

Port Curtis Mangrove Monitoring Programme

Gladstone Port Authority

October, 1999

R. Johnson, D. Shearer, A. Melzer, D. Wild,
and W. Houston.

Centre for Environmental Management

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Faculty of Arts, Health and Sciences

Central Queensland University
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EXECUTIVE SUMMARY

The Gladstone region, a centre for industry in Queensland, is undergoing further development of facilities in Port Curtis to support continuing industrial expansion. The Gladstone Port Authority has identified a number of tidal wetland areas west of the Calliope River mouth and adjacent to the Fisherman's Landing Wharf for reclamation works. Additionally, Southern Pacific Petroleum Development is developing an oil-from-shale plant and mine abutting some tidal wetlands in the Targinie area. A mangrove monitoring programme was established to assess the possible impacts of these developments on adjacent mangrove communities and to opportunistically study the effects of a severe hail storm which struck mangroves on the Calliope River in 1994.

Key study areas and parameters were identified and sentinel sites established with corresponding reference sites on Curtis Island. Monitoring of productivity, basal area, foliage cover and sediment was undertaken in plots at each site over a three year period.

Litter (leaf, flower and stipule) fall appears to have occurred seasonally as expected. No evidence of environmental impact was apparent in this data.

Foliage projective cover declined in September 1997 at all sentinel and reference sites suggesting some regional influence. The return to normal levels in subsequent monitoring events suggests the communities are behaving normally. Differences between sites were consistent over time suggesting no environmental impacts in the sentinel sites.

Sediments are accreting at the sentinel scrub site. Reasons for this are not known as yet but the site will be revisited to consider this. However, litter fall and foliage projective cover did not indicate any change in community health at this site. Otherwise there is no suggestion of any impacts on mangrove substrates.

Basal area per hectare of live stems was different between sites but generally constant over the three years of monitoring. There is no evidence of changes in live tree cover associated with the sentinel sites relative to the reference sites.

Generally, the mangrove communities monitored in Port Curtis have changed with season and probably with natural environmental influences. There is no evidence of impacts associated with anthropogenic influences.

1.0 INTRODUCTION

1.1 *Background*

The Queensland Government has targeted Gladstone for further industrial expansion and, in conjunction with the Gladstone Port Authority (GPA), has identified the requirement of long-term development of Port Curtis waterfront facilities to accommodate this expansion.

The region immediately west of the Calliope River mouth has been prioritized for major development. In an associated development, the GPA has been granted licenses to reclaim a number of tidal wetland areas (mangroves, saltmarshes and sand/mudflats) on the northern side of the Calliope River. Additionally, further development is to occur adjacent to the Fisherman's Landing Wharf and recently in late 1998 an area has been bunded for reclamation.

An estimated 680 hectares of saltmarsh and saltflats will be lost to these reclamation projects (WBM, 1990), as well as the removal of approximately 40 hectares of mangroves. This equates to around 23% of total Port Curtis saltflats/saltmarsh and 1.2% of remaining mangroves (Houston, 1999). Surviving mangrove areas adjacent to the landfill sites may be indirectly impacted by the reclamation through possible sedimentation processes. Consideration of this possibility prompted the establishment of the Port Curtis Mangrove Monitoring Programme in response to a request from the GPA.

Southern Pacific Petroleum Development (SPPD) is establishing an oil extraction plant in association with oil shale mining in the Targinie region just north of the Calliope River. The SPPD project development and operation has the potential to impact communities in the bay. Consequently, SPPD has joined the GPA in monitoring mangrove communities within Port Curtis.

Additionally, the impact of a severe hailstorm, which struck mangroves near the Calliope River in 1994, provided the opportunity to observe the effects of natural environmental impacts on the mangroves. Hence, the hail affected mangrove community was included in the monitoring programme.

1.2 Aims and objectives

The general aim of the programme is to consider the health of the mangrove communities associated with the proposed development. The objectives of this monitoring programme include:

- To monitor the impacts of land reclamation on mangrove environments north of the Calliope River and bordering the wharf development areas at the Calliope River mouth and QCL Fisherman's Landing Wharf;
- To compare the health of these mangroves with the established reference communities on Curtis Island;
- Comparison with additional sites established for SPPD and the Stuart Oil Shale IAS, and
- To monitor the effects of a severe hailstorm which struck mangrove areas north of the Calliope River in October, 1994.

1.3 Study area

The area under study extends west from the Calliope River mouth at 23°50' S and 151°12' E with an additional sentinel site situated very close to the northern bund wall at Fisherman's Landing Wharf at 23°48' S and 151°10' E (Figure 1& 2). Reference sites are located opposite the study area on Curtis Island (Figure 1).

Climate is subtropical and annual rainfall is approximately 1000mm with most falling in the summer months, January and February generally the wettest, and least in August and September (Bureau of Meteorology, Brisbane). Average temperatures range from 20.5°C to 31°C in summer and 13.1°C to 23°C in winter. Evaporation rates exceed rainfall.

Zonation and community structure of sentinel site mangroves varies slightly but the general pattern (QDEH/EPA, 1994; Houston, 1995) is as follows:

1. ***Avicennia* Forest zone** – *Avicennia marina* occurs intermittently as a narrow fringe along the seaward margin of the mangroves. This species is virtually absent from the low inter-tidal region at the mouth of the Calliope and the fringe just north of Fisherman's Landing Wharf.
2. ***Rhizophora* Forest Zone** – This zone tends to be reasonably broad and is dominated by *Rhizophora stylosa*. Also known as the mid-high inter-tidal zone, this forest is frequently inundated at high tide.
3. ***Rhizophora* Scrub Forest** – This zone is broad and dominated by *Rhizophora stylosa* growing as a thicket rather than open forest. Tidal inundation is less frequent particularly on the landward margins of this zone where *Ceriops tagal* and, in places, *Avicennia marina* are frequently present.
4. **Heath Zone** – This zone is highly variable and usually quite narrow, sometimes absent. Situated in the high inter-tidal landward margin of the mangrove band, tidal inundation is infrequent and dominant species include mixed associations of *Ceriops tagal*, *Rhizophora stylosa*, *Avicennia marina* with some *Aegilitis annulata* and *Lumnitzera racemosa* in places.
5. **Saltflat** – Broad expanse of hypersaline claypan virtually devoid of vegetation. Some colonisation of these pans by samphire (*Halosarcia* sp. and *Sueda australis*).
6. ***Sporobolus* grassland** – Patches of the grass species *Sporobolus virginicus* occurs in some places associated with other halophytic species such as samphires and usually colonising a

beach ridge where present. On the landward fringe of the Calliope River mangrove sites, saltflats were observed to continue behind the *Sporobolus* beachridge.

7. **Landward Zone** – This zone occurs at the landward extreme bordering terrestrial vegetation where tidal inundation is infrequent. Monospecific zones of *Ceriops tagal* characterise this zone west of the Calliope River mouth. North of Fishermans Landing Wharf, mixed associations of *Ceriops tagal*, *Lumnitzera racemosa*, *Aegilitis annulata*, *Osbornia octodonta* and occasionally, *Aegiceras corniculatum* (associated with channel flows) were observed.

Although the reference sites on Curtis Island had similar species composition and general community structure to the mainland sites, zonation was different, particularly in the higher intertidal areas. Some of the differences observed were:

1. The heath zone was very limited on Curtis Island due to the abrupt increase in topography at most sites. *Bruguiera gymnorhiza* was observed to be more prevalent in the narrow heath fringes present.
2. Dense *Rhizophora* scrubs abutting large flats were common at the southern Curtis Island mangrove forests.
3. *Aegiceras corniculatum* grew more prolifically, particularly near the Graham Creek G sites.
4. *Avicennia marina* was more common at the low inter-tidal fringes.

2.0 MATERIALS AND METHODS

2.1 The mangrove monitoring strategy

Collection of baseline data started prior to the onset of reclamation works in June, 1994. Details of the initial design of the programme were reported in February, 1996 (Houston, 1996a) and a progress report submitted in August (Houston, 1996b).

Site classification was based primarily on community structure and canopy cover with most plots installed in *Rhizophora* forest and scrub due to the relatively uniform distribution of this species in Port Curtis. *Avicennia marina* and *Ceriops tagal* generally occurred as sub-dominant species in many landward plots with the exception of two sites where *Ceriops tagal* was dominant. Plots

have been grouped into three forest (Sentinel, Reference 1, and Reference 2) and two scrub (Sentinel and Reference) sites for analysis. Figure 1 shows the locations of sites around Port Curtis and Figure 2 details the locations of Calliope River Sentinel Sites. Table 1 details the classification of plots according to site. The date at which each plot was established is listed as the “start code”.

Table 1. Summary of site characteristics. See Figure 1 for locations.

Site	Plot	Start Code	Size (m)	Community Structure / Dominant Species	Location	Tidal Aspect
Sentinel Forest	B5	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Wiggins Channel	Seaward
	B8	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Wiggins Channel	Seaward
	B10	96-3	10x10	Forest / <i>Rhizophora stylosa</i>	Calliope River mouth	Seaward
	B11	96-3	10x10	Forest / <i>Rhizophora stylosa</i>	Calliope River mouth	Seaward
	D1	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	QCL	Seaward
Reference Forest 1	C1	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (Tide Bay)	Seaward
	C2	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (Tide Bay)	Seaward
	C3	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (Garden Bay)	Seaward
	C8	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (Garden Bay)	Seaward
Reference Forest 2	G1	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (Graham Creek)	Seaward
	G2	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (Graham Creek)	Seaward
	G3	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (South-west)	Seaward
	G4	96-1/2	10x10	Forest / <i>Rhizophora stylosa</i>	Curtis Island (South-west)	Seaward
Sentinel Scrub	B1	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Landward
	B2	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Creekward
	B3	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Landward
	B9	96-3	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Landward
	B12	96-4	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Landward
	B13	96-4	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Landward
Reference Scrub	C4	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Curtis Island (Garden Island)	Landward
	C5	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Curtis Island (Crabpot Bay)	Landward
	C6	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Curtis Island (Tide Bay)	Landward
	C7	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Curtis Island (Tide Bay)	Landward
Hail Affected	B4	96-1/2	5x5	Scrub / <i>Rhizophora stylosa</i>	Calliope River (Bund wall)	Landward
	B4a	96-1/2	10x10	Mixed Heath / no dominant sp.	Calliope River (Bund wall)	Landward
	B6	96-1/2	5x10	Scrub / <i>Ceriops tagal</i>	Calliope River mouth	Landward
	B7	96-1/2	10x10	Mixed Heath / <i>Ceriops tagal</i>	Calliope River mouth	Landward
SPPD Study	NFP	97-4	10x10	Forest / <i>Rhizophora stylosa</i>	North of Friend Point	Seaward
	GC	97-4	10x10	Forest / <i>Rhizophora stylosa</i>	Gully C	Seaward
	SC	97-4	10x10	Forest / <i>Avicennia-Ceriops-Rhizophora</i>	Scrubby Creek (Targinie)	Seaward

2.2 The monitoring programme

Sampling protocols were based largely on methods outlined in English, Wilkinson and Baker (1994).

2.2.1 Permanent plots

Plot sizes were determined by the density of the trees and ranged from 10 x 10 m in the *Rhizophora* Forest Zone to 5 x 5m in the *Rhizophora* Scrub Zone. Larger plot sizes were necessary in the former due to wider tree spacing.

The plots were marked by corner pegs, (1.5m tomato stakes with painted white tops) with the perimeter marked by surveyors tape. Quantitative data was obtained on the condition of the plots by the record of the following variables:

- One corner of the plot was marked as the origin co-ordinate (0,0) from which the location and species of each plant was mapped in terms of its XY co-ordinates.
- Individual plants were classified into plant classes according to the following definitions:
 1. Shrub – applied only to scrub and heath mangrove types (>25mm DBH - if <1.3m high must be multi-stemmed);
 2. Tree – applied only to forest mangrove types (>24mmDBH);
 3. Sapling - (<24mm DBH or >10mm basal diameter - if it was in a scrub plot then it had to be clearly distinguishable as an individual plant);
 4. Seedling – (<130cm high and <10mm basal diameter).
- A FPC (foliage projective cover) tube was used to estimate the canopy density. Twenty five readings were taken along each of the four sides of the plot perimeter (to avoid trampling the plot) giving a total of 100 readings per plot. The viewer recorded what was seen through the tube as sky, branch or leaf and these were then converted to percentages.
- Stainless steel screws and tags were positioned in tree stems at breast height (~1.2m) in forest sites. These allowed identification of individual plants and served as a reference point from which measurements of girth and sedimentation/erosion (nail heights) were taken.

Measurements of girth were taken with a tailors tape and Vernier callipers and used to record basal diameters and diameters at breast height. Basal area was calculated by dividing the summed means of live tree girth measurements by the plot area and given as the area covered by mangrove stem in (m^2) per hectare. Sedimentation/erosion was recorded by taking the vertical distance from the screw to the sediment surface with a measuring pole (1cm graduations).

- Seedlings were tagged and dated, with height, basal diameter, a health rating and number of nodes recorded.
- A sediment corer was used to obtain sediment samples at 0-5cm and 15-20cm in depth. These samples were then processed to determine particle size distribution and combustible matter. The basic colour and surface tint and texture of the sediment were recorded.
- Rates of leaf fall were measured quarterly using 3 litter traps in each plot - 1m x 1m square with tubular PVC frames to which tapering bags of shade cloth were attached (Duke *et al.*, 1981). These were suspended in the canopy (above the high water mark) within close proximity to the plot. Litter collected in these traps was separated into components (leaves, stipules and reproductive parts). Components were counted and oven dried at 70°C for 72 hours and weighed. Productivity was calculated as dry weight of litter per square metre per day. Shoot production was assessed for *Rhizophora* sp. by determining the dry weight of stipules (the shoot emerges within a stipule pair which protects the new growth) found in the leaf litter (grams/day). Flowers in traps were tallied and their means calculated for each plot.

2.3 Sediment physical characteristics

2.3.1 Air dry moisture content

Sediment samples were obtained by pooling three samples extracted using a stainless steel corer at each site. Prior to the analysis of particle size distribution, the moisture content of air dry soil was determined to correct for the extra mass of water present in air dried samples (Bruce and Rayment, 1982). About 100g of air dried sediment from each mangrove site was weighed and placed in an oven at 105°C until constant mass was achieved through subsequent weighing. Air dry moisture content was taken as the water remaining in the air dry sample expressed as a percentage of the oven dry sample mass (AS1289. B1.1, 1977).

2.3.2 Particle size analysis

Approximately 100 g¹ of air dried sediment was ground with mortar and pestle so as to retain discreet particles. The resultant sample was weighed and then sieved through an agitated stack of Endecott test sieves with apertures of 2mm, 1mm, 500µm, 250µm, 125µm and 63µm respectively. After dry sieving², the sediment fractions remaining on the sieves were then moistened with sodium hexametaphosphate dispersing solution³ and allowed to stand for approximately one day. The resultant slurry was then hand washed through the sieve stack until the wash water was clear and the remaining material air dried at 40°C until constant mass was reached. Each fraction's mass was calculated as a percentage of the total sample mass and corrected for air dry moisture content. The fraction less than 63µm was calculated as the difference between the sum of the fractions greater than 63µm and the total mass of the sample (AS 1289. C6.1, 1977).

¹For sediment with a range of very coarse to fine particles, at least one kilogram of sediment is needed to establish a more accurate distribution

²The dry sieving process is only applicable for coarse sediment. Sediment with a mixture of very coarse and fine particles may undergo both dry and wet sieving.

³Sodium Hexametaphosphate was initially diluted with demineralised water at 40mL/1000mL to make a stock solution. This was further diluted at 100mL/500mL to wash the sediment.

3.0 RESULTS and DISCUSSION

3.1 Leaf litter & plant measurements – (growth, productivity and shoot production)

3.1.1 Productivity

Figure 3. Leaf litter production for Sentinel Forest site at the Calliope River.

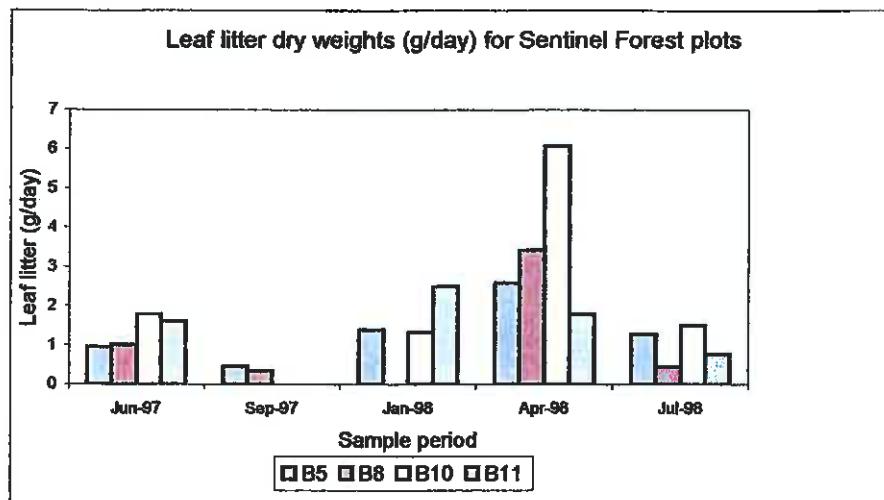


Figure 4. Leaf litter production for Reference Forest 1 site at Curtis Island

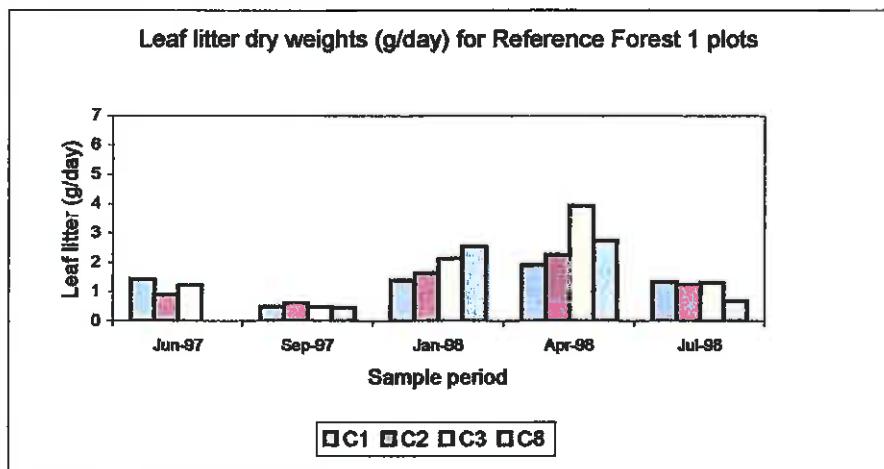


Figure 5. Leaf litter production for Reference Forest 2 site at Graham Creek and south-west Curtis Island.

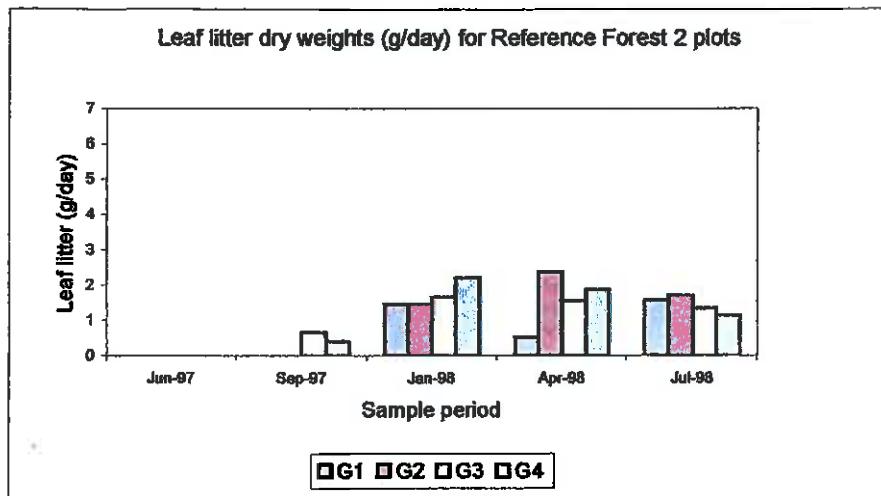


Figure 6. Leaf litter production for Sentinel Scrub site at the Calliope River (bund wall).

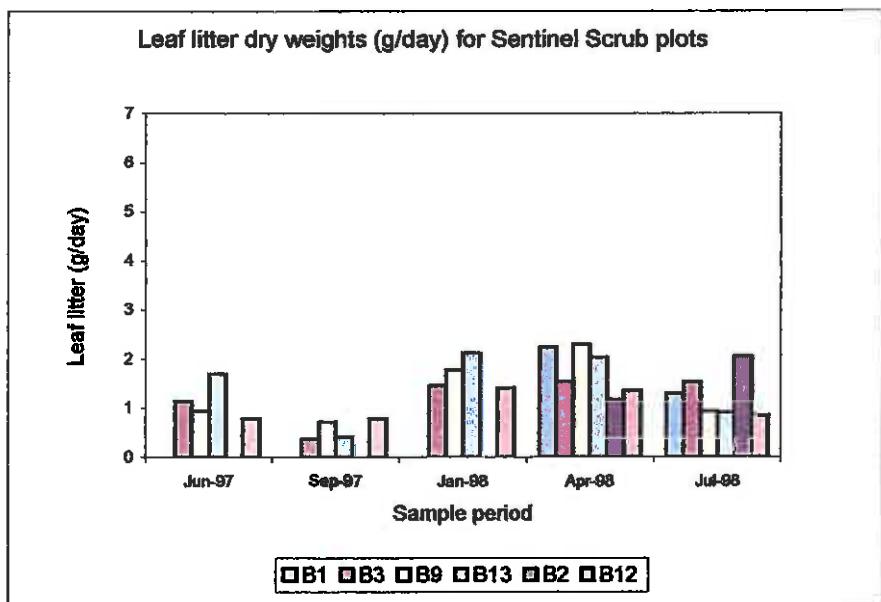
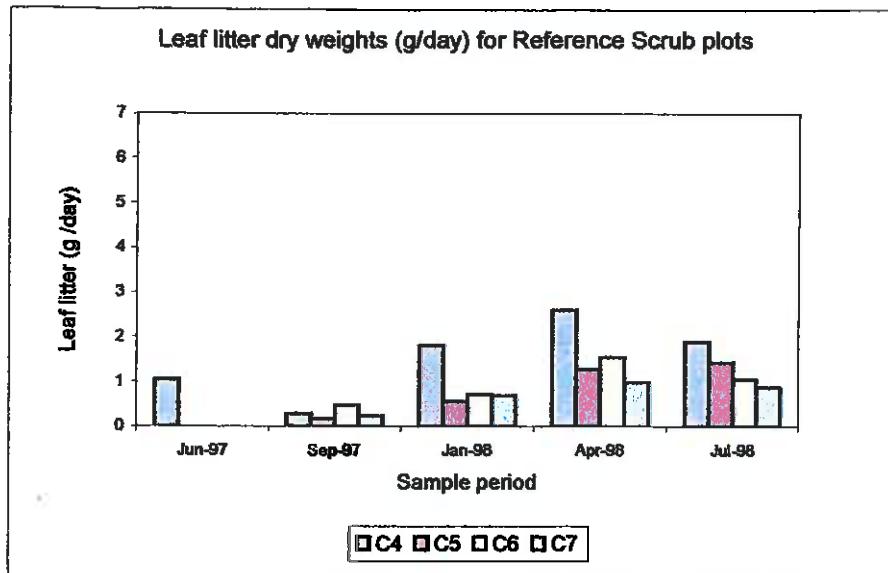


Figure 7. Leaf litter production for Reference Scrub site at Curtis Island.



Leaf litter production varied seasonally within forest and scrub sentinel and reference sites. Litter production peaked in Autumn. Rates of production varied within and between sentinel and reference sites (Figures 3 - 7).

3.1.2 Shoot production

Figure 8. Shoot (stipule) production for Sentinel Forest site at the Calliope River.

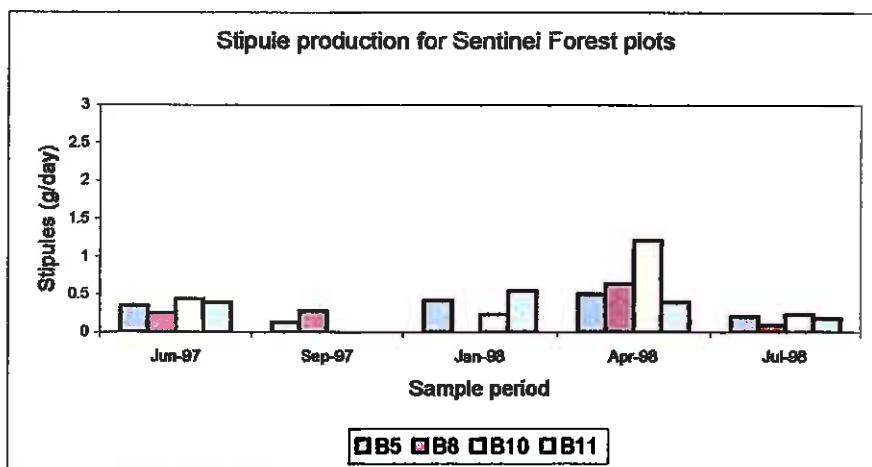


Figure 9. Shoot (stipule) production for Reference Forest 1 site at Curtis Island.

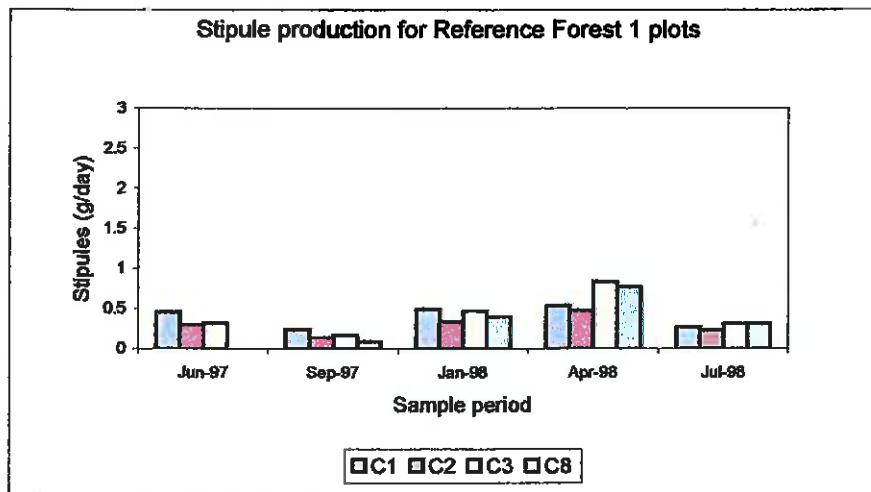


Figure 10. Shoot (stipule) production for Reference Forest 2 site at Graham Creek and south-west Curtis Island.

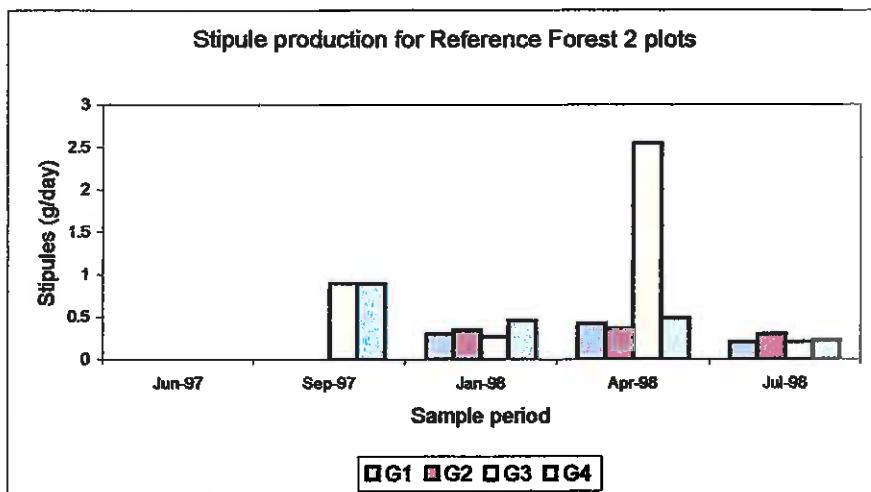


Figure 11. Shoot (stipule) production for Sentinel Scrub site at the Calliope River (bund wall).

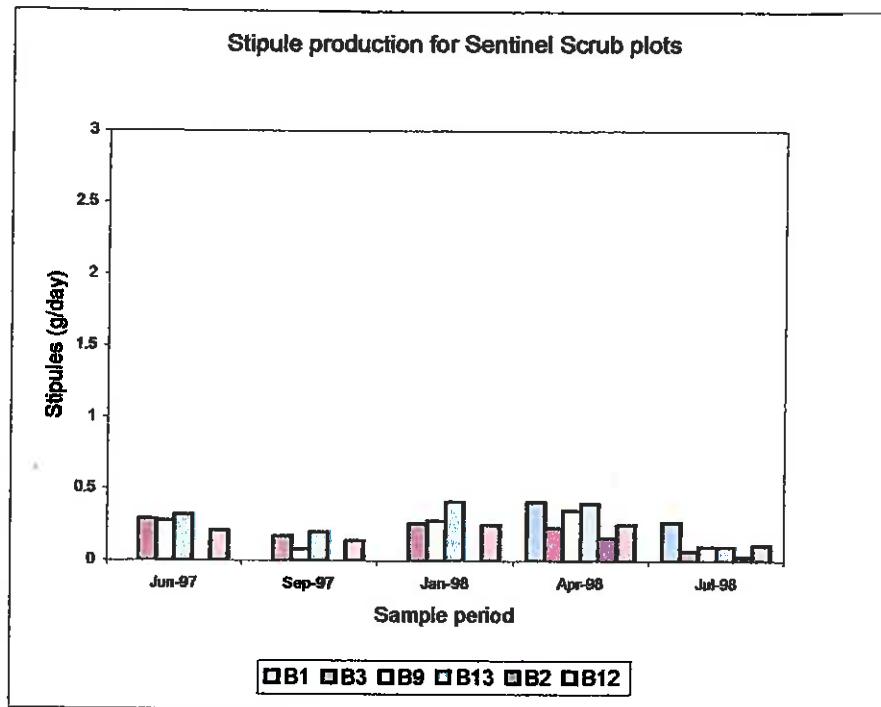
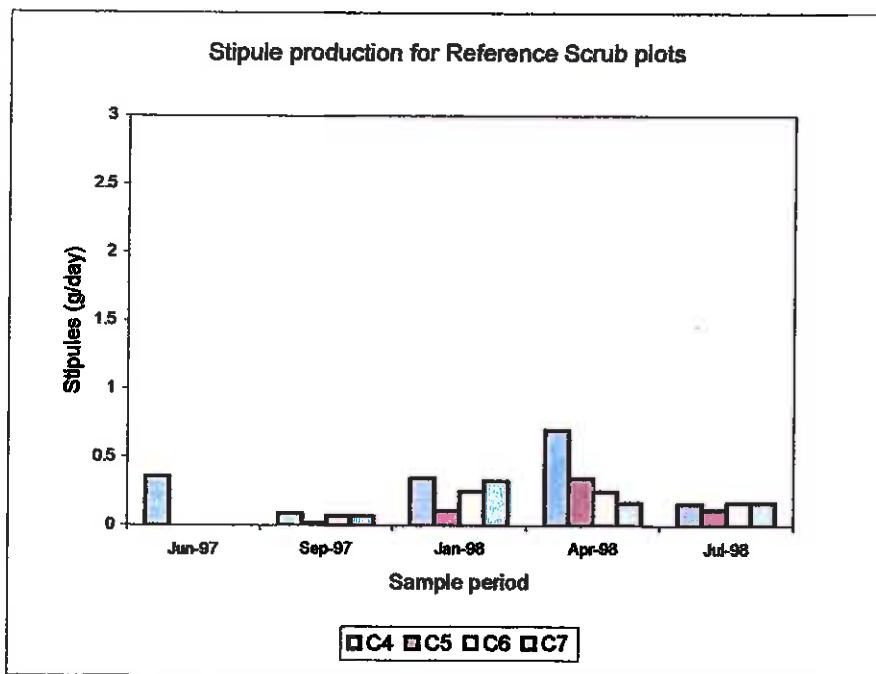


Figure 12. Shoot (stipule) production for Reference Scrub site on Curtis Island.



Stipule production (Figures 8 – 12) and hence shoot production followed a seasonal pattern similar to that of litter fall. Patterns were similar between reference and sentinel sites.

3.1.3 Flower production

Figure 13. Flower production for Sentinel Forest site at the Calliope River.

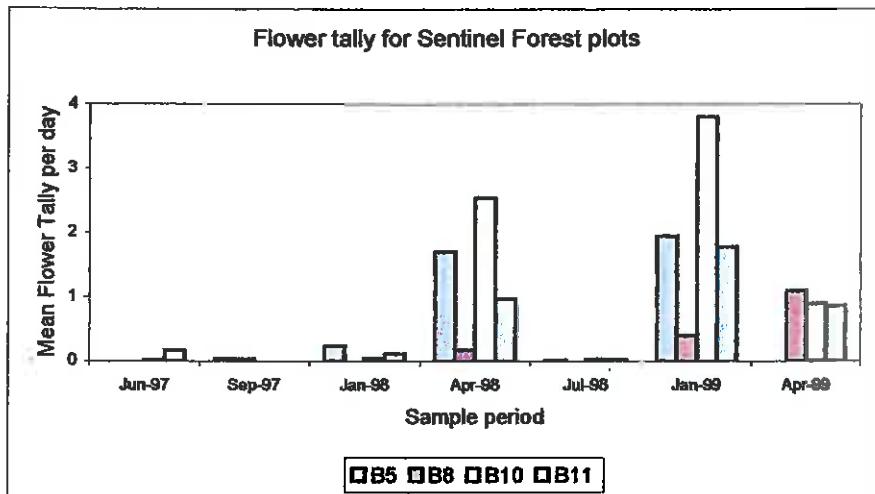


Figure 14. Flower production for Reference Forest 1 site at Curtis Island.

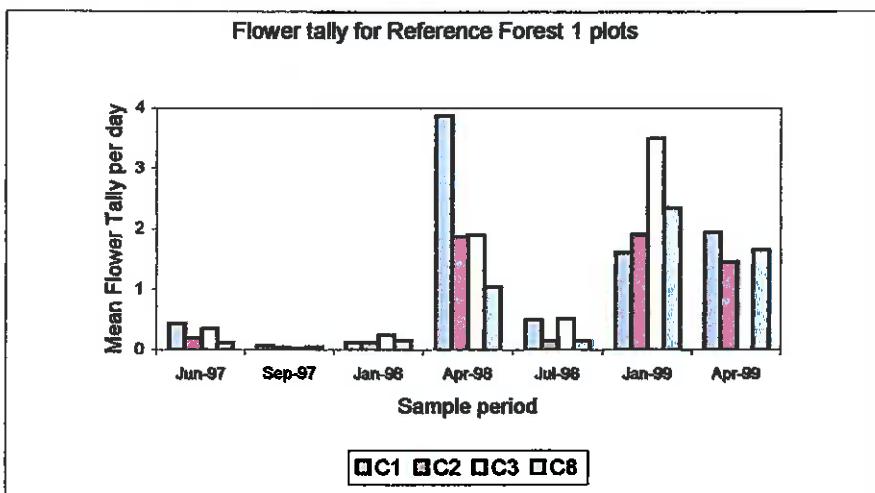


Figure 15. Flower production for Reference Forest 2 site at Graham Creek and south-west Curtis Island.

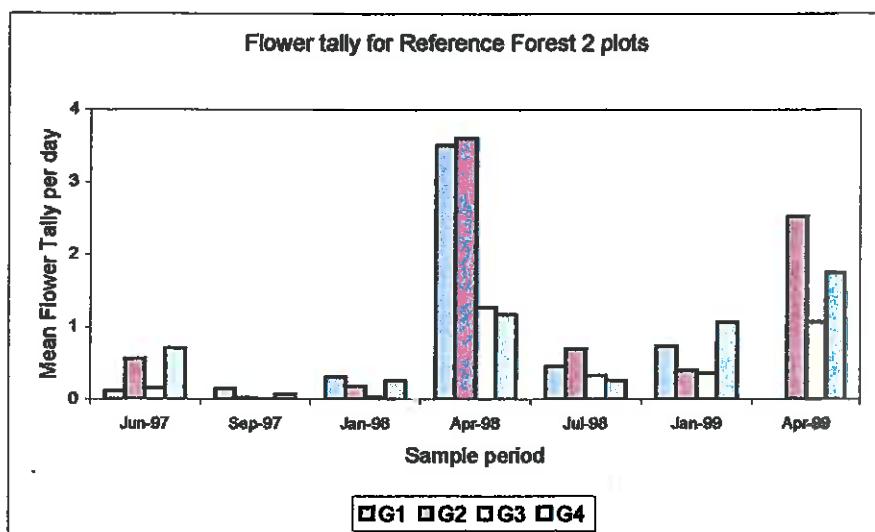


Figure 16. Flower production for Sentinel Scrub site at the Calliope River (bund wall)

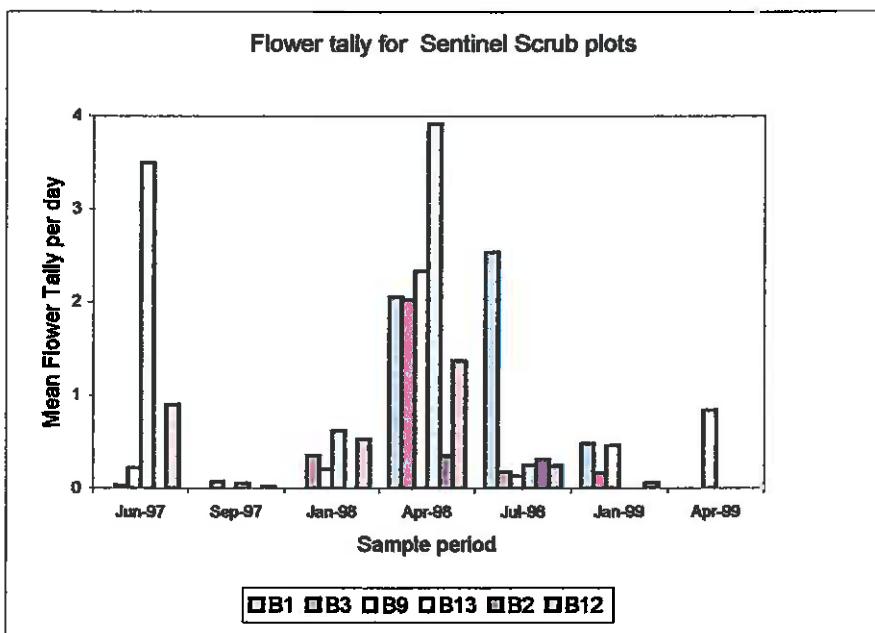
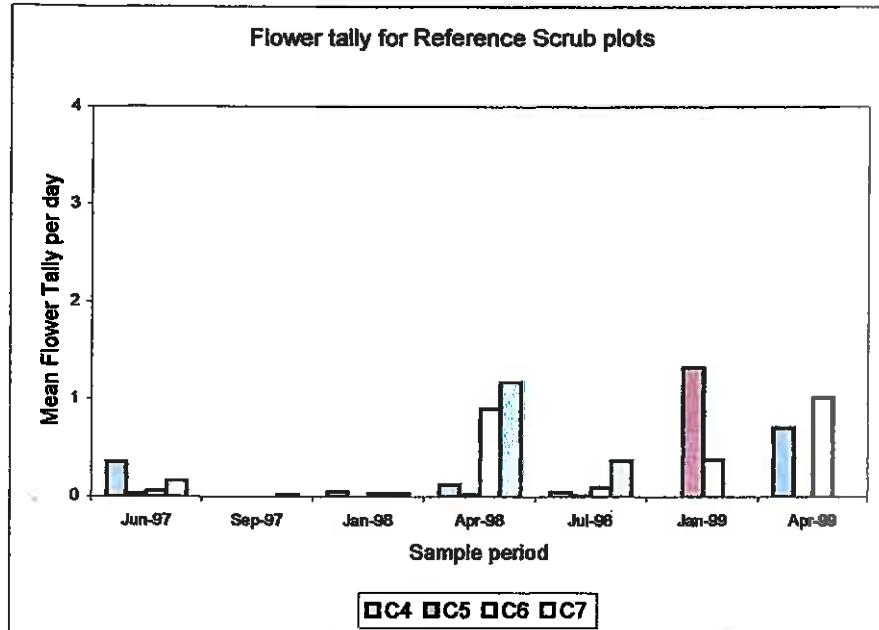


Figure 17. Flower production for Reference Scrub site at Curtis Island.



Flower drop occurred on the same basis as stipule and leaf litter fall. Again there was no obvious difference in flower production between reference and sentinel sites. However, there were some reference and sentinel sites (Sentinel Forest and Reference Scrub, Figures 13 and 17) where flower production was less than other sites.

3.1.4 Basal area

Table 2. Live basal area at breast height (m²/Ha)

Site	96-1/2	96-3	97-1	97-3	97-4	98-2	99-1
Sentinel Forest	22.1	22.4	22.6	21.7		21.2	25.5
Reference Forest 1	47.2	39.4	40.9	42.1		40.8	42.4
Reference Forest 2	48.5	40.8	NA	41.9		39.3	39.3
Sentinel Scrub	20.5	17.7	19.4	18.6		20.3	23.4
Reference Scrub	23.2	25.8	24.4	22.3		19.8	25.7
Hail-affected SPPD site	1	1.3	0.9	1.4		1.4	1.7
					27.3	25.9	25.8

Live basal area at all sites varied slightly from 1996 to 1999. No consistent changes are evident and, although there are differences between sites, they have not changed over time (Table 2).

3.2 Foliage projective cover (FPC)

Table 3. Percent FPC for Sentinel Forest – Calliope River

Plot	Apr-96	Sep-96	Mar-97	Sep-97	Apr-98	Jul-98	Feb-99
B5	39	37	41	40	43	46	NA
B8	NA	23	NA	35	NA	32	24
B10	38	41	38	42	45	50	49
B11	NA	49	47	49	50	51	49
D1	44	58	35	28	45	49	41
Average	40.3	41.6	40.3	38.8	45.8	45.6	40.8
SD	3.21	13.15	5.12	7.85	2.99	7.83	11.79

Table 4. Percent FPC for Reference Forest 1 – Curtis Island

Plot	Jun-96	Sep-96	Mar-97	Sep-97	Jul-98	Mar-99
C1	53	47	38	35	46	37
C2	58	45	39	37	60	57
C3	65	50	49	48	67	50
C8	42	37	32	34	58	46
Mean	54.5	44.75	39.5	38.5	57.75	47.5
SD	9.68	5.56	7.05	6.45	8.73	8.35

Table 5. Percent FPC for Reference Forest 2 – Graham Creek and South-west Curtis Island

Plot	Jun-96	Sep-96	Sep-97	Mar-98	Jul-98	Mar-99
G1	59	50	41	50	65	55
G2	50	51	36	50	71	51
G3	55	50	36	53	63	54
G4	46	55	42	58	62	70
Average	52.5	51.5	38.75	52.75	65.25	57.5
SD	5.69	2.38	3.20	3.77	4.03	8.50

Table 6. Percent FPC for Sentinel Scrub – Calliope River

Plot	Apr-96	Jul-98	Jan-99
B1	40	44	44
B2	54	50	32
B3	62	30	34
B9	42	52	42
B12	NA	34	38
B13	NA	52	54
Average	50	44	41
SD	10.38	9.58	7.97

Table 7. Percent FPC for Reference Scrub – Curtis Island

Plot	Jun-96	Jul-98	Feb-99
C4	38	32	22
C5	42	36	52
C6	34	28	26
C7	38	32	46
Average	38	32	36.5
SD	3.27	3.27	14.73

Foliage projective cover in the Port Curtis mangroves ranged from 32% to 65% cover. The Reference Scrub site (Table 7) had the least cover and cover was greatest in the Reference Forest 2 site (Table 5). FPC varied over time with the lowest percentage occurring in September 1997 at the three sites where data is available (Tables 3,4 and 5). Data from the Hail-affected site is being reviewed and will be reported later.

3.3 Sediment

3.3.1 Sediment physical characteristics

Data is presented in the following tables for particle size distribution within the mangrove site sediments. Standard deviation from the mean indicates the magnitude of variation within the size fraction of the sample between sampling periods. A basic description of the sediment is provided for simplicity. Data showing comparison of particle size distributions between sampling periods is tabulated in Appendix 1.

Table 8. Mean sediment particle size distributions and standard deviations for Sentinel Forest.

Sentinel Forest Plots	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm	Description
B5	Mean %	63.69	7.87	14.07	7.83	2.68	0.71	3.16
	S.D.	10.65	1.11	1.85	6.23	1.65	0.25	1.77
B8	Mean %	37.50	6.15	7.35	4.65	4.79	19.00	20.58
	S.D.	16.60	0.01	0.72	0.76	0.38	14.71	2.24
B10	Mean %	63.99	11.97	6.80	6.64	8.64	1.05	0.93
	S.D.	8.46	1.53	1.63	2.35	4.75	0.69	0.57
B11	Mean %	67.06	12.07	6.74	6.36	7.31	0.39	0.10
	S.D.	9.14	3.40	0.12	2.74	2.61	0.22	0.05
D1	Mean %	38.71	13.69	13.83	13.70	3.82	3.38	12.89
	S.D.	10.11	2.80	2.45	4.21	0.49	0.21	0.36

Table 9. Mean sediment particle size distributions and standard deviations for Reference Forest 1

Reference Forest 1 Plots	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm	Description
C1	Mean %	23.11	10.44	25.95	9.68	7.55	9.23	14.04
	S.D.	11.93	2.71	6.80	2.53	2.66	4.23	3.04
C2	Mean %	48.01	20.11	27.47	1.89	1.19	0.74	0.59
	S.D.	26.30	8.41	16.84	0.89	0.58	0.29	0.53
C3	Mean %	58.00	29.92	7.96	2.90	0.49	0.31	0.44
	S.D.	6.52	8.41	1.15	0.79	0.11	0.02	0.18
C8	Mean %	17.67	31.75	28.99	14.66	3.62	1.49	1.84
	S.D.	16.79	16.66	14.95	15.32	3.35	0.73	0.90

Table 10. Mean sediment particle size distributions and standard deviations for Reference Forest 2

Reference Forest 2 Plots		Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm	Description
G1	Mean	32.04	11.70	17.23	13.06	6.14	6.43	13.40	Sandy mud
	S.D.	24.73	1.17	5.64	6.60	3.22	3.93	6.81	
G2	Mean	65.02	10.63	14.28	7.04	1.15	0.78	1.09	Mud
	S.D.	8.84	2.32	3.90	2.19	0.60	0.86	1.44	
G3	Mean	45.30	9.99	19.04	10.46	4.48	4.95	5.80	Sandy mud
	S.D.	2.28	0.03	0.00	3.22	1.92	1.68	4.50	
G4	Mean	52.24	15.10	15.23	9.71	3.91	1.01	2.80	Sandy mud
	S.D.	6.37	0.79	2.05	5.55	2.16	0.72	0.80	

Table 11. Mean sediment particle size distributions and standard deviations for Sentinel Scrub

Sentinel Scrub – Calliope River		Clay and Silt <63µm	Very fine sand 63µm	Fine Sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granules – pebbles 2mm	Description
B1	Mean %	78.29	13.22	4.72	1.69	0.69	0.24	1.16	Mud
	S.D.	8.94	4.19	2.25	0.66	0.25	0.18	1.88	
B2	Jul-98	97.15	2.54	0.25	0.03	0.03	0.00	0.00	Mud
B3	Mean %	97.15	2.54	0.25	0.03	0.03	0.00	0.00	Mud
	S.D.	7.46	0.17	5.20	0.70	0.85	0.18	0.69	
B9	Mean %	79.85	9.12	6.78	1.46	0.68	0.35	1.76	Mud
	S.D.	7.54	3.96	2.74	0.33	0.27	0.09	1.97	
B12	Mean %	74.99	14.42	6.42	2.44	1.02	0.26	0.45	Mud
	S.D.	4.43	3.46	2.20	0.39	0.35	0.21	0.30	
B13	Mean %	92.29	3.20	1.53	0.35	0.18	2.42	0.03	Mud
	S.D.	7.84	2.70	1.10	0.03	0.03	4.05	0.01	

Table 12. Mean sediment particle size distributions and standard deviations for Reference Scrub

Reference Scrub – Curtis Island	Clay and Silt	Very fine sand	Fine Sand	Medium sand	Coarse sand	Very coarse sand 1mm	Granules – pebbles	Description
	<63µm	63µm	125µm	250µm	500µm	1mm	2mm	
C4	Mean	72.45	21.31	3.97	1.11	0.35	0.29	0.53
	S.D.	0.03	2.50	0.99	0.26	0.07	0.40	0.75
C5	Mean	75.30	17.53	3.24	2.01	0.69	0.41	0.82
	S.D.	2.96	2.03	0.83	1.09	0.21	0.03	0.99
C6	Mean	90.00	6.13	2.04	0.84	0.32	0.18	0.50
	S.D.	2.73	2.71	0.29	0.28	0.17	0.07	0.16
C7	Mean	66.41	7.89	8.82	5.46	5.71	3.82	1.90
	S.D.	0.95	3.27	0.83	0.34	0.18	1.19	0.47

Table 13. Mean sediment particle size distributions and standard deviations for Hail-affected site

Hail affected Plots	Clay & Silt	Very fine sand	Fine sand	Medium sand	Coarse sand	Very coarse sand 1mm	Granule – pebble 2mm	Description
	<63µm	63µm	125µm	250µm	500µm	1mm	2mm	
B4	Mean %	80.16	10.53	4.97	1.81	1.07	0.48	1.00
	S.D.	2.76	0.81	1.75	0.02	0.15	0.10	0.03
B4a	Mean %	83.86	8.90	3.04	2.38	1.49	0.24	0.10
	S.D.	0.16	2.12	0.28	0.78	0.49	0.27	0.14
B6	Mean %	78.59	8.14	5.28	4.47	2.72	0.48	0.34
	S.D.	4.59	1.27	0.58	1.03	1.37	0.13	0.21
B7	Mean %	91.19	5.44	2.09	0.81	0.30	0.10	0.08
	S.D.	1.34	0.82	0.47	0.13	0.11	0.01	0.05

Sediment substrates in Sentinel Scrub, Reference Scrub, Hail-affected and Reference Forest 2 sites were predominantly mud (clay/silt). Sentinel Forest plots were similar though D1 (Table 10) near Fisherman's Landing Wharf appeared to have higher proportions of fine sand and B8 (Table 10) bordering Wiggins Channel contained large fractions of coarse sand and shellgrit. Reference Forest 1 plots on Curtis Island were sandy in contrast to the Sentinel plots on the Calliope River.

Particle size distribution within plots remained generally constant though data was limited to one year. The fine fraction (clay/silt) in Reference Forest 1 plots (Table 4 – Appendix 1) declined with the substrate, changing over the year from mud and sandy mud to muddy sand. Sentinel Forest plots also showed some change.

3.3.2 Sedimentation / erosion

Figure 18. Change in height of sediment substrate in Sentinel Forest plots – Calliope River and Fisherman's Landing.

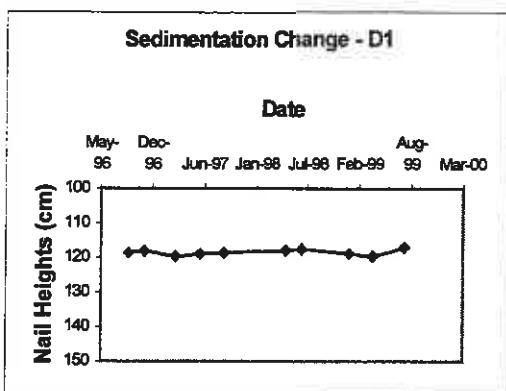
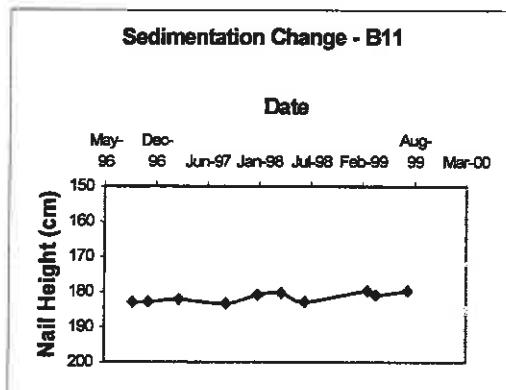
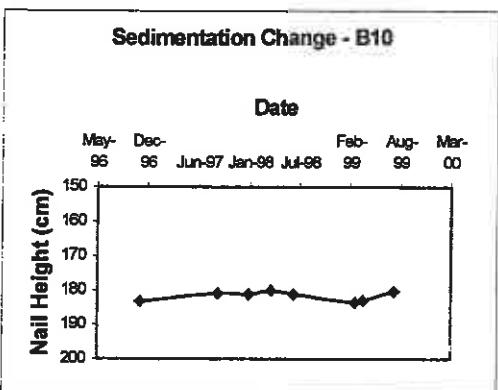
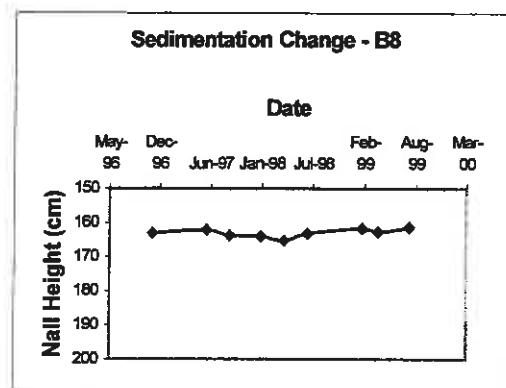
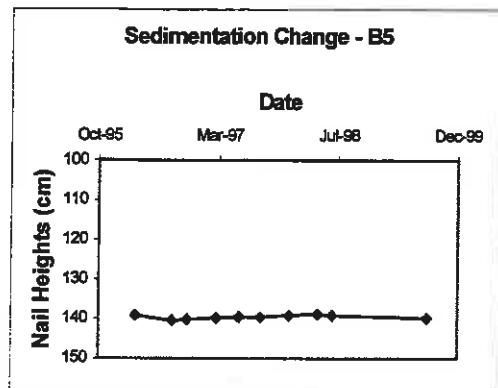


Figure 19. Change in height of sediment substrate in Reference Forest 1 plots – Curtis Island.

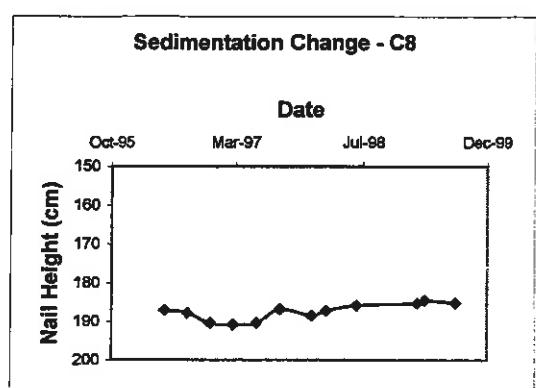
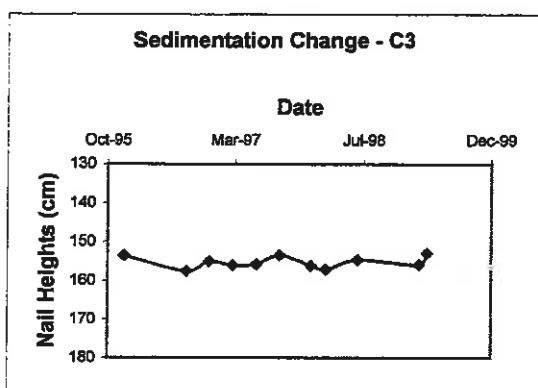
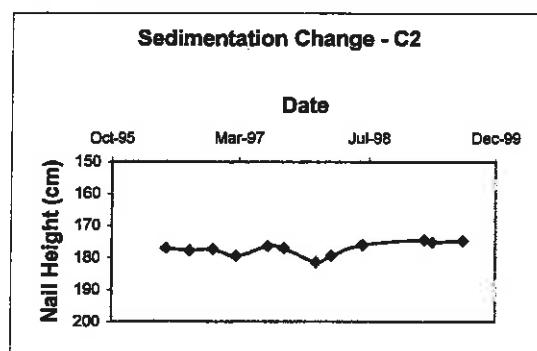
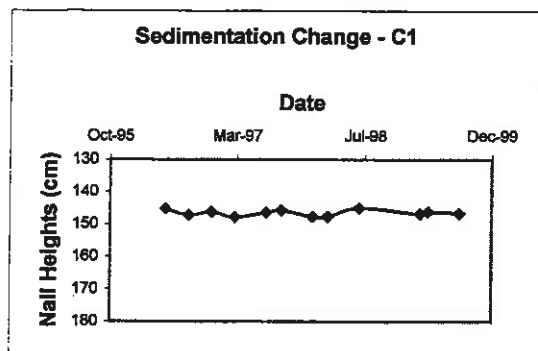


Figure 20. Change in height of sediment substrate in Reference Forest 2 plots – Graham Creek and south-west Curtis Island.

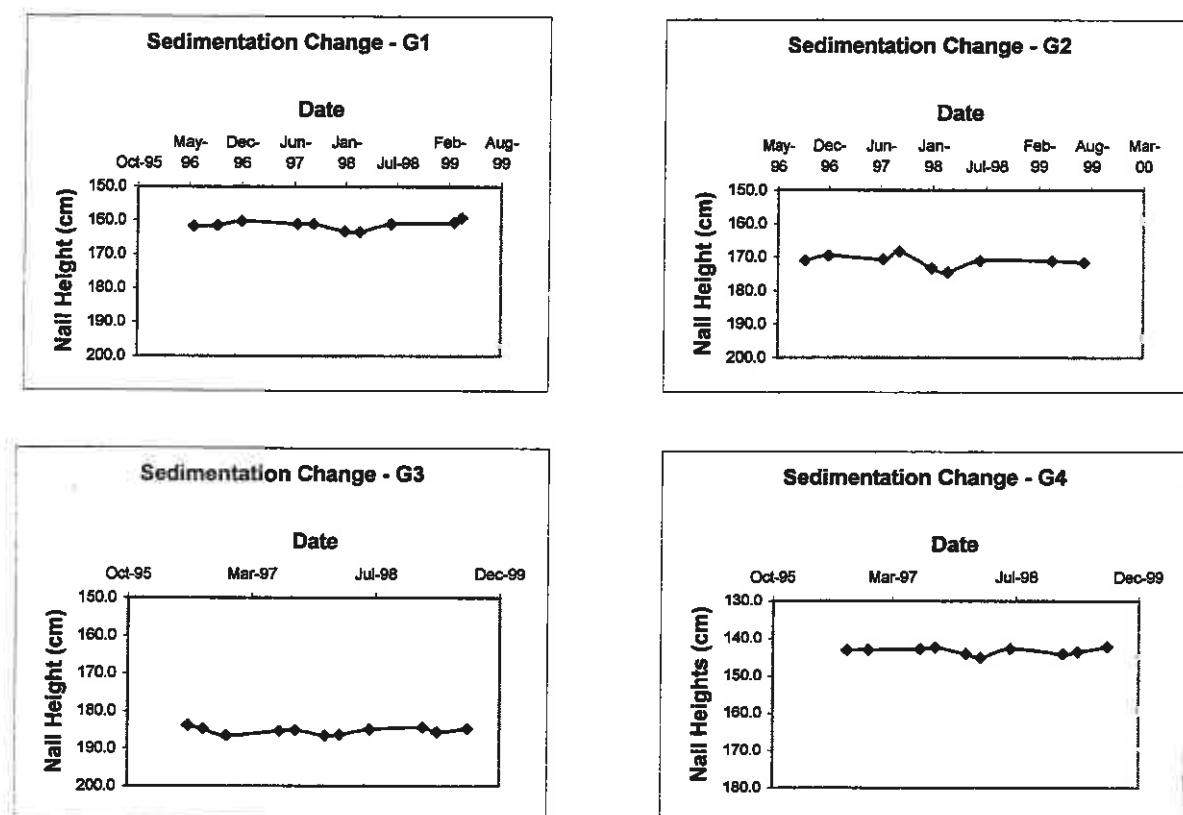


Figure 21. Change in height of sediment substrate in Sentinel Scrub plots – Calliope River (bund wall)

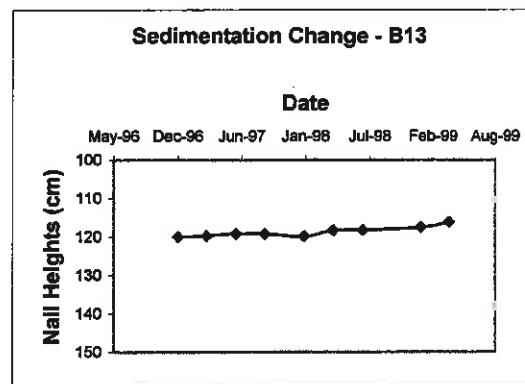
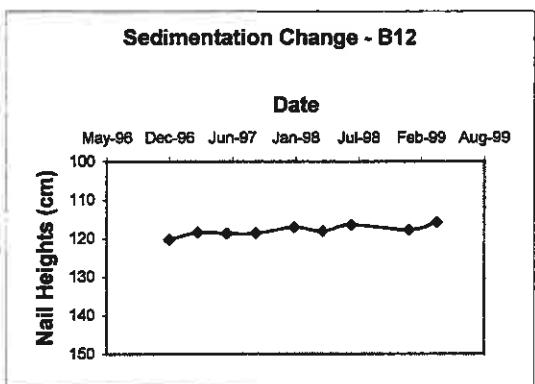
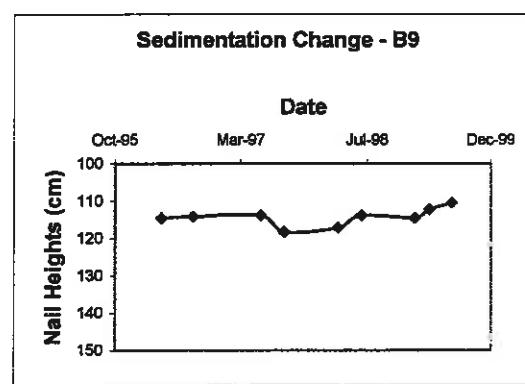
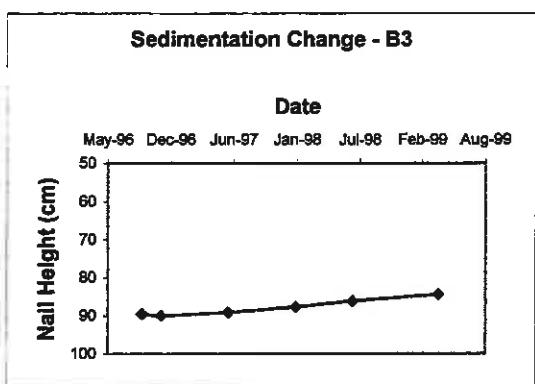
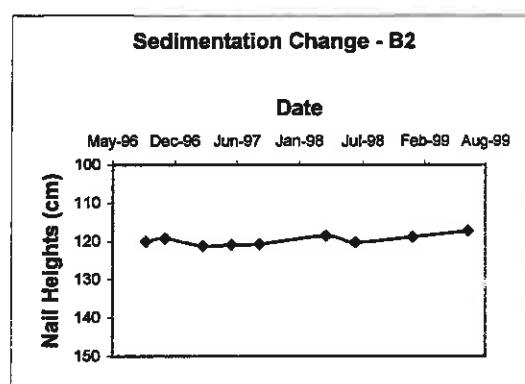
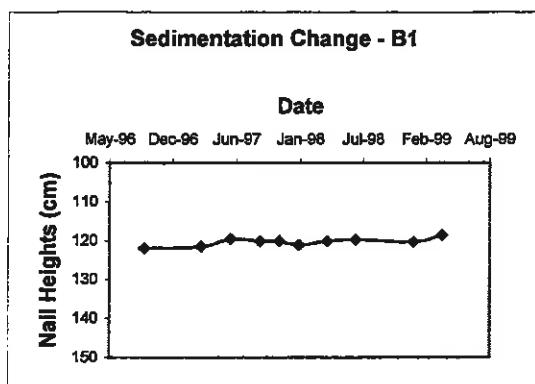


Figure 22. Change in height of sediment substrate Reference Scrub plots – Curtis Island.

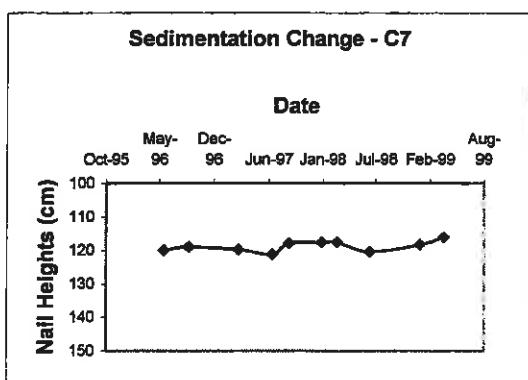
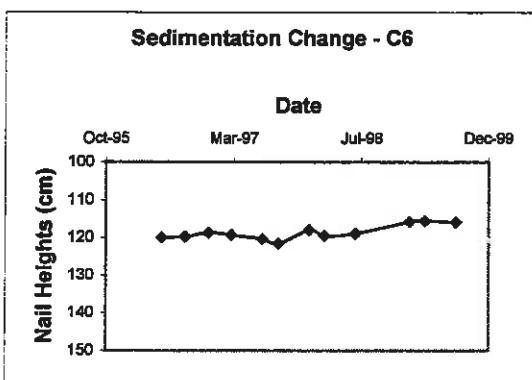
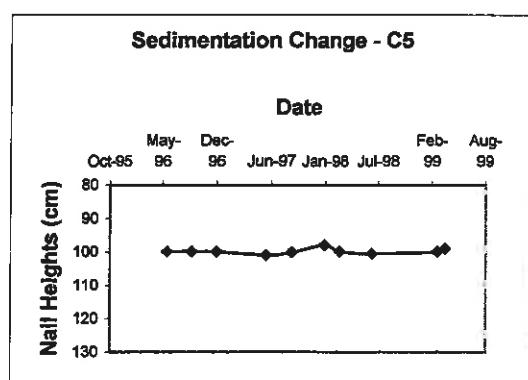
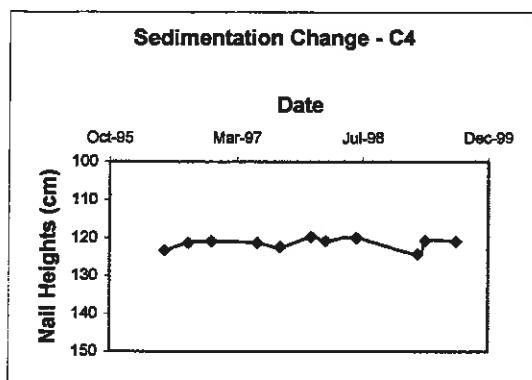


Figure 23. Change in height of sediment substrate in Hail-affected plots – Calliope River (bund wall)

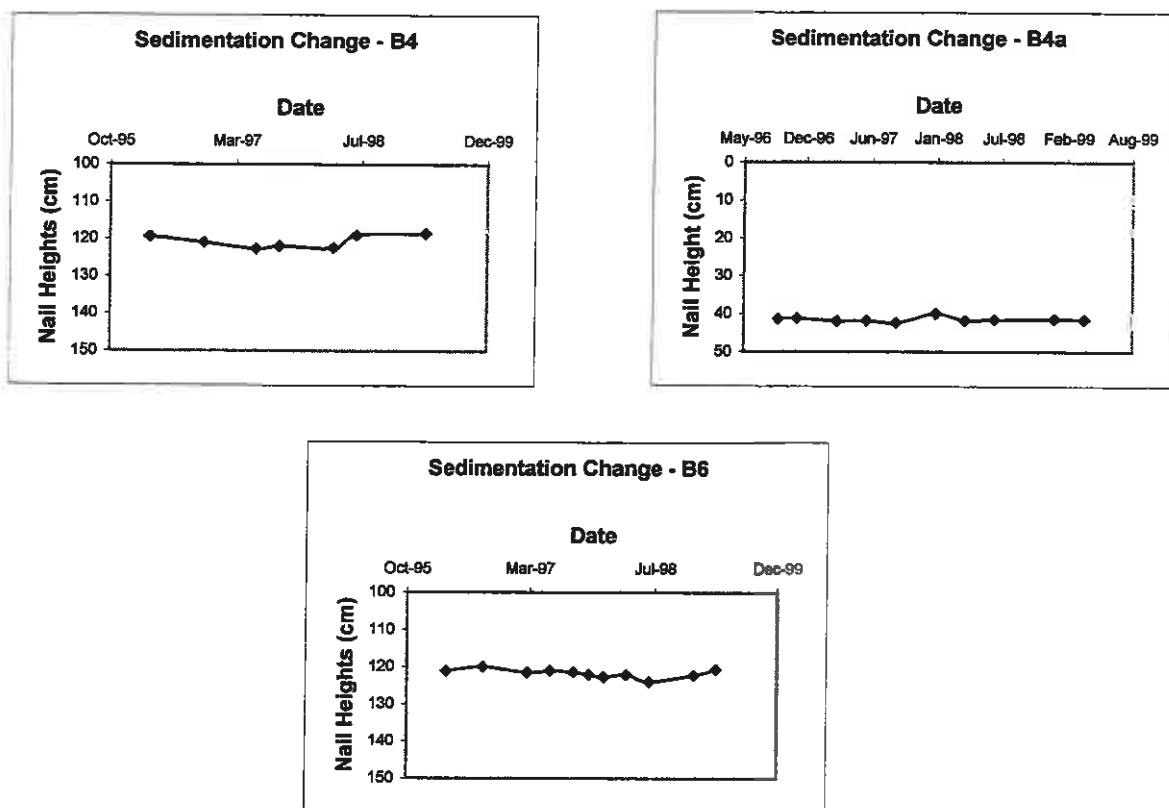


Figure 24. Change in height of sediment substrate in SPPD plots – Targinie.

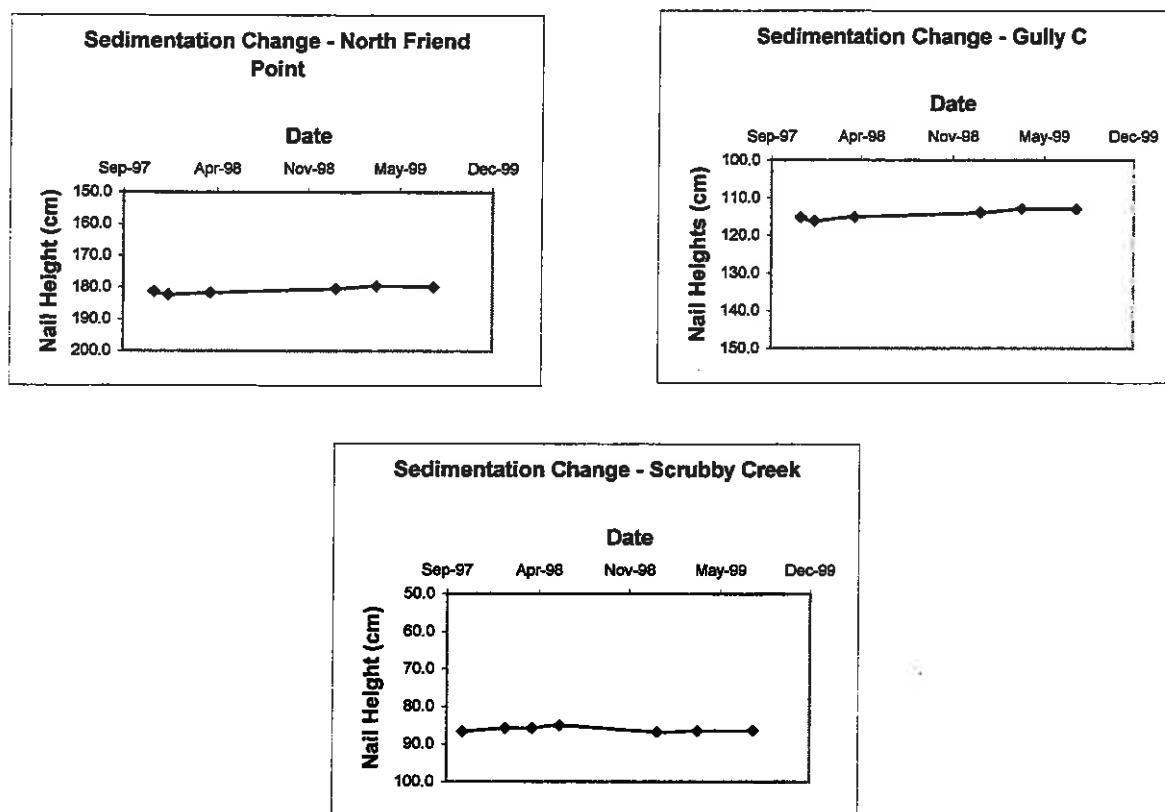


Table 14 : Nail height data (cm) representing sediment height change in Sentinel Scrub mangrove plots excluding plot B3. Site mean and SD are recorded at the bottom of the table. Nail height data for all sites is included in Appendix 2.

B1 Tag	96-3	97-2	97-3	98-2	98-3	99-1	99-2
8	130	126	126	125	125	128	126
84	120	120	125	120	121	118	116
85	120	118	116	120	117	118	115
86	120	116	116	117	118	120	117
87	120	118	118	119	118	118	119
Mean	122	119.6	120.2	120.2	119.8	120.4	118.6
SD	4.47	3.85	4.92	2.95	3.27	4.34	4.39
R2 Tag							
45	123	120	120	118	120	116	116
49	124	120	125	124	124	124	118
60	120	120	120	120	123	128	116
64	114	121	120	115	115	112	115
68	120	118	120	117	119	116	121
75	120	127	120	118	121	118	118
Mean	120.17	121.00	120.83	118.67	120.33	119.00	117.33
SD	3.49	3.10	2.04	3.08	3.20	5.90	2.16
B9 Tag							
1	109	110	112	112	112	110	110
11	117	117	113	113	112	112	110
14	120	120	122	120	115	118	114
15	120	119	120	120	111	112	112
18	120	120	121	120	119	114	117
19	120	120	121	112	115	112	115
2	110	105	115	115	110	110	98
3	110	110	116	120	112	112	110
4	115	113	122	120	120	120	120
6	105	110	120	117	113	120	115
8	110	109	120	120	114	120	115
Mean	114.18	113.91	118.36	117.18	113.91	114.55	112.36
SD	5.55	5.45	3.67	3.52	3.18	4.11	5.71
R12 Tag							
1	120	117	112	110	112	115	110
10	120	120	119	115	112	110	112
11	120	122	122	120	117	122	119
12	120	119	125	120	115	116	109
17	120	118	118	120	117	120	119
19	120	120	120	120	115	110	121
2	120	118	120	120	120	118	121
22	120	118	110	125	121	122	106
27	120	119	120	120	117	122	118
28	120	120	120	120	119	120	120
33	120	120	120	119	118	116	117
34	120	115	115	110	110	115	111
35	120	119	118	120	116	120	118
4	125	124	125	120	119	124	120

5	120	123	123	120	117	120	121
7	120	110	113	110	119	116	112
8	120	117	117	120	117	117	115
Mean	120.29	118.76	118.65	118.18	116.53	117.82	115.82
SD	1.21	3.17	4.24	4.29	2.98	4.02	4.85
B13 Tag							
1	120	120	120	120	119	120	117
10	120	124	122	125	121	120	120
15	120	118	116	116	118	112	115
22	120	120	120	117	119	116	116
23	120	118	120	120	120	120	117
24	120	119	118	120	116	116	115
30	120	120	122	123	121	120	120
31	120	120	119	110	114	112	110
33	120	121	120	120	120	122	120
4	120	120	120	120	119	118	117
5	120	117	120	117	118	116	114
7	120	116	116	110	114	110	111
8	120	118	120	120	118	122	118
9	120	117	116	119	118	122	118
Mean	120	119.14	119.21	118.36	118.21	117.57	116.29
SD	0	2.03	2.01	4.22	2.22	4.01	3.10
Site mean	119.09	118.19	119.13	118.26	117.17	117.45	115.68
Site SD	3.98	4.15	3.47	3.83	3.50	4.47	4.63

Sedimentation has increased significantly ($p<0.0001$) in the Sentinel Scrub site on the Calliope River (Table 14; Figure 21) with a mean accretion of 3.4cm in five plots between samplings in late 1996 and early 1999. Due to the relatively short period of sediment composition analysis, there is insufficient data to suggest sources of this accretion.

At other sites, despite variation over time, there appears to be no net gain or loss of sediment (Figures 18-20, 22-24).

4.0 CONCLUSIONS

Litter (leaf, flower and stipule) fall appears to have occurred seasonally as expected in a healthy mangrove system. No evidence of environmental impact was apparent in this data.

Foliage projective cover declined in September 1997 at sentinel and reference sites suggesting some regional influence. The return to normal levels in subsequent monitoring events suggests the

forests are behaving normally. Differences between sites are consistent over time suggesting no environmental impacts in the sentinel sites.

Sediments appear to be accreting at the Sentinel Scrub site. Reasons for this are not known as yet but the site will be revisited to consider this. However, litter fall and FPC do not indicate any change in community health at this site. Otherwise there is no suggestion of any impacts on mangrove substrates.

Basal area of live stems was different between sites but generally constant over the three years of monitoring. There is no evidence of changes in live tree cover associated with the sentinel sites relative to the reference sites.

Generally, the mangrove communities monitored in Port Curtis have changed with season and probably with naturally occurring environmental influences. There is no evidence of impacts associated with anthropogenic influences.

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APPENDIX 1

Table 1: Particle Size distributions, means and standard deviations of sediment in Sentinel Scrub Site.

Sentinel Scrub Plots	Sample Date	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm
B01	Jan-98	68.31	18.05	6.76	2.22	0.93	0.40	3.33
B01	Apr-98	81.01	10.90	5.08	1.89	0.70	0.26	0.16
B01	Jul-98	85.55	10.70	2.31	0.95	0.44	0.05	0.00
Mean		78.29	13.22	4.72	1.69	0.69	0.24	1.16
SD		8.94	4.19	2.25	0.66	0.25	0.18	1.88
B02	Jul-98	97.15	2.54	0.25	0.03	0.03	0.00	0.00
B03	Mar-98	65.80	11.43	14.55	4.23	2.21	0.60	1.18
B03	Jul-98	76.35	11.67	7.19	3.24	1.01	0.34	0.20
Mean		71.08	11.55	10.87	3.74	1.61	0.47	0.69
SD		7.46	0.17	5.20	0.70	0.85	0.18	0.69
B09	Jan-97	88.45	4.57	3.65	1.80	0.59	0.29	0.65
B09	Apr-98	74.39	11.00	8.00	1.14	0.99	0.45	4.03
B09	Jul-98	76.70	11.78	8.70	1.44	0.47	0.31	0.60
Mean		79.85	9.12	6.78	1.46	0.68	0.35	1.76
SD		7.54	3.96	2.74	0.33	0.27	0.09	1.97
B12	Jan-98	69.88	18.04	8.82	2.00	0.64	0.21	0.41
B12	Apr-98	77.79	11.15	5.95	2.76	1.09	0.49	0.77
B12	Jul-98	77.30	14.07	4.50	2.56	1.33	0.07	0.17
Mean		74.99	14.42	6.42	2.44	1.02	0.26	0.45
SD		4.43	3.46	2.20	0.39	0.35	0.21	0.30
B13	Jan-98	96.95	1.62	0.82	0.34	0.14	0.09	0.04
B13	Apr-98	96.69	1.66	0.97	0.39	0.20	0.07	0.02
B13	Jul-98	83.24	6.31	2.79	0.33	0.19	7.10	0.04
Mean		92.29	3.20	1.53	0.35	0.18	2.42	0.03
SD		7.84	2.70	1.10	0.03	0.03	4.05	0.01

Table 2 : Particle size distributions, means and standard deviations for sediment in Reference Scrub Site.

Reference Scrub Plots	Sample Date	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm
C4	Jan-98	72.43	23.08	3.27	0.92	0.30	0.00	0.00
C4	Mar-98	72.47	19.54	4.67	1.29	0.40	0.57	1.06
Mean		72.45	21.31	3.97	1.11	0.35	0.29	0.53
SD		0.03	2.50	0.99	0.26	0.07	0.40	0.75
C5	Jan-98	78.49	15.78	2.93	1.22	0.90	0.39	0.29
C5	Mar-98	72.64	17.05	4.18	3.25	0.48	0.44	1.96
C5	Jul-98	74.78	19.75	2.61	1.57	0.69	0.40	0.20
Mean		75.30	17.53	3.24	2.01	0.69	0.41	0.82
SD		2.96	2.03	0.83	1.09	0.21	0.03	0.99
C6	Jan-98	91.39	5.20	2.26	0.53	0.17	0.11	0.34
C6	Mar-98	91.76	4.01	2.15	0.90	0.28	0.25	0.65
C6	Jul-98	86.85	9.19	1.71	1.08	0.50	0.17	0.50
Mean		90.00	6.13	2.04	0.84	0.32	0.18	0.50
SD		2.73	2.71	0.29	0.28	0.17	0.07	0.16
C7	Jan-98	65.74	10.20	8.23	5.70	5.58	2.98	1.57
C7	Mar-98	67.08	5.58	9.40	5.22	5.83	4.66	2.23
Mean		66.41	7.89	8.82	5.46	5.71	3.82	1.90
SD		0.95	3.27	0.83	0.34	0.18	1.19	0.47

Table3 : Particle size distributions, means and standard deviations for sediment in Sentinel Forest Site.

Sentinel Forest Plots	Sample Date	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm
B05	Jan-98	68.63	6.98	12.05	5.54	2.68	0.68	3.44
B05	May-98	70.97	7.51	15.68	3.07	1.03	0.47	1.27
B05	Jul-98	51.47	9.12	14.47	14.88	4.32	0.97	4.77
Mean		63.69	7.87	14.07	7.83	2.68	0.71	3.16
SD		10.65	1.11	1.85	6.23	1.65	0.25	1.77
B08	Jan-98	25.76	6.14	6.84	5.18	4.52	29.40	22.16
B08	Apr-98	49.23	6.16	7.86	4.11	5.06	8.59	18.99
Mean		37.50	6.15	7.35	4.65	4.79	19.00	20.58
SD		16.60	0.01	0.72	0.76	0.38	14.71	2.24
B10	Apr-98	69.97	13.05	5.64	4.97	5.28	0.56	0.53
B10	Jul-98	58.00	10.88	7.95	8.30	12.00	1.54	1.33
Mean		63.99	11.97	6.80	6.64	8.64	1.05	0.93
SD		8.46	1.53	1.63	2.35	4.75	0.69	0.57
B11	Apr-98	60.59	14.47	6.82	8.30	9.15	0.54	0.13
B11	Jul-98	73.52	9.66	6.65	4.42	5.46	0.23	0.06
Mean		67.06	12.07	6.74	6.36	7.31	0.39	0.10
SD		9.14	3.40	0.12	2.74	2.61	0.22	0.05
D1	Jul-98	31.56	15.67	15.56	16.68	4.16	3.23	13.14
D1	Jan-99	45.86	11.71	12.09	10.72	3.47	3.52	12.63
Mean		38.71	13.69	13.83	13.70	3.82	3.38	12.89
SD		10.11	2.80	2.45	4.21	0.49	0.21	0.36

Table 4 : Particle size distributions, means and standard deviations for sediment in Reference Forest 1 and 2

Reference Forest 1 & 2 Plots	Sample Date	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm
C1	Jan-98	24.06	8.67	19.73	12.31	9.61	10.18	15.44
C1	Mar-98	34.54	13.56	24.92	7.27	4.55	4.60	10.56
C1	Jul-98	10.73	9.08	33.21	9.47	8.48	12.90	16.13
Mean		23.11	10.44	25.95	9.68	7.55	9.23	14.04
SD		11.93	2.71	6.80	2.53	2.66	4.23	3.04
C2	Jan-98	77.58	10.54	9.15	1.25	0.87	0.47	0.14
C2	Mar-98	39.19	26.31	30.99	1.52	0.84	0.70	0.45
C2	Jul-98	27.25	23.49	42.28	2.90	1.86	1.04	1.18
Mean		48.01	20.11	27.47	1.89	1.19	0.74	0.59
SD		26.30	8.41	16.84	0.89	0.58	0.29	0.53
C3	Mar-98	53.39	35.86	7.15	2.34	0.41	0.29	0.56
C3	Jul-98	62.61	23.97	8.77	3.46	0.56	0.32	0.31
Mean		58.00	29.92	7.96	2.90	0.49	0.31	0.44
SD		6.52	8.41	1.15	0.79	0.11	0.02	0.18
C8	Mar-98	29.54	43.53	18.42	3.82	1.25	0.97	2.47
C8	Jul-98	5.79	19.97	39.56	25.49	5.99	2.00	1.20
Mean		17.67	31.75	28.99	14.66	3.62	1.49	1.84
SD		16.79	16.66	14.95	15.32	3.35	0.73	0.90
G1	Jan-98	18.25	12.62	20.82	15.43	6.88	6.66	19.34
G1	Mar-98	60.59	12.10	10.73	5.61	2.62	2.39	5.96
G1	Jul-98	17.27	10.38	20.13	18.15	8.93	10.25	14.89
Mean		32.04	11.70	17.23	13.06	6.14	6.43	13.40
SD		24.73	1.17	5.64	6.60	3.22	3.93	6.81
G2	Jan-98	74.84	8.68	11.05	4.54	0.72	0.12	0.05
G2	Mar-98	62.53	10.02	13.18	7.95	1.84	1.75	2.73
G2	Jul-98	57.70	13.20	18.62	8.63	0.89	0.46	0.50
Mean		65.02	10.63	14.28	7.04	1.15	0.78	1.09
SD		8.84	2.32	3.90	2.19	0.60	0.86	1.44
G3	Mar-98	46.91	10.01	19.04	8.18	3.12	3.76	8.98
G3	Jul-98	43.68	9.97	19.04	12.73	5.83	6.13	2.62
Mean		45.30	9.99	19.04	10.46	4.48	4.95	5.80
SD		2.28	0.03	0.00	3.22	1.92	1.68	4.50
G4	Jan-98	46.06	14.19	15.04	15.95	5.89	0.86	2.01
G4	Mar-98	58.79	15.60	13.28	5.34	1.60	1.79	3.60
G4	Jul-98	51.86	15.51	17.37	7.84	4.25	0.37	2.80
Mean		52.24	15.10	15.23	9.71	3.91	1.01	2.80
SD		6.37	0.79	2.05	5.55	2.16	0.72	0.80

Table 5 : Particle size distributions, means and standard deviations for sediment in Hail-affected Site.

Hail-affected Plots	Sample Date	Clay & Silt <63µm	Very fine sand 63µm	Fine sand 125µm	Medium sand 250µm	Coarse sand 500µm	Very coarse sand 1mm	Granule – pebble 2mm
B04	Apr-98	78.21	11.10	6.20	1.79	1.17	0.55	0.98
B04	Jul-98	82.11	9.95	3.73	1.82	0.96	0.41	1.02
Mean		80.16	10.53	4.97	1.81	1.07	0.48	1.00
SD		2.76	0.81	1.75	0.02	0.15	0.10	0.03
B04a	Apr-98	83.97	7.40	3.23	2.93	1.84	0.43	0.20
B04a	Jul-98	83.75	10.40	2.84	1.82	1.14	0.05	0.00
Mean		83.86	8.90	3.04	2.38	1.49	0.24	0.10
SD		0.16	2.12	0.28	0.78	0.49	0.27	0.14
B06	Apr-98	75.34	9.04	5.69	5.19	3.69	0.57	0.48
B06	Jul-98	81.83	7.24	4.87	3.74	1.75	0.38	0.19
Mean		78.59	8.14	5.28	4.47	2.72	0.48	0.34
SD		4.59	1.27	0.58	1.03	1.37	0.13	0.21
B07	Jan-98	89.80	6.37	2.30	0.95	0.42	0.11	0.05
B07	Apr-98	92.47	4.86	1.55	0.78	0.20	0.09	0.05
B07	Jul-98	91.30	5.08	2.41	0.70	0.28	0.10	0.13
Mean		91.19	5.44	2.09	0.81	0.30	0.10	0.08
SD		1.34	0.82	0.47	0.13	0.11	0.01	0.05

APPENDIX 2

Table 1: Nail heights (cm) representing sediment height change for SPPD mangrove plots

Gully C	97-4	98-1	98-2	98-3	99-1	99-2	99-3
1	136	132	130		130	132	129
10	160	167	165		165	114	163
11	110	110	108		108	107	105
12	110	111	110		110	110	109
13	110	110	109		108	107	107
15	110	110	110		110	109	109
16	110	110	109		109	109	108
17	110	110	110		110	108	109
18	110	110	109		110	110	108
19	110	110	110		108	108	108
2	160	161	158		158	158	158
20	110	110	109		109	108	108
21	110	110	110		110	110	107
22	110	110	110		109	110	110
23	110	110	109		110	109	108
24	110	110	109		108	109	108
25	110	110	107		106	108	107
26	110	110	110		107	108	108
27	110	110	109		107	108	107
28	110	110	110		109	109	108
3	110	110	108		109	108	108
30	130	130	130		128	128	127
31	110	110	110		109	108	108
32	110	110	108		105	107	107
33	110	130	130		128	129	106
34	110	110	110		106	108	107
35	110	110	111		108	111	107
4	110	110	110		110	109	107
5	120	120	120		118	119	119
6	120	120	120		110	120	120
8	110	118	109		108	108	107
9	110	110	110		110	110	109
Mean	115.19	116.22	115.22		114.06	113.00	113.00
SD	13.22	14.10	13.78		13.93	10.56	13.70
NFP tag	97-4	98-1	98-2	98-3	99-1	99-2	99-3
11	140	140	138		137	138	139
12	160	160	160		160	160	158
13	175	161	160		161	160	160
14	175	165	170		170	170	168
15	175	167	161		163	161	161
16	150	150	153		149	146	149
17	220	225	230		224	224	224
18	190	197	185		197	193	194
19	190	200	200		195	192	190
20	180	178	175		174	171	172
21	200	200	200		200	200	200

22	200	204	220		200	202	204
23	200	210	210		210	210	210
24	180	181	178		180	177	178
25	150	176	177		174	175	175
26	175	175	175		176	172	173
27	180	178	176		174	172	173
29	240	233	235		232	230	232
30	160	172	170		170	169	167
31	200	201	197		200	200	202
32	150	153	150		150	149	148
33	170	168	162		160	162	162
34	210	200	200		194	198	199
Mean	181.30	182.35	181.83		180.43	179.61	179.91
SD	24.46	24.08	25.78		24.24	24.39	24.68
SC tag	97-4	98-1	98-2	98-3	99-1	99-2	99-3
1	130	130	130	127	124	134	128
14	90	91	91	111	87	91	90
15	60	61	59	110	60	62	58
17	110	110	110	92	110	108	106
18	130	110	110	60	110	108	107
19	60	54	58	110	65	66	50
21	60	64	50	110	60	64	64
23	50	50	50	55	52	50	104
25	50	45	46	56	48	49	46
26	60	60	60	50	66	60	60
29	50	50	54	46	58	56	55
30	80	80	80	65	80	78	98
31	80	80	80	51	74	76	80
32	60	59	55	80	56	57	57
33	50	50	50	80	44	44	42
34	60	60	60	57	62	60	54
37	80	80	80	46	80	81	79
38	70	68	64	57	65	64	62
39	70	70	70	80	70	70	67
40	110	110	110	65	114	108	108
41	80	80	80	70	90	86	82
45	50	53	50	110	50	54	50
47	110	108	110	81	110	108	104
48	110	105	110	53	110	108	108
49	100	100	100	106	104	93	98
5	110	113	117	106	116	110	112
50	120	119	120	98	120	117	116
51	130	130	130	117	136	138	124
52	120	122	123	128	120	128	123
53	140	139	140	120	140	142	138
6	110	110	112	138	110	111	112
Mean	86.77	85.84	85.77	85.00	86.81	86.48	86.52
SD	29.37	28.73	29.76	28.54	28.92	29.15	28.41

Table 2 : Nail heights (cm) representing sediment height change in Sentinel Scrub mangrove plots

B1 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-1	99-2	99-3
8		130		125	126	126	129	127	125	125	128	126	
84		120		125	120	125	120	120	120	121	118	116	
85		120		123	118	116	118	120	120	117	118	115	
86		120		118	116	116	116	119	117	118	120	117	
87		120		117	118	118	118	120	119	118	118	119	
Mean		122		121.6	119.6	120.2	120.	121.2	120.2	119.8	120.4	118.6	
SD		4.47		3.85	3.85	4.92	5.12	3.27	2.95	3.27	4.34	4.39	
B2 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-1	99-2	99-3
45		123	120	124	120	120			118	120	116	116	
49		124	124	124	120	125			124	124	124	118	
60		120	119	116	120	120			120	123	128	116	
64		114	119	115	121	120			115	115	112	115	
68		120	115	126	118	120			117	119	116	121	
75		120	119	123	127	120			118	121	118	118	
Mean		120.2	119.3	121.3	121.0	120.8			118.7	120.3	119.0	117.3	
SD		3.49	2.88	4.63	3.10	2.04			3.08	3.20	5.90	2.16	
B3 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-1	99-2	99-3
15		35	43		42			40		43		38	
17		120	119		119			110		110		116	
18		40	45		38			40		43		32	
20		120	120		120			120		114		120	
21		118	119		117			117		115		112	
5		120	120		120			118		116		118	
6		123	120		122			117		114		107	
D3		40	35		38			38		39		36	
D7		60	59		55			57		54		53	
D8		120	120		120			120		114		112	
Mean		89.6	90		89.1			87.7		86.2		84.4	
SD		39.99	38.73		39.75			38.27		35.90		38.95	
B9 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-1	99-2	99-3
1	110	109			110	112			112	112	110	110	107
11	120	117			117	113			113	112	112	110	110
14	120	120			120	122			120	115	118	114	112
15	120	120			119	120			120	111	112	112	111
18	120	120			120	121			120	119	114	117	113
19	120	120			120	121			112	115	112	115	115
2	110	110			105	115			115	110	110	98	97
3	110	110			110	116			120	112	112	110	108
4	110	115			113	122			120	120	120	120	118
6	110	105			110	120			117	113	120	115	113
8	110	110			109	120			120	114	120	115	112
Mean	114.6	114.2			113.9	118.4			117.2	113.9	114.6	112.4	110.6
SD	5.22	5.55			5.45	3.67			3.52	3.18	4.11	5.71	5.43

B12 Tag	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2
1	120	113	117	112	115	110	112	115	110
10	120	120	120	119	116	115	112	110	112
11	120	125	122	122	120	120	117	122	119
12	120	120	119	125	120	120	115	116	109
17	120	116	118	118	118	120	117	120	119
19	120	118	120	120	120	120	115	110	121
2	120	120	118	120	120	120	120	118	121
22	120	120	118	110	100	125	121	122	106
27	120	120	119	120	119	120	117	122	118
28	120	119	120	120	120	120	119	120	120
33	120	120	120	120	121	119	118	116	117
34	120	110	115	115	110	110	110	115	111
35	120	117	119	118	117	120	116	120	118
4	125	123	124	125	122	120	119	124	120
5	120	120	123	123	124	120	117	120	121
7	120	115	110	113	110	110	119	116	112
8	120	118	117	117	118	120	117	117	115
Mean	120.29	118.47	118.76	118.65	117.06	118.18	116.53	117.82	115.82
SD	1.21	3.56	3.17	4.24	5.77	4.29	2.98	4.02	4.85
B13 Tag	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2
1	120	120	120	120	120	120	119	120	117
10	120	120	124	122	128	125	121	120	120
15	120	118	118	116	119	116	118	112	115
22	120	120	120	120	120	117	119	116	116
23	120	118	118	120	120	120	120	120	117
24	120	120	119	118	119	120	116	116	115
30	120	121	120	122	122	123	121	120	120
31	120	120	120	119	120	110	114	112	110
33	120	120	121	120	120	120	120	122	120
4	120	120	120	120	120	120	119	118	117
5	120	120	117	120	119	117	118	116	114
7	120	120	116	116	115	110	114	110	111
8	120	120	118	120	120	120	118	122	118
9	120	120	117	116	117	119	118	122	118
Mean	120.00	119.79	119.14	119.21	119.93	118.36	118.21	117.57	116.29
SD	0.00	0.80	2.03	2.01	2.84	4.22	2.22	4.01	3.10

Table 3 : Nail heights (cm) representing sediment height change in Sentinel Forest mangrove plots

B5 Nail	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1	112	120	117	119	117	116	120	118	117	116		
6	141	142	140	144	145	143	141	140	143	140		
66	203	200	204	200	200	202	200	200	200	209		
69	120	120	121	120	120	120	120	120	120	118		
70	120	120	119	116	116	117	115	116	116	116		
Mean	139.2	140.4	140.2	139.8	139.6	139.6	139.2	138.8	139.2	139.8		
SD	37.25	34.65	36.83	35.47	35.81	36.60	35.44	35.54	35.74	39.99		
B8 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
3				160	163	157	160	166	161	157	160	158
4					160	162	160	166	158	159	160	157
5			159		161	163	165	162	161	157	160	157
56				204	207	205	207	210	208	206	204	205
57				161	164	163	167	165	163	163	164	161
6			150		150	155	150	150	148	148	148	146
60				142	144	145	140	144	140	145	143	143
61			154		156	155	155	160	159	156	156	155
62				185	187	180	186	180	184	176	182	182
7			156		130	153	151	150	150	150	150	151
Mean			163.1		162.2	163.8	164.1	165.3	163.2	161.7	162.7	161.5
SD			18.08		21.57	17.11	19.43	18.79	19.54	17.81	17.99	18.56
B10 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
19				150		152	150	150	152	148	149	150
25				208		193	200	195	192	212	192	197
44			190		193	194	190	190	191	186	191	
46				187		188	185	189	189	192	197	187
48			185		185	190	185	185	182	195	187	
49			183			173	170	172	173	172	171	171
50				180		183	180	180	187	188	191	180
Mean			183.29			181.00	181.29	180.14	181.14	183.57	183.00	180.43
SD			17.28			14.50	16.88	15.25	14.28	19.81	17.29	15.75
B11 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
19		190	192	185		191	192	192	190	186	190	190
26		180	184	190		184	175	180	179	174	179	178
29		180	163	160		166	165	167	165	166	164	164
31		240	242	240		240	242	240	245	230	233	225
33		210	210	207		212	210	210	212	216	210	212
35		200	210	205		209	200	210	211	200	208	208
36		200	202	200		203	190	200	198	200	200	199
41		150	152	150		154	155	150	150	152	150	149
42		140	133	140		134	135	135	136	134	136	134
5		140	141	145		141	145	120	143	140	140	139
Mean		183	182.9	182.2		183.4	180.9	180.4	182.9	179.8	181	179.8
SD		32.34	34.97	32.58		34.20	32.50	37.47	34.93	32.26	32.79	32.17

D1 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1		110	111	112	114	114		112	110	113	114	112
14		118	117	119	118	119		115	118	117	116	115
18		120	119	121	123	120		120	119	120	121	118
2		120	120	120	118	119		118	118	118	118	119
30		120	117	120	118	120		117	114	116	119	115
5		120	119	123	118	118		117	118	118	120	118
51		120	122	123	123	121		121	123	124	124	121
56		123	121	121	124	120		120	121	124	122	122
61		120	118	120	118	117		120	116	118	119	114
72		116	118	120	118	120		120	119	120	125	118
81		119	118	118	117	117		118	117	119	118	116
Mean		118.73	118.18	119.73	119.00	118.64		118.00	117.55	118.82	119.64	117.09
SD		3.35	2.86	2.97	3.03	2.01		2.68	3.45	3.22	3.26	3.02

Table 4 : Nail heights (cm) representing sediment height change in Reference Forest 1 mangrove plots – Curtis Island

C1 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1	160	160	158	160	158	158	164	166	146	157	156	158
10	140	139	138	140	139	138	140	140	139	148	139	139
16	160	160	160	160	156	158	160	160	159	161	159	160
22	140	140	140	146	143	143	141	142	140	145	142	141
27	140	140	139	138	139	137	140	140	140	142	147	141
36	140	170	170	170	172	170	172	175	171	168	170	171
5	130	130	130	134	130	130	132	134	136	128	130	132
50	140	140	140	145	142	142	143	142	140	139	138	140
57	150	150	149	152	151	149	151	150	150	149	149	148
58	180	180	176	177	177	176	178	178	164	180	178	189
60	140	140	139	150	143	142	145	140	140	138	138	136
61	120	120	120	120	119	121	120	120	123	120	120	119
62	130	130	129	125	126	122	126	128	125	127	123	124
63	160	160	160	161	158	156	162	156	160	163	159	161
64	150	150	146	141	144	145	143	145	144	140	146	143
Mean	145.3	147.3	146.3	147.9	146.4	145.8	147.8	147.7	145.1	147.0	146.3	146.8
SD	15.06	16.28	15.75	15.89	15.96	15.85	16.56	16.51	13.59	16.48	16.26	18.30
C2 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
19	170	170	165	170	167	170	170	170	163	163	163	163
22	230	230	228	240	227	230	230	230	229	220	228	225
30	180	175	178	180	175	175	180	180	177	178	178	179
36	180	180	181	175	177	178	190	190	183	180	175	178
4	170	180	176	175	174	172	180	180	174	170	171	169
42	160	160	160	163	163	160	170	163	157	160	161	159
5	150	150	154	154	152	155	150	144	149	150	151	150
Mean	177.1	177.9	177.4	179.6	176.4	177.1	181.4	179.6	176.0	174.4	175.3	174.7
SD	25.63	25.47	24.43	28.03	23.92	24.70	24.78	26.72	26.21	22.64	25.00	24.45

C3 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
16	140	140	141	143	143	142	142	144	144	142	140	
2	160	160	160	160	159	150	150	152	149	150	147	
21	150	154	152	155	155	140	156	154	153	158	152	
31	160	166	160	163	163	160	160	160	158	152	153	
33	140	150	140	145	143	140	147	142	140	145	142	
46	150	150	150	157	153	151	156	156	153	160	150	
49	150	152	151	153	150	152	150	154	150	158	147	
72	140	136	135	140	137	139	140	140	137	138	137	
81	180	182	183	168	180	180	185	185	182	183	182	
87	160	173	164	168	163	164	162	165	165	163	163	
89	160	170	170	165	168	170	170	177	170	166	169	
Mean	153.6	157.6	155.1	156.1	155.8	153.5	156.2	157.2	154.6	155.9	152.9	
SD	12.06	14.14	14.18	9.95	12.54	13.62	13.01	14.08	13.42	12.63	13.51	
C8 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
10	190	190	188	196	192	193	195	195	193	196	194	192
11	190	190	194	195	187	187	190	190	192	186	188	187
27	180	182	181	187	177	175	175	177	177	180	176	179
28	180	178	181	189	177	180	180	179	174	185	175	174
29	180	178	175	175	180	179	180	180	179	165	176	177
30	190	197	191	190	190	190	194	190	184	185	179	183
8	200	200	223	204	230	204	206	200	202	200	204	205
Mean	187.1	187.9	190.4	190.9	190.4	186.9	188.6	187.3	185.9	185.3	184.6	185.3
SD	7.56	8.84	15.79	9.01	18.48	9.92	10.86	8.79	10.16	11.34	11.16	10.63

Table 5 : Nail heights (cm) representing sediment height change in Reference Forest 2 mangrove plots - Graham Creek and south-west Curtis Island

G1 Tag	96-1/2	96-3	96-4	97-2	97-3	98-1	98-2	98-3	99-1	99-2
19	180	180	178	179	177	178	180	175	180	176
25	140	138	139	137	138	140	140	139	140	137
27	190	195	192	193	199	195	192	197	190	192
28	180	180	180	180	182	180	181	180	180	180
29	190	197	200	200	200	201	200	200	194	196
30	200	200	199	198	199	200	200	198	200	193
34	190	190	190	193	194	198	197	194	196	191
40	160	160	157	156	159	160	160	157	160	158
55	140	140	137	143	140	140	143	140	144	139
56	160	160	156	162	158	165	162	160	154	150
57	160	160	160	161	160	163	164	160	164	161
60	160	160	155	155	155	160	165	152	158	155
61	155	155	150	152	154	150	160	158	150	150
62	180	175	175	173	171	176	177	172	162	175
64	140	140	136	138	136	138	138	138	140	135
65	130	120	125	125	124	130	127	128	123	124
69	160	164	160	161	160	165	160	160	160	159
71	160	160	160	160	160	165	164	159	160	160
75	140	137	137	138	137	140	140	138	138	137
77	120	120	120	120	120	120	120	119	120	119
Mean	161.75	161.55	160.3	161.2	161.15	163.2	163.5	161.2	160.65	159.35
SD	22.44	24.20	24.11	23.89	24.73	24.16	23.84	23.95	23.41	23.59
G2 Tag	96-1/2	96-3	96-4	97-2	97-3	98-1	98-2	98-3	99-1	99-2
18		210	210	216	174	218	220	214	200	213
19		199	200	204	200	203	200	200	204	201
20		197	195	196	196	200	200	197	200	200
21		189	187	188	188	182	190	190	192	193
29		150	149	148	148	152	150	149	150	151
30		167	166	168	169	170	170	168	166	171
31		180	179	181	182	189	190	186	184	183
46		170	170	170	170	175	176	171	174	172
47		170	169	169	170	175	178	170	172	172
48		165	163	170	165	178	177	157	172	170
49		180	177	179	177	180	184	180	181	180
52		185	184	183	185	186	186	185	185	185
53		154	153	153	152	154	159	157	152	152
55		136	135	138	140	139	140	139	139	139
56		137	130	133	131	136	146	134	138	135
57		140	140	140	141	146	143	140	140	140
58		216	217	215	216	220	218	215	214	214
59		140	140	140	138	138	140	145	137	140
60		157	160	156	154	158	155	156	155	156
62		170	167	167	167	170	170	166	168	167
63		172	169	169	168	168	172	171	170	170
64		180	173	174	174	179	178	176	177	175
Mean		171.09	169.68	170.77	168.41	173.45	174.64	171.18	171.36	171.77
SD		22.94	23.39	23.75	21.60	23.94	23.35	23.25	22.78	23.41

G3	96-1/2	96-3	96-4	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1	180	180	185	181	180	181	184	178	180	182	182
19	170	175	175	176	174	171	170	170	170	174	171
20	170	170	171	170	168	178	175	169	170	170	169
21	160	160	160	162	160	165	160	160	160	160	162
23	160	163	162	161	161	160	165	158	160	158	154
24	190	194	195	187	192	180	190	190	194	190	188
25	160	160	160	165	161	167	165	160	164	162	163
26	180	182	191	180	180	180	180	180	180	184	178
27	190	200	200	200	198	200	210	192	200	190	190
29	160	165	163	163	168	163	165	161	164	170	163
30	180	190	185	182	185	187	185	183	180	184	185
31	170	170	175	174	176	175	180	177	174	175	175
37	230	230	238	234	235	230	235	237	230	236	238
38	240	238	239	243	240	240	240	245	235	240	241
39	210	210	215	210	209	220	210	222	216	212	212
40	180	180	182	182	186	186	187	184	184	182	182
41	170	170	174	174	172	175	166	170	170	180	173
42	180	175	175	176	173	171	174	170	170	178	176
43	190	187	190	191	188	191	191	190	184	186	192
44	210	210	214	210	207	222	200	211	210	210	213
46	165	160	165	162	165	162	170	167	164	164	165
47	200	196	190	195	194	200	197	195	196	196	194
Mean	183.86	184.77	186.55	185.36	185.09	186.55	186.32	184.95	184.32	185.59	184.82
SD	22.36	22.07	23.00	22.45	22.05	23.04	21.91	24.40	22.04	22.07	23.22
G4	96-1/2	96-3	96-4	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1		120	120	120	120	120	120	121	120	126	121
14		139	136	138	138	140	140	137	136	138	138
15		136	130	135	131	132	134	133	136	133	130
16		140	140	140	139	143	141	138	142	144	140
17		124	124	122	123	124	127	122	128	124	124
2		118	119	122	120	121	116	122	114	122	118
28		140	142	141	139	144	144	140	142	142	138
29		160	158	160	158	165	163	160	161	158	159
44		144	143	142	142	144	147	141	144	144	141
45		139	139	140	140	141	142	138	140	140	137
46		150	150	151	147	150	150	149	160	152	148
47		145	145	141	143	146	150	145	146	144	143
49		157	160	156	157	160	160	156	158	158	155
50		160	160	160	160	161	160	160	160	160	160
51		180	180	177	178	182	184	183	186	180	186
52		190	185	180	184	181	187	183	180	178	190
53		160	160	159	159	160	170	160	164	158	160
55		160	159	160	160	162	161	160	164	160	158
56		136	138	140	139	140	142	139	140	139	138
57		138	140	138	137	140	140	137	136	139	135
58		131	131	129	131	130	130	131	130	129	128
59		120	122	122	122	120	120	121	120	120	116
60		130	131	132	128	130	130	129	132	134	130
61		120	120	124	122	123	125	122	122	124	121
Mean		143.21	143.00	142.88	142.38	144.13	145.13	142.79	144.21	143.58	142.25
SD		18.70	18.10	16.89	17.62	18.10	19.18	17.99	18.91	16.61	19.46

Table 6 : Nail heights (cm) representing sediment height change in Reference Scrub mangrove plots - Curtis Island

C4 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
13	130	128	127		126	128	117	130	126	128	127	124
17	130	128	129		130	130	132	130	128	130	132	125
26	130	120	120		120	120	120	120	127	130	123	124
27	120	110	107		111	111	112	108	90	122	112	112
28	120	116	118		118	118	120	120	117	120	113	112
29	120	120	118		118	128	115	112	122	120	121	121
3	120	120	121		120	124	110	120	120	114	117	116
32	120	125	121		121	124	120	122	120	121	122	120
35	120	122	120		125	122	122	124	120	122	121	120
36	120	120	118		116	118	118	117	120	133	113	130
42	120	120	123		122	117	125	120	120	122	120	120
43	130	128	130		130	130	126	128	130	130	129	128
Mean	123.33	121.42	121.00		121.42	122.50	119.75	120.92	120.00	124.33	120.83	121.00
SD	4.92	5.33	6.11		5.62	5.93	6.11	6.68	10.28	5.69	6.41	5.67
C5 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1	120	120	119		120	117	115	118	118	120	116	
16	70	70	68		70	70	70	73	71	70	69	
18	70	70	68		70	69	60	70	70	70	64	
2	120	119	118		120	120	120	118	119	120	121	
3	120	120	119		119	120	120	120	123	120	122	
36	80	80	85		80	85	81	80	80	80	80	
5	120	120	123		128	120	120	120	123	120	121	
Mean	100.00	99.86	100.00		101.00	100.14	98.00	99.86	99.86	100.57	100.00	99.00
SD	25.17	25.04	25.32		26.26	24.41	26.64	24.07	25.44	25.17	26.68	
C6 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
1	120	120	115	117	118	120	110	115	115	109	107	110
15	120	116	119	119	120	121	120	118	117	116	119	119
16	120	123	122	121	125	126	123	125	126	118	118	118
21	120	120	118	120	119	116	117	120	117	117	116	116
29	120	120	120	120	120	125	120	120	120	119	118	117
Mean	120	119.8	118.8	119.4	120.4	121.6	118	119.6	119	115.8	115.6	116
SD	0.00	2.49	2.59	1.52	2.70	4.04	4.95	3.65	4.30	3.96	4.93	3.54
C7 Tag	96-1/2	96-3	96-4	97-1	97-2	97-3	98-1	98-2	98-3	99-1	99-2	99-3
19	120	120		121	124	120	117	120	120	120	117	
21	120	120		120	120	125	120	121	120	124	120	
22	120	120		120	121	110	120	120	122	123	122	
25	120	120		120	121	120	120	118	117	112	113	
26	120	120		120	121	120	109	110	120	116	117	
45	120	115		118	118	106	108	107	119	108	112	
46	120	112		116	116	116	116	115	117	116	110	
47	120	122		127	127	128	129	127	127	128	118	
48	120	122		117	123	116	120	120	122	118	116	
Mean	120.00	119.00		119.89	121.22	117.89	117.67	117.56	120.44	118.33	116.11	
SD	0.00	3.32		3.14	3.23	6.86	6.34	6.06	3.05	6.20	3.86	

Table 7 : Nail heights (cm) representing sediment height changes in Hail-affected mangrove plots

B4 Nail	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-2	99-2
11	120		120		120	121			123	119	120	
19	120		119		120	120			118	115	114	
2	115		116		116	117			115	111	112	
20	120		118		118	118			113	111	107	
24	120		125		130	129			130	125	125	
25	120		118		116	118			110	112	114	
26	120		124		132	126			140	130	129	
28	120		128		130	127			131	129	127	
Mean	119.38		121		122.75	122			122.5	119	118.5	
SD	1.77		4.17		6.76	4.66			10.41	8.02	7.95	
B4a Nail	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-1	99-2
D1		40	42	43	42	42		42	42	42	42	43
D11		41	40	40	40	40		40	40	40	40	40
D3		42	43	47	45	45		43	43	46	44	46
D4		40	38	45	45	45		38	41	40	40	39
D7		43	45	40	42	45		42	41	42	42	42
D8		44	43	43	43	43		40	50	46	46	44
D9		40	38	36	36	37		35	36	35	36	37
Mean		41.43	41.29	42.00	41.86	42.43		40.00	41.86	41.57	41.43	41.57
SD		1.62	2.69	3.65	3.13	3.05		2.77	4.22	3.82	3.21	3.10
B6 Nail	96-1/2	96-3	96-4	97-1	97-2	97-3	97-4	98-1	98-2	98-3	99-1	99-2
12	120	120		120	122	124	121	123	123	124	122	125
13	120	120		122	121	124	120	120	120	118	118	120
16	120	120		124	122	120	129	125	125	126	124	120
17	120	120		120	120	120	128	125	120	128	128	119
19	120	120		120	120	120	118	120	120	119	119	120
2	120	120		120	120	120	120	119	120	119	120	121
22	120	120		125	120	122	122	122	120	121	120	120
24	120	120		120	120	120	117	120	120	125	120	118
25	120	120		123	120	120	123	125	125	125	126	126
37	120	120		118	120	118	119	120	120	127	121	114
9	132	120		125	126	128	125	131	130	131	126	124
Mean	121.09	120.00		121.55	121.0	121.45	122.00	122.73	122.09	123.91	122.18	120.64
SD	3.62	0.00		2.38	1.84	2.84	3.92	3.58	3.33	4.18	3.31	3.38

Figure 1. Location of mangrove monitoring plots in Port Curtis

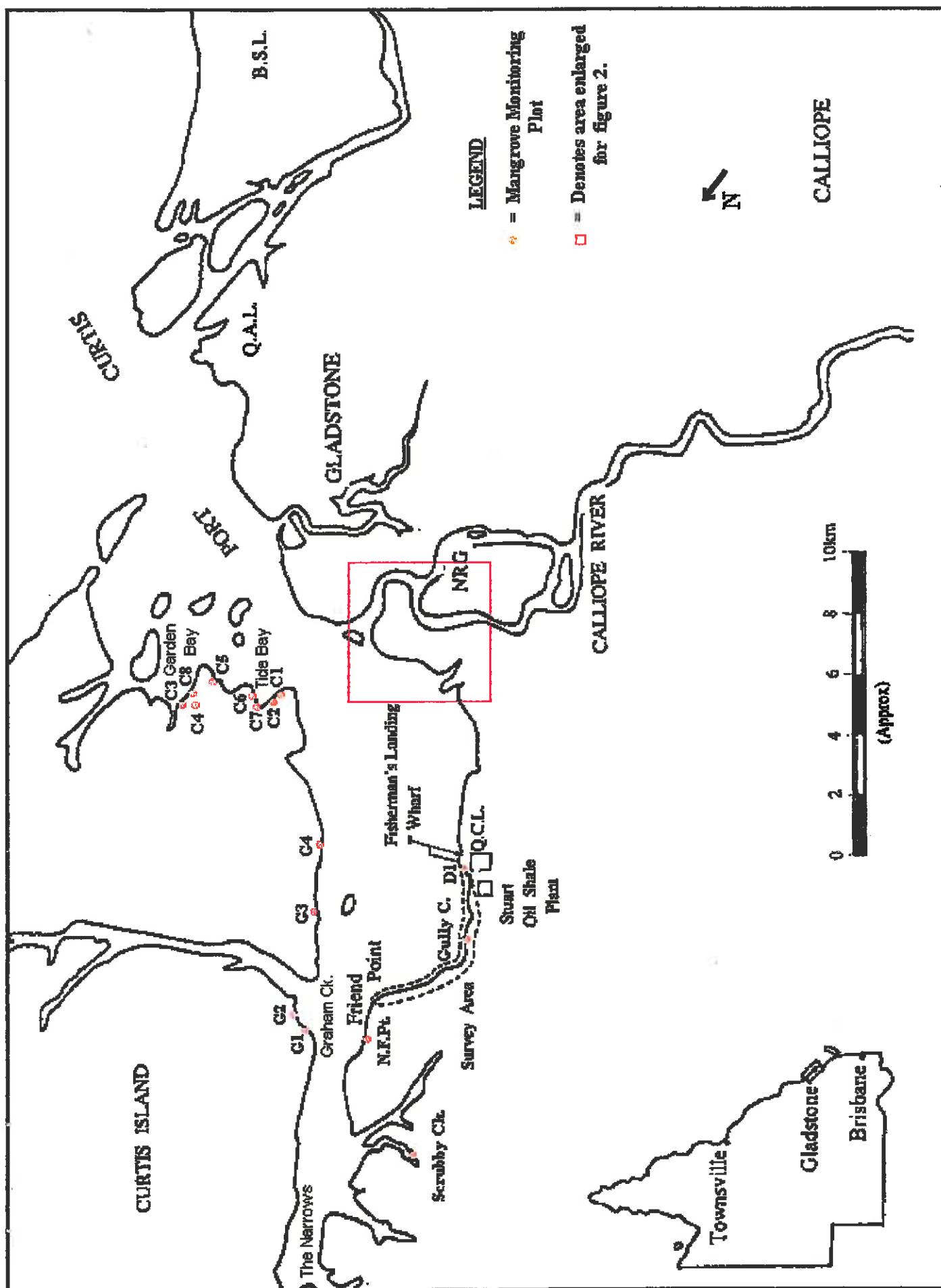


Figure 2. Sentinel sites on the Calliope River

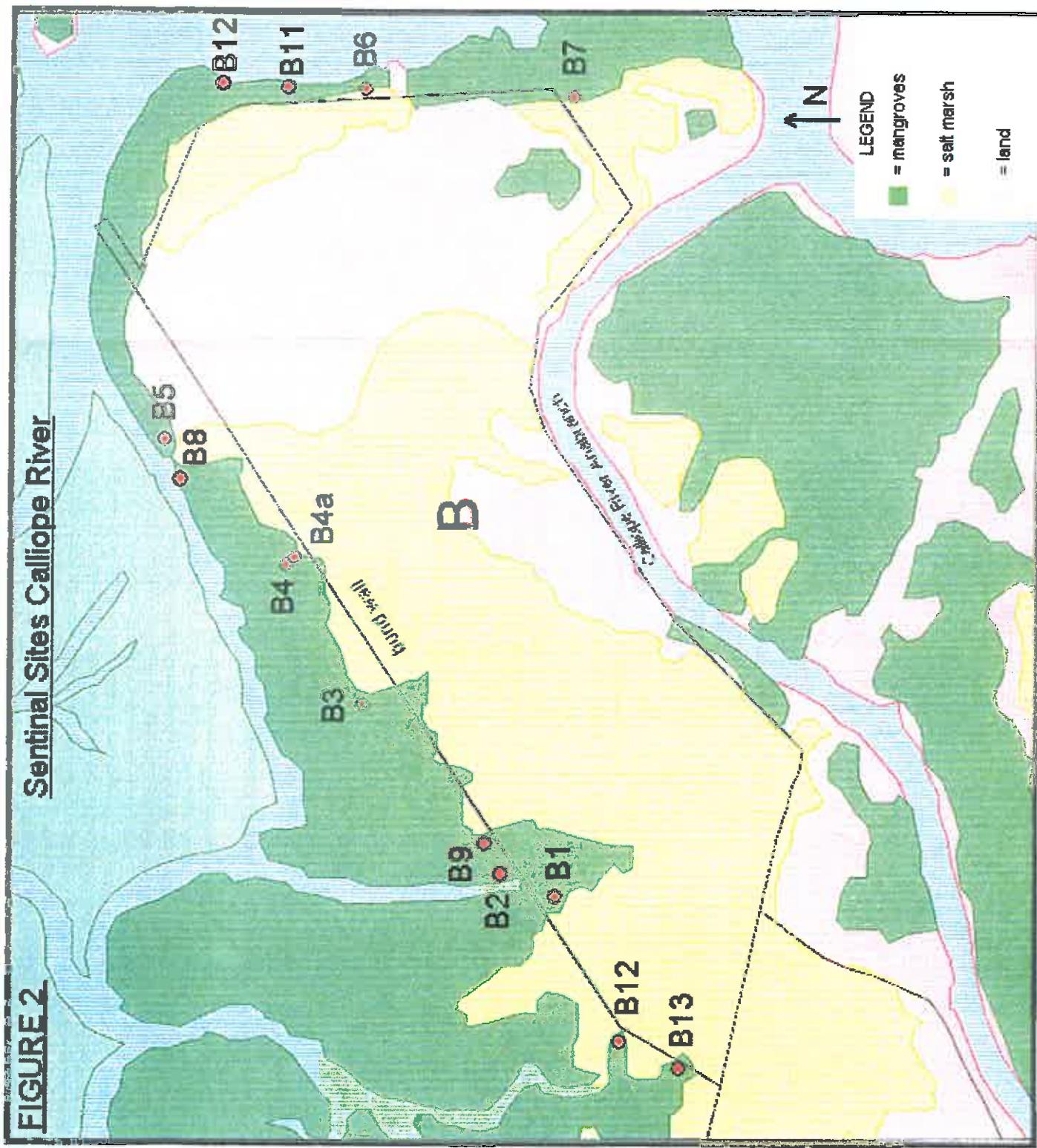




Plate 1: Litter fall collection in reference *Rhizophora* forest site



Plate 2: Sentinel *Rhizophora* forest site



Plate 3: Reference *Rhizophora* scrub site showing tagged shrubs



Plate 4: Sentinel *Rhizophora* scrub site showing tagged shrubs



Plate 5: Hail affected site



Plate 6: Hail affected *Ceriops* forest site