CHAPTER 6

DISCUSSION

6.1 LARGE TREES - COMPONENT DIFFERENCES BETWEEN SITES

The Deep site (1701 t ha^{-1}) has an above ground biomass 6.4
times that of McKenzie (265 t ha^{-1}) which in turn is 3.5 times greater
than that of Wabby (76.4 t ha^{-1}). Perusal of Table 6.1 shows that there
are species differences which have resulted from silvicultural treatment
to favour blackbutt. This is particularly evident on McKenzie. When
treatment ceased on McKenzie, coppice growth of the non blackbutt began,
often in clumps from a common stump. These shade tolerant species (satinay,
corkwood, brush box) continue to grow beneath the upper canopy of the more
intolerant blackbutt. Satinay and brush box attained a large biomass on
the Deep site. Corkwood does not grow to the large sizes in this old growth
island forest that it reaches on the mainland, and its biomass (Table 6.1) reaches
a peak about 12 years from seedling or coppice regeneration.

The *Banksia* sp. and *Acacia* sp. appear only in the newly regenerated
forest, probably as a result of the burn. *Banksia aemula* is a post-fire
pioneer, the seedlings resulting from serotinous cones on the ground which
are opened by the heat of the fire (Gill 1976), and by wind dispersal of
seed from individuals adjacent to the burnt site. The seed of *Acacia* sp.
remain viable on the surface and in the ground for many years, so that
when a fire eventuates, dormancy is overcome and massive regeneration occurs.
The prolific post germination growth is probably aided by nitrogen fixing
nodules (Westman and Rogers 1977). *Monotoca scoparia* has not reached large
tree size on Wabby after 15 years growth, but is evident on McKenzie. This
species would not have been selectively removed during silvicultural treat-
ment, as it is not considered a threat to blackbutt. It is not present under
the dense canopy of the Deep site, except where openings have been created by
logging.

The standing dead biomass is directly related to species dominance
and silvicultural treatment on the Wabby site and to treatment on the
McKenzie site, while at Deep, it seems due to the small amount of damage
caused by logging, and from natural death. The Wabby site contains 63% of
the large tree biomass as dead stems (Table 6.1) which is much greater than
that recorded for McKenzie (6.2%) and Deep (0.1%).

Table 6.1 Biomass (kg ha^{-1}) and standard errors (in parentheses) of the forest fractions on Wabby, McKenzie and Deep sites.

	WABBY			McKENZIE			DEEP		
ABOVE GROUND									
Large Trees									
Eucalyptus pilularis	43824.3	(3744.5)	(8.5%)	246218.3	(5341.7)	(2.2%)	586808.4	(449018.9)	(76.5%)
Eucalyptus intermedia	21137.7	(1303.8)	(6.2%)	-			-		
Eucalyptus resinifera	246.8	(46.1)	(18.7%)	-			-		
Eucalyptus microcorys	-			-			121716.1	(64520.3)	(53.0%)
Tristania conferta	1411.3	(103.6)	(7.3%)	2541.2	(114.5)	(4.5%)	38282.9	(2489.4)	(6.5%)
Syncarpia hillii	7214.4	(266.5)	(3.7%)	5982.6	(262.2)	(4.4%)	946701.8	(354553.7)	(37.4%)
Endiandra sieberi	652.9	(73.6)	(11.3%)	8043.5	(224.2)	(2.8%)	4058.9	(370.8)	(9.1%)
Banksia aemula	1710.5	(141.5)	(8.3%)	-			-		
Acacia falciformis	173.3	(36.0)	(20.8%)	-			-		
Eugenia coolminiana	-			432.8	(49.1)	(11.3%)	-		
Monotoca scoparia	-			2352.4	(122.1)	(5.2%)	399.3	(33.6)	(8.4%)
Backhousia myrtifolia	-			-			3685.7	(115.2)	(3.1%)
Large standing dead	129609.7	(120970.0)	(93.3%)	17638.0	(78.1)	(0.4%)	2479.8	(2479.8)	(100.0%)
Total Live	76371.2	(3978.9)	(5.2%)	265570.8	(5355.7)	(2.0%)	1701653.1	(575756.5)	(33.8%)
TOTAL	205980.9	(121035.4)	(58.8%)	283208.8	(5356.3)	(1.9%)	1704132.9	(575761.8)	(33.7%)
Small Trees									
Eucalyptus pilularis	4266.4	(722.0)		304.6	(243.6)		-		
Eucalyptus intermedia	370.0	(219.0)		-			-		
Eucalyptus resinifera	-			195.5	(66.7)		-		
Eucalyptus microcorys	-			-			210.4	(126.1)	
Tristania conferta	7917.8	(1942.3)		4524.2	(1760.7)		2893.9	(911.5)	
Syncarpia hillii	796.9	(445.8)		4803.2	(576.1)		47.1	(31.0)	
Endiandra sieberi	3957.7	(1103.0)		6964.6	(1799.3)		1658.7	(677.8)	
Acacia falciformis	15901.5	(3499.0)		44.4	(30.2)		-		
Monotoca scoparia	3059.5	(962.5)		572.9	(252.3)		192.6	(146.5)	
Leucopogon margarodes	1287.1	(289.5)		-			722.2	(248.4)	
Banksia aemula	1224.3	(501.9)		-			-		
Phebalium woombye	22.4	(13.7)		83.2	(48.5)		-		
Dodonaea triquetra	52.7	(15.4)		75.2	(30.2)		-		
Persoonia virgata	291.9	(143.9)		-			121.9	(84.3)	
Eugenia coolminiana	-			447.1	(258.6)		184.1	(121.3)	
Elaeocarpus reticulatus	-			606.8	(251.3)		9.5	(5.2)	
Notelaea longifolia	-			176.7	(110.4)		137.9	(59.4)	
Myrsine variabilis	-			519.0	(355.6)		8.7	(6.2)	
Cryptocarya glaucescens	-			-			320.4	(191.3)	
Canthium coprosmoides	-			-			43.8	(26.7)	
Denhamia pittosporoides	-			-			175.7	(53.3)	
Backhousia myrtifolia	-			-			25987.9	(3600.8)	
Vines	-			-			425.0	(10.0)	
Standing dead	5440.5	(603.7)		843.7	(394.4)		-		
TOTAL	44588.7	(4432.6)	(9.9%)	20161.1	(2683.0)	(13.3%)	32714.8	(3794.8)	(11.6%)
Understorey									
Austromyrtus dulcis	29.5	(17.1)		180.8	(58.7)		-		
Caustis blakei	813.4	(127.2)		176.2	(58.1)		-		
Macrozamia miquelii	231.6	(231.6)		1672.6	(264.8)		425.2	(179.3)	
Xanthorrhoea macronema	231.4	(78.7)		184.5	(52.4)		-		
Backhousia myrtifolia	-			-			698.1	(59.3)	
Remaining species	359.9	(53.3)		173.6	(33.9)		170.6	(35.2)	
TOTAL	1665.8	(281.3)	(16.9%)	2387.8	(284.3)	(11.9%)	1293.9	(192.1)	(14.8%)
Litter									
Unincorporated	11108.3	(1144.8)		8240.8	(821.2)		2738.8	(1497.8)	
Incorporated	11302.4	(850.9)		7901.7	(496.1)		3974.3	(1146.0)	
Total	22410.7	(1426.4)		16142.5	(959.4)		6713.1	(1885.9)	
Large	32522.8	(26664.1)		138072.5	(58449.5)		39762.6	(26918.0)	
TOTAL	54933.5	(26702.2)	(48.6%)	154215.0	(58457.4)	(37.9%)	46475.7	(26984.0)	(58.1%)
TOTAL LIVE	115516.7	(5924.5)	(5.1%)	287276.0	(5983.9)	(2.1%)	1735661.8	(575769.0)	(33.2%)
TOTAL DEAD	189983.9	(123883.5)	(65.2%)	172696.7	(58458.8)	(33.8%)	48955.5	(27097.7)	(55.4%)
ABOVE GROUND TOTAL	305500.6	(124025.1)	(40.6%)	459972.7	(58764.3)	(12.8%)	1784617.3	(576406.3)	(32.3%)
BELOW GROUND (0 - 150 cm)									
Fine Roots	19250.0	(650.0)	(3.4%)	21529.0	(744.9)	(3.4%)	15368.0	(568.2)	(3.7%)
Medium Roots	20620.0	(6036.0)	(29.3%)	34230.0	(8899.4)	(26.9%)	21350.0	(2372.7)	(11.1%)
Large Roots	13740.8	(398.5)	(2.9%)	39523.5	(1037.2)	(2.6%)	140085.9	(8492.6)	(6.1%)
TOTAL	53610.8	(6084.0)	(11.3%)	95282.5	(8990.5)	(9.4%)	176803.9	(8836.1)	(5.0%)
Dead Organic Matter	54226.2	(3326.2)	(6.1%)	83813.8	(5091.3)	(6.1%)	34660.0	(2551.6)	(7.4%)
BELOW GROUND TOTAL	107837.0	(6933.8)	(6.4%)	179096.3	(10332.0)	(5.8%)	211463.9	(9197.1)	(4.3%)
GRAND TOTAL	413337.6	(124218.8)	(30.0%)	639069.0	(59665.7)	(9.3%)	1996080.2	(576479.7)	(28.9%)

The high proportion of dead stems on Wabby is mainly due to the ringbarked seed trees and to the dead *Acacia*. This high proportion of standing dead, although not caused by a natural phenomenon in this case, is probably similar to that caused by wildfires which can completely devastate the upper tree stratum. Such fires usually lead to regeneration of a new forest, and in the case of blackbutt forests, can lead to the prevalence of grasses and wiry vines (Van Loon 1969), and *Acacia* sp. The percentage of dead trees is much higher than any other east coast forest reported, but is similar to the 49% of large tree biomass in brigalow forest (Moore *et al.* 1967). The value for McKenzie of 6.2% is also higher than in comparable eucalypt forests, such as *E. obliqua* (4.3%), *E. regnans* (3.0%), (Feller 1980) and *E. obliqua* (3.7%) Attiwill 1972). The Stradbroke Island eucalypt forest studied by Westman and Rogers (1977) showed 10.2% of the large trees as being dead. The large percentage of standing dead on McKenzie is mainly the result of treatment.

The proportions of the components of the trees contributing to the biomass differs among sites. Foliage contributes 6.8% of the above ground live trees on the Wabby site (Table 5.7) and 2.0% and 2.4% on the McKenzie and Deep sites respectively. The percentage of foliage biomass on the blackbutt for the three sites is: Wabby, 7.8%; McKenzie, 1.8%; and Deep, 2.4%. This indicates that the saplings on Wabby, which have in most cases a 1:1 crown to bole ratio, exhibit an open canopy. The blackbutt on McKenzie, where canopy closure has been effected, have lost most of the leaves on their lower branches, with the result that foliage is concentrated in the upper crown. The slight increase in foliage percentage on the blackbutt on Deep site may be due to the epicormic shoots on the lower structural and supportive branches as well as on the canopy branches. These results, in general, contrast slightly with those of Attiwill (1979), who showed a generally uniform proportion of biomass attributed to foliage for stems averaging 18 cm dbh and 36 cm dbh. The Fraser Island data indicate that blackbutt with a mean dbh of 18 cm (Wabby), has foliage much greater than the 3% reported for *E. obliqua* (Attiwill 1979). The proportion of foliage of the blackbutt trees on McKenzie (mean dbh 36 cm) was similar to *E. obliqua* (Attiwill 1979) and *E. signata* (3.1%) and *E. umbra* (2.5%) (Westman and Rogers 1977). The latter two species, which are probably as old as the blackbutt on the Deep site, compare closely with the proportion of foliage on blackbutt on Deep of 2.4%, and also with the blackbutt near

Myall Lakes(2.6%)(Lewis 1978). In Western Australia, Hingston *et al.*
(1979) calculated that the foliage on karri and marri contributed 2.0% and
1.9% respectively while Hingston *et al.* (1980) reported that the foliage
of jarrah and marri contributed 2.0% and 3.0% of the biomass respectively.
In Victoria, Feller (1980), working in forests of similar age to that of
McKenzie, found that the foliage of *E. regnans* contributed 0.4% of the
above ground weight of the trees while the foliage from *E. obliqua*
contributed 1.0%, and *E. dives* 1.1%. Moore *et al.* (1967) found in an
arid region of Australia that foliage in a brigalow forest was 6.4% of the
above ground biomass. The foliage proportion of poplar box was reported as
3.7% (Burrows 1976) and 4.1% (Harrington 1979). Rodin and Bazilevich (1967)
reported that the contribution of foliage in subtropical forests is between
3 and 4% and is usually constant.

The data indicate that about 20% of the biomass of sapling blackbutt
is in live branches, 10% in the pole growth stage and a little over 30%
in mature trees. As saplings grow into the pole stage, the lower branches
die and prune themselves. This results in the majority of live branches
being concentrated in the crown, where they tend to be small due to the
general closure of the canopy in the forest. In the mature and overmature
stage, the crown has broken into large structural branches which persist
and support a large number of smaller branches. The live branches on
blackbutt at Myall lakes (Lewis 1978) were reported to be 65.7 t ha^{-1} or
28.9% of the above ground biomass of blackbutt, which is within the range
of blackbutt on the more productive sites of Fraser Island. *E. signata*
and *E. umbra* growing on similar podzol soils on Stradbroke Island (Thompson
and Ward 1975) were reported to contribute 36% and 37.5% (Westman and
Rogers 1977) of tree biomass which is similar to the contribution by the
blackbutt on Deep. Although the trees on Stradbroke Island were of
woodland form, their age is probably similar to those old growth blackbutt
on Fraser Island. The branch proportion of poplar box of woodland form was
70.7% (Harrington 1979), while Holland (1969) reported 49% for smaller
woodlands of *E. dumosa*, 52% for *E. incrassata*, and 44% for *E. oleosa*.

E. obliqua of 15 cm dbh and 50 cm dbh was reported to have a
branch biomass of 3.4% and 10.5% of above ground weight respectively
(Attiwill 1979). He found as a general trend that *E. obliqua* branch
weight was slightly curvilinear with increasing dbh. Although the dbh of
the *E. obliqua* was similar to the mean dbh of the blackbutt on Wabby and

McKenzie, the contribution made by branches from the smaller trees of
E. obliqua is much less than blackbutt on Wabby. Feller (1980) found that
the branches of *E. regnans* c. 40 years old contributed 5.2% of the biomass
with *E. obliqua* and *E. dives* of similar age, contributing 6.5% and 3.4%
respectively. The branches of karri and marri grown in Western Australia
contributed 11.7% and 8.5% respectively (Hingston *et al.* 1979) while
branches of pole size jarrah contributed 11.3% of the above ground biomass
of this species. Hence the percentage of branches for pole stands of the
stringybark species, jarrah and *E. obliqua*, is similar to the pole stand
of blackbutt on McKenzie.

The biomass of the stems of the large trees on the three sites is
shown in Tables 5.7, 5.8 and 5.9. The contribution of the stem to the
above ground biomass of all species for Wabby, McKenzie and Deep is 67%, 85%
and 46% respectively. The proportion that the blackbutt stems contribute
to their above ground weight on the three sites is 72%, 85% and 50%. Table
6.2 shows the contribution made to the blackbutt stem by bark, sapwood and
heartwood.

Table 6.2 Stem component weights of *Eucalyptus pilularis* on the three sites
expressed as percentages (%)

	Bark (%)	Sapwood (%)	Heartwood (%)
Wabby	17.7	37.8	44.5
McKenzie	14.2	14.6	71.2
Deep	13.2	11.2	75.6

This indicates that the percentage of bark with sapwood contributing
to stem weight decreases most rapidly from sapling to the pole stage, while
the proportion of heartwood increases most rapidly during the same phase
change. The blackbutt stem percentage for Wabby (Table 6.2) is slightly
smaller than in *E. obliqua* (Attiwill 1979) with the value of bark and
heartwood on McKenzie being similar to *E. obliqua*. Jarrah also shows
similar proportions of bark (15.7%) to blackbutt (Hingston *et al.* 1980) and
karri slightly smaller (13.6%)(Hingston *et al.*1979). Feller (1980) found
that the bark of *E. regnans* contributed a smaller proportion of stem weight
than did the blackbutt on Fraser Island, but the bark of *E. obliqua* and *E.
dives* contributed 23.6% and 22% respectively. The larger percentage in the
latter species could reflect the fact that they have persistent, thick

fibrous bark on the small branches, whereas *E. regnans* and blackbutt have the fibrous bark mainly on the lower bole.

The stem biomass of blackbutt saplings is 72% of the above ground biomass and is a far smaller proportion of the above ground weight than for saplings of *E. regnans* (90.5%) (Attiwill 1979), but the pole stages of the two species compare favourably. The stems of the McKenzie blackbutt comprise 85% of the above ground weight, and those of *E. regnans* (Attiwill 1979) contribute 86% of the above ground weight of the stems.

Similar percentages to those of the pole stage blackbutt were reported for jarrah and marri (85% and 84% respectively) by Hingston *et al.* (1980), while on another site Hingston *et al.* (1979) reported karri as 90% and 85% and marri as 89%. Feller (1980) found that the percentage of the above ground biomass contributed by the stem was higher in forests near Melbourne than in other forests: the stems of *E. regnans* contributed 93%, *E. obliqua* 92% and *E. dives* 93%, which are higher than the figures quoted for other eucalypt forests in Australia of similar age. The stems of brigalow contributed 70.8% of the tree weight (Moore *et al.* 1967) while woodland species carry only 24.4% of the above ground tree weight in the stem (Harrington 1979). This low figure reflects the usual 1:1 bole to canopy ratio and the relative size and number of the branches which comprise the canopy (Harrington 1979).

The northern hardwood species of the Hubbard Brook forest in New Hampshire which has a slightly larger basal area than the Wabby stand, contain similar proportions of their above ground weight in the stem (Whittaker *et al.* 1974). Similar results were also found in the young (15 m^2 ha^{-1} basal area) oak-pine forests in Brookhaven (Whittaker and Woodwell 1968). The McKenzie blackbutt, which carry a basal area comparable to the tulip tree forest in the Great Smokey Mountains (Whittaker 1966), contains a slightly larger proportion of the tree as stem, than the latter, where stems constitute 75% of the tree weight.

It is apparent from this limited selection of data that the percentage of the biomass contributed by the stems of different broadleaved species is relatively uniform and it is remarkable that even large trees of quite different form and species should exhibit similar proportions of the tree in the stem.

6.2   ROOTS

6.2.1 Large Roots

Structural features of the large blackbutt roots ($\geq$10 cm) were common to all the root systems excavated. The root crown extended initially to about 10 cm below the surface into the A_1 horizon, which contained a large amount of humic material. The root at this point produced a small swelling from which small feeder roots originated, possibly in reference to, or to take advantage of the relatively high organic matter content of this zone immediately surrounding the tap-root. Below this, large lateral roots radiated out from the tap-root at approximately 0.5 m below the surface to a distance of at least 3 m without decreasing significantly in diameter. In eucalypt forests on Stradbroke Island, Westman and Rogers (1977) excavated lateral roots to a distance of 10 m from the tap-root, and also found minor changes in diameter. From the large lateral roots, sinker roots branched off and grew vertically downward, again without apparent decrease in diameter, to at least 2 m in depth. The tap-root itself tapers quite abruptly at 1 to 1.5 m into the A_2 horizon of white sand where it branches into two or more separate tap-roots of approximately 5 cm diameter. In the case of Tree 500, the tap-root branched into three separate tap-roots, each one about 10 cm diameter. Whitton (1962) found also that large trees growing on bleached sands had well developed tap-roots which acted primarily as anchors (Klinge 1976). The eucalypts on Stradbroke Island on sands of similar origin to those of Fraser Island, appear to show similar rooting tendencies to blackbutt but are fundamentally similar to *E. regnans* (Ashton 1975) growing on much finer textured soils. The blackbutt trees on Fraser Island appear to have a root spread/crown spread ratio of 1:1 and this allows capture of their own nutrients, a distinct advantage in this low nutrient status environment. The biomass of the large roots on the three sites becomes greater as the trees increase in size, but the proportion of root biomass of the total tree weight decreases. Table 6.3 shows the biomass and proportion of large roots on the three sites.

Table 6.3 Biomass of large roots on Wabby, McKenzie and Deep and the proportion of the total biomass contributed by the roots.

	All Species		Blackbutt	
	$(t\ ha^{-1})$	% of total tree weight	$(t\ ha^{-1})$	% of total tree weight
Wabby	13.7	15.0	6.9	13.5
McKenzie	39.5	13.0	36.6	12.9
Deep	140.1	7.6	43.5	6.9

There is a decrease in proportion of the biomass in the roots from sapling to pole stage and an even larger decrease to the old growth forest.

A comparison of the biomass of large roots on Fraser Island with those of other eucalypt dominated ecosystems is difficult because very few workers have estimated root biomass. Westman and Rogers (1977) calculated large root biomass for *E. signata* and *E. umbra* as $27.5\ t\ ha^{-1}$ and $10.4\ t\ ha^{-1}$ which was 30.8% and 36% of the total tree biomass respectively. The percentage contribution to the biomass made by these species is twice as large as those measured on Fraser Island, but this is probably due to the loss of branches which had died and fallen from the crown of these woodland trees, thus decreasing the total weight. Also roots appear to have been estimated deeper in the profile than the 1.5 m on Fraser Island. These two factors coupled together could explain the apparent anomaly.

The large root biomass in blackbutt forests near Myall Lakes (Lewis 1978) was estimated to be $60.8\ t\ ha^{-1}$ or 21.1% of the total. This is intermediate between the estimates for Stradbroke Island (Westman and Rogers 1977) or Fraser Island (this study). The root weights of Lewis (1978) include stumps, so their results are biased towards an overestimate of large roots and their contribution to the ecosystem.

Moore *et al.* (1967) working in brigalow forest in a subtropical, semi-arid environment, reported that the roots contributed 16% of the total tree biomass, which is slightly larger than the Wabby trees.

The large roots of some other forest communities which grow in temperate and tropical regions can also be compared with the Fraser Island forests. In tall (80 m) *Pseudotsuga menziesii* forests in Oregon, Grier and Logan (1977) reported the large root biomass to be $141.3\ t\ ha^{-1}$ or 16.7% of the total tree weight. The tropical forest of Central Amazonia contains

197.7 t ha^{-1} as large roots (Klinge 1976) while the montane forest of

Jamaica (5 - 7 m in height) contain 27.7 t ha^{-1} as large roots which is

10.9% of the total tree weight (Tanner 1980). Rodin and Bazilevich (1967)

indicated that the biomass of roots of tropical rainforest contribute

16.2% of the total tree biomass.

6.2.2 Fine and Medium Roots and Dead Organic Matter

Tables 5.10, 5.11, 5.12 and 6.1 show the biomass of the fine roots,

medium roots and dead organic matter in the soil to a depth of 1.5 m.

The fine root biomass is greater on the McKenzie site (21.5 t ha^{-1})

than on Wabby (19.2 t ha^{-1}), and this probably reflects the fact that the

saplings on Wabby have not yet fully captured the site.

It has been suggested by Kimmins and Hawkes (1978) that the fine

root biomass reaches a maximum, then stabilises, or decreases as does

foliage biomass at canopy closure. Karizumi (1968) found that the fine

root biomass maximised at 20 years in *Cryptomeria japonica*. Moir and

Bachelard (1969) noted that fine root biomass (<3 mm) decreases from

3.4 t ha^{-1} in 10 year old *Pinus radiata* to 2.1 t ha^{-1} at 36 years old.

The comparatively small fine root biomass on Deep (15.4 t ha^{-1})

is not surprising, as this site was sampled at the end of an extremely

long drought, when the sand was quite dry to a depth of 1 m. Water stress

is known to inhibit root growth (Farrel and Leaf 1974). Fine root

production is seasonal (Kimmins and Hawkes 1978) and because of this,

comparisons between studies undertaken at different times may be of

limited value. Ovington *et al.* (1963) recorded the root biomass in an

oak-wood ecosystem as 12.7 t ha^{-1} in April and 20.7 t ha^{-1} in July, then

10.0 t ha^{-1} in December.

During extremely dry periods, it is unlikely that seasonal temperatures

differences would influence root activity, as the drought conditions would

dominate. As a result of the drought, the fine roots and tips would likely

die, slough off, and become part of the dead organic matter.

The medium roots on McKenzie (34.2 t ha^{-1}) had a larger biomass than

those on Wabby (20.6 t ha^{-1}) or Deep (21.4 t ha^{-1}) and this reflects the

relative size of the lateral roots of the McKenzie small tree species, and

the smaller blackbutt trees. Most of the root systems of the non blackbutt

species are smaller than the large root category, and consequently, their

contribution to the medium root biomass is relatively greater. Another

factor which helps to maintain a smaller medium root biomass on the Wabby and Deep sites is that the understorey and small tree layers are generally not as dense as those on McKenzie.

Figures 5.11, 5.12 and 5.13 show the distribution of the fine and medium roots on the three sites.

On all three sites, including the moister Deep site, the fine roots are not concentrated near the surface but peak at 15 - 20 cm below the surface. This concentration of depth on the McKenzie site is much more pronounced than on the other two sites and extends over a wider interval. The large peak in the root biomass at this depth (15 - 20 cm) is mainly due to the free drainage of the top layers of sand even after heavy rain. From observations made on Fraser Island, the top layer of soil dries out in a relatively short time, accounting for the comparative lack of roots in this region. Below the major peak of fine root biomass, there is a smaller, secondary peak at 65 cm on Wabby and McKenzie, and a still smaller and shallower (40 cm) one on Deep. The fine roots on the Deep site near the surface are of comparable biomass to those on McKenzie and this could be due to the rapid rate of decay in this forest, but it should be kept in mind that the value for Deep may have been drastically reduced compared to a year of normal rainfall.

The medium root biomass distribution on Wabby and Deep (Figures 5.11 and 5.13) show a peak concentration at a depth of 15 - 20 cm, with one or more minor peaks occurring further down the profile. On the McKenzie site (Figure 5.12), the major peak occurs at 55 cm and this contributes one third of the medium root biomass. This unusually large peak was due to a number of samples containing roots which were close to 10 cm diameter.

The fine and medium root biomass is also concentrated at 15 - 20 cm (Figures 5.11, 5.12, and 5.13) with the McKenzie roots showing a peak between 25 - 30 cm and the major concentration at 55 - 60 cm.

The dead organic matter biomass (Tables 5.10, 5.11 and 5.12) concentrated in the upper 30 cm on Wabby, 52.5% of the 54.2 t ha^{-1} being presented in this part in the profile. The organic matter content for McKenzie is 83.8 t ha^{-1} with 45% being concentrated in the upper 30 cm. The Deep site does not show a similar concentration of organic matter in the upper 30 cm, but rather a slight concentration between 20 - 60 cm in the profile and another peak at 110 - 150 cm. The total dead organic matter content is 34.6 t ha^{-1} which is the smallest of the three sites.

The secondary peak lower down in the profile is due to the dead woody material, mainly charcoal. This material might have been buried by shifting sand or could have originated from dead root systems which have carried a smouldering fire.

The large concentration of the dead organic matter in the upper surface layers on Wabby and McKenzie is a result of the slower rate of decomposition caused by the drier microclimate and on the latter site, to the high rate of return to the soil by falling branches of the pole stage blackbutt. These branches tend to abscisse from the stem and spear into the ground. Often, after the cyclone season, branches as large as 20 cm diameter have been found buried in the ground to a depth of half a metre. The large accumulation of dead organic matter on Wabby is mainly due to the numerous dead acacias and the roots of long-dead large trees. The regeneration burn in 1964 would also help account for charcoal and charred dead woody material, probably from dead root systems which carried the fire. Decomposition of this charred material has not been rapid, because the open canopy of the shrub and tree strata, results in it drying rapidly.

The biomass of dead organic material in the soil in Australian forest ecosystems has not been studied very often. In arid zones, it has been estimated to be 37.1 t ha^{-1} (Charley and Cowling 1968), and 18.8 t ha^{-1} by Burrows (1972). This apparent disinterest is somewhat surprising, because, as Charley and Cowling (1968) indicated, the upper soil layers contain a substantial quantity of organic matter which is a potential source of nutrients for plant communities. The loss of this material on or near the surface layer would have important implications for management, especially in infertile soils (Charley and Cowling 1968). This may be especially pertinent on Fraser Island where the soils are particularly low in nutrients. This could be an important source of nutrient for the ecosystem.

The method of sampling may have produced a bias towards an underestimate, as most of the pits were situated away from large trees which tend to have roots concentrated around their base. However, Santantonio *et al.*(1977), using the polygon of occupancy approach, could detect no correlation between the biomass of fine roots and the distance of the sample from the tree. The distribution of the roots of forest trees has been studied for a long period of time (Santantonio *et al.* 1977). They indicated that roots generally are concentrated in the top 50 cm of the profile and the fine roots used for uptake of nutrients and water, in the

top centimetre. Most previous research has concentrated on the upper layers and has tended to neglect the deeper parts of the profile. In this study, the soil was sampled to a depth of 1.5 m, which is as deep as it is practicable to excavate in sand, with safety, without the aid of machinery. The sandy substrate allowed pits to be dug easily and accurate samples to be taken using the device described previously (4.3.5). The lack of coherence of the sand grains also permitted their relatively easy removal and separation from the roots and organic matter with minimal loss.

Due to the different size classification for roots in many studies, comparable analysis is often difficult. Most biomass studies define fine roots as those roots <5 mm diameter and coarse roots as those ⩾5 mm diameter (Ovington and Madgwick 1959; Santantonio *et al.* 1977). In this study, a medium root category was recognised so that the large structural roots of the large trees could be calculated separately and more accurately than by the use of conventional coring techniques. Large roots are usually taken to be ⩾10 cm, and this is how they were defined in this study.

One of the earliest studies of root biomass in Australia was that of Moore *et al.* (1967) in brigalow who found that the biomass of all roots to a depth of 90 cm was 41 t ha^{-1}. In more arid regions of Australia, Charley and Cowling (1968) recorded 0.9 t ha^{-1} in *Spinifex* communities, Burrows (1972), 0.7 t ha^{-1} in shrub communities, and Pressland (1975) 19.7 t ha^{-1} in mulga (fine roots <5 mm only).

The fine root biomass in mulga peaked at 15 - 30 cm depth, similar to the depth recorded in the Fraser Island forest. Feller (1980) also found less fine root biomass in the 0 - 20 cm horizon than between 20 and 50 cm. He recorded 18.3 t ha^{-1} fine roots (<1 cm) in the upper 50 cm beneath an *E. regnans* forest. In forests which grow on sandy podzols, similar to those of Fraser Island, Westman and Rogers (1977) recorded the fine root biomass of an *E. signata* - *E. umbra* community as 14.8 t ha^{-1}, and Lewis (1978) found 23.6 t ha^{-1} (<1 cm) under blackbutt. Although this latter figure is much higher than the fine root biomass recorded for Fraser Island blackbutt forests, the size of the root class would allow more roots to be included, in which case the estimate is not greatly dissimilar from that of the fine roots on McKenzie. Lewis (1978) recorded a peak biomass of 7.1 t ha^{-1} at a depth of 50 - 75 cm with a gradual buildup to this level, then a sharp decrease to 3.0 t ha^{-1} between 75 and 100 cm.

In temperate forests in the northern hemisphere, Kimmins and
Hawkes (1978) reported that most of the roots are in the upper 50 cm with
the absorbing roots concentrated in the top 20 cm. McQueen (1968) also
reported 96% of the fine root biomass in the top 20 cm of soil. Below
50 cm, the fine and medium roots are not evenly distributed, and as a
result, larger samples should be taken below this point to incorporate
more of the variability (Orlov 1967, cited by Kimmins and Hawkes 1978).
This uneven distribution of smaller roots at depth was evident in the
blackbutt forests on Wabby and McKenzie sites on Fraser Island. Hoffmann
and Kummerow (1978) studied the Chilean matorral forests and also found
root biomass concentrated in the 20 - 40 cm horizon in a deep fertile
soil. In tropical rainforests of the Amazon basin, Klinge (1973a) found
20 - 40% of the fine root biomass (<2 mm) in the top 20 cm of soil, and
50% in the top 50 cm. Huttel (1975) working in tropical rainforests on
the Ivory Coast, sampled roots to a depth of 130 cm and found half of the
24.8 t ha^{-1} fine root biomass (<2 mm) in the top 30 cm. Most of the roots
were concentrated in the top 10 cm which was ascribed to the high cation
exchange capacity of the surface soils. In the Wabby and McKenzie sites,
approximately 70% of the fine root biomass was found in the upper 50 cm,
reinforcing the point that fine roots are concentrated in this part of
the profile which coincides with the zone of high organic matter content
(Tables 5.10, 5.11 and 5.12).

The total root biomass for all sites is shown in Table 6.1.

The Wabby root biomass is 53.6 t ha^{-1} which is 32% of the total
live weight of the ecosystem. The root biomass increases to 95 t ha^{-1} on
McKenzie but the proportion of the roots in this ecosystem decreases to
25%. The Deep site contains a total root biomass of 176.0 t ha^{-1}, which
is nearly twice that of McKenzie, and only 9.2% of the total living biomass
on the site. It is evident from these data that as the blackbutt community
matures, the biomass of the large roots of these large trees increases,
even though their proportion of the total biomass decreases. Charley and
Cowling (1968) found that 40.8% of the living biomass for arid communities
was in the roots. In brigalow forests, Moore *et al.* (1967) recorded 34%
and in an *Eremophila* sp. community, Burrows (1972) recorded 32.7%.

The root biomass in other eucalypt forests studied in Australia
is more variable. Lewis (1978) estimated that 26.1% of the total live
biomass in the blackbutt forests near Myall Lakes was in the roots, while

in an *Eucalyptus signata* - *Eucalyptus umbra* forest (Westman and Rogers 1977) the proportion was 42.8%. In *E. regnans* and *E. obliqua* forests in Victoria, Feller (1980) recorded the root contribution between 10 and 11%. For mature temperate forests in the northern hemisphere, Nihlgard and Lindgren (1977) state that the contribution of roots to total biomass ranges from 8 to 15%, while Rodin and Bazilevich (1967) quoted a figure of 20%. In the young regrowth forests of the Hubbard Brook ecosystem, Whittaker *et al.* (1974) estimated that 21.4% of the biomass was in the roots. In a 450 year old Douglas fir forest, Grier and Logan (1977) estimated the root biomass to be 152.7 t ha^{-1} which was 17.5% of the total living biomass while Santantonio *et al.* (1977) found a similar forest to contain 209.0 t ha^{-1} as roots.

Mature forests in tropical and sub-tropical regions of the world have been reported as containing 328.0 t ha^{-1} of which 23.5% of total living biomass was in roots, and in evergreen tropical forests in Brazil, 201.0 t ha^{-1} or 23% (Rodin and Bazilevich 1967). Rainforests in Ghana contained 23.1% of biomass or 54.0 t ha^{-1} as roots (Greenland and Kowal 1960) whereas the mature south-east Asian forests as studied by Ogawa *et al.* (1965) contained about 35%. In Jamaica, root biomass of montane forests is 53.7 t ha^{-1} which is 18.8% of total living biomass (Tanner 1980). The figure cited above for the mature temperate and tropical forests of the world also indicates, as this study did, that as the actual biomass of these forest increases, the contribution made by the roots decreases.

6.3   SMALL TREES

The biomass of small trees (above ground weight) on Wabby was 39.0 t ha^{-1} which comprises 34% of the living above ground weight for the site. On the McKenzie and Deep sites, this component weighed 19.2 t ha^{-1} and 32.7 t ha^{-1} which is 6.7% and 1.9% of the above ground weight respectively.

The low small tree biomass on the McKenzie site is due primarily to silvicultural treatment and thinning of the regrowth stand resulting in a considerable depletion of the larger individuals which contribute greatly to the biomass of this fraction. Most of the tree species remaining are clumps of shade-tolerant species, which have regenerated or coppiced subsequent to the last treatment, or are residuals that survived the treatment operations.

The majority of trees on the Wabby site are 14 years old and

as such, many have not grown into the large tree category and consequently this inflates the biomass figure of the small tree fraction.

The small tree fraction on the Deep site comprised 79% (26 t ha^{-1}) carrol, which appears to be a relatively new coloniser of the site. The many thickets of carrol, along with the numerous rainforest species, have contributed to the 32.7 t ha^{-1} of small trees on Deep. The biomass of this fraction on the Wabby and Deep sites is similar and a possible explanation can be provided, if the carrol in the Deep site is thought of as a 'young' forest, comparable with that on Wabby, commencing beneath the large overstorey species.

When comparing the relative contributions of the various fractions on the three sites, it is evident that as the biomass of the large trees increases in the maturing forest, the proportion of the total biomass contributed by the small trees decreases from 34% on Wabby to 6.7% on McKenzie, to 1.9% on Deep.

Changes in species dominance as reflected by their contribution to biomass can be noted in Table 6.1. The most obvious are the post-fire species which in tall open forests reach their maximum number at 10 years, then decrease (Ashton 1981). After these species have died out, the floristic composition will depend on the fertility preceding their death, and on the proximity to a seed source (Purdie and Slatyer 1976). Burning of the Wabby site, which contains heath species, accelerated the release of seeds in the woody fruits and also stimulated the germination of seeds to regenerate (Ashton 1981). As reported by Specht (1981) *Leucopogon* reaches a maximum biomass of 1.0 t ha^{-1} at 2 years, then tapers off to zero at 10 years. *Leptospermum* is slow to grow after fire, but reaches a peak at 26 years of 4.0 t ha^{-1} and disappears by 36 years. There is evidence of this phenomenon on the Wabby and McKenzie sites where the fireweed species, *Persoonia, Dodonaea, Banksia, Acacia, Monotoca* and *Leucopogon* contribute a small amount on Wabby (age 16 years) but are nearly absent on McKenzie (age 46 years).

The coppice shoots of satinay, brush box and corkwood are evident on Wabby but have a higher biomass on the McKenzie site. This may not reflect the biomass trend in an untreated forest however, as it is mainly a result of coppice shoot growth since the last treatment. The biomass of brush box on McKenzie is smaller than on Wabby, indicating that this species was drastically reduced, probably as a result of continual

silvicultural treatment.

If the Wabby site is an indicator of what McKenzie was like at a similar age, it is worth noting that the fireweed species have all but died out on McKenzie, indicating their failure to regenerate and survive in the absence of subsequent fires or equivalent disturbances. No attempt was made to eliminate the fireweed species on McKenzie by silvicultural treatment, as they were considered to be only shortlived and consequently, would not affect the growth of blackbutt by competition.

The Deep site contains a lower stratum of mesic and sclerophyll species. It is seen from Table 6.1 that the sclerophyll species in the sapling stage blackbutt forest (McKenzie) have decreased in biomass on Deep, but the myrtaceous carrol now dominates the lower stratum (26.0 t ha^{-1}).

The standing dead biomass in the small tree category is maximised on the Wabby site with 5.4 t ha^{-1}. This figure is depleted on McKenzie and is due to this fraction, which is comprised of fire induced species, falling and becoming incorporated in the litter component.

6.4   UNDERSTOREY

The biomass of the above ground portion of the understorey fraction is at its greatest on the McKenzie site where it weighed 2.4 t ha^{-1}. Although this figure seems large, it represents less than 1% of the total live weight of the above ground biomass of the forest. The understorey, although containing only a small biomass, can however, play an important role in forests in the cycling of nutrients. It not only increases litter-fall, but it often has a high nutrient content and decomposes quite rapidly (Ovington 1959).

The same species which are prominent on Wabby also dominate on McKenzie and consequently, an indication of species dominance in terms of biomass was obtained by recording the component and total weights of the main species separately. *Austromyrtus dulcis* and *Caustis blakei*, which are present on Wabby and McKenzie but not on Deep, represented 1.8% and 49% of the understorey biomass respectively on Wabby, and 7.5% and 7.4% on the McKenzie site. The biomass of *Caustis*, although being similar on the two sites, contributes considerably more to the understorey on Wabby than on McKenzie. This species could be an opportunist and although it maintains its place in the stand, the biomass of the other species increase relative to it. In a mixed eucalypt forest on Stradbroke Island, *Caustis*

contributed 88 kg ha^{-1} (Westman and Rogers 1977) which is nearly one-tenth of that found on the Fraser Island sites. *Austromyrtus* sp. was also of minor importance on Stradbroke as it contributes only 4.3 kg ha^{-1}.

Xanthorrhoea macronema appears to have reached its maximum development in terms of biomass on the Wabby site (231.4 kg ha^{-1}) then decreased on McKenzie (184.5 kg ha^{-1}), to be non-existent on Deep. Specht *et al.*(1958) found that *Xanthorrhoea australis* in South Australia was virtually absent 10 years after fire but its biomass maximised at 35 years, and remained stationary to age 50 years. This contrasts with the *Xanthorrhoea* sp. on Fraser Island which apparently reaches a peak around 10 years (Wabby) and then gradually decreases. The difference could be due to the effect of the fire on vegetative and reproductive growth process-es (Gill 1981; Specht 1981). Ethylene production, during a fire, may stimulate the growing apex 20 - 30 cm below the ground in stemless *Xanthorrhoea* (Gill 1981), and this could explain why the stemless *X. macronema* maximises its growth earlier in life than *X. australis*. The biomass of *Xanthorrhoea* on Stradbroke Island was 150 kg ha^{-1} (Westman and Rogers 1977) which was less than that on McKenzie.

Macrozamia miquelii is present on all three sites, but its maximum development is on McKenzie (1.6 t ha^{-1}) and this is 70% of the understorey biomass on this site. This species weighed only 0.2 t ha^{-1} or 14% of the understorey biomass on Wabby and the few individuals present were quite small compared with those on McKenzie. The drier environment and a smaller number of plants present on the Wabby site prior to the regeneration burn, could explain this. The biomass of 0.4 t ha^{-1} of *Macrozamia* sp. on Deep is less than that on McKenzie, yet it still represents 33% of the under-storey biomass.

Macrozamia spp. have coralloid roots containing blue-green algae which have the capacity to fix atmospheric nitrogen. In Western Australia, *M. riedlei* has been found to fix 18.8 kg N ha^{-1} yr^{-1} (Halliday and Pate 1976). If a similar amount is fixed by *Macrozamia* on Fraser Island, this component of the understorey could be a very important nitrogen source on the Fraser Island sands which are infertile compared with other forest soils (Richards 1976).

It is apparent from the data in Table 6.1 that carrol (*Backhousia myrtifolia*) has invaded the Deep site and is not only dominant in the small tree stratum, but comprises 54% of the understorey biomass. This

species was not recorded on the other two sites and this could reflect its shade tolerance and the need for filtered light for its growth.

The understorey biomass of other coastal eucalypt forests in Australia, exceeds that of those on Fraser Island. Westman and Rogers (1977) reported 3.6 t ha^{-1} on Stradbroke Island which is 10% of the stand biomass, while Lewis (1978) reported 11.3 t ha^{-1}. Attiwill (1977) recorded 4.0 t ha^{-1} in the understorey of *E. obliqua* forests which is 1.0% of their biomass. This figure contrasts with 2% that Guthrie (1976) found on an *E. obliqua* - *E. radiata* site and with the McKenzie site (0.8%). Hingston *et al.* (1979) reported 10.3 t ha^{-1} and 1.2 t ha^{-1} in karri understorey on two different soil types. Malajczuk and Grove (1977) found that the biomass of the leguminous understorey in mature karri forests (36 years old) 12 years after burning, weighed 29.3 t ha^{-1} and represents 5% of the biomass. Even 6 months after burning, the understorey biomass of *Bossiaea* sp. and *Acacia* sp. was 16.0 t ha^{-1} in karri forests while that of *Acacia* and *Kennedia* sp. in jarrah forests was 27.0 t ha^{-1}. Hingston *et al.* (1980) estimated understorey (<1.5 m) biomass as 1.7 t ha^{-1} or 0.6% in jarrah. This latter figure is similar to that found on the Fraser Island sites, and the individuals belong to the same family as those on Wabby and McKenzie. Feller (1980) reported the understorey biomass of an *E. regnans* forest as 53.4 t ha^{-1} while the understorey in an *E. obliqua* forest weighed 0.9 t ha^{-1}. It is evident that although the contribution made by the understorey is small in most of the moist hardwood eucalypt forests, the situation is quite variable.

In tropical forests outside Australia, Tanner (1980) estimated understorey biomass (<2.5 m) in Jamaican rainforests as 1.8 t ha^{-1} and 1.6 t ha^{-1}, which is similar to that on Wabby. Whittaker *et al.* (1974) estimated the understorey to be 0.19 t ha^{-1} in the Hubbard Brook forest.

6.5   TOTAL LITTER

The total litter component was greatest on McKenzie, at 154.2 t ha^{-1}, compared with 54.9 t ha^{-1} on Wabby and 46.5 t ha^{-1} on Deep (Table 6.1).

The majority of the litter on McKenzie was contributed by the large litter component (138.1 t ha^{-1}). The large standard error shown in Table 6.1 is due to the great spatial variation compared with the fine litter (Westman and Rogers 1977). If the total litter biomass is compared with that of other ecosystems where results include the biomass of the

large dead wood, it can be seen that the litter is comparable with pole stage jarrah and marri forests which contain 141.1 t ha^{-1} (Hingston et $al.$ 1980).

The litter component was largest on Wabby (22.0 t ha^{-1}) and as shown in Table 6.1, it decreased to 16.1 t ha^{-1} on McKenzie and to 6.7 t ha^{-1} on Deep. The high biomass of the litter on Wabby indicates that the regeneration burn may not have consumed all the debris which accumulated on the site during the preparation for the burn. A similar explanation was offered by Hingston et $al.$ (1980) when explaining the high litter biomass, 11.1 t ha^{-1} and 13.0 t ha^{-1}, in jarrah forests when compared with the results of Peet (1971). The large litter biomass on Wabby is also inflated by the leaf and twig material from dead and dying fire induced species falling onto the forest floor.

On the Wabby and McKenzie sites, the incorporated litter was larger than that of the unincorporated litter, but the reverse occurred on Deep. This apparent anomaly on Deep can be explained when it is appreciated that this site was sampled just as leaf inputs began to rise which resulted in an increase in the unincorporated layer relative to the incorporated layer. When comparing the Fraser Island sites with other sites of comparable age and development, the Wabby litter biomass is larger than that found by Meakins (1966) who estimated litter biomass beneath different eucalypts to be 18 t ha^{-1}, 17.8 t ha^{-1} and 9.8 t ha^{-1}.

The litter biomass on McKenzie was comparable with other pole stage eucalypt forests, but the results indicated the spatial variability within these forests. Peet (1971) estimated litter biomass in karri and jarrah forests to be 18.8 t ha^{-1} and 7.3 t ha^{-1}, 7 and 5 years after fire, and Hingston et $al.$ (1978) recorded 13 t ha^{-1} 6 years following fire. A site adjacent to the McKenzie site was sampled by Richards and Charley (personal communication) and they estimated the biomass of the litter to be 15.3 t ha^{-1}. Hurditch (1981) also sampled this area in May 1975 and June 1979 and recorded weights of 13.1 t ha^{-1} and 15.6 t ha^{-1} respectively. These compare favourably with the sampling for this study on McKenzie carried out in September 1979 when 16.1 t ha^{-1} was measured. As a comparison, Van Loon (1969) estimated the litter pack beneath a pole stage blackbutt forest near Taree in New South Wales to be 17.3 t ha^{-1}.

The litter biomass on Deep was estimated by Richards (1976) to be 15.0 t ha^{-1} (date of sampling unknown) and Hurditch (1981) recorded

12.8 t ha^{-1} and 11.0 t ha^{-1} in August 1975 and May 1979 respectively. These figures are nearly twice the biomass recorded in the present study (6.7 t ha^{-1}) on the same site. The litter fall data (collected in September 1979 by the author) for this site showed that in the six months preceding the sampling on Deep (this study) the input of litter was c. 2.0 t ha^{-1}* while in the six months preceding the sampling carried out by Hurditch (1981) in May 1979, the litter input was c.6.0 t ha^{-1}. Assuming that the rate of decomposition in 1979 was relatively uniform due to drought conditions, the weights obtained in the present study are feasible.

On an old growth blackbutt site on the north coast of New South Wales, Hurditch (1981) recorded litter biomass as 25.9 t ha^{-1} and 24.8 t ha^{-1} on one site with collections estimated 8 months apart, and 23.1 t ha^{-1} and 19.9 t ha^{-1} on another site also estimated 8 months apart. Another site on the mid north coast of New South Wales had a litter biomass of 12.1 t ha^{-1} and 12.2 t ha^{-1} with samples being taken 4 months apart.

In mixed mature forests near the east coast of Stradbroke Island, Westman and Rogers (1977) recorded 27 t ha^{-1} and Lewis (1978) estimated that blackbutt forests contained 13.1 t ha^{-1} as leaf and twig material and 23.4 t ha^{-1} as large woody material, Birk (1979) reported a fine litter biomass of 10.2 t ha^{-1} in mixed forests near Brisbane. In temperate eucalypt forest, Attiwill (1972) found litter to weigh 18 t ha^{-1} and Richards and Charley (1977) obtained weights of 12.3 t ha^{-1} under *Eucalyptus saligna* dominated forests and 4.5 t ha^{-1} under forests dominated by *E. viminalis*. In an *E. obliqua* forest near Adealide, Lee and Correll (1978) estimated the litter biomass as 9.8 t ha^{-1}. In arid communities, biomass estimates of 4.3 t ha^{-1} for leaf and twig litter (Moore *et al.* 1967) and 0.8 t ha^{-1}* (Burrows 1972) have been reported.

The variation between samples on similar sites in different seasons as reported previously, can be due to the seasonal variation in litter fall with most eucalypts shedding their foliage from November to February with the minimum in June and July (Rogers and Westman 1977). The

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* The litter input data was collected by me for Bill Hurditch while I was on Fraser Island.

magnitude of leaf fall of brush box, a major species on the Fraser
Island sites, does not fluctuate greatly throughout the year and the
amount of litter which falls is considerably less than the eucalypt
species (Rogers and Westman 1977). A similar trend was found in brush box/
satinay forests on Fraser Island where the litter layer was estimated at
6.3 t ha^{-1} (Hurditch 1981). The variability of litter accession can also
be caused by bimodal growth patterns throughout the year which are
exhibited by some eucalypts (Specht and Brouwer 1975). Richards and Charley
(1977) reported that variations can also be due to the spatial variability
of the stand.

6.6   TOTAL FOREST

The biomass of the total forest components, both above ground
and below ground on the three Fraser Island sites, is compared with
other forests in Australia in Table 6.4 and 6.5.

It is seen in Table 6.4 that there is a general trend for moist
hardwood forests to contain a larger biomass than those on drier sites,
the exception being the 27 year old *Eucalyptus sieberi* forests (Ashton
1976). This forest has a biomass twice that of the McKenzie site and
appears to be a gross overestimation when compared with other similar
aged forests. The estimated biomass of the Wabby and McKenzie sites, lie
within the range of estimates recorded for other eucalypt forests, if an
allowance is made for site and age differences and the method used to
obtain such estimates. The Deep site, however, has the largest biomass
of any eucalypt forest, or indeed of any plant community studied in
Australia. This is due to the large myrtaceous species which dominate
this old growth forest.

The sapling/pole stage dominated sub-tropical moist forests
examined here contain 13 - 15% of their biomass below ground as roots,
which is slightly larger than the 8 - 10% found in moist temperate
eucalypt forests (Feller 1980). The difference may be due to the fact
that Feller sampled roots to a depth of only 50 cm.

The old growth site on Deep contains only 9% of the total biomass
as roots, indicating that as the forest matures, the proportion of the
below ground tree biomass decreases relative to the total. The forests
on the drier sites, in general, have a larger proportion of the biomass
as roots. This phenomenon is also evident in the root biomass of arid
and semi-arid woodlands and heaths (Table 6.5). It is also depicted by

Table 6.4 Total biomass (t ha^{-1}) of the above and below ground
components in eucalypt forests in Australia.

	Eucalypt Forest			
Dominant Species	Above ground	Below ground	Total	Reference
E. pilularis (14 years old) wet sclerophyll	305.5	R 53.6 O 54.2 † (150 cm)	413.3	This study
E. pilularis (45 years old) wet sclerophyll	460.0	R 95.3 O 83.8 † (150 cm)	639.1	This study
E. pilularis (old growth) wet sclerophyll	1784.6	R 176.8 O 34.6 † (150 cm)	1996.0	This study
E. pilularis (mature) dry sclerophyll	285.5	R 84.5 † (100 cm)	370.0	Lewis (1978)
E. signata - E. umbra (mature) dry sclerophyll	120.1	R 76.5	196.6	Westman & Rogers (1977)
E. regnans (38 years old) wet sclerophyll	720.3	R 63.2 † (50 cm)	783.5	Feller (1980)
E. regnans (27 years old) wet sclerophyll	831.4			Ashton (1976)
E. obliqua - E. dives (38 years old) wet sclerophyll	405.0	R 45.4 † (50 cm)	450.4	Feller (1980)
E. obliqua (mature) dry sclerophyll	334.0			Attiwill (1972)
E. sieberi (27 years old) dry sclerophyll	928.6			Ashton (1976)
Mixed dry sclerophyll			175.6	Hannon (1958)
E. diversicolor (37 years old) wet sclerophyll	262.6			Hingston *et al.* (1979)
E. marginata - E. calophylla (60 years old) dry sclerophyll	407.3			Hingston *et al.* (1980)

R: roots
O: dead organic matter
†: depth to which roots were sampled

Table 6.5   Total biomass (t ha^{-1}) of the above and below ground
            components in semi arid woodlands in Australia.

	Woodlands			
Dominant Species	Above ground	Below ground	Total	Reference
Atriplex vesicaria	2.2	R 0.9 † (45 cm)	3.1	Charley & Cowling (1968)
Eremophila gilesii	3.2	R 0.8	4.0	Burrows (1972)
Acacia harpophylla	93.2	R 40.7 † (90cm)	133.9	Moore *et al.* (1967)
Acacia aneura - *Eucalyptus populnea*	84.1	R 25.4 † (100 cm)	109.5	Burrows (1976)
Eucalyptus socialis - *Eucalyptus dumosa*	51.5	R 28.6	80.1	Burrows (1976)
Mallee - (15 years old)				
Eucalyptus socialis *Eucalyptus gracilis* *Eucalyptus foecunda*	27.1	R 20.5 O 80.0	127.6	Burrows (1976)

R: roots
O: dead organic matter
†:   depth to which roots were sampled

Specht (1981) whose data indicates that the biomass of the oligotrophic habitats of sclerophyllous flora in Australia is higher in roots compared with shoots. It is evident from Table 6.4 that not all authors have included an estimate of the below ground biomass and even those who have, usually considered only roots and ignored the dead organic matter. The latter is a significant component of the forest as this study has shown. The Wabby site contains 50% of the below ground weight as dead organic matter; McKenzie 45% and Deep 17%.

The different methodologies and size class dimensions of components, and the variable depths of soil sampling used in biomass studies in Australia and overseas have precluded any accurate comparisons between forests, even though certain trends are discernible. In particular, when comparisons are made between below ground components in different ecosystems, the depth to which the roots were sampled should be carefully noted, likewise whether the dead organic matter below ground was included in the ecosystem estimate. Westman and Rogers (1977) estimated that 95% of the root biomass lies in the top 1 m of soil on Stradbroke Island. Huttel (1975) found that the 130 - 250 cm layer contained 5% of the root weight in the profile, hence estimates of roots taken only in the upper soil layers will undoubtedly be negatively biased.

The Fraser Island forests, when compared with other forests of the world (Table 6.6) are seen to lie within the range of biomass estimates reported elsewhere. Table 6.6 indicates that the biomass of tropical forest ecosystems is less than that of the large temperate forests in North America and Europe, but are similar to the values obtained for the Fraser Island forests when age, size and structure are accounted for in any comparison. The biomass of the old growth forest on Deep is comparable to other large tree forests of the world, and is the third largest biomass reported for any forest. The largest forests in terms of biomass are dominated by *Sequoia sempervirens* in California where above ground biomass was estimated to be 3190 t ha^{-1} (Westman 1978) and 2300 t ha^{-1} (Fujimori, cited by Parde 1980).

As is the case with many Australian forest studies, those undertaken in overseas ecosystems have also frequently omitted to sample the below ground components. Some researchers have concentrated on root estimation in tropical forests (Ogawa *et al.* 1965 ; Klinge 1973a,b; Huttel 1975; Tanner 1980). Other root studies have been carried out in

Table 6.6 Above and below ground biomass (t ha^{-1}) of forest
ecosystems in the world.

Large Temperate Forests			
Dominant Species or Forest Type	Above ground	Below ground	Reference
Sequoia sempervirens	3190.0	–	Westman (1978)
Sequoia sempervirens (260 years old)	2300.0	–	Parde (1980)
Pseudotsuga menziesii (375 years old)	1600.0	–	Parde (1980)
Pseudotsuga menziesii (<450 years old)		R 209	Santantonio *et al.* (1977)
Pseudotsuga menziesii (450 years old)	983.6	R 153 O 112	Grier & Logan (1977)
Cryptomeria japonica (130 years old)	1200.0	–	Parde (1980)
Hubbard Brook	151.5	–	Whittaker *et al.* (1974)
Brookhaven	65.0	–	Whittaker & Woodwell (1967)
Great Smokey Mountains			Whittaker (1966)
Uppercove	500	–	
Grey birch	170	–	
Tulip tree	220	–	
Tropical/Sub-tropical Forests			
Brazilian rainforests	–	250	Klinge (1973 a,b)
Tropical rainforests (average)	416.0	101	Rodin & Bazilevich (1967)
Jamaican rainforests	235.4	54	Tanner (1980)
Evergreen seasonal forests	731.0	255	Klinge & Rodrigues (1973)
Thailand rainforests	371.0	33	Ogawa *et al.* (1965)
Ghana rainforests	233.0	54	Greenland & Kowal (1960)
Sub-tropical laurel forests	324.0	78	Rodin & Bazilevich (1967)
Sub-tropical deciduous forests	326.0	82	Rodin & Bazilevich (1967)

large temperate forests by Santantonio *et al.* (1977) in 400 year old *Pseudotsuga menziesii* and in 200 year old *Picea abies* in the U.S.S.R. (Rodin and Bazilevich 1967). Root and dead organic matter estimates were reported by Grier and Logan (1977). Root biomass estimates of similar magnitude to those on Wabby were recorded in Ghana by Greenland and Kowal (1960), 54 t ha^{-1}; and in a 33 year old *Alnus rubra* by Rodin and Bazilevich (1967); and in 55 year old birch forest by Ovington and Madgwick (1959). Ecosystems with a root biomass comparable to the McKenzie site have been recorded in very few temperate forests apart from 97 t ha^{-1} reported by Rodin and Bazilevich (1967) in a 220 year old oak forest in the U.S.S.R. Most of the root biomass estimates for tropical and sub-tropical forests have either been very high (Klinge 1973 a,b), or very low, e.g. only 16 t ha^{-1} in Thailand forests (Ogawa *et al.* 1965). The average value for tropical forests, reported by Rodin and Bazilevich (1967) was 101 t ha^{-1}, and 82 t ha^{-1} for sub-tropical deciduous forests, which is still below the 176 t ha^{-1} estimated for the Deep site.

CHAPTER 7

MANAGEMENT IMPLICATIONS AND CONCLUSION

This chapter discusses how biomass estimates in forests can be used as a tool in forest management and how some of the methods used in this study can provide a means of monitoring management practices on Fraser Island. The errors associated with the estimates of biomass on the three sites are also discussed along with the procedures which could be adopted to improve them.

7.1   MANAGEMENT IMPLICATIONS

The blackbutt forests on Fraser Island grow on poor siliceous sands, yet appear as luxuriant as if grown on fertile soil. The understorey and small tree biomass data are quite high and could result from the open forest structure which typifies these sites. This high lower stratum biomass might provide the means whereby nutrients are conserved and yet provide for a rapid turnover and thus maintain a high rate of supply to the forest (Kimmins and Hawkes 1978). It is this flux of nutrients from one pool to another which maintains productivity and not the total nutrient store *per se* (Richards and Charley 1977). As an example of the high turnover rate of understorey species, *Caustis blakei*, a species which is abundant on both the Wabby and McKenzie sites, has cladodes which Rogers and Westman (1981) found to persist for only two years; thus the live biomass of this species comprises only two years growth at a maximum. The annual production of *Xanthorrhoea* was also found by these authors to be half the current biomass.

Forest biomass estimates hold the key to forest management (Young 1979) as the manager should know the weight by component of the fractions in the forest in order to determine the allowable cut. To achieve complete-forest management, the biomass and production of the forest by site and type needs to be estimated and the impact of utilization and silvicultural treatments on biophysical processes in the forest assessed. It is no longer defensible in an ecological context, to consider sustained yield only in terms of stem volume production of the merchantable large tree fraction.

Because the biochemical characteristics of the site have not yet been adequately defined, implications for managing these forests must be

based largely on the present biomass estimates.

Harvesting of timber is a major drain on the biomass and some
of the nutrients of the large trees. Given that nutrients are removed
in the logs, it must be ascertained whether sustained yield management
can be maintained and not lead to a degradation of forest production by
nutrient loss. It is of little consequence if the adverse aesthetic
effects of intensive logging can be ameliorated if logging itself leads
to a loss in production.

Biomass, estimated from regression equations or weight tables, can
be used in conjunction with the nutrient data of the various pools in
order to determine production changes within the forest. If only the
bolewood is removed in logging operations, nutrient removal is readily
calculated, and by monitoring this in different operations, it should be
possible to manipulate the forest, and if necessary, alter the allowable
cut to maintain productivity, even if this involves a reduction in the
sustainable yield. This would have to be studied in relation to the
nutrient in the remaining vegetation, the soil and the possibility of
using fertilizers.

One of the initial steps in this process is to estimate the
biomass and nutrient content of the standing crop of all components
and fractions on the site. This coupled with nutrient cycling data,
allows calculation of nutrient budgets, and the flux of these nutrients
from one biomass pool to another. It will then be possible to estimate
the effect which different logging regimes and intensities will have on
all forest components and which, if any, will lead to a decline in
productivity of the commercial crop and to the whole forest. This
manipulation of the data is possible by simulation studies, using growth
models in association with input, output and transfer of nutrients, and
superimposing different logging regimes.

Silvicultural treatment operations are often carried out in moist
hardwood forests and the results of this treatment can be monitored in
terms of productivity by a sequence of biomass estimations. Treatment
and thinning operations are designed to increase the basal area of
selected stems and to concentrate the productivity on these stems. The
effect of this can be ascertained by estimating what organic matter and
nutrients are being made available to the ecosystem by treatment, i.e.

cutting down the competing species and placing their store of nutrients directly on the forest floor. This silvicultural procedure has been developed on the basis that growth response is related to the amount of competition removed and presupposes that blackbutt trees will take up the nutrients and water which the competing vegetation would use if allowed to remain on the site. Thus the selected trees benefit both directly from the influx of nutrients provided by decomposition of the treated species, and indirectly from the additional nutrients and water which are no longer being used by the treated species.

The biomass estimates of the dead organic matter on the forest floor (litter) and below ground (dead organic matter) will allow the results of mineralization studies to be used to estimate the production and the accumulation of various nutrients in the soil. Prior to this study, the biomass and distribution of the below ground component, down to 150 cm, was unknown. It is now apparent that this component is quite large and, given that the nutrient status of the soil is extremely low, it is likely to contribute greatly to the nutrient budget of the ecosystem. It may be a particularly important source of the major elements, nitrogen and phosphorus.

Estimation of the biomass of the fine root component, coupled with the litter and dead organic matter, can be synthesised into a model of carbon and nutrient flow in the soil litter fraction in order to relate major environmental parameters to rates of mineralization. This can then be used to simulate the effects which management practices have on the functioning of the total forest.

Fuel reduction burns carried out on Fraser Island could also lead to a decrease in biomass and nutrient content of the site in the long term, particularly in the understorey which is potentially important in maintaining the rapid turnover of nutrients. Burning consumes litter and the smaller understorey plants and sometimes results in an increase in the litter component. Loss of nutrients can occur through volatilization,· particularly of sulphur and nitrogen (Richards 1976) through the loss of particulate matter (ash, etc.) in convection columns and movement of ash by overland flow and leaching by rain immediatley following the burn.

A knowledge of the biomass and nutrient content of the forest components before and after fire, will indicate the loss or gain of biomass

and nutrients which has occurred in the various components, and provide essential input to nutrient budgets monitoring productivity.

Biomass studies can be useful in determining burning plans,as they give accurate estimates of fuel loadings in forests of different ages and structure. If they are repeated in the components which are likely to be affected by the burn, fuel loadings for different forests at different times of the year can be estimated. These results, coupled with a knowledge of species and component flammability, provide the information needed to manipulate the forest for a particular use, be it mill logs, maintenance of ecosystem structure or promotion of particular plant or animal populations.

Other practices which represent massive disturbances, yet are likely to be used, are clearfelling and replanting, or burning to obtain regeneration. The latter was the form of silvicultural treatment applied to both the Wabby and McKenzie sites. By estimating the component biomass on the sites, 30 years apart in age, and then on an old growth site, trends in biomass pool sizes and the relationship between biomass and net primary production under a particular management regime can be determined. Coupled with a knowledge of the nutrient store in these pools, the different sizes of similar components in the several forests can be used to determine the flux of nutrients in the forest as it ages. An understanding of the movement of nutrients through the various components and fractions and the sizes of these, assists the forest manager in predicting the effect the management strategy will have on forest productivity, floristic composition and community structure.

This study provides a basis for further experimentation to include the estimation of accession and depletion of nutrients. This should lead to a further understanding of the functioning of the forest ecosystem which should be a prerequisite to any form of forest management. Thus by incorporating the results of this study with those proposed, the goal of maintaining forest productivity based on sound ecological principles will be brought a step closer.

It was indicated in the introduction that biomass as a means of stem management is a viable alternative to volume. If the techniques of regression analysis used in this study are adopted with a larger sample to cover the size limits of the commercial species, then an accurate and more efficient means of assessing the timber resource could be implemented

This technique could also be adopted in the selling of hardwood timber if an allowance for defect could be agreed upon. As was shown by the data, there is a strong correlation between bole weight and dbh (r^2 = .986   McKenzie blackbutt) with a small error, (<5% Wabby and McKenzie) within which the estimates vary. Once the regression equations are established, this method of selling timber should save measuring time at the stump and log dump, thus reducing costs and, as Young (1964) has indicated, timber is being used for many other products in addition to sawn wood, many of which are marketed by weight. Once the selling of sawlogs by weight as opposed to volume is accepted, weight scaling as practised in some softwood forests in Australia, could become a possibility in moist hardwood forests. This could be a viable proposition, particularly in clearfelling and salvage operations or where a wood chip harvest is envisaged.

7.2   CONCLUSION

Biomass studies give a quantitative measure of the static distribution of the components of the forest. The estimation of foliage, branches, stems and roots, which are components of trees, shrubs and understorey and the below ground fraction, is a holistic approach which is valid as a basis for determining forest productivity. If forest biomass studies are repeated sequentially, net primary productivity (rate of change of biomass) can be determined among the components of the stand, and as indicated previously, used as a tool in forest management. Attiwill (1979) studied the relationship between biomass and net primary production in *Eucalyptus obliqua* stands, and reported on the proportion of net primary production going to the various growth stages.

After a survey of the literature of overseas (IUFRO 1971, 1973 and 1976) and Australian studies, a regression analysis approach to the large trees was accepted as a satisfactory basis for this fraction. The minor vegetation fractions were estimated by regression techniques or by some form of harvest (plot) method on an area basis.

It was also evident that below ground biomass (roots and dead organic matter) had all but been ignored by previous workers, and consequently, an appropriate methodology had to be developed to estimate this component. Furthermore, even though many different ecosystems have been studied, ranging from alpine steppe to tropical rainforest, including

the large *Sequoia* forests, estimates of biomass which include standard errors are negligible. As a result, it was decided to measure the biomass of the forest components on Fraser Island through the development of mensurational techniques which would be appropriate in mixed species stands, and to quantify these estimates within known statistical limits.

Because the forests are complex in that they comprise diverse life forms, species and sizes, with varying proportions of components among fractions (trees and understorey, etc.), sampling strategies to provide accurate estimates are difficult to derive. This is particularly the case when below ground components are studied, and when the resources available are limited. Taking a 100 per cent sample of the stand was not feasible, so each fraction was examined separately and sampled using techniques appropriate to that particular fraction. Details were given in Chapter 3.

The study showed that in the large tree fraction, which ranges from 10 to 128 cm dbhob, component weight (including the large roots) can be estimated from dbh. The biomass distribution of the other root components and the dead organic matter below ground, raises some interesting points. The biomass of fine and medium root components on the three sites to a depth of 150 cm is considerable, and there is a mat of fine roots slightly below the soil surface. Fine and medium roots were concentrated in the 15 - 50 cm layer of the profile and the upper 10 cm, which contains the largest concentration of roots in many other forest ecosystems, was sparsely populated by roots in the Fraser Island blackbutt forests. The large biomass of fine roots some distance below the surface is presumed to act as an efficient net for collecting nutrients passing down through the profile, and this could lead to a rapid nutrient turnover rate (Kimmins and Hawkes 1978).

Using the regression analysis approach with dbh as the independent variable, estimates of the large tree biomass were made within 'acceptable' limits. The use of d^2h as the independent variable, did not improve the regression estimate even when height was included as an additional variable. It was shown that standard errors could be calculated from the regression equations for individual trees in the stand, for the other stand fractions, and for the overall total biomass of the stand. The standard errors (%) for the various stand fractions on the three sites are shown in Table 7.1.

The variation is large in some instances, and could only be reduced by a greater input of labour, equipment, and financial resources than was available to this project. In any event, as Satoo (1967) has pointed out, further refinements of such studies cost very much more than the improvement in the accuracy warrants and can, in fact, lead to a point of diminishing returns.

Obvious avenues for improvement, however, include further sampling of the large blackbutt (over 10 cm dbh), sampling the non blackbutt large tree component on the old growth site, where the biomass of brush box, satinay and tallowwood was calculated using the blackbutt regression equation. To refine the estimate for these species would require determining regression equations from sample trees of the same species, but this was beyond the resources of the present study. There is a clear need for this to be done, so that they can be compared with that established for blackbutt.

Table 7.1 Standard errors (%) of the estimation of biomass of forest fractions on Wabby, McKenzie and Deep sites.

	Wabby (%)	Site McKenzie (%)	Deep (%)
Living Large Trees	5.2	2.0	34.0
	(2.8)	(2.4)	(5.3)
Dead Trees	5.2	4.0	100.0
Living Small Trees	11.0	13.0	11.0
Dead Trees	11.1	46.7	nil stems
Understorey	17.0	12.0	14.0
Litter: (<10 cm)	6.0	6.0	28.0
large	81.9	42.3	67.7
Total	49	38	58
Total above ground	41	13	32
Roots: Large	(11.3)	(9.4)	(5.0)
Medium	29.3	26.0	11.0
Fine	3.4	3.4	3.7
Dead Organic Matter	6.0	6.0	7.0
Total Biomass	30.0	9.0	29.0

The figures in parenthesis show the figure when calculated by regression using the total weight as opposed to the summation of the individual component weights (calculated by regression).

The standard error of the litter estimates suggest that the number of samples should be increased for the litter (<10 cm) on Deep and that samples should be taken several times during the year over a larger area, to try to account for the spatial and temporal variability which is apparent in the litter layer on this site. The quadrat size and number of samples should also be increased for the large litter, to cope with the variability of distribution and size of this component on the three sites.

It became evident during the course of this study, which sampled all the vegetative organic matter of the forest, that there would be merit in formalizing the terminology and unifying the dimension classes of various components. This point is particularly relevant in the below ground biomass where all root categories discussed in the literature vary considerably in definition as does the depth of sampling. If a uniform methodology could be agreed upon, useful comparisons between forests of similar genera or similar forest types and structure, would then become possible. This should be a useful aid to forest management in the eucalypt dominated forests of Australia, where the maintenance of long term productivity is essential if they are to survive the increasing pressures to which they are being subjected, without diminishing their value to society as a source of the many goods and services which forests can provide.

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APPENDIX A

Some Plant Species Recorded on Fraser Island

This list of 650 species and 143 families has been, in part, compiled from collections and observations made while undertaking a study of the biomass in the *Eucalyptus pilularis* Sm. forests on Fraser Island in 1979. The study was a joint project involving the University of New England and The Department of Forestry, Queensland. The other sources of information used to compile the list are as follows:

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All species entered on the list have been identified by botanists from the Queensland Herbarium, Brisbane.

Definitions of Plant Habit

Tree	—	T	woody plant more than 5 m high and usually with one stem.
Shrub	—	S	woody plant less than 5 m high, usually with more than one stem arising from near ground level.
Parasitic Shrub	—	PS	a shrub living on another plant and obtaining nourishment from the host plant.
Palm	—	P	
Herb	—	H	non woody plant
Aquatic herb	—	AH	
Tufted herb	—	TH	
Succulent herb	—	SH	
Rhizomatous herb	—	RH	
Vine	—	V	
Parasitic vine	—	PV	
Epiphyte	—	E	plant living on another plant but not obtaining nourishment from that plant.
Tree fern	—	TF	

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
ACANTHACEAE										
Pseuderanthemum variabile (R.Br.) Radlk.	Pastel Flower									H
AGAVACEAE										
Cordyline rubra Huegel ex Kunth	Cordyline									S
Cordyline stricta (Sims.)Endl.	Blue Lilly									S
Cordyline terminalis (L.) Kunth	Broad Leafed Lilly									S
AIZOACEAE										
Carpobrotus aequilaterus (Haw.) N.E. Brown	Noonflower			SH						
Carpobrotus glaucescens (Haw.) Schwantes	Pig Face			SH						
Macarthuria neocambrica F.Muell.				H		E		E		
Sesuvium portulacastrum L.	Sea Purslane			H	H					
AMARANTHACEAE										
Achyranthes aspera L.	Chaff Flower			H						
AMARYLLIDACEAE										
Crinum pedunculatum R.Br.	Swamp Lilly			H			E			
ANACARDIACEAE										
Euroschinus falcata Hook. f.	Ribbon Wood					T				
Pleiogynium timorense (DC.) Leenh.	Burdekin Plum				T	T			T	
ANNONACEAE										
Polyalthia nitidissima (Dunal.) Benth.					T	T				
Rauwenhoffia leichhardtii (F.Muell.) Diels	Zig Zag Vine					V			V	
APOCYNACEAE										
Alyxia ruscifolia R.Br.	Chain Fruit					S		S	S	
Melodinus acutiflorus F.Muell.										V
Melodinus australis (F.Muell.) Pierre										V
Parsonsia ventricosa F.Muell.	Pointed Silk Pod					V			V	
Parsonsia straminea (R.Br.) F.Muell.	Common Silk Pod				V	V		V	V	
ARALIACEAE										
Astrotricha longifolia Benth.	Star Hair Bush					S	S	S	S	
Astrotricha glabra Domin						S	S	S	S	
Cephalaralia cephalobotrys (F.Muell.) Harms.										V
Tieghemopanax elegans (C.Moore &F.Muell.) Viguier	Celerywood					T			T	
ARECACEAE										
Archontophoenix cunninghamiana (H.Wendl.)H.Wendl.& Drude	Piccabeen Palm									P
Livistona australis (R.Br.) Mart.	Cabbage Tree Palm				P	P				
ARAUCARIACEAE										
Agathis robusta C.Moore	Sth.Qld.Kauri Pine								T	T
Araucaria bidwillii Hook	Bunya Pine								T	
Araucaria cunninghamii Ait ex D.Don	Hoop Pine								T	T
ASCLEPIADACEAE										
Asclepias fruiticosa L.	Balloon CottonBush			H			H			
Hoya australis R.Br. ex Traill	Hoya			V		V			V	
Ischnostemma carnosum (R.Br.) Merr. &Rolfe.	Star-hair					V			V	
Marsdenia fraseri Benth.	Fraser's Milk Vine	V						V	V	
Marsdenia glandulifera C.T.White	Monkey Rope							V	V	

			Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
			STRAND								
				LITTORAL FLAT							
					FORE DUNE						
							HIND DUNE				
							HIGH DUNE				
Family	Scientific Name	Common Name									
ASTERACEAE											
	Actites megalocarpa (Hook. f.) N. Lander.				H						
	Bidens pilosa L.	Cobbler's Pegs			H	H	H				
	Conyza canadensis (L.) Cronq.	Fleabane			H	H	H				
	Crassocephalum crepidioides (Benth.) S.Moore	Thickhead			H	H	H				
	Elyonurus citreus (R.Br.) Munno. ex Benth.				H				H		
	Epaltes australis Less.	Spreading Nutheads	H		H		H				
	Galinsoga parviflora Cav.	Potato Weed			H	H	H				
	Glossogyne tenuifolia (Labill.) Cass.	Native Cobbler's Pegs			H						
	Gnaphalium luteo-album L.	Jersey Cudweed				H	H				
	Gnaphalium pennsylvanicum Willd.	Cudweed			H	H	H				
	Helichrysum albicans Sieber	Everlasting Daisy					H			H	
	Helichrysum bracteatum (Vent.) Andr.	Golden Everlasting Daisy			H		H		H	H	
	Helichrysum insigne Domin.	Everlasting Daisy			H					H	
	Helichrysum luteolum Pedley ms.									H	
	Helichrysum oxylepis F. Muell.	Pointed Everlasting Daisy					H			H	
	Helichrysum semiamplexicaule Domin.	Yellow button							H	H	
	Podolepis arachnoidea (Hook.) Druce	Podolepis			H						
	Podolepis longipedata Cunn. in DC.	Podolepis			H						
	Podolepis neglecta G.L.Davis	Podolepis			H						
	Senecio lautus Forster f. ex Willd.	Groundsel					S				
	Sonchus oleraceus L.	Sowthistle			H		H				
	Vernonia cinerea Less.	Vernonia					H			H	
	Wedelia biflora L.	Seashore Wedelia			H						
AVICENNIACEAE											
	Avicennia marina (Forssk.) var. *australasica* (Walp.) Moldenke	Grey Mangrove			T						
BARRINGTONIACEAE											
	Planchonia careya (F.Muell.) Knuth.	Cocky Apple					T			T	
BAUERACEAE											
	Bauera capitata Ser.	Clustered Bauera		S							
BIGNONIACEAE											
	Pandorea jasminoides (Lindl.) K.Schum.	Pink TrumperFlower					V			V	V
	Pandorea pandorana (Andr.) van Steenis	Wonga Wonga Vine					V			V	
	Tecomanthe hillii (F.Muell.) van Steenis									V	V
BURMANNIACEAE											
	Burmannia disticha L.	Forked Burmannia		S							
BURSERACEAE											
	Canarium australasicum (F.M. Bailey) Leenh.									T	T
CACTACEAE											
	Opuntia sp.	Prickley Pear			SH		SH				
CAESALPINIACEAE											
	Caesalpinia scortechinii (F.Muell.) Hattink									S	S
	Caesalpinia subtropica Pedley									S	
	Cassia mimosoides L.									S	
CAMPANULACEAE											
	Lobelia alata Labill.	Angled Lobelia		H	H						
	Lobelia purpurascens R.Br.	White Root							H		
	Lobelia trigonocaulis F.Muell.	Forest Lobelia								H	

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
CYPERACEAE										
Bulbostylis barbata (Rottb.) C.B.Clarke			TH	TH						
Carex pumila Thunb.	Sedge		RH	RH						
Caustis blakei Kukenthal ex S.T.Blake	Foxtail					H		H	H	
Caustis recurvata Sprengel	Foxtail					H	H			
Cladium procerum S.T.Blake	Twigrush		H	H						
Cyperus conicus (R.Br.) Boeck	Sedge					H	H	H	H	
Cyperus cyperoides (L.) Kuntze	Sedge					H	H	H	H	
Cyperus enervis R.Br.	Sedge					TH	TH	TH	TH	
Cyperus haspan L.	Sedge				H	H	H	H		
Cyperus laevigatus L.	Sedge					H		H	H	
Cyperus lucidus R.Br.	Sedge					H		H	H	
Cyperus pedunculosus (R.Br.) Kern	Sedge								H	H
Cyperus polystachyos Rottb.	Bunchy Sedge			H	H	H		H	H	
Cyperus scaber (R.Br.) Boeck	Sedge			H		H	H			
Cyperus stradbrokensis Domin	Sedge			H	H			H	H	
Cyperus subulatus R.Br.	Sedge					H	H	H		
Eleocharis caribaea (L.) Blake			H							
Eleocharis cylindrostachys Boeck			H							
Eleocharis equisetina Presl			H							
Eleocharis difformis S.T.Blake			H							
Eleocharis ochrostachys Steudel			H							
Fimbristylis ferruginea (L.) Vahl	Rush		H	H				H		
Fimbristylis nutans (Retz.) Vahl	Rush						H	H	H	
Fimbristylis polytrichoides (Retz.) Vahl	Rush		H				H	H	H	
Gahnia clarkei Benl	Tall Sword Grass						H	H		
Gahnia sieberana Kunth	Sword Grass		H				H			
Lepidosperma laterale R.Br.	Broad Sword Grass				H	H		H	H	
Lepidosperma longitudinale Labill	Sword Sedge				H	H		H	H	
Lepironia articulata (Retz.) Domin			RH			RH			RH	
Schoenus apogon Roemer & J.A. & J.H.Schultes	Fluke Bogrush		H							
Schoenus brevifolius R.Br.	Bogrush		H				H			
Schoenus calostachyus (R.Br.) Poiret	Bogrush		H				H			
Schoenus nitens (R.Br.) Poiret	Bogrush		H							
Schoens ornithopodioides (Kukenthal) S.T.Blake	Rush		H							
Schoenus paludosus (R.Br.) Poiret	Bogrush		H		H			H	H	
Schoenus scabripes Benth.	Bogrush		H		H			H	H	
Scirpus nodosus Rottb.	Clubrush			TH			TH			
Scirpus validus Vahl	Clubrush			H						
Trachystylis stradbrokensis (Domin) Kukenthal								H	H	
DILLENIACEAE										
Hibbertia acicularis (Labill) F.Muell	Prickly Guinea Flower						S		S	
Hibbertia fasciculata R.Br.	Bundled Guinea Flower						S	S	S	
Hibbertia linearis R.Br.	Showy Guinea Flower						S		S	
Hibbertia linearis var. *floribunda* (Cunn.)Benth.	Guinea Flower						S		S	
Hibbertia salicifolia DC.	Willow Guinea Flower							S		

				STRAND	LITTORAL FLAT	FORE DUNE	HIND DUNE	HIGH DUNE			
Family	Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
CAMPANULACEAE											
Wahlenbergia sp.		Australian Blue Bell			H						
CARYOPHYLLACEAE											
Polycarpon tetraphyllum	L.	Four-leaved Allseed					S				
Silene gallica	L.	Mother Marm			H		H				
CASUARINACEAE											
Casuarina equisetifolia L. var. *incana* Benth.		Coast She Oak			T		T				
Casuarina glauca Sieber ex Sprengel		Wallum Oak				T			T		
Casuarina littoralis Salisb.		Black She Oak							T	T	
Casuarina torulosa Ait. on ex Dryander		Forest Oak								T	
CELASTRACEAE											
Denhamia pittosporoides F.Muell.										T	
CENTROLEPIDACEAE											
Centrolepis exserta Roemer & J.A.Schultes		Centrolepis			H						
CHENOPODIACEAE											
Arthrocnemum halocnemoides J.M.Black		Blackseed Samphire			SH						
Arthrocnemum leiostachyum (Benth.) Paulsen		Samphire			SH						
Suaeda arbusculoides L.S.Smith		Seablite			SH						
Suaeda australis (R.Br.) Maq.		Seablite			SH						
CHLOANTHACEAE											
Chloanthes parviflora Walp.		Small Chloanthes						S	S		
COMBRETACEAE											
Lumnitzera racemosa Willd.		Black Mangrove				T					
COMMELINACEAE											
Commelina cyanea R.Br.		Scurvy Weed			H	H	H				
Commelina lanceolata R.Br.		Wandering Jew								H	
CONVOLVULACEAE											
Calystegia soldanella R.Br.		Sea Bind Weed	V		V						
Evolvulus alsinoides L.											
Ipomoea indica (Burman) Merrill					H		H		H	H	
Ipomoea pes-caprae (L.) R.Br.		Goat's Foot Convolvulus			H					H	
CRUCIFERAE											
Lepidium virginicum L.		Peppercress			H						
CUNONIACEAE											
Schizomeria ovata D.Don		Crab Apple									T
CUPRESSACEAE											
Callitris columellaris F.Muell.		White Cypress Pine				T			T		
Callitris macleayana (F.Muell.) F.Muell.		Stringy Bark Cypress Pine								T	
Callitris rhomboidea R. Br. ex A.L.C.Rich.		Dune Cypress					T				
CYMODOCEACEAE											
Halodule uninervis (Forssk.) Aschers					H						
CYPERACEAE											
Baumea articulata (R.Br.) S.T.Blake				RH							
Baumea juncea (R. Br.) Palla				RH							
Baumea muelleri (C.B.Clarke) S.T.Blake				RH							
Baumea rubiginosa (Sprengel) Boeck.				RH							
Baumea teretifolia (R.Br.) Palla				RH							

HIGH DUNE
  HIND DUNE
  FORE DUNE
  LITTORAL FLAT
  STRAND

Family / Scientific Name / Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
DILLENIACEAE									
Hibbertia scandens (Willd.)Dryander — Snake Vine		V			V				
Hibbertia stricta (D C.) F.Muell. — Erect GuineaFlower					S		S	S	
Hibbertia vestita Cunn. ex Benth. — Hairy GuineaFlower				S	S	S	S	S	
DIOSCOREACEAE									
Dioscorea transversa R.Br. — Native Yam					V		V	V	
DROSERACEAE									
Drosera binata Labill — Fork Sundew	H						H	H	
Drosera indica L. — Sundew	H								
Drosera peltata Smith ex Willd. — Sundew	H								
Drosera pygmaea DC. — Sundew	H								
Drosera spathulata Labill — Spoon Leaved Sundew	H								
ELAEOCARPACEAE									
Elaeocarpus eumundi F.M.Bailey — Eumundi Quandong									T
Elaeocarpus grandis F.Muell. — Blue Quandong								T	T
Elaeocarpus obovatus G.Don — Hard Quandong							T	T	T
Elaeocarpus reticulatus Smith — Blueberry Ash					T		T	T	T
EPACRIDACEAE									
Acrotriche aggregata R.Br. — Tall Ground Berry					S			S	
Brachyloma daphnoides (Smith) Benth. — Daphne Heath					S			S	
Epacris microphylla R.Br. — Coral Heath						S			
Epacris obtusifolia Smith — Common Heath						S			
Epacris pulchella Cav. — Wallum Heath						S			
Leucopogon leptospermoides R.Br. — Tree Bearded Heath							S	S	
Leucopogon margarodes R.Br. — Bearded Heath					S		S	S	
Leucopogon parviflorus (Andr.) Lindl. — Coast Bearded Heath					S		S	S	
Leucopogon pedicellatus C.T.White — WallumBearded Heath					S		S	S	
Leucopogon pimeleoides Cunn ex DC. — Feather Bearded Heath					S		S	S	
Monotoca scoparia (Smith) R.Br. — Prickly Broom Heath					S		S	S	
Sprengelia sprengelioides (R.Br.) Druce — White Swamp Heath						S			
Styphelia viridis Andr. — Green Five Corners						S			
Trochocarpa laurina (R.Br. ex Rudge) R.Br. — Tree Heath							T	T	T
Woollsia pungens (Cav.) F.Muell. — Woolsia						S			
ERIOCAULACEAE									
Eriocaulon scariosum Smith — Pipewort	H						H		
EUPHORBIACEAE									
Breynia oblongifolia Muell. Arg. — Coffeebush								S	S
Claoxylon australe Baillon — Claoxylon								S	S
Excoecaria agallocha L. — Milky mangrove				T					
Glochidion ferdinandi (Muell.Arg.) F.M.Bailey — Cheese Tree							T	T	
Glochidion lobocarpum (Benth.) F.M.Bailey						T	T	T	
Glochidion perakense Hook. f. var. *supra-axillare* (Benth.) — Button Wood						T	T	T	
Omalanthus populifolius Graham — Native Bleeding Heart						T	T	T	
Petalostigma pubescens Domin — Quinine Berry						T	T	T	T

			HIGH DUNE								
				HIND DUNE							
			FORE DUNE								
			LITTORAL FLAT								
		STRAND									
Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
EUPHORBIACEAE										
Phyllanthus virgatus G. Forster				H				H	H	
Poranthera microphylla Brongn.	Small Poranthera			H				H		
Pseudanthus orientalis F.Muell.	Sandhill Pseudanthus					S		S	S	
Ricinocarpos pinifolius Desf.	Wedding Bush						S	S	S	
EUPOMATIACEAE										
Eupomatia laurina R.Br.	Bolwarra									S
FLACOURTIACEAE										
Scolopia braunii (Klotzch) Sleumer	Brown Birch						S	S	S	
FLAGELLARIACEAE										
Flagellaria indica L.	Vine Reed Cane								V	V
FLINDERSIACEAE										
Flindersia bennettiana F.Muell. ex Benth.	Bennet's Ash									T
Flindersia schottiana F.Muell.	Bumpy Ash									T
GENTIANACEAE										
Centaurium spicatum L. Fritsh	Australian Centaury			H						
GOODENIACEAE										
Dampiera stricta (Smith) R.Br.	Blue Dampiera								S	
Goodenia rotundifolia R.Br.	Goodenia			H					H	
Goodenia stelligera R.Br.	Goodenia			H					H	
Scaevola calendulacea (Andr.) Druce	Scented Fan Flower			H						
Velleia spathulata R.Br.	Wild Pansies			H						
GUTTIFERAE										
Hypericum gramineum Forst. f.				H						
HAEMODORACEAE										
Haemodorum tenuifolium Cunn. ex Benth.	Blood Root		H							
HALORAGACEAE										
Gonocarpus micranthus Thunb. subsp. *ramosissimus* Orchard							H	H	H	
Myriophyllum sp. L.	Water Milfoil		AH							
HYDROCOTYLACEAE										
Centella asiatica (L.) Urb.	Pennywort			H						
Hydrocotyle acutiloba (F.Muell.) N.A.Wakefield										
Platysace lanceolata (Labill.) Druce	Shrubby Platysace							S	S	
Platysace ericoides (Sieber ex DC.) Norman	Heath Platysace						S	S	S	
Platysace linearifolia (Cav.) Norman	Narrow Leaf Platysace		S							
Xanthosia pilosa Rudge	Woolly Xanthosia							H	H	
IRIDACEAE										
Patersonia glabrata R.Br.	Bush Iris				RH			RH	RH	
Patersonia sericea R.Br. ex Ker-Gawl.	Wild Iris				RH			RH	RH	
Sisyrinchium micranthum Cav.	Rush-Leaf					H				
JUNCACEAE										
Juncus kraussii Hochst. subsp. *australiensis* ms.	Rush			H	H					
Juncus polyanthemus Buchenau	Common Rush		H						H	
JUNCAGINACEAE										
Triglochin procera R.Br.	Water-ribbons		AH						AH	
Triglochin striata Ruiz & Pavon	Streaked Arrow-grass		AH							

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
LABIATAE										
Plectranthus parviflorus Willd.	Cockspur Flower			H						
LAURACEAE										
Beilschmiedia elliptica C.T.White & Francis	Brown Walnut								T	T
Beilschmiedia obtusifolia (F.Muell. ex Meissner) F.Muell.	Black Walnut								T	T
Cassytha filiformis L.	Dodder					PV	PV	PV		
Cassytha paniculata R.Br.	Dodder						PV	PV		
Cassytha pubescens R.Br.	Downy Devils Vine						PV	PV		
Cinnamomum baileyanum (F.Muell. ex F.M.Bailey) Francis									T	T
Cinnamomum oliveri F.M.Bailey	Oliver's Sassafras									T
Cryptocarya cunninghamii Meissner										T
Cryptocarya foetida R.T.Baker	Stinking Cryptocarya									T
Cryptocarya glaucescens R.Br.	Jackwood								T	
Endiandra discolor Benth.	Donatia Tree								T	T
Endiandra sieberi Ness.	Hard Corkwood								T	
Litsea leefeana (F.Muell.) Merr.	Brown Bolly Gum								T	T
Litsea reticulata (Meissner) F.Muell.	Bolly Gum									T
Neolitsea dealbata (R.Br.) Merr.	White Bolly Gum								T	
LENTIBULARIACEAE										
Utricularia biloba R.Br.	Moth Bladderwort		H							
Utricularia caerulea L.	Blue Bladderwort		H							
Utricularia lateriflora R.Br.	Small Fairy Aprons		H							
Utricularia uliginosa Vahl	Asian Bladderwort		H							
LILIACEAE										
Blandfordia grandiflora R.Br.	Christmas Bells						H			
Burchardia umbellata R.Br.	Milk-maids		H							
Clivia sp.	Lilly								H	
Dianella ensifolia (L.) DC.	Blueberry Lilly			H				H	H	
Dianella caerulea Sims	Blueberry Lilly			H				H	H	
Dianella laevis R.Br.	Blueberry Lilly			H				H	H	
Gloriosa superba L.	Glory Lilly			H						
Laxmannia gracilis R.Br.	Slender Wire Lilly			H			H	H	H	
Sowerbaea juncea Smith	Vanilla Lilly		H							
Thysanotus tuberosus R.Br.	Fringed Lilly		H						H	
Tricoryne elatior R.Br.	Rush Lilly						H	H	H	
Tricoryne muricata Baker	Rush Lilly						H	H	H	
LORANTHACEAE										
Amyema bifurcatum (Benth.) Tiegh.	Mistletoe			PS				PS	PS	
Amyema congener (Sieber ex J.A. & J.H.Scultes) van Tieghem	Erect Mistletoe			PS				PS	PS	
Amyema mackayense (Blakely) Danser	Mistletoe			PS						
Amyema miquelii (Lehm. ex Miq.) van Tieghem	Box Mistletoe			PS				PS	PS	
Amylotheca dictyophleba (F.Muell.) van Tieghem	Red Mistletoe			PS				PS	PS	
Lysiana spathulata (Blakely) Barlow	Mistletoe			PS		PS		PS	PS	
Muellerina bidwillii (Benth.) Barlow	Mistletoe			PS				PS		
Muellerina celastroides (Sieber ex Roemer & J.A.Schultes) van Tieghem	Mistletoe					PS		PS	PS	

Family / Scientific Name / Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
MALVACEAE									
Hibiscus diversifolius Jacq. — Swamp Hibiscus				S	S				
Hibiscus tiliaceus L. — Cotton Tree				T	T				
Sida rhombifolia L. — Sida Retusa			H		H		H		
MELASTOMATACEAE									
Melastoma polyanthum Blume — Blue Tongue					S	S	S		
MELIACEAE									
Melia azedarach L. var. *australasica* C.DC — White Cedar									T
Synoum glandulosum (Smith) Andr. Jess — Scentless Rosewood									T
Toona australis (F.Muell.) Harms — Red Cedar									T
Xylocarpus granatum Koenig — Cannonball Mangrove				T					
MENISPERMACEAE									
Hypserpa decumbens (Benth.) Diels								V	V
Stephania japonica (Thunb.)Miers var. *timorensis* (DC.) Forman — Tape Vine				V	V				
MENYANTHACEAE									
Nymphoides exiliflora (F.Muell.) Kuntze — Marsh Wort		H							
Villarsia reniformis R.Br. — Running Marshflower		H							
MIMOSACEAE									
Acacia aulacocarpa Cunn. ex Benth. — Hickory Wattle		T	T	T			T	T	
Acacia baueri Benth. — Tiny Wattle						S	S	S	
Acacia complanata Benth. — Flat-Stemmed Wattle							T	T	
Acacia concurrens Pedley — Curracabah					T		T	T	
Acacia falcata Willd. — Sickle Wattle						S	S	S	
Acacia falciformis DC. — Broad-leaved Hickory							T	T	
Acacia fimbriata Cunn. ex G.Don — Fringed Wattle						S			
Acacia flavescens Cunn. ex Benth. — Toothed Wattle					T		T	T	
Acacia leiocalyx (Domin) Pedley — Black Wattle					T		T	T	
Acacia pennivervis DC. — Hickory Wattle					T		T	T	
Acacia quadrilateralis DC. — Wattle						S			
Acacia suaveolens (Smith) Willd. — Sweet Wattle						S	S	S	
Acacia ulicifolia (Salisb.) Court — Prickly Moses					S	S	S	S	
Pithecellobium lovellae F.M.Bailey — Baconwood							T	T	
MONIMIACEAE									
Wilkiea huegeliana (Tul.) A.DC.									S
Wilkiea macrophylla (Cunn) A.DC. — Wilkiea									S
MORACEAE									
Ficus fraseri Miq. — Sandpaper Fig								T	T
Ficus obliqua Forst. f. var. *obliqua* — Small-leaf Fig								T	T
Ficus obliqua var. *petiolaris* (Benth.) Corner — Small-leaf Fig								T	T
Ficus opposita Miq. — Sandpaper Fig								S	S
Ficus platypoda (Miq.) Cunn. ex Miq. — Small-leaved Moreton Bay Fig								T	T
Ficus watkinsiana F.M.Bailey — Strangler Fig									T
Malaisia scandens (Lour.) Planchon — Burney Vine					V			V	

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
MYOPORACEAE										
Myoporum acuminatum R.Br. sens. lat.	Boobialla		S			S				
MYRSINACEAE										
Aegiceras corniculatum (L.) Blanco	River Mangrove				S					
Embelia australiana (F.Muell.) Mez	Embelia								S	S
Myrsine porosa F. Muell.						S				
Myrsine variabilis R.Br.	Rapanea					S		S	S	
MYRTACEAE										
Angophora costata (Gaertn.) J.Britten	Smooth-barked Apple					T		T		
Austromyrtus dulcis (C.T.White) L.S.Smith	Midgen Berry					S	S	S	S	
Backhousia myrtifolia Hook & Harvey	Carrol								T	T
Baeckea frutescens L.								S	S	
Baeckea linearis C.T.White	Straggly Baeckea							S	S	
Baeckea stenophylla F.Muell.	Weeping Baeckea							S	S	
Baeckea virgata (J.R. & G.Forster) Andr.	Twiggy Baeckea							S	S	
Callistemon pachyphyllus Cheel	Smooth Bottlebrush							S	S	
Decaspermum fruticosum Forster							S	S	S	
Eucalyptus drepanophylla F.Muell. ex Benth.	Qld.Grey Iron Bark					T				
Eucalyptus gummifera (Gaertn.) Hochr	Red Bloodwood					T		T	T	
Eucalyptus grandis W.Hill ex Maiden	Flooded Gum								T	
Eucalyptus intermedia R.T.Baker	Pink Bloodwood					T		T	T	
Eucalyptus microcorys F.Muell.	Tallow-wood								T	
Eucalyptus patentinervis									T	
Eucalyptus pilularis Smith	Blackbutt							T	T	
Eucalyptus planchoniana F.Muell.	Needlebark Stringybark						T			
Eucalyptus resinifera Smith	Red Mahogany							T	T	
Eucalyptus robusta Smith	Swamp Mahogany						T			
Eucalyptus signata F.Muell.	Scribbly Gum						T	T	T	
Eucalyptus tereticornis Smith	Forest Redgum						T		T	
Eucalyptus tessellaris F.Muell.	Moreton Bay Ash						T			
Eucalyptus umbra R.T.Baker	White Stringy-Bark						T	T		
Eugenia australis Wendl. ex Link	Lilly Pilly								T	T
Eugenia coolminiana (C.Moore)	Blue Lilly Pilly								T	T
Eugenia hemilamphra F.M.Bailey	Broad-leaved Lilly Pilly									T
Eugenia leuhmannii F.Muell.	Riberry									T
Eugenia smithii Poiret	Narrow-leaved Lilly Pilly								T	T
Homoranthus virgatus Cunn.	Mouse & Honey Bush						S	S	S	
Leptospermum attenuatum Smith	Wild May							S	S	
Leptospermum flavescens Smith	Common Tea Tree						S	S	S	
Leptospermum juniperinum Smith	Wild May						S	S		
Leptospermum lanigerum (Aiton) Smith	Wild May							S	S	
Leptospermum liversidgei R.T.Baker & H.T.Smith	Wild May						S	S		
Leptospermum petersonii F.M.Bailey	Lemon Scented Tea Tree								S	
Leptospermum semibaccatum Lindl.	Wild May						S	S	S	
Leptospermum speciosum Cheel	Wild May							S	S	
Leptospermum stellatum Cab.	Wild May						S	S		

			HIGH DUNE								
				HIND DUNE							
			FORE DUNE								
			LITTORAL FLAT								
			STRAND								
Family	Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
MYRTACEAE											
	Melaleuca dealbata S.T.Blake	Soapy Tea Tree						S	S		
	Melaleuca nodosa (Gaertn.) Smith							S			
	Melaleuca quinquenervia (Cav.) S.T.Blake	Paper-bark						T	T		
	Melaleuca viridiflora Solander ex Gaertn.							T	T		
	Osbornia octodonta F.Muell.	Myrtle Mangrove					T				
	Pilidiostigma glabrum Burret	Plum Myrtle								S	S
	Rhodamnia acuminata C.T.White									T	T
	Rhodamnia argentea Benth.	White Myrtle								T	T
	Syncarpia hillii F.M.Bailey	Fraser Is.Satinay								T	
	Tristania conferta R.Br.	Brush Box					T	T	T	T	T
	Tristania suaveolens Smith	Swamp Box							T		
NYMPHAEACEAE											
	Nymphaea capensis Thunb.	South African Blue Waterlilly		H							
OLACACEAE											
	Olax retusa F.Muell. ex Benth.	Olax						H	H	H	
OLEACEAE											
	Notelaea longifolia Vent.	Large Mock Orange								T	T
	Notelaea punctata R.Br.									T	T
ONAGACEAE											
	Oenothera drummondii Hook.	Beach Primrose			H						
ORCHIDACEAE											
	Bulbophyllum aurantiacum F.Muell.										E
	Caladenia alba R.Br.								H	H	
	Caladenia carnea R.Br.	Pink Fingers							H	H	
	Calanthe tripilicata (Willemet) Ames	Scrub Lilly								E	E
	Caleana major R.Br.	Flying Duck Orchid						H	H		
	Calochilus campestris R.Br.	Copper Beards								H	
	Cymbidium suave R.Br.	Snake Flower							E	E	
	Dendrobium aemulum R.Br.	Ironbark Orchid								E	E
	Dendrobium linguiforme Swartz	Tongue Orchid									E
	Dendrobium tetragonum Cunn.	Spider Orchid									E
	Dipodium punctatum (Smith) R.Br.	Hyacinth Orchid					H	H	H		
	Diuris aurea Smith	Golden Diuris						E	H		
	Diuris punctata Smith var. *alba* (R.Br.) Dockr.							H	H		
	Galeola cassythoides (Cunn.) Reichenb. f.	Climbing Orchid									V
	Geodorum pictum Lindl.	Painted Orchid							H	H	
	Glossodia minor R.Br.	Small Waxlip Orchid						H	H	H	
	Liparis simmondsii F.M.Bailey							H			
	Oberonia palmicola F.Muell.	Solider Crest Orchid		H							E
	Pterostylis baptistii Fitzg.	King Greenhood								H	H
	Pterostylis nutans R.Br.	Nodding Greenhood								E	E
	Thelymitra ixioides Swartz	Dotted Sun Orchid						H	H	H	

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OXALIDACEAE										
Oxalis corniculata L.	Creeping Oxalis			H		H		H	H	
Oxalis stricta L.				H		H		H	H	
PALMAE										
Linospadix monostachya (Mart.) H. Wendl.	Walking Stick Palm									P
PANDANACEAE										
Freycinetia gaudichaudii Bern. et. Horsf.	Brand Bean									V
Freycinetia propinqua Domin						V			V	
Freycinetia scandens Gaudich.	Climbing Pandanus									V
Pandanus pedunculatus R.Br.	Long-leaved Pandanus	T				T				
Pandanus stradbrokensis St.John		T				T				
PAPILIONACEAE										
Aotus ericoides (Vent.) G.Don	Common Aotus						S	S		
Aotus lanigera Cunn. ex Benth.	Pointed Aotus						S	S		
Bossiaea brownii Benth.	Downy Bossiaea					S		S		
Bossiaea ensata Sieber ex DC.	Small-leafless Bossiaea						S	S	S	
Bossiaea heterophylla Vent.							H			
Bossiaea rhombifolia Sieber ex DC.	Appressed Bossiaea							S		
Bossiaea rupicola Cunn. ex Benth.	Rock Bossiaea						S	S		
Canavalia rosea (Schwartz) DC.	Beach Bean			H						
Crotalaria linifolia L. f.	Rattlepod			H						
Daviesia aciularis Smith	Bitter Pea						S			
Daviesia umbellulata Smith	Bitter Pea						S	S	S	
Dillwynia floribunda Smith	Showy Parrot Pea					S		S	S	
Dillwynia retorta (Wendl.) Druce var. *retorta*	Hairy Parrot Pea					S	S	S	S	
Glycine clandestina Wendl.	Twining Glycine			H						
Glycine tabacina Benth.	Glycine			H				H		
Glycine tomentella Hayata	Woolly Glycine							H	H	
Gompholobium latifolium Smith	Broad Wedge Pea								S	
Gompholobium nitidum Solander								S	S	
Gompholobium pinnatum Smith	Poor Man's Gold							S	S	
Gompholobium virgatum Sieber var. *virgatum*	Wallum Wedge Pea					S	S	S	S	
Hardenbergia violacea (Schneev.) Stearn	Native Sarsaparilla Vine					V		V	V	
Hovea acutifolia Cunn. ex G.Don	Hovea								S	
Hovea longifolia R.Br.	Hovea							S	S	
Jacksonia scoparia R.Br.	Dogwood					S	S	S		
Jacksonia stackhousii F.Muell.	Wallum Dogwood						S	S		
Kennedia rubicunda (Schneev.) Vent.	Dusky Coral Pea					V	V	V	V	
Kunstleria blackii (F.Muell.) Polhill	Blood Vine				V					
Millettia megasperma F. Muell.									V	V
Mirbelia rubiifolia (Andr.) G.Don							S			
Mucuna gigantea (Willd.) DC.	Velvet Bean									V

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PAPILIONACEAE										
Phyllota phylicoides (Sieber ex DC.) Benth.							S	S	S	
Platylobium formosum Smith	Handsome Flat Pea						S			
Pultenaea euchila DC.	Large Flower Bush Pea						S			
Pultenaea myrtoides Cunn. ex Benth.	Bush Pea				S		S	S		
Pultenaea paleacea Willd.	Hairy Bush Pea						S			
Pultenaea villosa Willd.	Bronze Bush Pea						S			
Sesbania cannabina (Retz.) Poiret	Yellow Pea Bush			H					H	
Tephrosia filipes Benth.						H				
Vigna marina (Burm.) Merr.	Beach Vigna			H						
Zornia diphylla Pers.						H	H	H	H	
Zornia dyctiocarpa DC.							H	H		
PASSIFLORACEAE										
Passiflora suberosa L.	Corky Passion Flower							V		
PHILESIACEAE										
Eustrephus latifolius R.Br.	Wombat Berry					V			V	V
Geitonoplesium cymosum (R.Br.) Cunn. ex Hook.	Scrambling Berry								V	V
PHILYDRACEAE										
Philydrum lanuginosum Banks & Solander ex Gaert.	Woolly Water Lilly			AH						
PIPERACEAE										
Piper novae-hollandiae Miq	Giant Pepper Vine									V
PITTOSPORACEAE										
Pittosporum revolutum Ait.f. ex Dryander	Hairy Pittosporum								S	S
PLUMBAGINACEAE										
Aegialitis annulata R.Br.	Club Mangrove						S			
Limonium australe (R.Br.) Kuntze	Native Sea Lavender					H	H			
POACEAE										
Aristida benthamii Henrard	Wire Grass						TH			
Aristida calycina R.Br.	Wire Grass	TH					TH			
Axonopus sp.	Carpet Grass	H		H						
Cenchrus echinatus L.	Mossman River Grass			H						
Cymbopogon refractus (R.Br.) A. Camus	Barb Wire Grass			TH						
Cynodon dactylon (L.) Pers.	Green Couch	H		H						
Digitaria ciliaris (Retz.) Koeler	Summer Grass			H						
Digitaria didactyla Willd.	Q'ld. Blue Couch			H	H					
Digitaria leucostachya (Domin) Henrard	Coastal Dune Digitaria	TH		TH						
Digitaria parviflora (R.Br.) Hughes	Small Flower			TH						
Entolasia marginata (R.Br.) Hughes			H							
Entolasia stricta (R.Br.) Hughes			H							
Eragrostis australasica (Steudel) C.E. Hubbard	Love Grass			H						
Eragrostis brownii (Kunth) Nees ex Steudel	Love Grass			H						
Eragrostis interrupta Beauv.	Coastal Dune Love Grass			H						
Eragrostis pubescens (R.Br.) Steudel	Love Grass			H						

Column group headers (dune profile): HIGH DUNE, HIND DUNE, FORE DUNE, LITTORAL FLAT, STRAND

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
POACEAE										
Eragrostis spartinoides Steudel	Love Grass			H						
Eriachne anomala Hartley	Wanderrie Grass					TH		TH		
Eriachne insularis Domin	Wanderrie Grass					TH		TH	TH	
Eriachne muelleri Domin	Wanderrie Grass					TH		TH		
Eriachne pallescens R.Br.	Wanderrie Grass					TH		TH		
Eriochloa procera (Retz.) C.E. Hubbard	Early Spring Grass			.		TH		TH	TH	
Imperata cylindrica (L.) Beauv.var *major* (Nees) C.E.Hubbard	Blady Grass				RH	RH		RH	RH	
Ischaemum fragile R.Br.		RH				RH		RH	RH	
Ischaemum triticeum R.Br.				H						
Leersia hexandra Swartz	Swamp Rice Grass		AH							
Lepturus repens (Forst.) R.Br.	Beach Lepturus			H						
Oplismenus aemulus (R.Br.) Roemer & Schultes	Slender Panic Grass					H		H	H	
Oplismenus undulatifolius (Ard.) Roemer & Schultes var *mollis* Domin	.					H		H	H	
Panicum lachnophyllum Benth.						H		H	H	
Panicum simile Domin	Two Colour Panic							H	H	
Paspalidium constrictum (Domin) C.E.Hubbard			H	H			H			
Paspalidium gausum S.T.Blake			H						H	
Paspalum distichum L.	Salt Water Couch		AH						AH	
Paspalum scrobiculatum L.	Dutch Millet					TH		TH	TH	
Phragmites australis (Cav.) Trin. ex Steudel	Common Reed		AH						AH	
Pseudoraphis paradoxa (R.Br.) Pilger	Slender Mudgrass					H		H	H	
Schizachyrium fragile (R.Br.) A.Camus				H	H	H		H	H	
Setaria surgens Stapf				TH				TH	TH	
Spinifex hirsutus Labill.	Beach Spinifex	H								
Sporobolus virginicus (L.) Kunth.	Marine Couch			RH	RH					
Themeda australis (R.Br.) Stapf	Kangaroo Grass			TH	TH	TH		TH	TH	
Zoysia macrantha Desvaux	Dune Couch	RH		RH						
PODOCARPACEAE										
Podocarpus elatus R.Br. ex Endl.	Plum Pine									T
POLYGALACEAE										
Comesperma defoliatum F.Meull.	Leafless Milkwort								S	
Comesperma retusum Labill.									S	
POLYGONACEAE										
Polygonum orientale L.	Smart Weed					H				
Rumex acetosella L.	Dock			H		H		H	H	
PORTULACACEAE										
Portulaca bicolor F.Muell.	Pigweed			H	H	H				
Portulaca oleracea L.	Pigweed			H	H	H				

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PROTEACEAE										
Banksia aemula R.Br.	Wallum Banksia		T			T	T	T	T	
Banksia integrifolia L. f.	Coastal Banksia				T	T				
Banksia oblongifolia Cav.	Dwarf Banksia		T				T	T		
Banksia robur Cav.	Broad-Leaved Banksia					S	S	S		
Banksia serrata L.f.	Red Honeysuckle						T	T		
Conospermum taxifolium Smith	Devils Rice						S	S		
Grevillea robusta A.Cunn.	Silky Oak								T	
Hakea gibbosa (Smith) Cav.										
Persoonia cornifolia Cunn. ex R. Br.	Broad-leaved Geebung					S	S	S		
Persoonia linearis Andr.	Geebung						S	S	S	
Persoonia media R.Br.	Geebung						S	S		
Persoonia prostrata R.Br.	Geebung						S	S		
Persoonia virgata R.Br.	Small-leaved Geebung						S	S	S	
Petrophila shirleyae F.M. Bailey	Conesticks						S	S		
Strangea linearis Meissner	Strangea							S		
Xylomelum pyriforme Knight	Woody Pear				T	T		T		
RANUNCULACEAE										
Clematis glycinoides DC.	Forest Clematis								V	V
RESTIONACEAE										
Coleocarya gracilis S.T.Blake	Sedge		H							
Empodisma minus (Hook. f.) L.A.S. Johnson& Cutler	Spreading Rope-rush		H							
Hypolaena fastigiata R.Br.	Tassel Rope-rush		H							
Leptocarpus tenax (Labill.) R.Br.			H							
Lepyrodia caudata L.A.S. Johnson & Evans			H							
Lepyrodia interrupta F.Muell.			H							
Restio pallens R.Br.	Cord-rush		H	H						
Restio tenuiculmis S.T.Blake	Cord-rush		H							
Restio tetraphyllus Labill.subsp. *meiostachyus* L.A.S.Johnson & O.D.Evans	Feather plant		H	H						
RHAMNACEAE										
Alphitonia excelsa (Frenzl) Reisseck ex Benth.	Red Ash					T	T		T	
Alphitonia petriei C.T.White & Braid									T	T
Emmenosperma alphitonicides F. Muell.	Yellow Ash								T	T
RHIZOPHORACEAE										
Bruguiera gymnorhiza (L.) Lam.	Orange Mangrove				T					
Ceriops tagal (Perrottet) C.B.Robinson	Yellow Mangrove				S					
Rhizophora stylosa Griff.	Spotted Leaved Red Mangrove				T					
RUBIACEAE										
Canthium coprosmoides F.Muell.	Coast Canthium		T		T				T	
Canthium odoratum (Forster f.) Seem.	Sweet Susie				T			T	T	
Coelospermum paniculatum F.Muell.					V				V	
Morinda acutifolia F.Muell.	Morinda							V	V	
Morinda jasminoides Cunn.	Morinda							V	V	
Pomax umbellata (Gaertn.) Solander ex Rich.						H			H	H

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RUBIACEAE											
	Psychotria daphnoides Cunn.	Smooth Psychotria					S		S	S	
	Psychotria loniceroides Sieber ex DC.	Hairy Psychotria				S	S		S	S	
	Randia chartacea F.Muell.								T	T	
	Richardia brasiliensis Gomez						H		H		
	Spermacoce brachystema R.Br. ex Benth.				H		H		H		
	Timonius timon (Sprengel) Merr.	Timonius				T	T				
RUTACEAE											
	Acronychia imperforata F.Muell	Beach Acronychia				T	T			T	
	Acronychia laevis J.R. & G.Forster	Glossy Acronychia				T	T		T	T	
	Acronychia pubescens (F.Muell.)C.T.White	Hairy Acronychia							T	T	
	Acronychia wilcoxiana (F.Muell.) T.Hartley	Silver Aspen								T	T
	Bauerella simplicifolia (Endl.)T.Hartley									T	T
	Boronia bipinnata Lindl.	Rock Boronia							S	S	
	Boronia falcifolia Cunn.	Wallum Boronia						S			
	Boronia rivularis C.T.White	Wide Bay Boronia						S	S		
	Boronia rosmarinifolia Cunn.	Forest Boronia							S	S	
	Citrus limon (L.) Burm. f.	Bush Lemon				T	T		T	T	
	Eriostemon australasius Pers.	Pink Wax Flower					S	S	S		
	Euodia elleryana F.Muell.	Pink Euodia							T	T	
	Halfordia kendak (Montrouz) Guillaumin	Saffron Heart								T	T
	Medicosma cunninghamii (Hook.) Hook. f.	Medicosma									S
	Melicope melanophloia C.T.White										T
	Phebalium woombye (F.M.Bailey) Domin	Woombye					S		S	S	
	Zieria laevigata Smith	Twiggy Midge Bush				S	S		S	S	
	Zieria smithii Andr.					S	S		S	S	
SANTALACEAE											
	Choretrum candollei F.Muell. ex Benth.	White Sour Bush					S			S	
	Exocarpos cupressiformis Labill.	Native Cherry					PS		PS	PS	
	Leptomeria acida R.Br.	Sour Curr nt Bush					S		S	S	
SAPINDACEAE											
	Arytera lautererana (F.M.Bailey) Radlk.	Corduroy								T	T
	Cupaniopsis anacardiodes (A.Rich.) Radlk.	Cupania Tree				T	T				
	Cupaniopsis foveolata (F.Muell.) Radlk.	Tamarind							T	T	
	Dodonaea triquetra Andr.	Hop Bush							S	S	
	Dodonaea viscosa (L.)Jacq.var. *viscosa* f.*burmannia* (DC.)Radlk.	Hop Bush					S		S	S	
	Dodonaea viscosa (L.)Jacq.var. *viscosa* f.*repanda* (K.Schum & Thorn.) Radlk.	Sticky Hop Bush				S	S				
	Elattostachys nervosa (F.Muell.) Radlk.	Beetroot									T
	Guioa acutifolia (F.Muell.) Radlk.									T	T
	Harpullia alata F.Muell.	Winged Leaved Tulip									T
	Harpullia pendula Planchon ex F. Muell.	Tulipwood									T
	Jagera pseudorhus (A.Rich.)Radlk.	Foam Bark Tree				T	T				

Family / Scientific Name / Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
SAPINDACEAE									
Mischocarpus pyriformis Radlk. — Yellow Pear Fruit									T
Mischocarpus sundaicus Blume.									T
Sarcopteryx stipitata (F.Muell.) Radlk. — Corduroy Tree									T
Toechima tenax (Benth.) Radlk. — Pitted-leaf Steelwood									T
SAPOTACEAE									
Planchonella australis (R.Br.) Pierre — Black Apple					T		T	T	
Planchonella chartacea (F.Muell. ex Benth.) H.J.Lam.								T	T
Planchonella laurifolia (A.Rich) Pierre — Blush Coondoo								T	T
SCROPHULARIACEAE									
Bacopa monnieri (L.) Wettst.		H							
Buchnera urticifolia R.Br.		H	H						
SMILACEAE									
Ripogonum discolor F.Muell.									V
Smilax australis R.Br. — Barb Wire Vine							V	V	V
Smilax glycophylla Smith							V	V	V
SOLANACEAE									
Solanum hispidum Pers.				H					
Solanum nigrum L. — Nightshade				H					
SPIGELIACEAE									
Mitrasacme paludosa R.Br. — Swamp Mitrewort						H	H	H	
Mitrasacme polymorpha R.Br. — Varied Mitrewort							H	H	
STERCULIACEAE									
Brachychiton populneus (Schott) R.Br. — Kurrajong								T	
STYLIDIACEAE									
Stylidium graminifolium Swartz — Trigger Plant							H	H	
Stylidium ornatum S.T.Blake					.		H		
THYMELIACEAE									
Pimelea linifolia R.Br. — Slender Riceflower						S		S	S
Pimelea collina Smith — Slender Riceflower						S	S	S	
ULMACEAE									
Trema aspera (Brongn.) Blume — Poison Peach						S	S		S
VERBENACEAE									
Clerodendrum floribundum R.Br. — Smooth Clerodendrum						S	S		S
Gmelina leichhardtii F.Muell. — White Beech									T
Lantana camara L. — Lantana						S	S		
Phyla nodiflora (L.) Greene — Frogfruit			H				H	H	
VIOLACEAE									
Hybanthus enneaspermus (L.) F.Muell. — Ladies Slipper							H	H	H
Hybanthus monopetalus (Roemer & J.A. Schultes) Domin							H	H	H
Viola hederacea Labill. — Ivyleaf violet						H	H	H	H

					HIGH DUNE				
					HIND DUNE				
				FORE DUNE					
			LITTORAL FLAT						
	STRAND								
Family Scientific Name Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
VISCACEAE									
Notothixos subaureus Oliver Golden Mistletoe					PS		PS	PS	
Viscum articulatum Burm. f. Mistletoe				PS	PS		PS	PS	
VITACEAE									
Cissus hypoglauca A.Gray Five-leaved Water Vine				V	V		V	V	V
Cissus opaca F.Muell. Water Vine				V	V		V	V	V
Cissus sterculifolia (F.Muell.) Planchon Water Vine				V	V		V	V	V
WINTERACEAE									
Drimys insipida (R.Br. ex DC.) Pilger Brush Pepper Bush									S
XANTHORRHOEACEAE									
Lomandra elongata (Benth.) Ewart. Mat Rush								TH	
Lomandra confertifolia (F.M.Bailey) Fahn Mat Rush				TH	TH		TH	TH	TH
Lomandra filiformis (Thunb.) J.Britten Mat Rush							TH	TH	
Lomandra laxa (R.Br.) A.T.Lee Mat Rush					TH			TH	
Lomandra longifolia Labill. Common Lomandra					TH		TH	TH	
Lomandra multiflora (R.Br.) J. Brittin Mat Rush					TH		TH		
Xanthorrhoea johnsonii A.T.Lee Grass Tree					S		S		
Xanthorrhoea macronema F.Muell. ex Benth. Grass Tree							S	S	
Xanthorrhoea resinosa Pers. subsp. *fulva* A.T.Lee						S	S	S	
XYRIDACEAE									
Xyris juncea R.Br. Hatpins					TH		TH	TH	
ZAMIACEAE									
Macrozamia miquelii (F.Muell.) A.DC. Zamia Palm				P	P		P	P	P
ZINGIBERACEAE									
Alpinia arundelliana (F.M.Bailey) K.Schum.									H
Alpinia caerulea (R.Br.) Benth. Native ginger									H
PTERIDOPHYTES									
ANGIOPTERIDACEAE									
Angiopteris evecta (Forster f.) Hoffman									H
ASPLENIACEAE									
Asplenium australasicum (John Smith) Hook. Crows Nest Fern									E
Asplenium polyodon Forster f.									E
BLECHNACEAE									
Blechnum camfieldii Tindale		H				H			
Blechnum cartilagineum Swartz Gristle Fern								H	H
Blechnum procerum (Forster f.) Swartz Hard Water Fern								H	H
CYATHEACEAE									
Cyathea leichhardtiana (F.Muell.) Copel Prickly Tree Fern									TF
DAVALLIACEAE									
Davallia pyxidata Cav. Haresfoot Fern									H

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
DENNSTAEDTIACEAE										
Histiopteris incisa (Thunb.) John Smith	Batswing Fern									E
Pteridium esculentum (Forster f.) Cockayne	Bracken Fern				E	E		E	E	
DICKSONIACEAE										
Culcita dubia (R.Br.) Maxon	Common Ground Fern								E	
Dicksonia youngiae C.Moore ex Baker	Soft Tree Fern									E
GLEICHENIACEAE										
Gleichenia dicarpa R.Br.	Fan Fern						E	E	E	
Gleichenia microphylla R.Br.								E	E	
Sticherus flabellatus (R.Br.) H.St.John	Umbrella Fern								E	E
Sticherus lobatus N.A.Wakefield	Lobed Fan Fern								E	E
HEMIONITIDACEAE										
Pityrogramma austroamericana Domin									E	E
HYMENOPHYLLACEAE										
Gonocormus saxifragoides Presl. van den Bosch										E
Macroglena caudata (Brack.) Copel.	Jungle Bristle Fern									E
LINDSAECEAE										
Lindsaea brachypoda (Baker) Salomon									E	E
Lindsaea ensifolia Swartz									E	E
Lindsaea fraseri Hook.									E	E
Lindsaea incisa Prentice									E	E
Lindsaea orbiculata (Lam.) Mettenius ex Kuhn										E
LYCOPODIACEAE										
Lycopodium cernuum L.	Club Moss						E		E	E
Lycopodium laterale R.Br.	Slender Club Moss		E				E			E
Lycopodium serpentinum Kunze	Club Moss						E			E
NEPHROLEPIDACEAE										
Nephrolepis cordifolia (L.) Presl.	Fishbone Fern								E	E
OPHIOGLOSSACEAE										
Ophioglossum pendulum (L.)	Ribbon Fern									E
OSMUNDACEAE										
Todea barbara (L.) T.Moore	King Fern									E
POLYPODIACEAE										
Drynaria rigidula (Swartz) Bedd.	Basket Fern									E
Microsorum punctatum (L.) Copel.									E	E
Platycerium bifurcatum (Cav.) Christensen	Elkhorn									E
Platycerium superbum Jonch. & Hennipan	Staghorn									E
Pyrrosia rupestris R.Br. Ching										E
PSILOTACEAE										
Psilotum nudum (L.) Beauv.	Skeleton Fork Fern									E

Family / Scientific Name	Common Name	Grassland	Sedgeland	Herbland	Low Woodland	Low Open Forest	Heath	Woodland	Open Forest	Closed Forest
PTERIDACEAE										
Pteris comans Forster f.										H
SCHIZAEACEAE										
Lygodium japonicum (Thunb.) Swartz					H	H		H	H	H
Lygodium microphyllum (Cav.) R.Br.	Snake Fern			H	H	H		H	H	H
Schizaea bifida Willd.	Comb Fern							H	H	H
Schizaea dichotoma (L.) Smith	Fork Comb Fern							H	H	H
Schizaea fosteri Spreng.								H	H	H
SELAGINELLACEAE										
Selaginella uliginosa (Labill.) Spring	Swamp Selaginella		H				H			
SINOPTERIDACEAE										
Pellaea paradoxa (R.Br.) Hook.										H
THELYPTERIDACEAE										
Cyclosorus interruptus (Willd.) H.Ito	Shield Fern								H	H
TMESIPTERIDACEAE										
Tmesipteris truncata (R.Br.) Desvaux										E
VITTARIACEAE										
Vittaria elongata Swartz	Vittaria									E

Column grouping headers (over the habitat columns): STRAND, LITTORAL FLAT, FORE DUNE, HIND DUNE, HIGH DUNE

.APPENDIX B

Physiographic Units on Fraser Island

Strand: This area is comprised of the beach and dune sand and extends up to a height of approximately 5 m above sea level. It includes the first berm and small seepage areas above the high water mark.

Fore Dune: The sands immediately behind the Strand and up to 20 m in height comprise this unit. This area includes the second berm and larger seepage areas such as swales, creeks and lagoons.

Hind Dunes: These are the series of parabolic dunes which extend up to a height of 80 m above sea level and push inland about 2 to 3 km. The sands are yellow/brown with little organic matter in the surface layers.

High Dunes: The majority of the central part of the island can be included in this unit. It contains most of the better developed forests which includes those dominated by blackbutt, the satinay/box type and 'rainforest'. Included also in this unit are many of the lakes and lake infills which dot the island.

Littoral Flats: The western side of the island which includes the mangrove woodlands, salt marsh and the transition zone between the marsh and the forests of the dune sand, is encompassed in this unit. Most of the area is inundated at high tide with intermittent covering of the transition zone occurring during the spring high-water tides.

APPENDIX C

Stratigraphic Sequences
of the High Dunes on Fraser Island

A1   0 - 60   cm - dark brown/grey sand speckled with fine white
sand and organic material.

A2   60 - 4.5 m - fine white sand

B   4.5 - 7.2 m - dark brown carbonaceous sand (coffee rock)

    7.2 - 15.0 m - fine brown sand

    15 - 19.0 m - mid brown fine sand

    19 - 26.0 m - light brown fine sand - clay bands

    26 - 43.0 m - light brown fine sand

    43 - 50.0 m - fine brown sand - clay bands

    50 - 65.0 m - dark brown fine sand

    65 - 75.0 m - light brown fine sand - clay bands

    75 - 76.0 m - dark brown peat layer

    76 - 79.5 m - grey/green mudstone (burrum coal formation)

APPENDIX D

Growth Stages of Eucalypts on the Three Sites
(extract from Jacobs 1955).

Sapling Stage: The sapling stage is characterised by a crown of small branches, all of which should be shed as the tree gains height. The boundary between the juvenile and sapling form may be said to be the stage where the branches commence to be shed from the base of the crown and the formation of a clear bole is started. A vigorous sapling crown would be making fast height growth and the living part of the new crown would represent 3 to 4 years growth; the crown would be long and thin.

Within the sapling crown, the branches which vie with each other for leadership, are called competing branches. When leadership of a shoot is evenly disputed between two competing branches, the result is "bifurcated" stems.

Pole Stage: After it·has gained a certain height which varies with the quality of the site, a young eucalypt enters the pole stage. In this stage, the tree has a strongly developed mainstem and a crown outline like that of a sapling, but the larger lower branches are no longer quickly and cleanly shed. The upper part of the crown is still gaining height, and the upper part of the pole crown is like that of a sapling.

The semi-permanent lower branches of a pole crown come from competing branches of an earlier sapling stage. In some ways they are like modified saplings growing outwards from the mainstem. They form leaf-bearing units which give the crowns of eucalypts their characteristic appearance, the mature crowns being made up of a number of such units arising from the mainstem or main branches.

Mature Stage: At a certain period of its life, the eucalypt loses its pole form and develops large persistent branches. It becomes the structure we recognise as a mature tree. The difference between the pole and the mature tree is that in the pole the semi-permanent branch units grow from the mainstem. In the mature tree they also grow from the large persistent branches forming the framework of the crown. These persistent branches may be called the shaping branches because they decide the outline of the crown.

The height at which forest eucalypts form the shaping branches of maturity varied with the quality of the site on which the trees grow. In low quality forest, the boles may fork and develop major branches at a height of from 2 m or less to 10 m. Here the total height of the mature trees may be 18 - 22 m. In high quality forest, the pole stage may carry on until the poles are 25 - 30 m high. The mature forest may then be around 45 m high.

Eucalypt leaves do not have a long life. A branch of the primary crown must always push outwards to retain a tuft of leaves at its end. As it pushes outwards, it is weighed downwards. There is a limit to the distance from the trunk it can grow as a primary branch. It may grow outwards 6 or 10 m, but somewhere about this distance the leafy portion at the end becomes inefficient. Epicormic shoots then develop from dormant buds on the top and sides of the branch. These epicormic shoots develop into the leaf-bearing units of the main crown. The epicormic unit nearest the end of the branch usually continues the outward extension of the branch. The epicormic leaf-bearing units contribute to the diameter growth of the parent branch and it becomes stiffer and more stable than it was under the influence of its own primary leafy shoots. This process may be repeated several times during the formation of a large shaping branch in a fully mature eucalypt crown. The enlargement and stiffening of the branch and its extension to a distance of perhaps 12 - 15 m from the trunk, would be the work of the epicormic units developing from dormant buds.

A eucalypt may remain in the fully mature stage for decades or even hundreds of years. During this time, its height and crown spread may change very little. Both may fluctuate as the extremities die and are replaced by new crown units. There will always be dead branches in a healthy mature crown. An undue proportion of dead branches — "stagheadedness" — is an unhealthy sign, but the death of a reasonable proportion of the crown units should be accepted as normal.

Overmature Stage: The patching up of a mature eucalypt crown by the development of dormant buds from the shaping branch may go on for a long period in the life span of the tree. All this time fungal attack is weakening the inside of trunk and branches alike. The shaping

branches are usually the first to fall because their place is taken by branches which develop from dormant buds on the trunk. These new branches are never as efficient as the branches of the primary crown. They may live for a few years, or even a decade or two, break and be replaced. This process may be repeated several times as the tree becomes old and decrepit.

APPENDIX E

Check List of Species on the Wabby Site.

Species	Voucher No.
Acacia falciformis	26
Austromyrtus dulcis	31A
Banksia aemula	
Boronia rosmarinifolia	45
Caustis blakei	27
Conospermum taxifolium	12
Dodonaea triquetra	78
Dodonaea viscosa var *viscosa*	84
Endiandra sieberi	20
Eucalyptus gummifera	82A
Eucalyptus intermedia	123
Eucalyptus pilularis	213
Eucalyptus resinifera	
Hibbertia scandens	65
Leucopogon margarodes	55
Lomandra confertifolia	164
Lomandra longifolia	32
Macrozamia miquelii	
Monotoca scoparia	
Patersonia sericia	124
Persoonia virgata	76
Phebalium woombye	11
Platysace lanceolata	149
Pteridium esculentum	
Smilax australis	167
Smilax glycophylla	71
Syncarpia hillii	67
Tristania conferta	200
Xanthorrhoea macronema	

APPENDIX F

SOIL PROFILE DETAILS

1.   Wabby Site

   Group: Podzol

Profile 1.

Depth (cm)	pH	Conductivity (µS/cm)	Munsell Colour (moist)
0 - .5	4.76	16.9	10YR 4/1
.5 - 1.0	5.08	5.9	10YR 5/1
1.0 - 1.5	5.33	4.3	10YR 5/1
1.5 - 2.0	5.15	7.9	10YR 6/1
			↓
5.5 - 6.0	5.52	2.8	10YR 7/1
6.0 - 6.5	5.42	4.1	10YR 4/2
6.5 - 7.0	5.36	4.8	10YR 3/3
7.0 - 7.5	5.58	8.1	10YR 3/3
7.5 - 8.0	5.45	3.8	10YR 3/2
8.0 - 8.5	5.54	4.1	10YR 3/2
8.5 - 9.0	5.48	5.9	10YR 2.5/1
			↓
11.0 -11.5	5.53	6.9	10YR 2.5/1
11.5 -12.0	5.33	7.9	10YR 3/2
			↓
12.5 -13.0	5.44	6.1	10YR 3/2

Profile 2.

Depth (cm)	pH	Conductivity (µS/cm)	Munsell Colour (moist)
0 - .5	4.82	11.9	10Yr 3/1
.5 - 1.0	5.14	3.9	10YR 4/1
1.0 - 1.5	5.17	4.9	10YR 5/2
1.5 - 2.0	5.30	4.9	10YR 6/2
			↓
3.0 - 3.5	5.31	6.2	10YR 6/2
3.5 - 4.0	5.32	5.6	10YR 5/3
4.0 - 4.5	5.24	5.2	10YR 5/3
4.5 - 5.0	5.35	4.4	10YR 4/3
5.0 - 5.5	5.30	6.4	10YR 4/3
5.5 - 6.0	4.96	10.3	10YR 4/4
6.0 - 6.5	4.87	11.3	10YR 5/4
6.5 - 7.0	4.74	12.9	10YR 5/8
7.0 - 7.5	4.68	17.9	10YR 4/4
7.5 - 8.0	4.90	13.8	10YR 3/2
8.0 - 8.5	5.45	8.5	10YR 3/2
8.5 - 9.0	5.23	6.2	10YR 3/3
9.0 - 9.5	5.07	6.2	10YR 3/3
9.5 -10.0	5.09	6.4	10YR 4/3
10.0 -10.5	5.10	5.6	10YR 4/3

2.   McKenzie Site

   Group: Podzol

Profile 1.

Depth (cm)	pH	Conductivity (µS/cm)	Munsell Colour (moist)
0 - .5	4.70	11.5	10YR 2.5/1
0.5 - 1.0	4.78	8.7	10YR 2.5/1
1.0 - 1.5	5.10	4.4	10YR 4/1
1.5 - 2.0	5.21	5.2	10YR 4/1
2.0 - 2.5	5.37	3.9	10YR 6/1
			↓
8.5 - 9.0	5.64	4.0	10YR 6/1
9.0 - 9.5	4.97	5.7	10YR 4/3
9.5 -10.0	4.96	7.5	10YR 3/3
10.0 -10.5	5.06	7.1	10YR 3/2
10.5 -11.0	5.15	6.9	10YR 3/2
11.0 -11.5	4.93	10.2	10YR 2.4/1
11.5 -12.0	5.24	5.9	10YR 3/1
			↓
12.5 -13.0	5.37	6.1	10YR 3/1

Profile 2.

Depth (cm)	pH	Conductivity (µS/cm)	Munsell Colour (moist)
0 - 0.5	4.53	22.0	10YR 4/1
0.5 - 1.0	4.71	11.6	10YR 4/1
1.0 - 1.5	5.08	5.6	10YR 6/1
			↓
8.0 - 8.5	5.75	3.3	10YR 6/1
8.5 - 9.0	5.49	4.4	10YR 5/3
9.0 - 9.5	5.40	6.9	10YR 3/3
9.5 -10.0	5.35	5.9	10YR 4/2
10.0 -10.5	5.03	14.8	10YR 3/1
			↓
11.0 -11.5	4.89	12.0	10YR 2.5/1
11.5 -12.0	4.86	10.7	10YR 3/2
12.0 -12.5	5.31	6.6	7.5YR 3/2
12.5 -12.6	5.03	11.2	5 YR 3/4

3.   Deep Site

        Group: Podzol

Profile 1.

Depth (cm)	pH	Conductivity (μS/cm)	Munsell Colour (moist)
0.0 - 0.5	5.53	12.7	10YR 5/1
0.5 - 1.0	5.31	13.3	10YR 4/1
1.0 - 1.5	5.25	14.5	10YR 6/1
			↓
3.0 - 3.5	5.67	6.7	10YR 6/1
3.5 - 4.0	5.85	10.9	10YR 3/3
			↓
5.5 - 6.0	5.67	9.8	10YR 3/3
6.0 - 6.5	5.84	11.8	10YR 3/2
6.5 - 7.0	5.88	12.2	10YR 3/2
7.0 - 7.5	5.96	14.7	5YR 4/3
7.5 - 8.0	5.98	12.0	10YR 3/3
8.0 - 8.5	6.10	19.3	10YR 3/2
			↓
9.0 - 9.5	6.06	11.1	10YR 3/2
9.5 -10.0	6.05	11.3	10YR 3/1
10.0 -10.5	6.00	11.9	10YR 3/1
10.5 -11.0	6.02	9.8	10YR 3/2
11.0 -11.5	5.98	8.7	10YR 4/3
11.5 -12.0	6.05	6.8	10YR 4/4
12.0 -12.5	5.94	5.9	10YR 4/4

Profile 2.

Depth (cm)	pH	Conductivity (μS/cm)	Munsell Colour (moist)
0.0 - 0.5	5.12	10.4	10YR 5/1
0.5 - 1.0	5.30	5.5	10YR 6/1
			↓
7.0 - 7.5	5.60	4.8	10YR 6/1
7.5 - 8.0	4.82	14.3	10YR 4/4
8.0 - 8.5	4.58	24.3	7.5YR 4/3
			↓
9.0 - 9.5	4.76	13.5	7.5YR 4/3
9.5 -10.0	4.92	13.1	5.0YR 3/4
10.0 -10.5	4.49	27.9	50YR 3/4
10.5 -11.0	4.35	45.7	5YR 2.5/2
			↓
11.5 -12.0	4.83	25.1	5YR 2.5/1
12.0 -12.5	5.25	28.1	10YR 2.5/1
12.5 -13.0	5.20	15.0	5YR 2.5/2
13.0 -13.3	4.97	14.3	10YR 3/2

APPENDIX G

Check List of Species on the McKenzie Site

Species	Voucher No.
Acacia falciformis	26
Austromyrtus dulcis	31A
Caustis blakei	27
Cissus hypoglauca	177
Dianella sp.	73
Dodonaea triquetra	22
Elaeocarpus reticulatus	5
Endiandra sieberi	20
Eucalyptus pilularis	213
Eucalyptus resinifera	
Eugenia coolminiana	58
Eustrephus latifolius	29
Hibbertia scandens	65
Imperata cylindrica var *major*	
Leucopogon margarodes	55
Lomandra confertifolia	164
Lomandra longifolia	32
Macrozamia miquelii	
Monotoca scoparia	
Myrsine variabilis	54
Notelaea longifolia	60
Persoonia virgata	76
Phebalium woombye	11
Pteridium esculentum	
Smilax australis	167
Smilax glycophylla	71
Syncarpia hillii	67
Tristania conferta	200
Xanthorrhoea macronema	

APPENDIX H

Check List of Species on the Deep Site

Species	Voucher No.
Acronychia wilcoxiana	17
Alyxia ruscifolia	72
Backhousia myrtifolia	19
Breynia oblongifolia	102
Canthium coprosmoides	95
Cordyline terminalis	96
Cryptocarya glaucescens	
Denhamia pittosporoides	98
Dianella sp.	73
Dodonaea triquetra	22
Elaeocarpus reticulatus	5
Embelia australiana	131
Endiandra sieberi	20
Eucalyptus microcorys	225
Eucalyptus pilularis	213
Eugenia coolminiana	58
Eustrephus latifolius	29
Flagellaria indica	160
Geitonoplesium cymosum	135
Halfordia kendak	133
Hibbertia scandens	65
Hypserpa decumbens	97
Leucopogon margarodes	55
Lomandra confertifolia	164
Lomandra longifolia	32
Macrozamia miquelii	
Millettia megasperma	89
Monotoca scoparia	
Mysine variabilis	93

Appendix H (continued)

Notelaea longifolia	60
Notelaea punctata	118
Persoonia virgata	76
Polyscias elegans	104A
Psychotria loniceroides	112
Smilax australis	167
Smilax glycophylla	71
Syncarpia hillii	67
Tristania conferta	200
Trococarpa laurina	92
Wilkea macrophylla	
Xanthorrhoea macronema	

APPENDIX I

Measurement of Tree Diameter

Diameter at breast height, over bark, (dbhob) was taken at 1.3 m above the ground, but where this was not possible, due to some obstruction or malformation, the distance above the ground most suitable was used and this distance recorded.

Breast height (bh) was located using a 1.3 m stick carried by the measurer and used on each tree.

On sloping ground, the 1.3 m stick was placed on the top side of the stem, and bh noted. When taking the 1.3 m mark, all loose mounds of soil and litter were displaced and all loose material at bh, i.e. vines, mosses, and loose bark, moved at this point.

Trees which fork below bh were treated as double stems and given separate tree numbers, and the diameter measurements bracketed on the measure sheets. Trees with fork above 1.3 m were treated as single stems.

In all cases, stems were measured at right angles to the stem axis and tapes kept taut. The tapes used were steel with a winding mechanism on a return spring and diameters were recorded to the nearest 0.1 cm.

When measuring leaning or badly bent trees, e.g. *Monotoca* sp. the 1.3 m point was taken from ground level on the under side of the tree, but in the vertical plane. This had to be carried out in this manner because the trees in this category will not facilitate the 1.3 m measurement along the axis of the stem due to the severe bends which are characteristic of the *Monotoca* sp.

APPENDIX J

Measurement of Tree Height

A Suunto clinometer was used to measure total height of the tallest 50 trees ha^{-1} on each site, except Deep where 8 trees ha^{-1} only were heighted. The readings to the top of the trees were recorded in percent (%) as were the readings to a measured distance up the bole from ground level, usually 1.5 m.

The distance from the trees to the observer was measured and used to obtain top height using the method outlined below.

When taking the height of the specified number of trees used for height determination, it was necessary to take heights of more than the required number to ensure that the tallest trees, in fact, were measured.

When measuring the top of these umbrageous spp., i.e. one with a poorly defined top, it was necessary to measure to a point just over the top of the crown. By doing this, it ensured consistency of measurement point between trees.

The following calculation is the standard manner of estimating the total height of a tree on sloping ground, when the deflection angle can be any angle up to 90°.

% to top of tree from E	= 130%
% to top of 1.5 m from E	= 6%
Distance EB	= 20 m
Height AC	= AB + 1.5
	= 20 cos 6% (tan α - tan 6%) + 1.5
	= 20 cos 3.4° (1.24) = 1.5
Height of tree	= 26.26 m
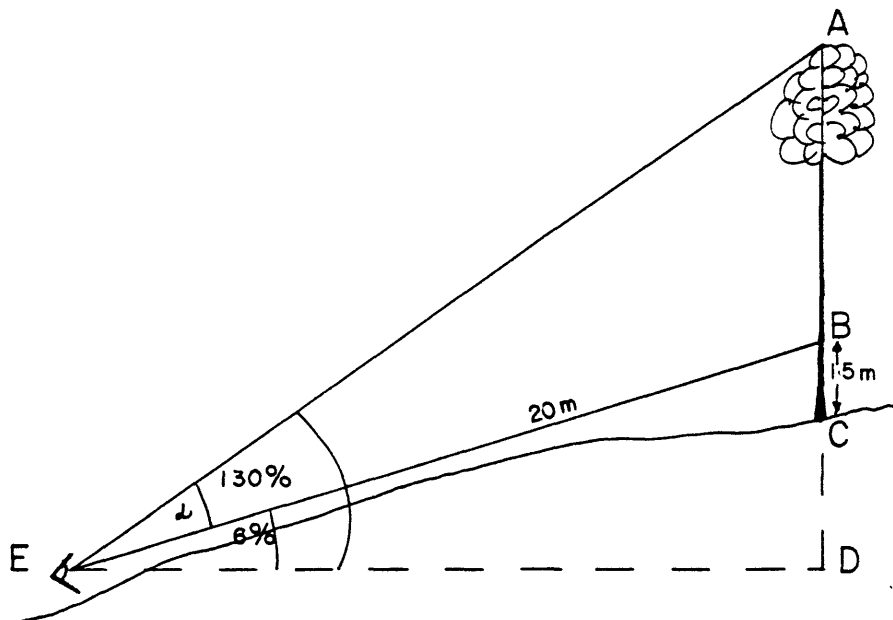
APPENDIX K

Method Used for Loss on Ignition Tests
to Determine Sand Percentage

1. The sample was thoroughly mixed, then spread evenly over a large sheet of paper and the sample quartered. This process was necessary because sand is heavier than the organic matter and is always toward the base of the sample. The quartered sample was remixed, spread again and quartered. This process was continued until a sub-sample of c. 2 g was obtained.

2. A 2 g of oven-dried sub-sample was weighed out on to a vitreous china crucible.

3. The crucible was placed in a muffle furnace and the temperature slowly raised to 600°C. The ash which resulted was greyish-white.

4. The crucible was then removed from the oven and when cool the ash was moistened with distilled water under the cover of a watch glass. Approximately 3 ml of 5 N HCL was pipetted under the glass.

5. The covered crucible was placed in a water bath and digested.

6. When digested, the suspension was filtered, and the residue oven-dried to constant weight and weighed. The net weight of sand was then obtained and hence the precentage of sand in the sample was calculated.

7. This figure was then used to calculate the net weight of litter.