combined with site inventory data.	Both assessment techniques were used at this site - three 10 m x 10 m quadrats were established along a 150 m transect, and a the plot-less technique was also employed with six sampling points spaced 40 m apart along a 240 m transect. Cover of *Cenchrus ciliaris* was assessed in 10 m x 10 m plots adjacent to each of the sampling points.		Adams, M.A. *et al.* (2001)			
	Floodplain of the Fortescue River, soils were deep sandy loams and sandy-clay loams. Dominant plants were *Cullen leucanthum, Acacia victoriae* and *Cenchrus ciliaris.*	23° 55.702 S / 120° 11.196 E	2.1		2000	Allometrics derived for all species combined with site inventory data.	Plant dimensions and distribution were measured using the plot-less method with 6 sampling points every 40 m. Cover of *Cenchrus ciliaris* was assessed in 10 m x 10 m plots adjacent to each of the sampling points.		Adams, M.A. *et al.* (2001)			
	Fortescue River floodplain, alluvial loam and clay-loam soils. Dominant species were *Acacia aneura, A. citrinoviridis, A. victoriae, Cullen leucanthum* and mixed tussock grasses. There was evidence of recent flooding in this area. Lower parts of the landscape had dead plants (usually *Senna artemisioides* spp. *oligophlla* and *Cenchrus ciliaris*) that were not included in the assessment.	23° 02.879 S / 120° 09.480 E	n/a		2000	Allometrics derived for all species combined with site inventory data.	Vegetation was assessed for density and dimensions using the plot-less method, with six sampling points separated by 100 m. No plants were harvested at this site.		Adams, M.A. *et al.* (2001)			
	Floodplain of Yandicoogina Creek. Soils were alluvial, mainly sand to fine sand with occasional pebbles and larger rocks. The vegetation consisted of sparse woodland over mixed tussock grass. Dominant trees included Bloodwood (*Eucalyptus deserticolia*), and *Hakea subera.*	22° 39.391 S / 119° 26.675 E	2.54		2000	Allometrics derived for all species combined with site inventory data.	Only grass cover (primarily *Cenchrus ciliaris*) was estimated along a 300 m transect with sampling points every 50 m. Cover in 10 x 10 m plots was estimated independently by five people.		Adams, M.A. *et al.* (2001)			

	Relatively flat sand plain adjacent to the Fortescue River flood plain. Plant species included *Acacia. pyrifolia, A. binervosa, A. ancistrocarpa, Hakea suberea* and *Senna glutinosa*.	21° 46.672 S / 116° 39.877 E	4.33		2000	Allometrics derived for all species combined with site inventory data.	Shrub density was assessed using the plot-less method along a 250 m transect, with sampling points at every 50 m. Cover of *Triodia* in 10 x 10 m plots was independently estimated by five people.	Adams, M.A. *et al.* (2001)	
4	**Snappy gum (*Eucalyptus leucophloia* communities (tree-steppe).** Low stoney hills with skeletal soil amidst rocky outcrops. Vegetation included 10 species of *Acacia*, 2 of *Eucalyptus* and 1 of *Senna*. *Triodia wiseana* was extensive. *Eucalyptus leucophloia* and *E. deserticola* were sparse, while *Acacia pruinocarpa, A. orthocarpa* and *Senna glutinos* were relatively common and in places formed a low canopy.	22° 21.690 S / 117° 35.490 E	16.86	19.81, 3.65	2000	Allometrics derived for all species combined with site inventory data.	Vegetation was assessed along a transect with three 50 m x 50 m plots at 100 m intervals. Canopy dimensions, height and stem diameters at 10 cm of all trees and shrubs were measured. Larger trees were also measured for stem diameter at crown break.	Adams, M.A. *et al.* (2001)	12,248
	Ridgeline of a south-facing slope and had patches of skeletal soil and rocky outcrops. Dominant species were *Eucalyptus leucophloia* over *Triodia* spp.	22° 51.101 S / 118° 37.341 E	26.99		2000	Allometrics derived for all species combined with site inventory data.	Tree density of *E. leucophloia* was estimated using the plot-less method with five sampling points separated by 100 m. Cover of *Triodia* spp. was assessed in 10 m x 10 m plots adjacent to each of the sampling points. Four branches from three *E. leucophloia* and five hummocks of *Triodia* spp. were harvested at this site.	Adams, M.A. *et al.* (2001)	
	Undulating hills and had rocky skeletal soil with some rock outcrops. Dominant species were *Eucalyptus leucophloia* over *Triodia* spp.	22° 14.541 S / 117° 57.567 E	31.38		2000	Allometrics derived for all species combined with site inventory data.	Tree density of *E. leucophloia* was estimated using the plot-less method with five sampling points separated by 50 m. Cover of *Triodia* spp. was assessed in 10 m x 10 m plots adjacent to each of the sampling points. Two branches from two *E. leucophloia* and three hummocks of *Triodia* spp. were harvested at this site.	Adams, M.A. *et al.* (2001)	
	Mid-way up Mt Sheila on a south-facing ridge with rocky, skeletal soil and frequent rock outcrops. Dominant species were *Eucalyptus leucophloia* over *Triodia* spp.	22° 13.738 S / 117° 35.817 E	22.39		2000	Allometrics derived for all species combined with site inventory data.	Tree density of *E. leucophloia* was estimated using the plot-less method with five sampling points separated by 50 m. Cover of *Triodia* spp. was assessed in 10 m x 10 m plots adjacent to each of the sampling points. Four branches from two different *E. leucophloia* were harvested at this site.	Adams, M.A. *et al.* (2001)	

Site	Description (vegetation, soil)	Location	Individual sites (t/ha)	Biomass (t/ha, SE) note: above-ground biomass factor ONLY	Year when biomass estimated	Method of Calculation (Allometric, expansion etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref, unpublished)	Reliability (AGO Criteria)	Comments	Area in the Pilbara region of this vegetation type (ha x 1000)
	Broad ridge in the north-eastern foothills of the Hamersley Range and had skeletal soils and rock outcrops. Dominant species were *Eucalyptus leucophloia* over *Triodia* spp. Tree density of *E. leucophloia* was estimated using the plot-less method with 5 sampling points separated by 100 m. Cover of *Triodia* spp. was assessed in 10 m x 10 m plots adjacent to each of the sampling points. No plants were harvested at this site.	22° 51.276 S / 119° 15.714 E	6.71		2000	Allometrics derived for all species combined with site inventory data.	Tree density of *E. leucophloia* was estimated using the plot-less method with 5 sampling points separated by 100 m. Cover of *Triodia* spp. was assessed in 10 m x 10 m plots adjacent to each of the sampling points. No plants were harvested at this site.		Adams, M.A. *et al.* (2001)			
	Valley/gorge sides between two flat-topped hills ("mesa") close to Pannawonica. Soils were skeletal and rocky. Dominant species were *Eucalyptus leucophloia* with mixed acacia shrubs and *Triodia* spp.	21° 42.218 S / 116° 16.556 E	14.54		2000	Allometrics derived for all species combined with site inventory data.	Tree density of mature *E. leucophloia* was estimated by counting trees along both sides of the valley along 200 m transects. Shrub density was calculated using the plot-less method with five sampling points separated by 100 m, repeated on both sides of the valley. Cover of *Triodia* spp. was assessed in three 20 m x 20 m plots on both sides of the valley. Branches from four *E. leucophloia* and one whole tree were harvested at this site.		Adams, M.A. *et al.* (2001)			
5	***Acacia anuera* woodlands (mulga).** Broad alluvial plain near Marandoo. Soils were alluvial loams and clay-loams with frequent pebbles in the profile. Vegetation was an overstorey of small mulga (*Acacia aneura*) trees with an understorey dominated by *Eremophila forrestii* and mixed grass and forbs.	22° 36.073 S / 118° 04.055 E	5.34	18.57, 7.50	2000	Allometrics derived for all species combined with site inventory data.	Plant density was estimated in three 50 m x 50 m quadrats placed 50 m apart along a transect running east-west. All individuals of *A. aneura* and *E. forrestii* were measured for height and canopy dimensions. All *A. aneura* were also measured for diameters of each stem at 0.1 m, 0.5 m, 1.3 m and crown break, canopy depth and assessment of form (see Section 2). Ten *E. forrestii* and six *A. aneura* were destructively sampled for both above- and below-ground biomass.		Adams, M.A. *et al.* (2001)			5,613

Broad alluvial plain near Marandoo. Soils were alluvial loams and clay-loams with frequent pebbles in the profile. Vegetation was an overstorey of small mulga (*Acacia aneura*) trees with an understorey dominated by *Eremophila forrestii* and mixed grass and forbs.	22° 36.267 S / 118° 02.213 E	2.82	2000	Allometrics derived for all species combined with site inventory data.	Plant density was estimated by measuring all *A. aneura* and *E. forrestii* in three 20 m x 20 m quadrats Separated by 20 m as described above. No plants were harvested at this site.	Adams, M.A. *et al.* (2001)
Some evidence of recent flooding and soil were alluvial clay-loams. Tall mulga woodland, dominated by *A. aneura* with patches of scatted *Eucalyptus victrix* with *Marsilea sp.* (Nardoo fern) and Juncaceae sp. covering most of the ground.	23° 01.481 S / 118° 46.719 E	26.6	2000	Allometrics derived for all species combined with site inventory data.	Plant density was estimated by measuring all *A. aneura* in three 50 m x 50 m quadrats separated by 50 m along an east-west transect. One large *A. aneura* was harvested at this site.	Adams, M.A. *et al.* (2001)
Extensive flat plain east of the Fortescue River with fine sandy loam or clay loam soils. Vegetation was distributed as irregular patches or groves of *Acacia* spp. Vegetation was dominated by *A. aneura* with other mixed shrubs, including *A. victoriae, Senna artemisioides* spp. *Oligophlla*. There was little or no vegetation between groves.	23° 01.325 S / 120° 26.884 E	36.19	2000	Allometrics derived for all species combined with site inventory data.	Vegetation was assessed for density and dimensions using the plot-less method, with six sampling points separated by 50 m. Two *A. aneura* were harvested for above-ground biomass at this site.	Adams, M.A. *et al.* (2001)
Extensive flat plain east of the Fortescue River with fine sandy loam or clay loam soils. Vegetation was distributed as irregular patches or groves of *Acacia* spp. Vegetation was dominated by *A. aneura* with other mixed shrubs, including *A. victoriae, Senna artemisioides* spp. *Oligophlla*. There was little or no vegetation between groves.	23° 01.882 S / 120° 28.859 E	1.97	2000	Allometrics derived for all species combined with site inventory data.	Vegetation was assessed for density and dimensions using the plot-less method, with six sampling points separated by 100 m. No plants were harvested at this site.	Adams, M.A. *et al.* (2001)
Floodplain of the Fortescue River with alluvial loam and clay-loam soils. Vegetation was arranged in irregular patches or groves and was dominated by *Acacia aneura, Eremophila forrestii* and mixed grass and forbs.	22° 34.350 S / 119° 31.675 E	51.9	2000	Allometrics derived for all species combined with site inventory data.	Plant density (and dimensions) was estimated using the plot-less method with six sampling points separated by 20 m. No plants were harvested at this site.	Adams, M.A. *et al.* (2001)

Site	Description (vegetation, soil)	Location	Individual sites (t/ha)	Biomass (t/ha, SE) note: above-ground biomass factor ONLY	Year when biomass estimated	Method of Calculation (Allometric, expansion etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref, unpublished)	Reliability (AGO Criteria)	Comments	Area in the Pilbara region of this vegetation type (ha x 1000)
	Adjacent to the flood plain of the Fortescue River with alluvial loam and clay-loam soils and close to site 20 and 22. Dominant species were *Acacia aneura, A, xiphyophylla, A. victoriae* and grass and forbs (including Chenopods).	22° 34.700 S / 119° 26.675 E	5.2		2000	Allometrics derived for all species combined with site inventory data.	Plant density (and dimensions) was estimated using the plot-less method with six sampling points separated by 50 m. No plants were harvested at this site.		Adams, M.A. *et al.* (2001)			

This analysis of above-ground biomass and its carbon content for the Pilbara encompassed:

Field work at 27 sites within an area of >60,000 km^2.

Dimension analysis of >2300 trees and shrubs and >100 analyses of the physical dimensions of tussock and hummock grasses.

Harvesting and destructive sampling (for dimensions and mass) of >200 trees and shrubs and >60 grass hummocks / tussocks.

Gravimetric analysis of >5000 plant samples.

Statistically rigorous (the number of sub-plots, *n*, varied between 3 and 11) measures of biomass and carbon content for 27 sites.

Site	Description (vegetation, soil)	Location	Individual sites (t/ha)	Biomass (t/ha, SE) note: above-ground biomass factor ONLY	Year when biomass estimated	Method of Calculation (Allometric, expansion etc)	Area Estimate and Basis (ha, plots etc)	Root biomass or root:shoot (t/ha, ~R/S)	Data source (Ref, unpublished)	Reliability (AGO Criteria)	Comments	Area in the Pilbara region of this vegetation type (ha x 1000)
1	Jarrah (*Eucalyptus marginata*) forest. Soils are Ferric Xanthosols (lateritic gravelly sands). Site harvested ~1922. Thinned in 1960 - protected from fire for at least 70 years.	Amphion Forest Block, Dwellingup. 32° 48', 116° 03'). Average rainfall for the site is 1235 mm and elevation is 267 m		82 t ha^{-1} includes understorey of *B. grandis.*	1998	Allometrics derived for dominant understorey and overstorey species.	Full assessment of all stems of *E. marginata* overstorey and understorey *B. grandis* in 6 50x50 m^2 plots across a ~100 ha site.	Mean fine root biomass - mean 12.5 t ha^{-1} (including seasonal and species variations). Total root biomass not measured.	Grierson and Adams, Oecologia (submitted)			

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Set the framework for development of the National Carbon Accounting System (NCAS) and document initial NCAS-related technical activities (see http://www.greenhouse.gov.au/ncas/ publications).

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Provide targeted technical information aimed at improving carbon accounting for Australian land based systems (see http://www.greenhouse.gov.au/ncas/publications).

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Of particular note is Technical Report No.

28. The FullCAM Carbon Accounting Model: Development, Calibration and Implementation for the National Carbon Accounting System.

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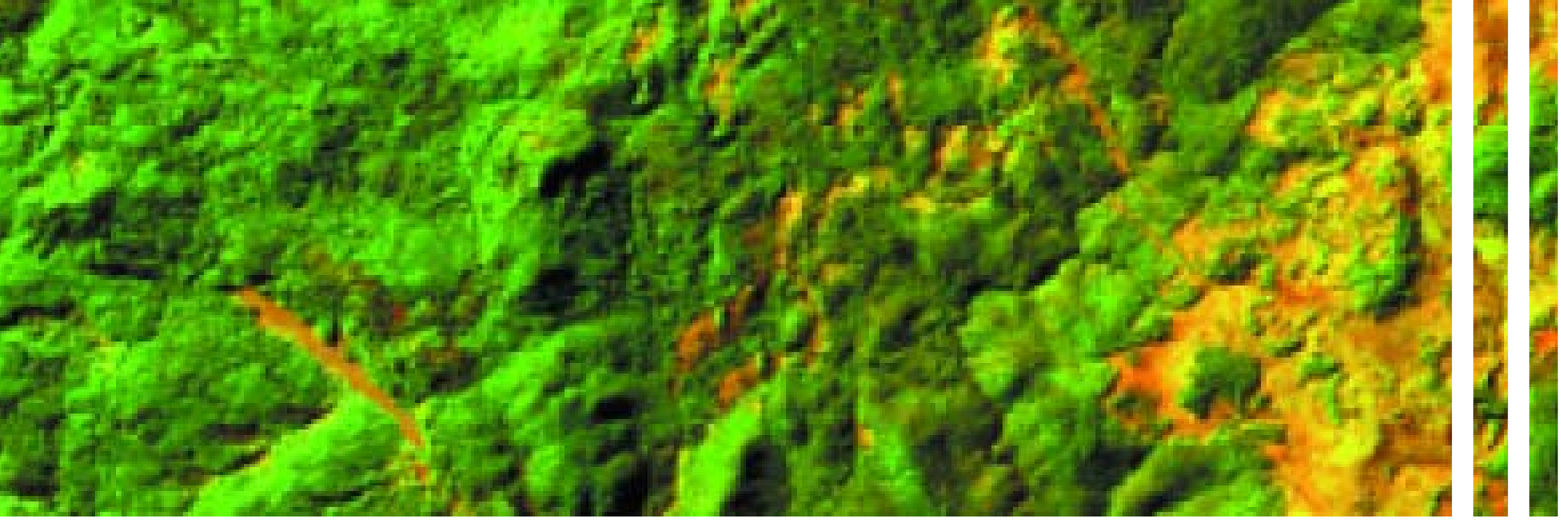

The National Carbon Accounting System provides a complete accounting and forecasting capability for human-induced sources and sinks of greenhouse gas emissions from Australian land based systems. It will provide a basis for assessing Australia's progress towards meeting its international emissions commitments.

technical report no. 44

Spatial Estimates of Biomass in 'Mature' Native Vegetation