3

PART THREE

FIELD SHEETS AND APPENDICES

BUSH FOR GREENHOUSE
Field Measurement Procedures
for Carbon Accounting

Version 1
February 2002

HOW TO USE THIS DOCUMENT

This document is Part 3 of three volumes that make up *Field Measurement Procedures for Carbon Accounting*. It provides the tools for recording field data and additional information on some aspects of Part 2.

This Part relates to the others as follows:

PART	PURPOSE
Part 1—Reference Document	Provides readers with background information about carbon estimation in environmental plantings and relates this information to the measurement of field variables and estimation of carbon stocks.
Part 2—Field Measurement Procedures	Provides a measurement methodology to estimate carbon stocks at a given point in time, based on field measurements and known mathematical relationships.
Part 3—Field Sheets and Appendices	**Provides users with a standard set of field sheets on which to record measured field variables, and contains more detailed information and discussion on specific sections of Part 2.**

TABLE OF CONTENTS—PART 3

Appendix 1

Forms—Field Sheets and Tables

Field Sheets

Form A—Initial Condition—General Site Description

Form B—Initial Condition—Stand-type Description and Site Plan

Form C—Initial condition—Area Record

Form D—Initial Condition—Existing Trees and Litter

Form E—Biodiversity and Ecosystem Health Assessment

Form F—Initial Condition—Works Record

Form G—Seedling Survival Sheet

Form H—Plot Sampling Cover Sheet

Form I—Stocking Plot Sheet

Form J—Fixed Area Plot Sheet

Form K—Basal Area Sheet

Tables

Form L—Distance Slope Correction Table

Form M(a)—Circular Fixed Area Plot Radii and Slope Correction Tables

Form M(b)—Rectangular Fixed Area Plot Dimensions

Form N—Random Number Table

Form O—Horizontal Marginal Distances for Basal Area Points

Form P—Plot Location Grid

Form L Distance Slope Correction Tables

Slope	Horizontal distance (m)											
Degrees	2	5	10	15	20	25	30	35	40	45	50	100
10	2.03	5.08	10.15	15.23	20.31	25.39	30.46	35.54	40.62	45.69	50.77	101.54
12	2.04	5.11	10.22	15.34	20.45	25.56	30.67	35.78	40.89	46.01	51.12	102.23
14	2.06	5.15	10.31	15.46	20.61	25.77	30.92	36.07	41.22	46.38	51.53	103.06
16	2.08	5.20	10.40	15.60	20.81	26.01	31.21	36.41	41.61	46.81	52.01	104.03
18	2.10	5.26	10.51	15.77	21.03	26.29	31.54	36.80	42.06	47.32	52.57	105.15
20	2.13	5.32	10.64	15.96	21.28	26.60	31.93	37.25	42.57	47.89	53.21	106.42
22	2.16	5.39	10.79	16.18	21.57	26.96	32.36	37.75	43.14	48.53	53.93	107.85
24	2.19	5.47	10.95	16.42	21.89	27.37	32.84	38.31	43.79	49.26	54.73	109.46
26	2.23	5.56	11.13	16.69	22.25	27.82	33.38	38.94	44.50	50.07	55.63	111.26
28	2.27	5.66	11.33	16.99	22.65	28.31	33.98	39.64	45.30	50.97	56.63	113.26
30	2.31	5.77	11.55	17.32	23.09	28.87	34.64	40.41	46.19	51.96	57.74	115.47
32	2.36	5.90	11.79	17.69	23.58	29.48	35.38	41.27	47.17	53.06	58.96	117.92
34	2.41	6.03	12.06	18.09	24.12	30.16	36.19	42.22	48.25	54.28	60.31	120.62
36	2.47	6.18	12.36	18.54	24.72	30.90	37.08	43.26	49.44	55.62	61.80	123.61
38	2.54	6.35	12.69	19.04	25.38	31.73	38.07	44.42	50.76	57.11	63.45	126.90
40	2.61	6.53	13.05	19.58	26.11	32.64	39.16	45.69	52.22	58.74	65.27	130.54

1. Determine Horizontal Distance to be travelled and select the column with that distance.
2. Determine average slope over the distance (in degrees) and select the row with that slope.
3. Where the column and row intersect, read off the slope distance to be travelled in metres.

Use this table to correct horizontal distance to slope distance

Form M (a) Circular Fixes Area Plot Radii and Slope Correction Tables

Slope	Plot Radii (m) for plot size (ha)									
Degrees	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**	**0.09**	**0.1**
0	5.64	7.98	9.77	11.28	12.62	13.82	14.93	15.96	16.93	17.84
4	5.65	7.99	9.78	11.30	12.63	13.84	14.95	15.98	16.95	17.86
6	5.66	8.00	9.80	11.31	12.65	13.86	14.97	16.00	16.97	17.89
8	5.67	8.02	9.82	11.34	12.68	13.89	15.00	16.04	17.01	17.93
10	5.69	8.04	9.85	11.37	12.71	13.93	15.04	16.08	17.06	17.98
12	5.70	8.07	9.88	11.41	12.76	13.97	15.09	16.13	17.11	18.04
14	5.73	8.10	9.92	11.46	12.81	14.03	15.15	16.20	17.18	18.11
16	5.75	8.14	9.97	11.51	12.87	14.10	15.22	16.28	17.26	18.20
18	5.79	8.18	10.02	11.57	12.94	14.17	15.31	16.36	17.36	18.29
20	5.82	8.23	10.08	11.64	13.01	14.26	15.40	16.46	17.46	18.40
22	5.86	8.29	10.15	11.72	13.10	14.35	15.50	16.57	17.58	18.53
24	5.90	8.35	10.22	11.81	13.20	14.46	15.62	16.70	17.71	18.67
26	5.95	8.42	10.31	11.90	13.31	14.58	15.75	16.83	17.85	18.82
28	6.00	8.49	10.40	12.01	13.43	14.71	15.89	16.98	18.01	18.99
30	6.06	8.57	10.50	12.13	13.56	14.85	16.04	17.15	18.19	19.17
32	6.13	8.66	10.61	12.25	13.70	15.01	16.21	17.33	18.38	19.37
34	6.20	8.76	10.73	12.39	13.86	15.18	16.39	17.53	18.59	19.59
36	6.27	8.87	10.86	12.55	14.03	15.36	16.60	17.74	18.82	19.84
38	6.36	8.99	11.01	12.71	14.21	15.57	16.82	17.98	19.07	20.10
40	6.45	9.12	11.16	12.89	14.41	15.79	17.05	18.23	19.34	20.38

1. Determine the plot size to be used and select the column with that size.
2. Calculate the average slope within the plot using the Suunto Clinometer and select the row with that slope.
3. Where the column and row intersect, read off the corrected plot radius in metres.

Use this table to determine the plot radius in metres for a given plot size and plot slope

Form M (b) Rectangular Fixed Area Plot Dimensions

Plot width (m)	Plot length (m)							
	5	**10**	**15**	**20**	**25**	**30**	**40**	**50**
5	0.0025	0.005	0.0075	0.01	0.0125	0.015	0.02	0.025
10	0.005	0.01	0.015	0.02	0.025	0.03	0.04	0.05
15	0.0075	0.015	0.0225	0.03	0.0375	0.045	0.06	0.075
20	0.01	0.02	0.03	0.04	0.05	0.06	0.08	0.1
25	0.0125	0.025	0.0375	0.05	0.0625	0.075	0.1	0.125
30	0.015	0.03	0.045	0.06	0.075	0.09	0.12	0.15
40	0.02	0.04	0.06	0.08	0.1	0.12	0.16	0.2
50	0.025	0.05	0.075	0.1	0.125	0.15	0.2	0.25

1. Determine the required plot size using the *Procedures* and select the column with that size.
2. Select a plot width (row).
3. Read across the body of the table until you reach the required plot size (in hectares).
4. Where the column and row intersect, read off the plot length in metres.

Use this table to determine rectangular plot length for a given plot size and width

Form N Random Number Table

299	3	312	155	154	251	305	71	59	326	4	282	332	277	71	192
208	121	49	297	344	0	114	219	270	16	283	349	346	101	167	147
3	7	255	216	259	39	357	278	163	114	95	260	36	351	183	14
9	50	303	295	114	68	135	140	136	8	74	238	23	150	11	172
256	298	136	19	206	170	191	257	9	38	45	94	231	339	324	203
305	320	147	114	33	262	335	213	318	276	76	271	133	211	253	156
242	200	238	134	341	250	141	157	215	69	315	192	325	81	182	357
312	332	45	7	244	267	93	311	158	307	280	147	314	42	2	154
199	152	299	289	331	19	268	6	26	132	76	99	343	23	303	183
205	315	41	3	26	323	134	113	10	46	327	145	338	229	165	131
87	197	220	243	349	213	294	0	6	79	12	359	335	128	13	30
161	216	120	273	71	50	354	198	178	100	178	250	187	284	223	257
243	204	246	147	340	59	192	117	78	337	71	305	31	220	48	214
345	340	166	325	311	133	58	279	315	356	331	8	81	305	51	286
39	281	110	281	286	65	330	7	75	311	329	248	143	27	2	17
329	66	337	167	237	350	88	104	200	279	220	194	155	190	217	192
206	149	271	320	360	221	9	337	130	218	65	160	61	115	358	53
116	269	71	217	273	216	8	66	300	183	113	35	23	129	56	164
102	333	341	51	228	218	5	245	221	331	338	73	142	350	96	227

The random number table is used for determining sample points during a litter transect or structured walk.

1. Start in the 1st row of the 1st column.
2. Select this number for the bearing.
3. Select the next number for distance.
4. Place a dot next to the numbers as they are used.

Use this table to find a random number for determining bearing and distance

Form O Horizontal Marginal Distances (m) for Basal Area Points

DBH	BAF							DBH	BAF						
	1	2	3	4	5	7	10		1	2	3	4	5	7	10
1	0.50	0.35	0.29	0.25	0.22	0.19	0.16	**51**	25.50	18.03	14.72	12.75	11.40	9.64	8.06
2	1.00	0.71	0.58	0.50	0.45	0.38	0.32	**52**	26.00	18.38	15.01	13.00	11.63	9.83	8.22
3	1.50	1.06	0.87	0.75	0.67	0.57	0.47	**53**	26.50	18.74	15.30	13.25	11.85	10.02	8.38
4	2.00	1.41	1.15	1.00	0.89	0.76	0.63	**54**	27.00	19.09	15.59	13.50	12.07	10.21	8.54
5	2.50	1.77	1.44	1.25	1.12	0.94	0.79	**55**	27.50	19.45	15.88	13.75	12.30	10.39	8.70
6	3.00	2.12	1.73	1.50	1.34	1.13	0.95	**56**	28.00	19.80	16.17	14.00	12.52	10.58	8.85
7	3.50	2.47	2.02	1.75	1.57	1.32	1.11	**57**	28.50	20.15	16.45	14.25	12.75	10.77	9.01
8	4.00	2.83	2.31	2.00	1.79	1.51	1.26	**58**	29.00	20.51	16.74	14.50	12.97	10.96	9.17
9	4.50	3.18	2.60	2.25	2.01	1.70	1.42	**59**	29.50	20.86	17.03	14.75	13.19	11.15	9.33
10	5.00	3.54	2.89	2.50	2.24	1.89	1.58	**60**	30.00	21.21	17.32	15.00	13.42	11.34	9.49
11	5.50	3.89	3.18	2.75	2.46	2.08	1.74	**61**	30.50	21.57	17.61	15.25	13.64	11.53	9.64
12	6.00	4.24	3.46	3.00	2.68	2.27	1.90	**62**	31.00	21.92	17.90	15.50	13.86	11.72	9.80
13	6.50	4.60	3.75	3.25	2.91	2.46	2.06	**63**	31.50	22.27	18.19	15.75	14.09	11.91	9.96
14	7.00	4.95	4.04	3.50	3.13	2.65	2.21	**64**	32.00	22.63	18.48	16.00	14.31	12.09	10.12
15	7.50	5.30	4.33	3.75	3.35	2.83	2.37	**65**	32.50	22.98	18.76	16.25	14.53	12.28	10.28
16	8.00	5.66	4.62	4.00	3.58	3.02	2.53	**66**	33.00	23.33	19.05	16.50	14.76	12.47	10.44
17	8.50	6.01	4.91	4.25	3.80	3.21	2.69	**67**	33.50	23.69	19.34	16.75	14.98	12.66	10.59
18	9.00	6.36	5.20	4.50	4.02	3.40	2.85	**68**	34.00	24.04	19.63	17.00	15.21	12.85	10.75
19	9.50	6.72	5.48	4.75	4.25	3.59	3.00	**69**	34.50	24.40	19.92	17.25	15.43	13.04	10.91

Use this table to determine marginal distance when checking borderline trees as part of a basal area sweep

Form O Horizontal Marginal Distances (m) for Basal Area Points

DBH	BAF							DBH	BAF						
	1	2	3	4	5	7	10		1	2	3	4	5	7	10
20	10.00	7.07	5.77	5.00	4.47	3.78	3.16	**70**	35.00	24.75	20.21	17.50	15.65	13.23	11.07
21	10.50	7.42	6.06	5.25	4.70	3.97	3.32	**71**	35.50	25.10	20.50	17.75	15.88	13.42	11.23
22	11.00	7.78	6.35	5.50	4.92	4.16	3.48	**72**	36.00	25.46	20.78	18.00	16.10	13.61	11.38
23	11.50	8.13	6.64	5.75	5.14	4.35	3.64	**73**	36.50	25.81	21.07	18.25	16.32	13.80	11.54
24	12.00	8.49	6.93	6.00	5.37	4.54	3.79	**74**	37.00	26.16	21.36	18.50	16.55	13.98	11.70
25	12.50	8.84	7.22	6.25	5.59	4.72	3.95	**75**	37.50	26.52	21.65	18.75	16.77	14.17	11.86
26	13.00	9.19	7.51	6.50	5.81	4.91	4.11	**76**	38.00	26.87	21.94	19.00	16.99	14.36	12.02
27	13.50	9.55	7.79	6.75	6.04	5.10	4.27	**77**	38.50	27.22	22.23	19.25	17.22	14.55	12.17
28	14.00	9.90	8.08	7.00	6.26	5.29	4.43	**78**	39.00	27.58	22.52	19.50	17.44	14.74	12.33
29	14.50	10.25	8.37	7.25	6.48	5.48	4.59	**79**	39.50	27.93	22.81	19.75	17.66	14.93	12.49
30	15.00	10.61	8.66	7.50	6.71	5.67	4.74	**80**	40.00	28.28	23.09	20.00	17.89	15.12	12.65
31	15.50	10.96	8.95	7.75	6.93	5.86	4.90	**81**	40.50	28.64	23.38	20.25	18.11	15.31	12.81
32	16.00	11.31	9.24	8.00	7.16	6.05	5.06	**82**	41.00	28.99	23.67	20.50	18.34	15.50	12.97
33	16.50	11.67	9.53	8.25	7.38	6.24	5.22	**83**	41.50	29.34	23.96	20.75	18.56	15.69	13.12
34	17.00	12.02	9.81	8.50	7.60	6.43	5.38	**84**	42.00	29.70	24.25	21.00	18.78	15.87	13.28
35	17.50	12.37	10.10	8.75	7.83	6.61	5.53	**85**	42.50	30.05	24.54	21.25	19.01	16.06	13.44
36	18.00	12.73	10.39	9.00	8.05	6.80	5.69	**86**	43.00	30.41	24.83	21.50	19.23	16.25	13.60
37	18.50	13.08	10.68	9.25	8.27	6.99	5.85	**87**	43.50	30.76	25.11	21.75	19.45	16.44	13.76
38	19.00	13.44	10.97	9.50	8.50	7.18	6.01	**88**	44.00	31.11	25.40	22.00	19.68	16.63	13.91

Use this table to determine marginal distance when checking borderline trees as part of a basal area sweep

Form O Horizontal Marginal Distances (m) for Basal Area Points

DBH	BAF							DBH	BAF						
	1	2	3	4	5	7	10		1	2	3	4	5	7	10
39	19.50	13.79	11.26	9.75	8.72	7.37	6.17	**89**	44.50	31.47	25.69	22.25	19.90	16.82	14.07
40	20.00	14.14	11.55	10.00	8.94	7.56	6.32	**90**	45.00	31.82	25.98	22.50	20.12	17.01	14.23
41	20.50	14.50	11.84	10.25	9.17	7.75	6.48	**91**	45.50	32.17	26.27	22.75	20.35	17.20	14.39
42	21.00	14.85	12.12	10.50	9.39	7.94	6.64	**92**	46.00	32.53	26.56	23.00	20.57	17.39	14.55
43	21.50	15.20	12.41	10.75	9.62	8.13	6.80	**93**	46.50	32.88	26.85	23.25	20.80	17.58	14.70
44	22.00	15.56	12.70	11.00	9.84	8.32	6.96	**94**	47.00	33.23	27.14	23.50	21.02	17.76	14.86
45	22.50	15.91	12.99	11.25	10.06	8.50	7.12	**95**	47.50	33.59	27.42	23.75	21.24	17.95	15.02
46	23.00	16.26	13.28	11.50	10.29	8.69	7.27	**96**	48.00	33.94	27.71	24.00	21.47	18.14	15.18
47	23.50	16.62	13.57	11.75	10.51	8.88	7.43	**97**	48.50	34.29	28.00	24.25	21.69	18.33	15.34
48	24.00	16.97	13.86	12.00	10.73	9.07	7.59	**98**	49.00	34.65	28.29	24.50	21.91	18.52	15.50
49	24.50	17.32	14.15	12.25	10.96	9.26	7.75	**99**	49.50	35.00	28.58	24.75	22.14	18.71	15.65
50	25.00	17.68	14.43	12.50	11.18	9.45	7.91	**100**	50.00	35.36	28.87	25.00	22.36	18.90	15.81

The table is used to determine marginal distances for borderline trees that cannot be determined to be "IN" or "OUT" using the wedge or string gauge.

1. Measure the slope distance from the plot centre to the centre point of the tree in metres.
2. Measure the diameter of the tree at 1.3m (breast height).
3. In the table, read off the marginal distance for the diameter of the tree and the BAF (Basal Area Factor) of the wedge.

Use this table to determine marginal distance when checking borderline trees as part of a basal area sweep

Form O Horizontal Marginal Distances (m) for Basal Area Points

If the distance to the tree is less than the marginal distance, the tree is "IN"; if it is exactly the same, the tree is a "TRUE BORDERLINE"; if the distance to the tree is greater than the marginal distance, the tree is "OUT".

Where the diameter of a tree is between the marginal distances, for example, a BAF of 2 for a 51.3cm diameter tree 18.20m from the plot point, the following method should be used. This method may also be used for BAFs not shown in the above table.

1. Divide the diameter (in cm) by the slope distance (in m) and compare the value to the figures in the table below.
2. If the value is less than the Limiting Factor, the tree is "OUT"; if it is equal, the tree is a "TRUE BORDERLINE"; if it is greater than the Limiting Factor, the tree is "IN".

BAF	1	2	3	4	5	7	10	15	20
Limiting factor	2.00	2.83	3.46	4.00	4.47	5.29	6.32	7.75	8.94

In the previous example, the test value of 2.82 (51.3/18.20) is less than the Limiting Factor, therefore the tree is "OUT".

Use this table to determine marginal distance when checking borderline trees as part of a basal area sweep

Appendix 2

Alternative Method for Calculating Number of Plots

Section 3 of the *Procedures* provides a simple method for determining the number of plots required by estimating the variability of the planting. An alternative and more accurate method for determining the number of plots is to use statistical theory. Some data regarding the resource is required such that an estimate of the mean and variability (expressed as the standard deviation of the estimate) can be obtained. An overall target error must also have been selected. An estimate of resource variability is obtained by measuring a few plots. This is often done using a basal area wedge or string gauge (Section 3.6 of the *Procedures* and Appendix 4).

The statistical equation for determining the required number of plots is:

$$\textit{Number of plots} = \frac{t_{(n-1,0.05)}{}^{2} \times s^{2}}{\textit{Error }\%^{2} \times \bar{x}^{-2}} \times 100^{2}$$

Where:

- t is the students' t;
- n is the number of plots to be measured;
- Error % is the target error (expressed as a % of the estimate);
- s is the standard deviation; and
- $\bar{x}$ is the estimate of the mean value.

Explanations of these terms and methods of calculating mean and standard deviation from basal area measurements are discussed in Section 4.6 of the *Procedures*.

Appendix 3

Technical Specifications

This section outlines some of the statistical assumptions used to work out the recommended numbers of plots needed to stay within a given target error (Section 3.3 of the *Procedures*). The equation in Appendix 2 were used to calculate numbers of plots. Numbers of plots have been calculated at the 95% confidence interval, using assumptions about the coefficient of variation for various planting types. The assumptions are conservative and may be revised as more information becomes available about environmental plantings.

Fixed area plots

The number of fixed area plots required depends on the number of trees that need to be sampled and the variability between trees. An average fixed area plot is assumed to contain 15 trees. The number of plots was calculated as the number of trees required divided by 15.

There are four tree variability classes. These classes and assumptions about the variability between trees within each class were informed by sample field data.

TREE VARIABILITY CLASS	ASSUMED COEFFICIENT OF VARIATION BETWEEN TREES (%)
Plantation	70
Low	90
Medium	110
High	130

Stocking plots

The number of stocking (point to plant) plots depends on the variability in stocking and the number of trees for which point to plant measurements are taken in each plot. In the *Procedures* stocking plots are based on point to plant measurement to the 4th closest tree. Changing the number of the tree for which point to plant distance is measured will affect the coefficient of variation.

STOCKING VARIABILITY CLASS	ASSUMED COEFFICIENT OF VARIATION BETWEEN PLOTS (%)
Excellent survival	50
Uniform survival	60
Patchy	80
Very patchy	90

As the fixed area plots are also used for stocking estimation, the number of stocking plots required equals the total number of plots required to estimate stocking minus the required number of fixed area plots.

Basal area points

The number of basal area points required depends on variability in both stocking and tree size. The variability description used in the *Procedures* is based on tree variability. The number of points was calculated using the following coefficients of variation, assuming an average of 7–12 trees per basal area sweep.

TREE VARIABILITY	ASSUMED COEFFICIENT OF VARIATION BETWEEN TREES (%)
Plantation	50
Low	60
Medium	70
High	80

Single tree sampling

Due to the smaller population size, sample size was calculated using the finite population equation shown in Section 4 of the *Procedures* rather than the equation in Appendix 2.

NUMBER OF SPECIES	ASSUMED COEFFICIENT OF VARIATION (%)
One species	70
Two or more species	100

Appendix 4

Equipment

GEOGRAPHIC POSITIONING SYSTEM (GPS)

What is it?

A **Global Positioning System** is used to provide an accurate location. Readings from a GPS consist of sets of x and y coordinates recorded along routes. These can be used to generate a map and calculate area.

Following the removal of selective availability in 2000, the accuracy of handheld GPS units increased significantly. It is now assumed that accuracy will be ±10m, although the exact figure will be influenced by climatic and atmospheric conditions, satellite positioning and crown cover. This increase in accuracy means that the use of a differential GPS is not required in most circumstances. To meet the Bush for Greenhouse standard in determining area, a GPS unit should have the following equipment and specifications:

- 12 channel receiver;
- an estimated accuracy display;
- a track log function with the option to record several different routes that can be saved and downloaded;
- point averaging feature, with points that can be saved and downloaded;
- sufficient memory to store several kilometres of boundary line and several points;
- at least six hours operating time or spare batteries; and
- data cable and relevant software.

Most newer, handheld GPS units will fulfil these criteria. Before going into the field, it is a good idea to check whether you are able to download data from the GPS to a computer.

Use

Prior to using the GPS it is important to determine the x and y coordinate system you wish to use. Australia is currently in the process of changing its base datum for coordinates from the old Australian Geodetic Datum (AGD) to the new Geocentric Datum of Australia (GDA). The difference between these two is about 200m on the ground, depending on location.

The datum used should be that used on relevant maps, farm plans or aerial photographs. This will allow a check of the location provided by the GPS against the map to ensure that the reading seems reasonable. GDA is preferred where these maps are available. Maps should have the datum noted on them, with all but the most recent maps likely to be using AGD coordinates. The datum being used should be noted before commencing measurement and should not be changed during measurement. Table 1 shows the settings for data, coordinates and units that should be used to meet the Bush for Greenhouse standard. Refer to the GPS unit's user manual for details on changing these parameters.

TABLE 1: Settings for GPS units

PARAMETER	PREFERRED	ACCEPTABLE
Datum	GDA (WGS84)	AGD66, AGD84
Coordinates	Universal Transverse Mercator (UTM)	As for preferred
Units	Metres	As for preferred

Note: Some GPS units may not offer GDA as a datum. For the purposes of measuring area using a handheld GPS unit, GDA can be considered the same as WGS84.

Precision

Since the removal of selective availability, most handheld GPS units should be able to achieve an accuracy of ±10m. This is normally displayed on the screen of the unit. To meet the Bush for Greenhouse standard, the error should not exceed ±7m at any one point.

Calibration

See user instructions.

Maintenance

See user instructions.

HIP CHAIN

What is it?

A **hip chain** is a distance-measuring device. The device incorporates a reel of cotton and a metering device. The cotton thread passes through a meter. The meter records how much thread is removed and displays this in metres travelled.

A hip chain is used for estimating distance where accuracy is less important or where the terrain and vegetation conditions make more accurate distance calculation methods inappropriate.

Use

The hip chain should be attached to the user's belt. The end of the cotton thread should be tied securely to a fixed object at the take-off point (or plot centre). The meter should be set to zero by turning the metal knob on the outer edge. The user can then commence the traverse until the required distance is displayed on the dial.

Precision

Hip chains are less precise than measuring tapes or polychains. Repeated measurements should be within 4%.

Calibration

The hip chain is not an accurate tool and cannot be re-calibrated by the user. However, the meter should be checked periodically by measuring a distance with the hip chain and with a more accurate instrument such as a polychain and comparing the results.

Maintenance

The hip chain should be kept clean and dry. Any build up of debris within the case or around the meter should be removed and/or cleaned. The meter should be checked to ensure that the cotton runs smoothly with no slippage.

FIBREGLASS MEASURING TAPE

What is it?

A **fibreglass measuring tape** is a device used for the accurate determination of short distances, usually up to 50m. It is used, for example, to measure to plots, measure plot radius for circular plots, to mark out plot boundaries for rectangular plots and can be used to measure the diameter of coarse woody debris.

Use

The tape is calibrated in centimetres on both sides, with centimetres and metres numbered. The zero point is usually at the very end of the tape (at the extent of the metal end). It is advisable to check this before any measurements are taken. One person should hold the zero point at the start point; the other person should extend the tape until the correct distance has been reached. The tape should be held tight such that it is in a straight line and is not twisted around any objects.

Precision

Measurements should be recorded in metres to the first decimal place, e.g., 12.6m. Repeated distance measurements should be within 2%.

The diameter of pieces of coarse woody debris can be measured by laying a normal tape across the sample. This method is less precise than using a diameter tape. Repeated measurements should not differ by more than 10%.

Calibration

Fibreglass measuring tapes tend to stretch over time. To calibrate, check the fibreglass tape against a metal measuring tape or alternate known distance.

Maintenance

The measuring tape should be kept clean and dry. Most measuring tapes are supplied on a spool and the tape should be rewound after use. If the tape becomes twisted, the twist should be removed. A tape that has stretched, been cut through or is knotted should be replaced.

POLYCHAIN

What is it?

A **polychain** is a measuring instrument used for accurate determination of distances while traversing between points. It consists of a plastic coating over a fibreglass inner, marked in 10cm increments. Polychains are very strong, resistant to stretching and less likely than tape to become snagged on trees and debris. This makes them ideal for accurately measuring long distances through bushland.

Use

The polychain is used in a similar manner to a measuring tape when moving from point to point. The polychain should be pulled tight between the crew members. This will not damage the polychain as it may a measuring tape and will increase the accuracy of the measurement. Do not roll up the polychain upon reaching the plot point, simply begin walking to the next point once the measurements have been completed and allow the polychain to drag through the bush.

Precision

The polychain can be more precise than a measuring tape over long distances. Polychain distance should be within 2% of repeated measurements.

Calibration

Polychains cannot be re-calibrated. Periodically check the length of the polychain against a known distance to ensure it is still accurate.

Maintenance

Following use, roll the polychain up like you would a length of rope. Prevent large heavy objects from crushing the polychain and damaging the outer coating. If a polychain should break, replace it immediately.

SUUNTO CLINOMETER

What is it?

A **clinometer** is an ocular device used to determine slope in either percent (%) or degrees (°). This is the simplest of the Suunto clinometer range of products.

For the purposes of the *Procedures*, measurements taken using a clinometer are used to correct distances for slope, for both hip chain use and laying out fixed area plots. The clinometer can also be used for the calculation of tree height, using trigonometric or mathematical procedures, when a distance from the object is known.

When the user sights through the eyepiece, a rotating wheel with a scale printed on it can be seen and a red line indicating the horizontal plane. The scale has degrees on the left and percent on the right. Care should be taken to ensure the correct scale is read.

Use

For determining slope. The user should sight through the eyepiece (with the instrument held vertically) and align the red horizontal band with an object of equal height to the observer's eye. An ideal object is another person, who moves away in the direction of the slope so that a sighting can be made to a point on their body. The left-hand scale should be read to determine slope in degrees.

For use in tree height determination. The observer should move away from the tree such that the top of the tree can be clearly seen and the slope is less then 120%. The distance from the observer's eye to the base of the tree must be known, and it is easier if this distance is a multiple of 10m.

The observer should then sight to:

1. The bottom of the tree and read the scale;
2. The observer's eye level on the tree; and
3. The top of the tree and read the scale.

The height can then be calculated by using the clinometer measurements, the known distance from the tree and trigonometry.

Precision

Height measurements should be recorded in metres to the first decimal place, for example, 8.4m. Repeated height measurements made using a clinometer should differ by no more than 5%.

Slope angles recorded using the clinometer are recorded to the nearest degree and should not be out by more than 5% of repeated measurements.

Calibration

A clinometer cannot be calibrated. However, for training purposes, a new user can follow the technique above to estimate the height of an object of known height.

Maintenance

The clinometer is a sealed instrument and cannot be serviced. If it is broken or develops a bubble in the housing, it should be discarded.

SUUNTO COMPASS

What is it?

A **compass** is a device used to determine magnetic north, which allows a user to travel between two points on a known bearing. A bearing is an angle between 0 degrees and 360 degrees.

A compass is used together with a hip chain or measuring tape to record the boundary of a planting area. It is also used to follow a bearing to locate plots in the field. It can also be used to determine aspect (the direction in which the ground slopes).

Use

The Suunto compass is similar to the Suunto clinometer. With the instrument held horizontally, the user sights through the eyepiece with one eye. The eye at the eyepiece is used to read the degree gradations at the red vertical line and selects an object to walk towards.

Be aware that a compass is a magnetic instrument and may be biased by metallic objects and certain terrain types. The risk of the former can be minimised by moving away from objects such as motor vehicles. The latter is an external risk and requires the user to be aware of local geology to ensure that the bearing shown by the compass is correct.

Precision

All measurements taken using the Suunto compass are recorded in degrees to the nearest whole number. Aspect recordings should repeatable to within 10 degrees of each other. Aspect is the direction which the slope faces.

When walking to plots the compass bearing followed should not vary by more than 2 degrees.

When constructing rectangular plots, the angles at each corner should not be out by more than 2 degrees at any point, that is, each point must be within 88–92 degrees of the next point.

Calibration

If the user is calculating a bearing from a map using true or grid north, the bearing must be adjusted by the magnetic declination. When going from a true bearing to a magnetic bearing, the declination must be added.

There are two things to calibrate, the first is that the user is reading the device properly, the second is to ensure the compass bearing is correct.

To assess whether an inexperienced user is using the compass correctly, an experienced user and the inexperienced user should stand in the same position (at different times!) and sight to the same object. Compare the two bearings, they should be within 1 degree.

The compass can be checked to ensure it is giving the correct bearing by placing it in a known spot and directing it at a known object of known bearing. The two readings should be the same.

Maintenance

The compass should be checked to make sure that the disk or needle rotates freely. The compass should be free of any large bubbles.

DIAMETER TAPE

What is it?

A **diameter tape** is a measuring tape with normal metric increments (nominally, in millimetres) printed on one side and diameter increments on the other. It can be bought in either steel or fibreglass.

The diameter tape is used to estimate the diameter of the tree. By wrapping the tape around the circumference of the tree stem at 1.3m (breast height), on the assumption that the stem is circular in cross section, the tape will convert circumference into diameter.

Use

The tape should be wrapped around the tree stem and pulled tight. Ensure that the tape is not kinked, twisted or biased by bark or branches. The diameter scale (0) should be facing out and the tape held at right angles to the plane of the stem. The zero mark on the tape should be held firmly against the tree. As the tape is wrapped around the tree, the other end should be overlaid such that the diameter scale can be seen. The diameter scale opposite the zero mark on the tape can now be read and this is the diameter of the tree.

Precision

Measurements should be recorded in centimetres to the first decimal place (e.g., 20.1cm). Repeated measurements should differ by no more than 2% from the original reading.

Calibration

Diameter tapes should not need to be calibrated, assuming that the metric and radius scales have been printed correctly.

Maintenance

The tape and tape housing (if applicable) should be cleaned routinely. This will remove dirt, bark residue and any sap build up. The tape should be checked to ensure that both printed scales can be read clearly. If the printed numbers are not clearly readable, the tape should be replaced. The tape ends should be intact and the body of the tape should not be kinked or damaged. If the tape is worn, it should be replaced.

BARK GAUGE

What is it?

A **bark gauge** is a device to measure bark thickness without damaging the tree. The bark gauge usually has a metric calibrated metal shaft, a large handle and a plate that can slide freely along the shaft.

Use

The user should stand next to the tree and mark 1.3m (breast height):

1. Place the point of the bark gauge just below 1.3m in contact with the tree;
2. Align the sleeve with the zero mark on the shaft;
3. Hold the shaft horizontally, and press or tap the shaft gently such that it penetrates the bark. Continue applying pressure until the tip of the shaft hits the wood; and
4. Once the tip has reached the wood, read the scale on the shaft.

Precision

Using a bark gauge to measure bark thickness is prone to a high degree of error. Measurements should be recorded in centimetres to the first decimal place. Repeated measurements, to obtain an average, should not vary by more than 20%.

Calibration

There is no calibration needed on this instrument.

Maintenance

The bark gauge should be kept clean, free from bark and sap residue. The shaft has a tendency to bend. A bent bark gauge should be replaced.

HEIGHT STICKS

What are they?

Height sticks are a direct method of measuring tree height, up to a total height of 5m.

Height sticks are sticks of a known length. The individual height sticks slot together. Usually, one height stick is further incremented into sub-meter accuracy. The sticks are either made of aluminium or fibreglass, and can be telescopic or segmented.

Alternatively, a budget height pole can be constructed using PVC pipe. PVC pipe is available from most hardware stores in various diameters and lengths. A 3m length of PVC is manageable in the bush, but ensure that the diameter chosen is large enough so that the pole does not flex when it is held vertically.

Making a height pole

To construct a height pole you will need; a piece of PVC pipe, a black, permanent marker pen and a tape measure with gradations to 10cm:

1. Hold the 0cm mark of a tape measure at one end;
2. At each 10cm point, place a single mark and the distance from the 0 point;
3. At each metre, mark a heavier line and also write the distance from the 0 point; and
4. Do this until the top of the pole has been reached.

This is the simplest of the homemade height poles. If desired, the pole can be cut in half, a sleeve fitted to one of the halves and then, when greater height is needed, the top half can be slipped onto the bottom half. A collapsible pole allows greater ease of movement in the forest.

Use

Two people are needed to operate fixed or telescopic height sticks and three when segmented poles are used for trees over 5m tall. One person is the observer and stands away from the tree so that they can see the stem and top of the tree. The observer's role is to ensure that the height poles are held vertical so that an accurate height can be determined and to tell the person at the base of the tree to stop once the pole height equals the tree height. The other person (or persons if segmented height sticks are used) should stand at the base of the tree, raising the height sticks as directed by the observer.

The determination of tree height is completed in two ways:

- Fixed or telescopic height poles. The height of the tree can be read directly from the height increments printed on the height pole; or
- Segmented height sticks. The number of full height sticks used should be counted and their sum multiplied by the length of the sticks to give a height (allowing for overlap between poles). The remaining height can be measured on the top stick, which is incremented, and added to give total height.

Segmented height sticks are potentially dangerous and can injure the user if they come apart when in use. Because of this it is important that people using height sticks wear hard hats to protect themselves if the sticks hang up in the canopy and fall onto the user. The operators under the tree should be alert to falling branches that may be dislodged as the height poles are raised.

Precision

Measurements are recorded in metres to a first decimal place, for example, 3.6m. Repeated measurements made using height sticks should not differ by more than 5%, assuming they are used to a maximum height of 5m.

Calibration

No calibration of height sticks is required beyond regular maintenance.

Maintenance

Any height measurement tools must be kept clean and dry. Any broken height instruments should be replaced. The additional issues with telescopic height poles include ensuring that they extend easily and the locking mechanisms operate effectively.

FINE LITTER TOOL

What is it?

The **fine litter tool** is used to estimate the depth of litter less than 6mm in diameter on the ground. This figure is then used to calculate the amount of fine littler biomass.

Making a fine litter tool

To construct a fine litter tool you will need: a ruler, some non-flexible sheet (e.g., masonite or perspex), and a drawing compass, saw and file.

1. Using the compass, draw a 200mm diameter circle on the non-flexible sheet and cut it out using the saw;
2. Using the saw and/or file, cut a hole in the centre of the disc which allows the ruler to move freely through it; and
3. File off the end of the ruler to the 0mm mark.

Use

The fine tool is placed over the litter and the ruler pushed through to mineral earth level. Remove any sticks greater than 6mm in diameter, stones or other objects projecting above the average litter bed height from under the disc. Avoid placing the disc over clumps of live grass, which may bias the measurement. Push the disc down with light pressure, using the fingertips, and record the litter depth. If the reading is taken at the top of the disc, do not forget to subtract the thickness of the disc from the measurement.

Precision

Measurements are recorded to the nearest millimetre. Repeated measurements should not differ by more than 3mm.

Calibration

No calibration of the fine litter tool is required.

Maintenance

The disc should be checked periodically to ensure it is still flat.

BASAL AREA WEDGE

What is it?

A **basal area wedge** is a tool to determine the basal area of a forest or plantation. The basal area is the sectional area of tree stems at 1.3m above ground level. The wedge is an optical device that creates an angle which "distorts" the image.

A basal area wedge is used to take a number of point samples of basal area to get a quick estimate of the basal area of a forest.

Use

The procedure is called a basal area sweep, where the person looks through the wedge at each tree, and completes a 360 degree turn around the plot centre;

1. The wedge must be held directly above the plot centre (marked with a peg);
2. The wedge should be held at right angles to the slope of the stem;
3. The user should sight, through the wedge, at the breast height mark. A 'T' shaped pole can assist to accurately determine whether the tree is "IN" or "OUT", and to view breast height;
4. As the person sights through the wedge at each stem, the tree stem will be displaced (due to the optics of the wedge):
   - If the image of the tree and the tree stem overlap, the tree is "IN".
   - If the image of the tree and the tree stem are clearly separated, the tree is "OUT".
   - If the image and the tree stem are aligned, the tree is considered "BORDERLINE" and the measurement procedure for checking borderline trees should be followed.
5. The basal area of the forest is then the sum of the "IN" trees multiplied by the basal area factor of the wedge.

Precision

There is no room for error when conducting a basal area sweep. No trees should be incorrectly recorded as "IN" or "OUT". "BORDERLINE" trees should be checked.

Calibration

An optical wedge is supplied with a basal area factor. The basal area factor refers to amount the image is moved. There should be no need for calibration.

Maintenance

The wedge should be stored clean inside the leather pouch. If the wedge is scratched or broken, it should be replaced.

ALTERNATIVE EQUIPMENT FOR BASAL AREA MEASUREMENT

How to make a string gauge

A **string gauge** can be made from a piece of plastic or similar material attached to a string of known length. The length of the string defines the distance between the string gauge and the measurer's eye. The length of the string and the width of the plastic together affect the Basal Area Factor of the string gauge. The required dimensions of the string gauge can be calculated using:

Equation 1 — Determining basal area factor

$$BAF = 2500 \times \left(\frac{d}{D}\right)^2$$

Where: d = width of the string gauge in metres; and
D = string length in metres.

Examples of dimensions giving known basal area factors are shown in Table 2.

TABLE 2: String gauge dimensions

BAF	GAUGE WIDTH (MM)	STRING LENGTH (CM)
1	10	50
2	17	60
3	18	52
4	20	50
5	18	40
7	18	34
10	32	50

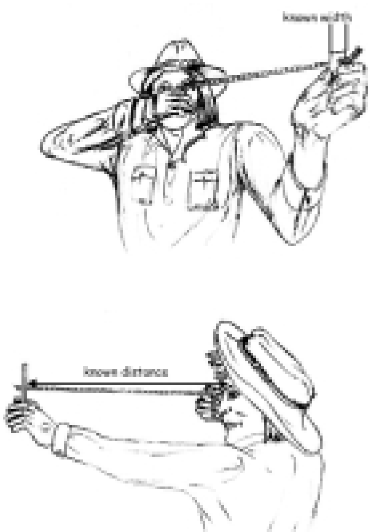

Figure 1 — Making a string gauge

Use

Use of the string gauge is similar to use of the basal area wedge except that the eye of the user must remain directly over plot centre. The string should be held near the user's eye and the string should be held taught.

"IN" trees are those which are not fully covered by the width of the string gauge. "OUT" trees are those which are fully covered and "BORDERLINE" trees are those where the stem aligns with the gauge.

Precision

A string gauge is less precise than a basal area wedge. Careful checking of "BORDERLINE" trees will improve the precision of measurements.

Calibration

The string length on a string gauge should be checked regularly to ensure it has not stretched and is the correct length.

Maintenance

A string gauge should be maintained to ensure that gauge width and string length remain constant.