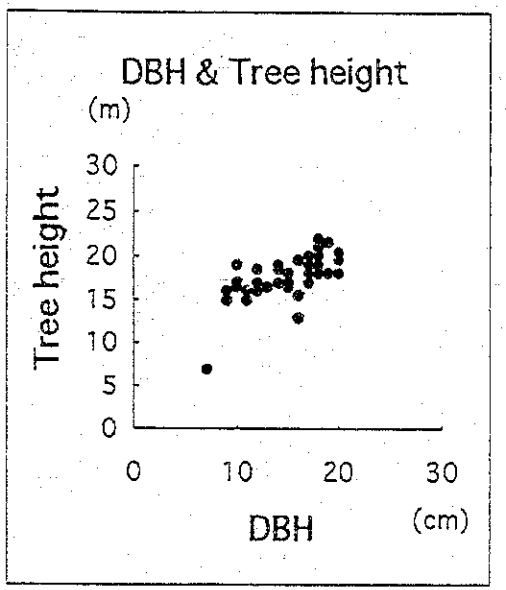
Plot No,1 Result of artificial forest survey

Date	7/27/93	Plot size	20m×20m 0.04ha
Plot No.	1	Planted year	1986.Dec. (7.5years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	NU-1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently) /8°	Tending	Fertilizing (planted)
Remarks			

No,	DBH (cm)	Tree height (m)	Volume eruation (m3)
1	7	7	0.01650
2	16	13	0.11668
3	16	16	0.13377
4	11	15	0.06683
5	11	16	0.07027
6	17	18	0.16742
7	20	20	0.23808
8	12	19	0.09187
9	14	19	0.12349
10	18	21	0.20898
11	18	20	0.20121
12	20	21	0.24752
13	18	21	0.20898
14	10	19	0.06775
15	19	22	0.23439
16	17	20	0.18170
17	16	20	0.15990
18	17	20	0.18170
19	15	18	0.13391
20	19	18	0.20416
21	17	17	0.16014
22	15	17	0.12516
23	14	17	0.11326
24	20	18	0.22372
25	17	17	0.16014
26	18	18	0.18539
27	10	17	0.06072
28	17	18	0.16742
29	13	17	0.09696
30	17	17	0.16014
31	13	17	0.09696
32	18	19	0.19334
33	17	19	0.17460
34	12	17	0.08603
35	10	17	0.06214
36	9	15	0.04672
37	19	18	0.20416
38	18	22	0.21668
39	18	21	0.20898
40	14	19	0.12095
41	9	16	0.04912
42	15	17	0.12516
43	12	16	0.08207
44	15	17	0.12809
Total	668	780	6.30318
Average	15.18182	18	
		Volume/ha (m3)	157.57962
		MAI(m3)	21.24860



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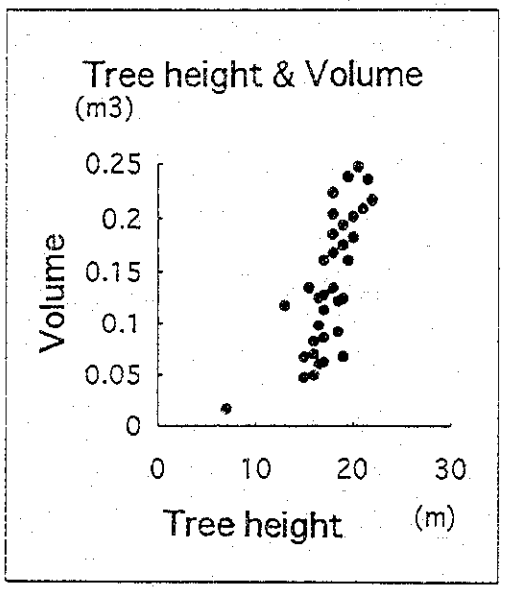

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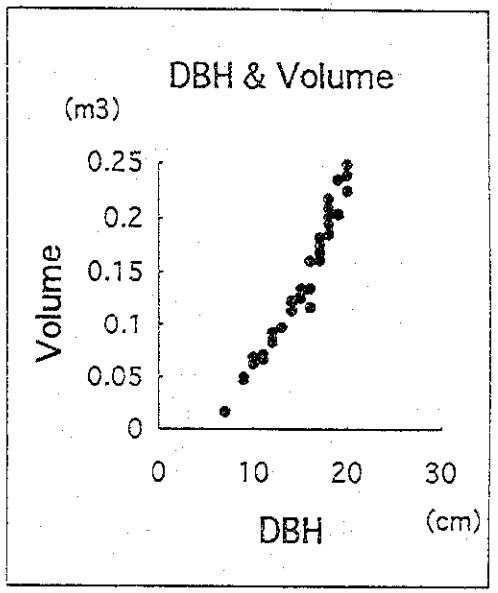
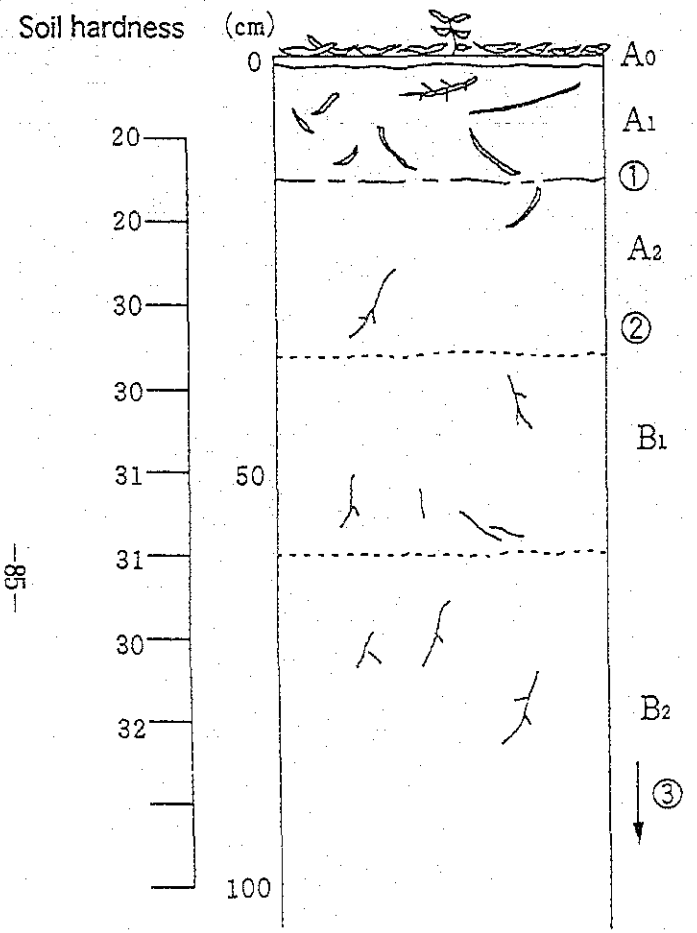


r= 0.97511

Plot No,1 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume



①Very gradually
②Little gleyzation
③gleyzation
Ferrous integration

Date	7/27/93
Plot No.	1
Area	Bengkoka
Compartment	NU-1
inclination	Slope land (gently) /8°

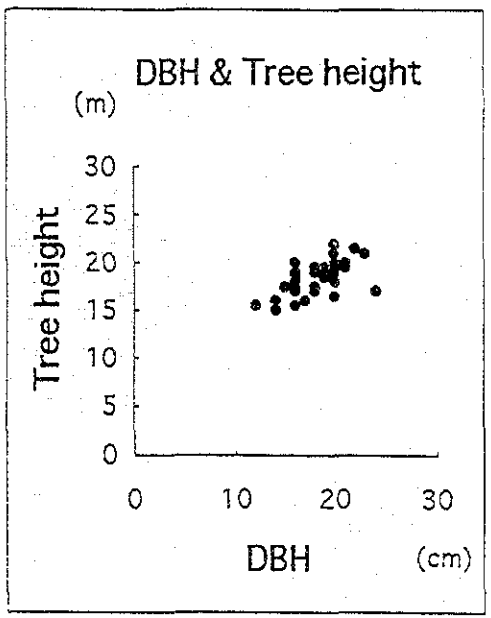
Horizon	Colour	Humus	Gravel	Structure	Moisture	Illuvation	Mycorrhiza	Root	pH	Remark
A1	2.5Y5/4	Poor	Nil	Little crumb	Dry	Nil	Nil	Rich	5.2	
A2	10YR6/6	Poor	Nil	Little crumb	Dry	Nil	Nil	Poor	5.2	
B1	7.5YR5/6	Nil	Nil	Massive	Little wet	Nil	Nil	Poor	5.2	
B2	2.5Y6/1	Nil	Nil	Massive	Little wet	Nil	Nil	Poor	5.4	

Plot No,1 Soil profile and Result of soil survey (Artificial forest)

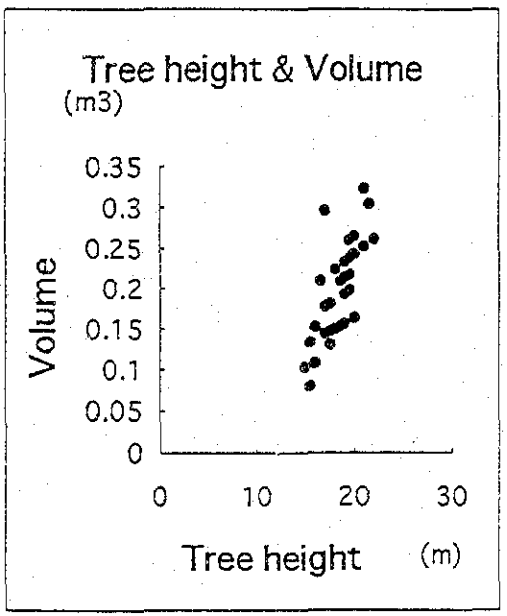
Plot No,2 Result of artificial forest survey

Date	7/27/93	Plot size	20m×20m 0.04ha
Plot No,	2	Planted year	1987.Feb. (6.5years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	KT-1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently) /7°	Tending	Fertilizing (planted)
Remarks			

No,	DBH (cm)	Tree height (m)	Volume eruation (m3)
1	20	17	0.20910
2	24	17	0.29626
3	17	16	0.15277
4	14	15	0.10276
5	16	16	0.13377
6	18	17	0.17733
7	20	18	0.22372
8	18	18	0.18137
9	20	20	0.24282
10	20	20	0.24282
11	16	19	0.15349
12	15	18	0.13101
13	12	16	0.08007
14	16	17	0.14373
15	18	19	0.19334
16	19	19	0.20856
17	20	19	0.23333
18	23	21	0.32362
19	14	16	0.10805
20	19	19	0.20856
21	16	18	0.14700
22	19	20	0.21726
23	20	20	0.23808
24	20	21	0.25220
25	20	22	0.26149
26	21	20	0.26490
27	21	20	0.25974
28	19	19	0.21292
29	16	18	0.15025
30	19	19	0.21292
31	18	20	0.19729
32	22	22	0.30446
33	16	19	0.15670
34	16	20	0.16308
Total	622	628	6.78476
Average	18.29412	18	
		Volume/ha (m3)	169.61892
		MAI(m3)	26.43686



r= 0.6162073



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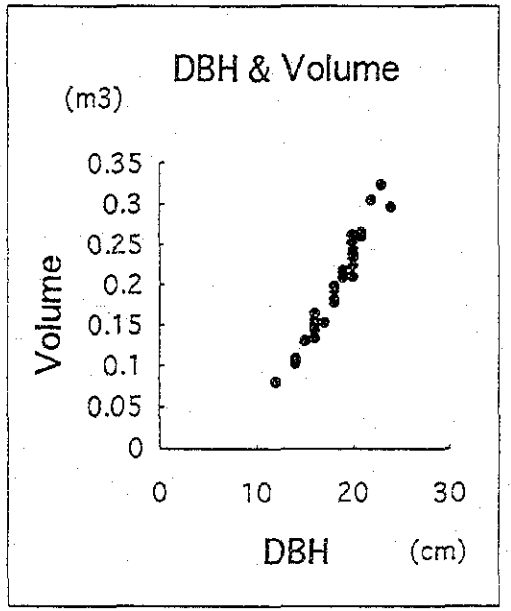
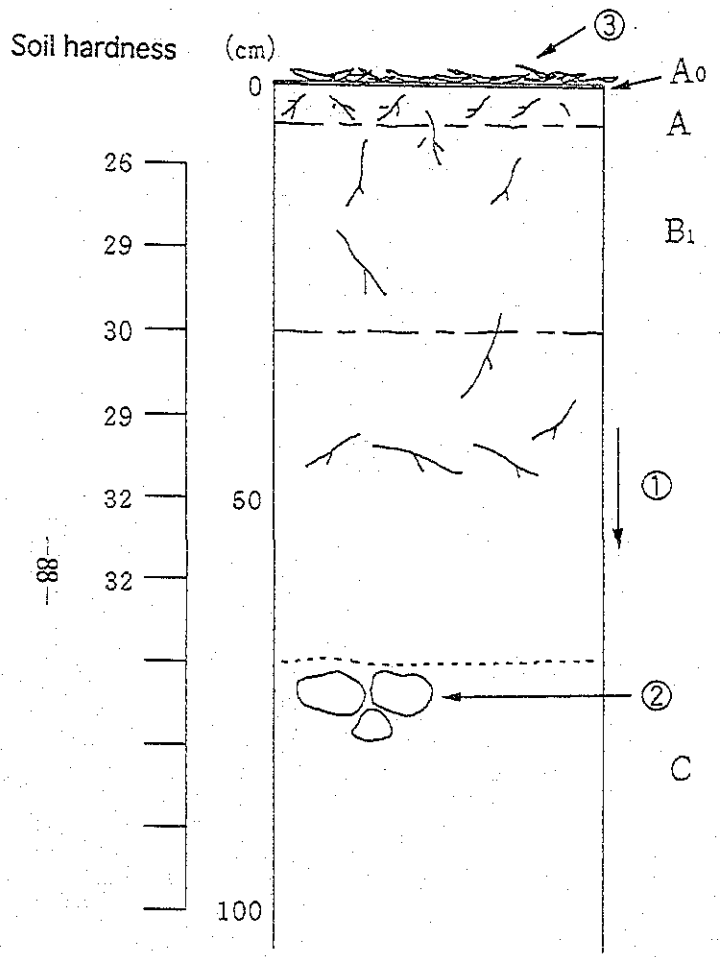


r= 0.9762176

Plot No,2 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume



Date	7/27/93
Plot No,	2
Area	Bengkoka
Compartment	KT-1
inclination	Slope land (gently) /8°

Horizon	Colour	Humus	Gravel	Structure	Moisture	Illuvation	Mycorrhiza	Root	pH	Remark
A	2.5Y5/4	Poor	Nil	Little crumb	Dry	Nil	Nil	Rich	5.8	
B1	2.5Y6/6	Nil	Nil	Massive	Little dry	Nil	Nil	Poor	5.6	
B2	2.5Y4/6	Nil	Nil	Massive	Little dry	Nil	Nil	Poor	5.6	
C	5Y5/2	Nil	Sand stone	Massive	Little dry	Nil	Nil	Nil		

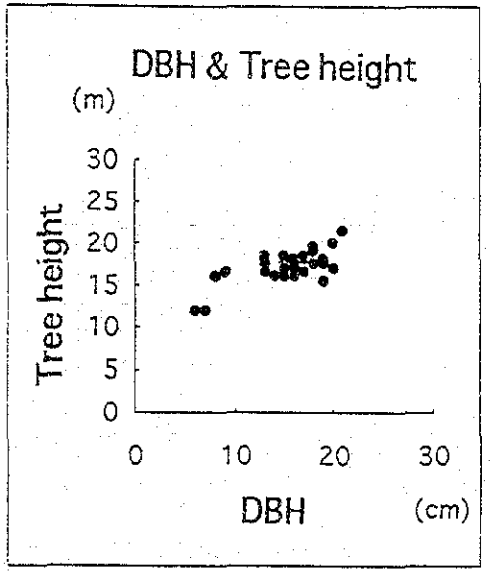
①Little gleyzation
Ferrous integration
②Sand stone
③Litter and seed of A.mangium

Plot No,2 Soil profile and Result of soil survey (Artificial forest)

Plot No,3 Result of artificial forest survey

Date	7/27/93	Plot size	20m×20m 0.04ha
Plot No,	3	Planted year	1985.Nov. (7.8years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	TG-1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	Fertilizing (planted)
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	19	16	0.18176
2	16	16	0.13711
3	20	17	0.21400
4	15	16	0.12220
5	15	18	0.13101
6	19	18	0.20416
7	13	18	0.10374
8	18	20	0.19729
9	13	19	0.10597
10	21	22	0.28021
11	6	12	0.01906
12	16	18	0.14700
13	13	18	0.10374
14	16	16	0.13711
15	9	17	0.05031
16	18	18	0.18137
17	17	18	0.16742
18	7	12	0.02509
19	15	19	0.13680
20	13	17	0.09696
21	16	18	0.15025
22	17	19	0.17102
23	16	17	0.14373
24	15	17	0.12516
25	17	17	0.15647
26	14	16	0.10805
27	16	17	0.14373
28	17	19	0.17102
29	15	17	0.12516
30	19	18	0.19974
31	20	20	0.24282
32	13	17	0.09696
33	16	17	0.14373
34	13	17	0.09696
35	16	17	0.14373
36	8	16	0.03981
37	18	19	0.19334
38	18	19	0.19334
39	19	18	0.20416
40	18	18	0.18137
41	16	18	0.14700
42	15	17	0.12809
43	13	18	0.10149
Total	664	741	6.14943
Average	15.44186	17	
		Volume/ha (m3)	153.73587
		MAI(m3)	20.05425



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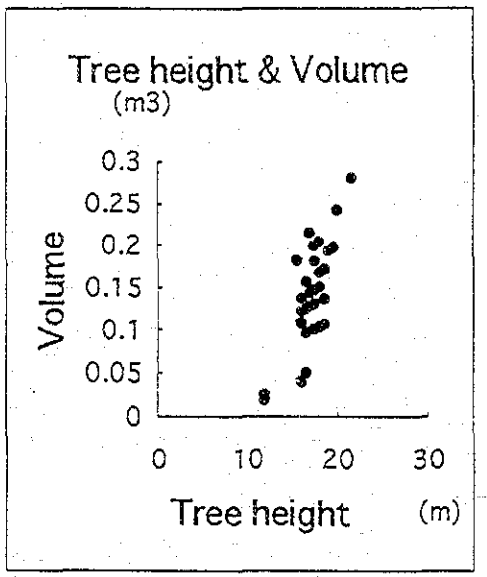

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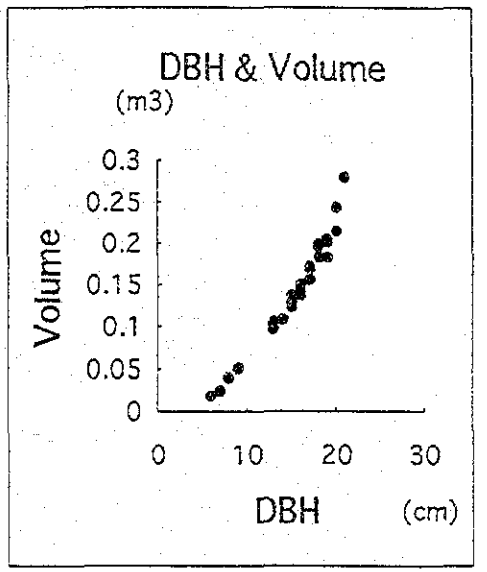


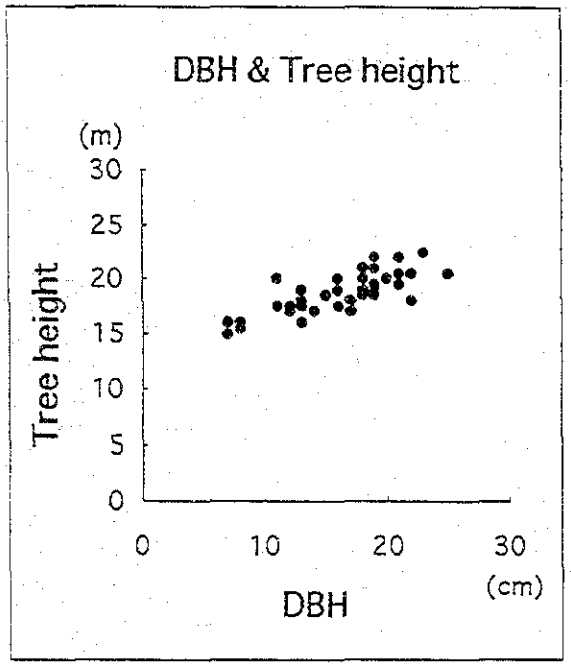
r= 0.9717593

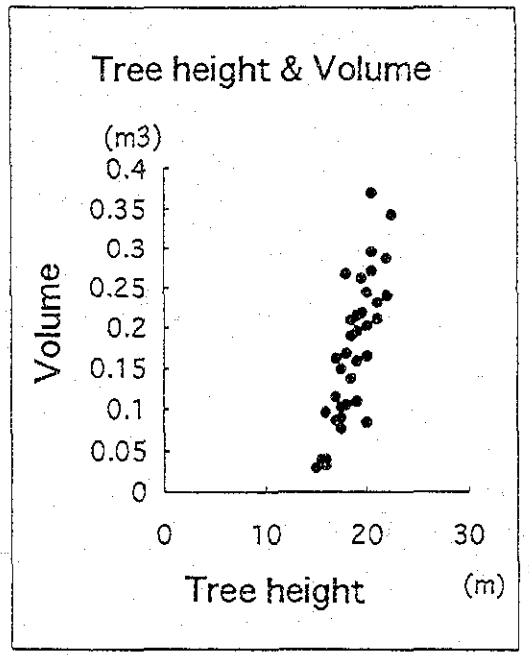
Plot No,3 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

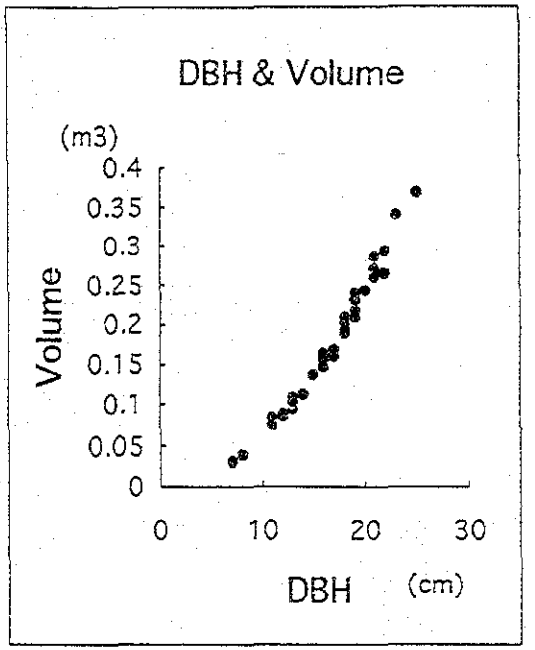
Plot No,4 Result of artificial forest survey

Date	7/27/93	Plot size	20m×20m 0.04ha
Plot No,	4	Planted year	1983.Dec. (9.7years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	BA-1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently) /8°	Tending	
Remarks	Undergrowth : Lahunnai(Eupatorium odoratum)		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	16	18	0.14700
2	13	16	0.09467
3	22	18	0.26519
4	18	19	0.19334
5	18	20	0.20121
6	7	15	0.02984
7	18	21	0.20898
8	19	22	0.23862
9	21	22	0.28527
10	13	18	0.10149
11	11	20	0.08358
12	19	21	0.23015
13	23	23	0.34144
14	7	16	0.03137
15	19	20	0.21726
16	19	19	0.20856
17	22	21	0.29340
18	8	16	0.03981
19	17	18	0.16742
20	16	19	0.15670
21	18	19	0.18938
22	19	19	0.21292
23	12	17	0.08603
24	11	18	0.07534
25	19	20	0.21726
26	16	20	0.16308
27	13	19	0.10819
28	19	19	0.20856
29	18	19	0.19334
30	17	18	0.16742
31	14	17	0.11326
32	12	18	0.08799
33	17	17	0.16014
34	21	20	0.25974
35	13	18	0.10374
36	8	16	0.03884
37	16	19	0.15670
38	15	19	0.13680
39	25	21	0.36855
40	21	21	0.27003
41	20	20	0.24282
42	16	19	0.15670
	15	19	0.13680
Total	701	806	7.38892
Average	16.30233	19	
		Volume/ha (m3)	184.72305
		MAI(m3)	19.27612







r= 0.7624506

r= 0.8057286

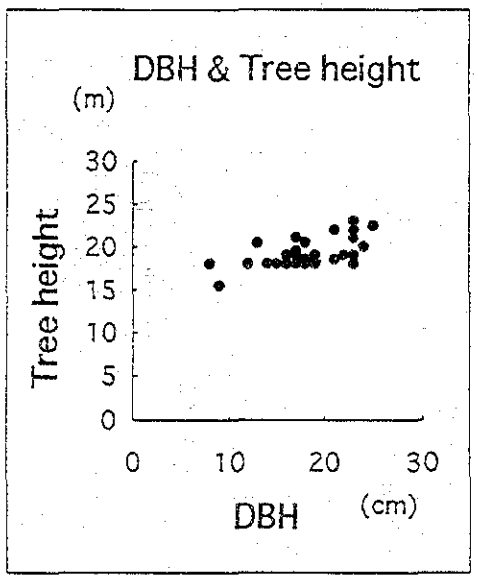
r= 0.9791036

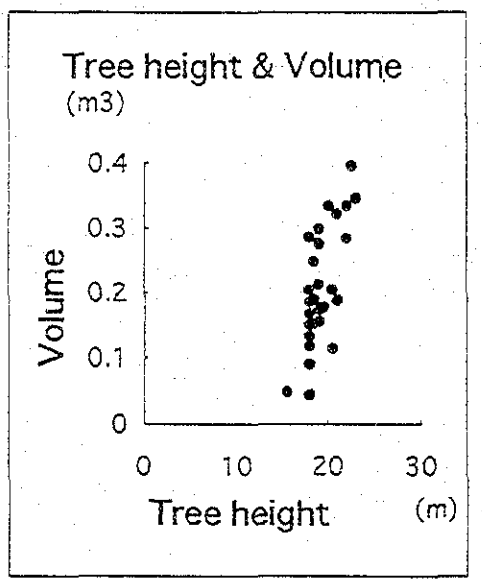
Plot No,4 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

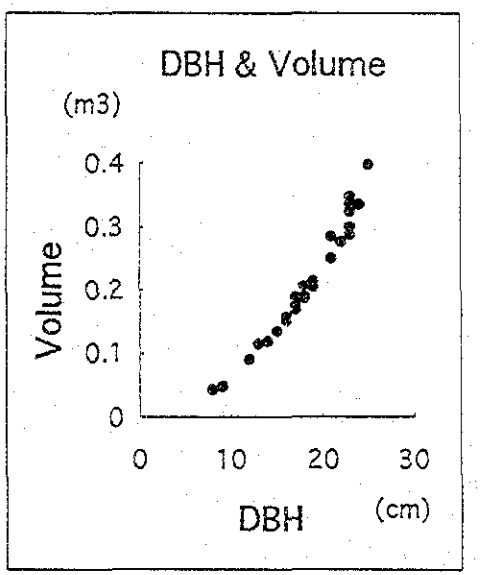
Plot No,5 Result of artificial forest survey

Date	7/27/93	Plot size	20m×20m 0.04ha
Plot No,	5	Planted year	1983.Dec. (9.7years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	AL-4	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently) /6°	Tending	50%thinning(1987)
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	19	19	0.21292
2	16	19	0.15349
3	23	18	0.28708
4	21	19	0.24932
5	17	18	0.16742
6	23	21	0.32362
7	14	18	0.11840
8	18	21	0.20511
9	17	20	0.17816
10	19	18	0.20416
11	15	18	0.13391
12	23	19	0.29940
13	17	19	0.17460
14	9	16	0.04793
15	25	23	0.39620
16	23	23	0.34732
17	24	20	0.33615
18	23	22	0.33553
19	21	22	0.28527
20	18	21	0.20511
21	12	18	0.08994
22	22	19	0.27657
23	23	19	0.29940
24	17	21	0.18872
25	13	21	0.11478
26	16	18	0.15025
27	16	19	0.15670
28	8	18	0.04363
29	18	19	0.18938
30	18	18	0.18539
31	19	19	0.21292
32	18	19	0.18938
Total	585	617	6.75816
Average	18.28125	19.28125	
		Volume/ha (m3)	168.95398
		MAI(m3)	17.63059







r= 0.5778522 r= 0.6861042 r= 0.97526618

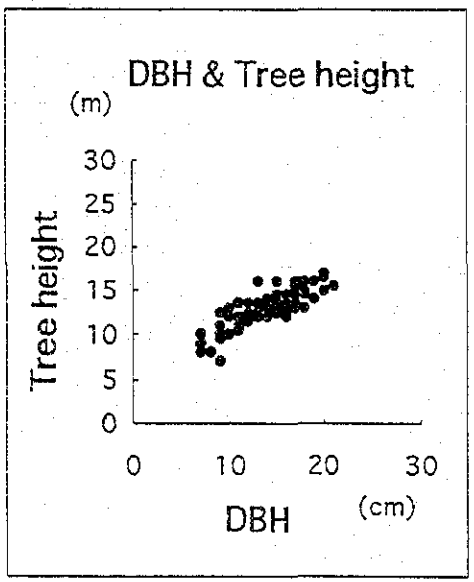
Plot No,5 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

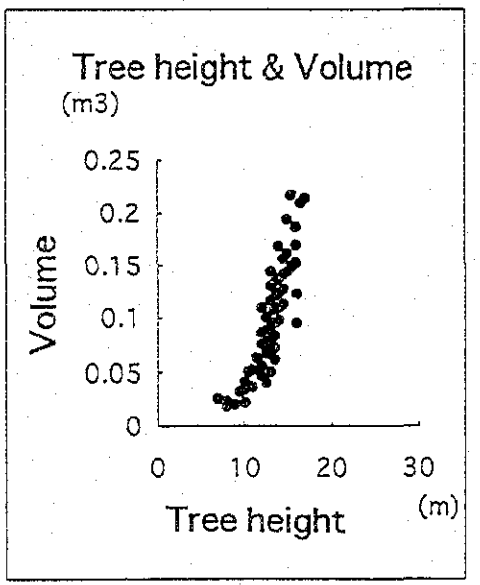
Plot No,6 Result of artificial forest survey

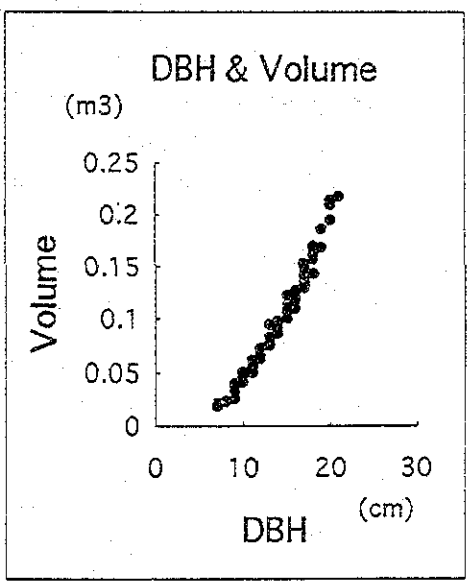
Date	8/3/93	Plot size	20m×20m 0.04ha
Plot No.	6	Planted year	1988Jan (5.6years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	TB-2	Planted interval	2m×5m
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume (m3)
1	18	13	0.14396
2	13	14	0.08296
3	10	13	0.05045
4	14	13	0.08918
5	13	12	0.07570
6	14	12	0.08640
7	16	12	0.10964
8	17	14	0.13771
9	13	13	0.08056
10	17	15	0.14152
11	10	12	0.04740
12	11	11	0.05252
13	17	14	0.13387
14	17	15	0.14530
15	13	13	0.08056
16	16	15	0.12701
17	14	14	0.09740
18	20	17	0.20910
19	15	14	0.11015
20	9	10	0.03409
21	11	12	0.05619
22	17	13	0.13000
23	18	15	0.15671
24	9	10	0.03409
25	14	13	0.08918
26	18	15	0.16090
27	19	14	0.16794
28	10	10	0.04114
29	19	16	0.18630
30	15	15	0.11320
31	20	17	0.21400
32	8	8	0.02323
33	20	15	0.19417
34	11	14	0.06158
35	14	13	0.09194
36	14	13	0.09194
37	21	16	0.21729
38	13	13	0.08056
39	12	13	0.06774
40	13	12	0.07570

41	9	13	0.04055
42	17	16	0.15277
43	13	13	0.07814
44	7	10	0.02177
45	13	12	0.07570
46	12	13	0.06774
47	13	14	0.08296
48	15	14	0.11015
49	15	14	0.10708
50	11	12	0.05619
51	16	14	0.12015
52	11	11	0.05065
53	12	12	0.06349
54	14	14	0.09468
55	17	16	0.14905
56	13	16	0.09467
57	14	13	0.09194
58	17	13	0.13000
59	17	15	0.14152
60	9	11	0.03671
61	7	9	0.02006
62	16	14	0.12359
63	16	15	0.12701
64	17	15	0.14530
65	12	14	0.07192
66	17	15	0.14152
67	17	15	0.14530
68	20	17	0.21400
69	18	16	0.16917
70	15	13	0.10087
71	16	14	0.12015
72	16	13	0.11668
73	9	7	0.02584
74	12	12	0.06349
75	7	8	0.01831
76	15	16	0.12220
77	9	10	0.03276
78	15	14	0.10708
Total	1102	1020.5	7.92045
Average	14.12821	13.08333	
		Volume/ha (m3)	79.20454
		MAI(m3)	14.40083







r= 0.8413536

r= 0.8662241

r= 0.9793595

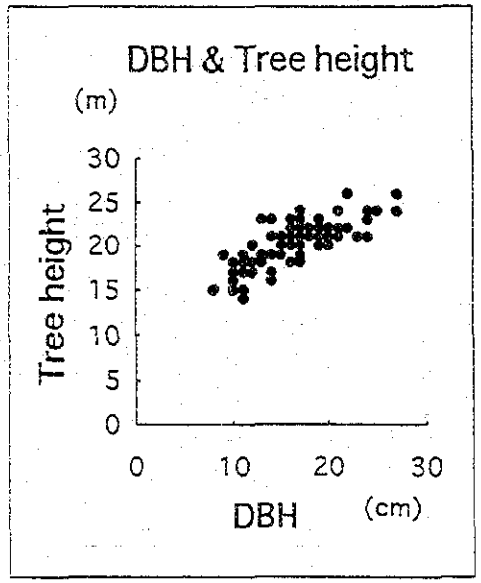
Plot No,6 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

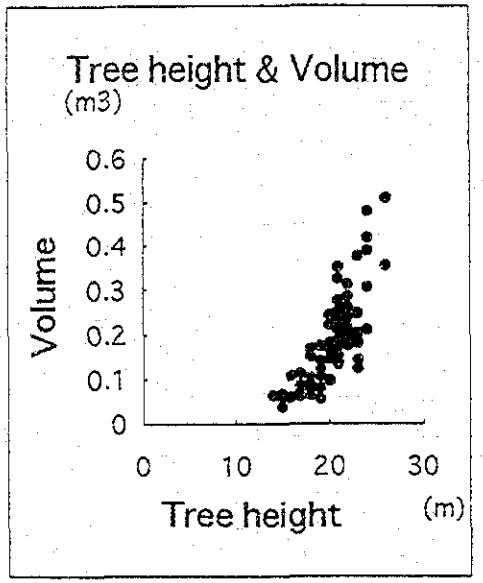
Plot No,7 Result of artificial forest survey

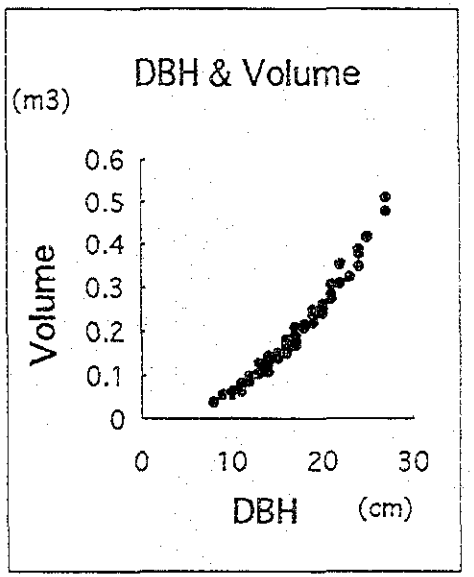
Date	8/3/93	Plot size	20m×20m 0.04ha
Plot No,	7	Planted year	1981.Oct. (11.9years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	NU-11	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	15	21	0.15096
2	9	19	0.05614
3	14	21	0.13347
4	19	23	0.24701
5	16	23	0.18179
6	21	24	0.30522
7	14	19	0.12349
8	16	23	0.18179
9	17	24	0.20936
10	13	23	0.12551
11	11	17	0.07366
12	14	21	0.13347
13	16	22	0.17561
14	14	19	0.12349
15	15	19	0.13966
16	14	19	0.12349
17	16	22	0.17561
18	19	23	0.24701
19	20	22	0.26149
20	17	22	0.19567
21	12	18	0.08994
22	17	23	0.20255
23	16	20	0.16308
24	17	20	0.18170
25	27	24	0.47789
26	11	17	0.07366
27	19	22	0.23862
28	19	21	0.23015
29	15	20	0.14534
30	13	18	0.10374
31	12	17	0.08603
32	11	14	0.06334
33	17	21	0.18872
34	17	20	0.18170
35	17	23	0.20255
36	14	23	0.14325
37	12	20	0.09761
38	24	23	0.37472
39	14	19	0.12349
40	23	21	0.32362
41	17	20	0.18170
42	12	17	0.08603
43	16	20	0.16308
44	10	15	0.05638
45	17	21	0.18872
46	21	21	0.27514
47	15	20	0.14534
48	10	18	0.06496
49	20	21	0.25220
50	17	18	0.16742
51	14	17	0.11326

52	18	22	0.21668
53	10	16	0.05928
54	17	21	0.18872
55	13	19	0.10819
56	24	21	0.34914
57	14	16	0.10805
58	19	20	0.22158
59	18	22	0.21668
60	18	21	0.20898
61	12	18	0.08994
62	17	24	0.20936
63	25	24	0.41658
64	11	19	0.08031
65	22	26	0.35292
66	27	26	0.50857
67	11	15	0.06683
68	21	22	0.28527
69	15	20	0.14534
70	15	20	0.14534
71	8	15	0.03787
72	15	19	0.13966
73	17	21	0.18872
74	11	18	0.07701
75	17	20	0.18170
76	16	20	0.16308
77	15	20	0.14534
78	20	21	0.25220
79	13	19	0.10819
80	24	24	0.38732
81	16	18	0.15025
82	10	16	0.05928
83	17	19	0.17460
84	10	17	0.06214
85	19	22	0.23862
86	15	20	0.14534
87	17	22	0.19567
88	20	21	0.25220
89	17	20	0.18170
90	21	22	0.28527
91	15	19	0.13966
92	15	19	0.13966
93	24	21	0.34914
94	22	22	0.30995
95	14	19	0.12349
96	20	20	0.24282
97	16	21	0.16938
98	18	21	0.20898
99	17	21	0.18872
100	19	22	0.23862
Total	1631	2029	18.26420
Average	16.31	20.29	
		Volume/ha (m3)	152.14077
		MAI(m3)	12.94815







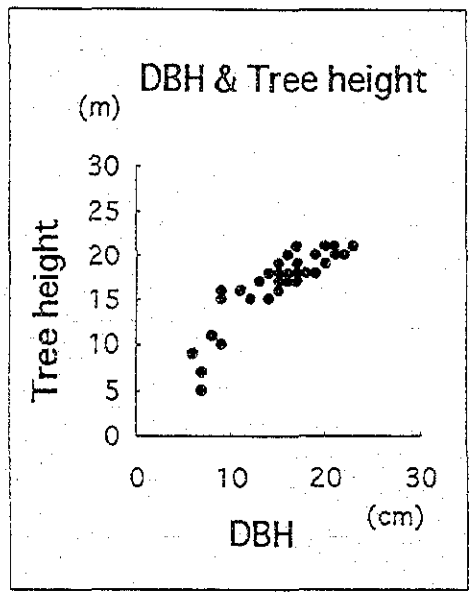
r= 0.7563244 r= 0.7829857 r= 0.9813867

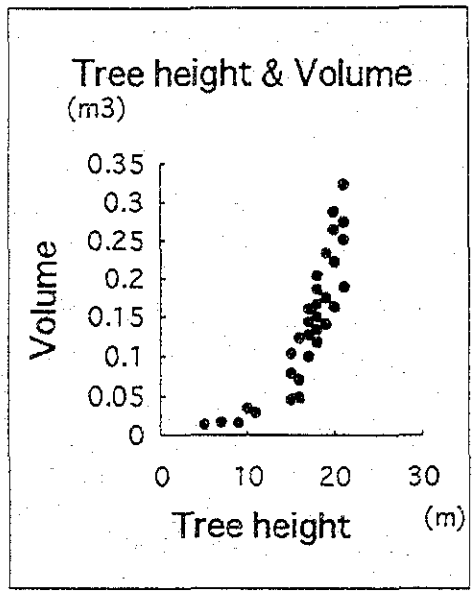
Plot No,7 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

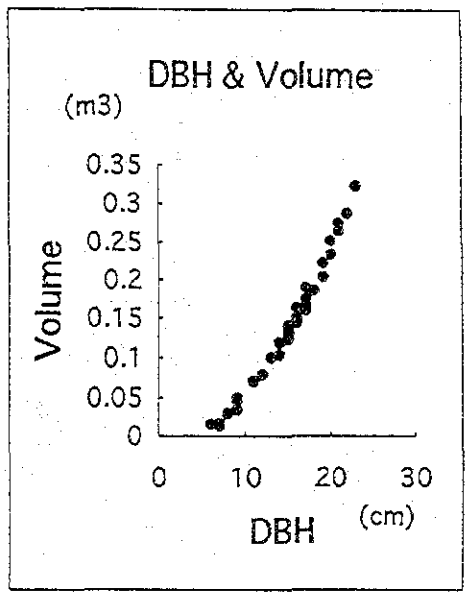
Plot No,8 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	8	Planted year	1983.Dec. (9.7years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	KO·1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently)	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	18	18	0.18539
2	16	17	0.14373
3	17	19	0.17460
4	15	19	0.13966
5	15	18	0.13391
6	9	15	0.04672
7	22	20	0.28782
8	18	18	0.18539
9	15	17	0.12809
10	17	17	0.16014
11	23	21	0.32362
12	16	18	0.15025
13	19	20	0.22158
14	19	18	0.20416
15	15	17	0.12809
16	20	19	0.23333
17	11	16	0.07027
18	15	16	0.12220
19	6	9	0.01524
20	21	21	0.27514
21	18	18	0.18539
22	7	7	0.01650
23	9	10	0.03409
24	15	16	0.12220
25	21	20	0.26490
26	13	17	0.09923
27	15	17	0.12809
28	17	18	0.16742
29	15	17	0.12809
30	8	11	0.02976
31	7	5	0.01270
32	14	15	0.10276
33	20	21	0.25220
34	12	15	0.07805
35	17	21	0.18872
36	9	16	0.04912
37	16	20	0.16308
38	14	18	0.11840
39	14	18	0.11840
40	20	19	0.23333
Total	608	672	5.82178
Aveage	15.2	16.8	
		Volume/ha (m3)	145.54448
		MAI(m3)	15.18778







r= 0.8629519

r= 0.8346598

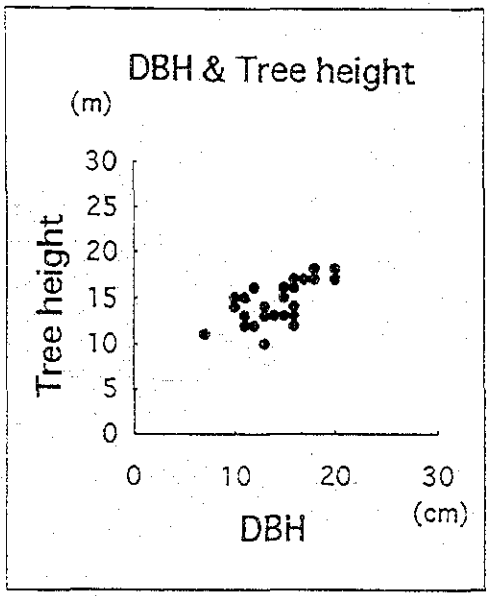
r= 0.9809409

Plot No,8 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

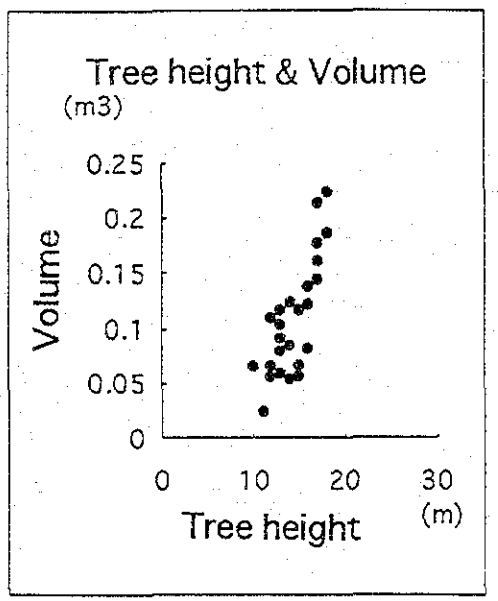
Plot No,9 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	9	Planted year	1983.Dec. (9.7years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	UN-1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently)	Tending	
Remarks			

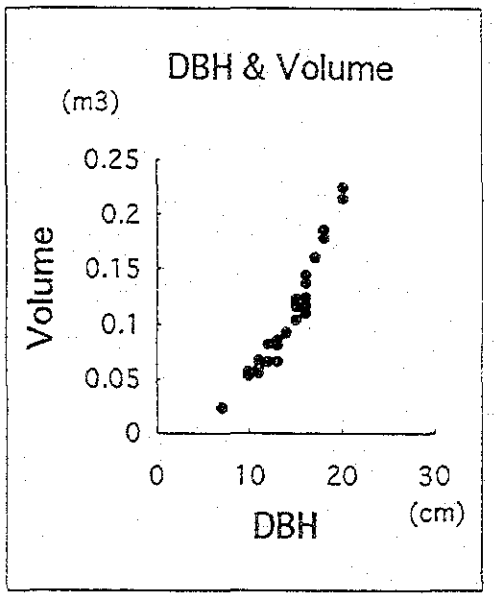
No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	15	16	0.12220
2	20	17	0.21400
3	17	17	0.16014
4	16	17	0.14373
5	15	16	0.12220
6	15	15	0.11622
7	15	15	0.11622
8	10	14	0.05344
9	11	13	0.05980
10	16	13	0.11668
11	13	13	0.08056
12	12	12	0.06563
13	11	12	0.05619
14	16	12	0.10964
15	11	15	0.06683
16	11	15	0.06683
17	18	17	0.17733
18	12	16	0.08207
19	15	13	0.10399
20	7	11	0.02345
21	14	13	0.09194
22	16	14	0.12359
23	16	17	0.14373
24	16	16	0.13711
25	13	10	0.06570
26	20	18	0.22372
27	10	15	0.05638
28	18	17	0.17733
29	13	14	0.08533
30	18	18	0.18539
31	16	14	0.12359
Total	446	455	3.47097
Average	14.38710	14.67742	
		Volume /ha (m3)	86.77417
		MAI(m3)	13.34987



r= 0.6265465



r= 0.7711581



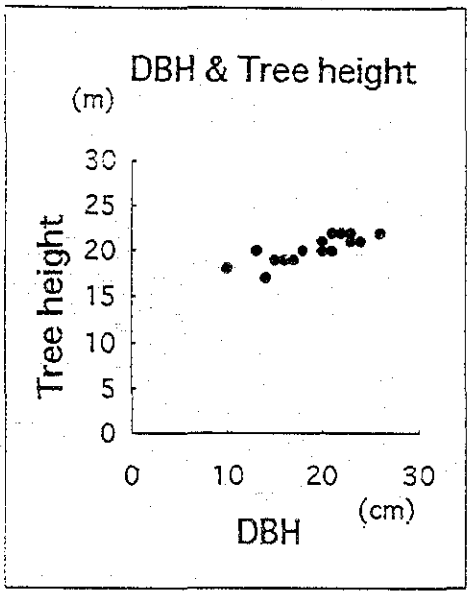
r= 0.9624011

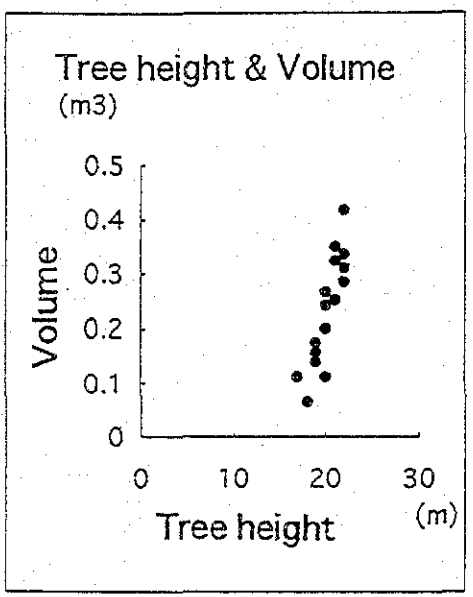
Plot No,9 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

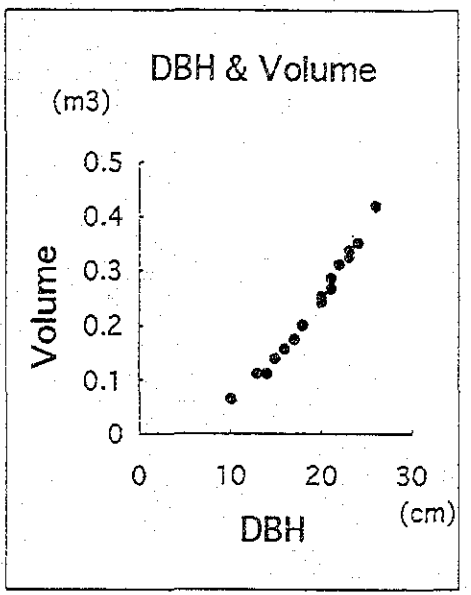
Plot No,10 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	10	Planted year	1981～2 (11.6years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	T-9	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	50%thinning(1987)
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	23	22	0.33553
2	21	22	0.28527
3	16	19	0.15670
4	18	20	0.20121
5	26	22	0.41756
6	20	20	0.24282
7	15	19	0.13966
8	20	21	0.25220
9	24	21	0.34914
10	21	20	0.26490
11	18	20	0.20121
12	13	20	0.11259
13	23	21	0.32362
14	17	19	0.17460
15	23	22	0.33553
16	22	22	0.30995
17	20	21	0.25220
18	16	19	0.15670
19	10	18	0.06496
20	14	17	0.11326
21	21	20	0.26490
Total	401	425	4.95451
Average	19.09524	20.23810	
		Volume/ha (m3)	123.86271
		MAI(m3)	10.77067







r= 0.8361946

r= 0.8692227

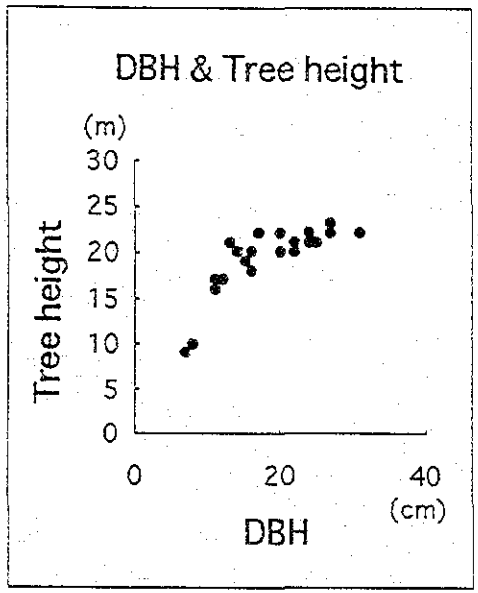
r= 0.9891692

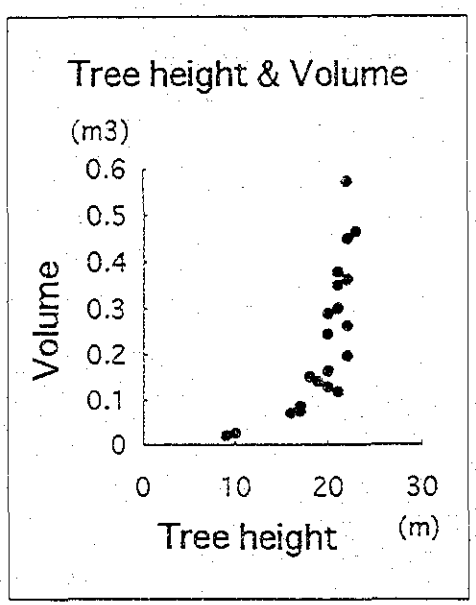
Plot No,10 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

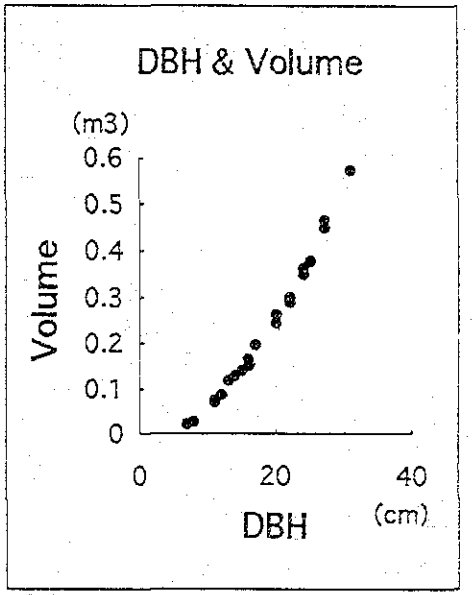
Plot No,11 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	11	Planted year	1982~3 (10.6years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	KT-6	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently)	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	20	22	0.26149
2	17	22	0.19567
3	11	16	0.07027
4	7	9	0.02006
5	24	22	0.36200
6	27	23	0.46235
7	24	21	0.34914
8	20	20	0.24282
9	8	10	0.02763
10	12	17	0.08603
11	16	20	0.16308
12	13	21	0.11695
13	14	20	0.12851
14	16	18	0.15025
15	11	17	0.07366
16	24	22	0.36200
17	22	21	0.29894
18	15	19	0.13966
19	25	21	0.37552
20	22	20	0.28782
21	31	22	0.57148
22	27	22	0.44664
Total	406	425	5.19196
Average	18.45455	19.31818	
		Volume/ha (m3)	129.79889
		MAI(m3)	12.36180







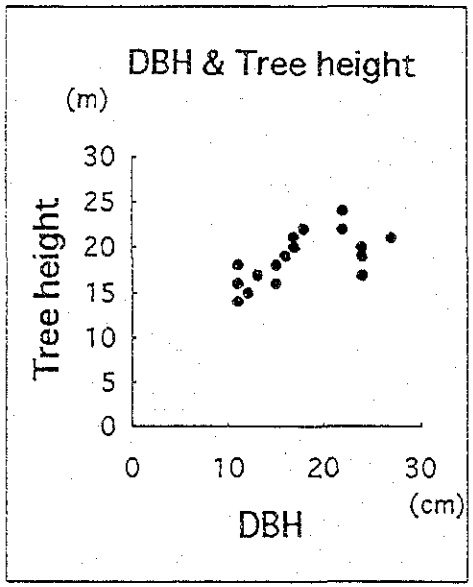
r= 0.7923291 r= 0.735855 r= 0.9891913

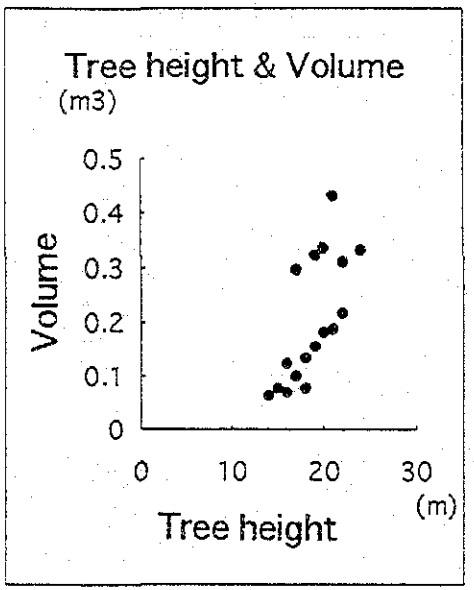
Plot No,11 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

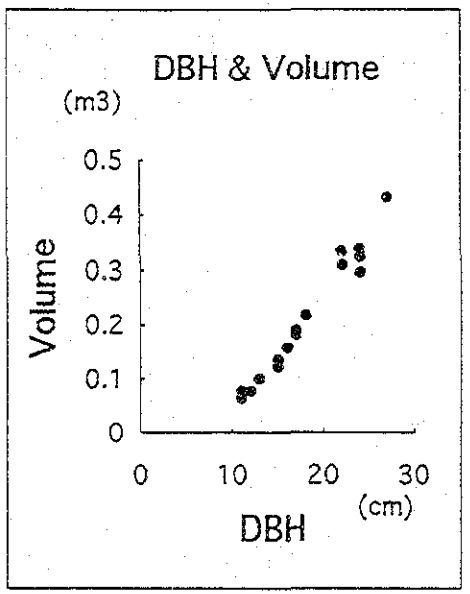
Plot No,12 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	12	Planted year	1984~5 (8.6years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	BE-1	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	50%thinning(1988)
Remarks			

No,	DBH (cm)	Tree height(m)	Volume equation (m3)
1	24	19	0.32301
2	24	20	0.33615
3	22	24	0.33164
4	11	16	0.07027
5	22	22	0.30995
6	16	19	0.15670
7	18	22	0.21668
8	11	18	0.07701
9	13	17	0.09923
10	17	21	0.18872
11	15	18	0.13391
12	27	21	0.43078
13	17	20	0.18170
14	27	21	0.43078
15	15	16	0.12220
16	12	15	0.07805
17	24	17	0.29626
18	11	14	0.06334
Total	326	340	3.84641
Average	18.11111	18.88889	
		Volume/ha (m3)	96.16025
		MAI(m3)	11.31297







r= 0.6492339

r= 0.7070163

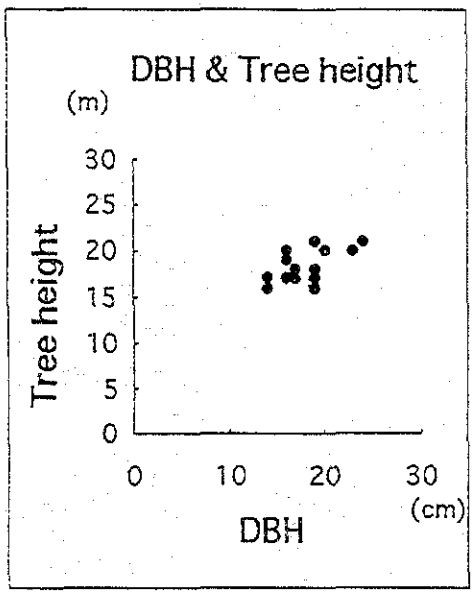
r= 0.9881616

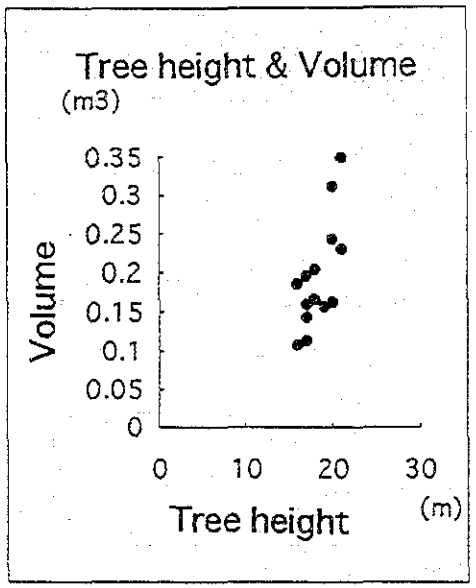
Plot No,12 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

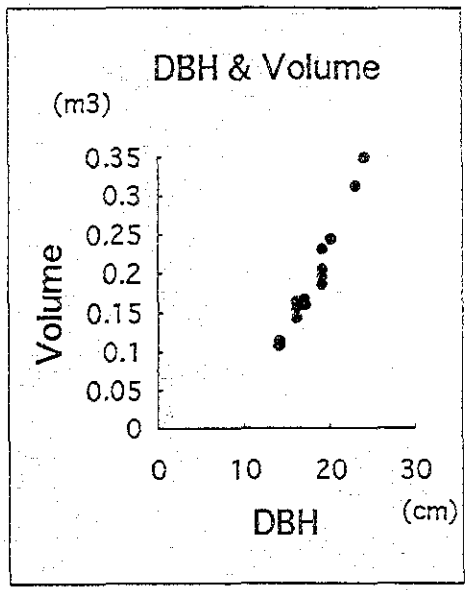
Plot No,13 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	13	Planted year	1987.Dec. (5.8years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	BE-3B	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land (gently)	Tending	50%thinning(1987)
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	17	17	0.16014
2	19	17	0.19529
3	17	18	0.16742
4	14	16	0.10805
5	19	17	0.19529
6	14	16	0.10805
7	19	16	0.18630
8	16	17	0.14373
9	19	18	0.20416
10	14	17	0.11326
11	16	17	0.14373
12	19	18	0.20416
13	17	18	0.16742
14	24	21	0.34914
15	17	18	0.16742
16	23	20	0.31157
17	16	19	0.15670
18	19	21	0.23015
19	20	20	0.24282
20	16	20	0.16308
21	16	19	0.15670
Total	371	380	3.87456
Average	17.66667	18.09524	
		Volume/ha (m3)	96.86394
		MAI(m3)	17.09565







r= 0.5814064

r= 0.7122049

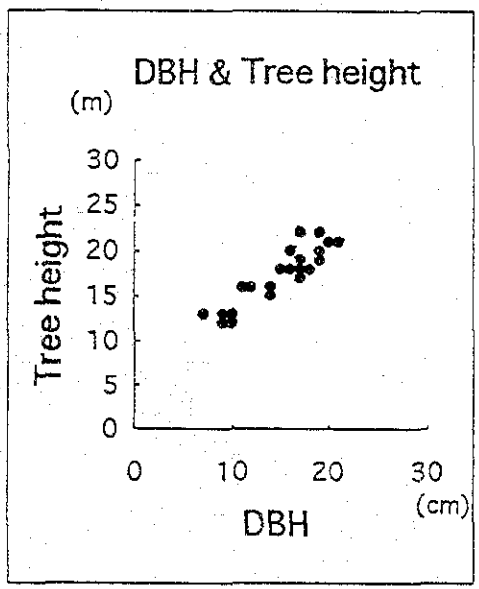
r= 0.9770299

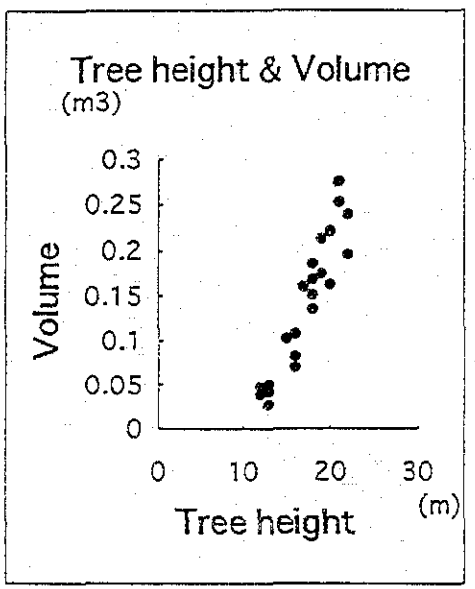
Plot No,13 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

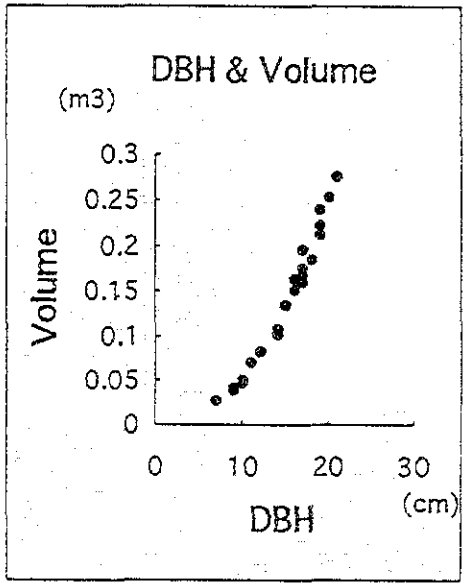
Plot No,14 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No,	14	Planted year	1982~3 (10.6years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	BA-4	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	17	22	0.19567
2	16	18	0.15025
3	12	16	0.08207
4	16	20	0.16308
5	19	22	0.23862
6	11	16	0.07027
7	18	18	0.18539
8	18	18	0.18539
9	17	17	0.16014
10	14	15	0.10276
11	17	18	0.16742
12	21	21	0.27514
13	19	20	0.22158
14	9	13	0.04180
15	16	18	0.15025
16	17	19	0.17460
17	19	20	0.22158
18	7	13	0.02670
19	20	21	0.25220
20	15	18	0.13391
21	19	19	0.21292
22	10	12	0.04740
23	14	16	0.10805
24	10	13	0.05045
25	9	12	0.03928
Total	380	435	3.65693
Average	15.2	17.4	
		Volume/ha (m3)	91.42320
		MAI(m3)	8.70697







r= 0.9051936

r= 0.9339816

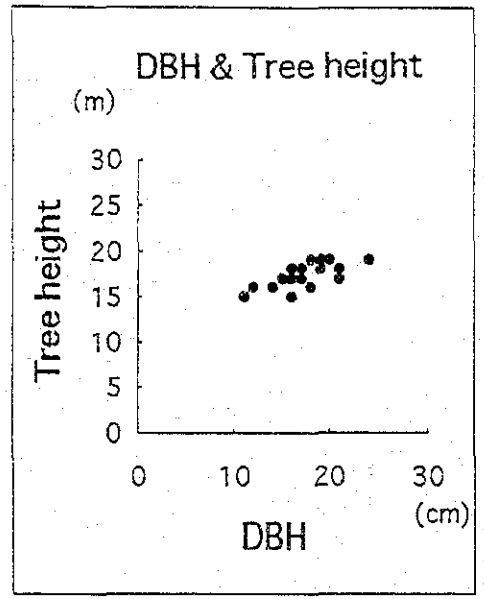
r= 0.981694

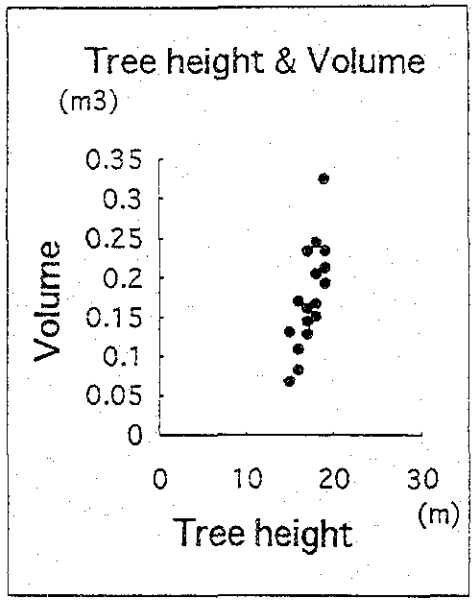
Plot No,14 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

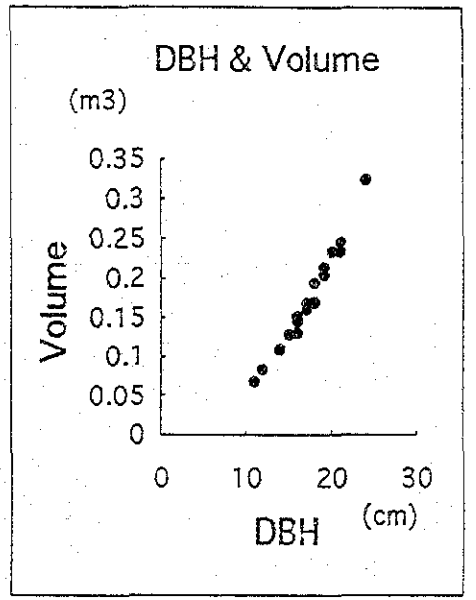
Plot No,15 Result of artificial forest survey

Date	8/4/93	Plot size	20m×20m 0.04ha
Plot No.	15	Planted year	1988.Feb. (5.5years)
Area	Bengkoka	Planted species	Acacia mangium
Compartment	KUP-2	Planted interval	4m×2m
Elevation		Crown density	Middle
Inclination	Slope land	Tending	Thinning
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	17	17	0.16014
2	24	19	0.32301
3	18	16	0.16917
4	21	18	0.24407
5	11	15	0.06683
6	14	16	0.10805
7	12	16	0.08207
8	21	17	0.23347
9	19	18	0.20416
10	18	19	0.19334
11	16	17	0.14373
12	19	18	0.20416
13	17	17	0.16014
14	16	15	0.13040
15	20	19	0.23333
16	18	19	0.19334
17	15	17	0.12809
18	16	18	0.15025
19	17	18	0.16742
20	19	19	0.21292
21	15	17	0.12809
Total	363	365	3.63620
Average	17.28571	17	
		Volume/ha (m3)	90.90500
		MAI(m3)	16.78453







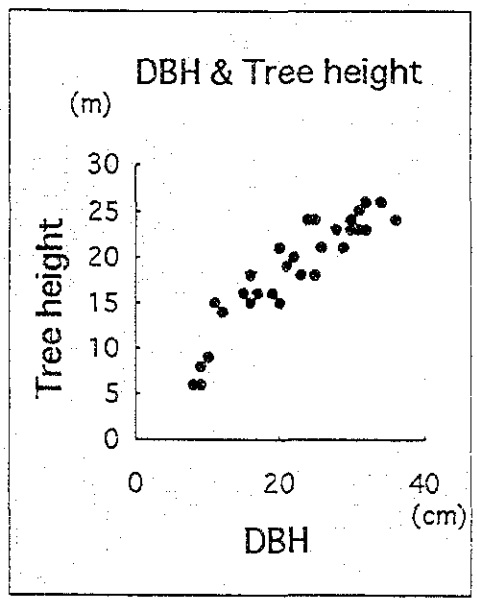
r= 0.6892878 r= 0.7495243 r= 0.9867283

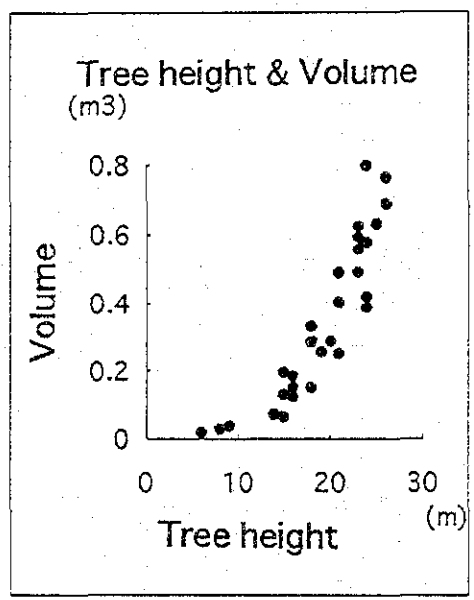
Plot No,15 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

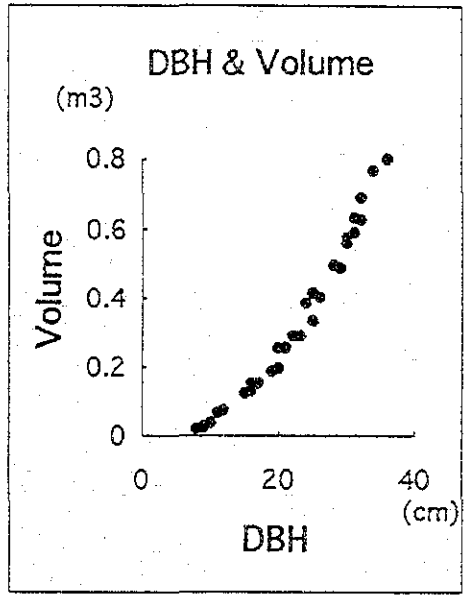
Plot No,16 Result of artificial forest survey

Date	8/9/93	Plot size	20m×20m 0.04ha
Plot No,	16	Planted year	1968. (25years)
Area	Ulu Kukut	Planted species	Pinas caribaea
Compartment	B-14	Planted interval	10ft×10ft
Elevation		Crown density	Thick
Inclination	Flat	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	25	18	0.33312
2	12	14	0.07398
3	29	21	0.48936
4	30	23	0.55795
5	26	21	0.40274
6	30	24	0.57672
7	20	15	0.19417
8	28	23	0.49334
9	19	16	0.18630
10	16	15	0.13040
11	23	18	0.28708
12	22	20	0.28782
13	17	16	0.15277
14	9	8	0.02866
15	15	16	0.12220
16	20	21	0.25220
17	9	6	0.02292
18	32	23	0.62604
19	8	6	0.01858
20	34	26	0.76728
21	32	26	0.68863
22	21	19	0.25455
23	11	15	0.06683
24	10	9	0.03791
25	16	18	0.15025
26	15	16	0.12220
27	24	24	0.38732
28	16	15	0.13040
29	36	24	0.79840
30	20	21	0.25220
31	31	23	0.59157
32	30	24	0.57672
33	31	25	0.63117
34	25	24	0.41658
Total	742	633	11.10835
Average	21.82353	19	
		Volume/ha (m3)	277.70865
		MAI(m3)	11.10835







r= 0.9125777

r= 0.8799069

r= 0.9785854

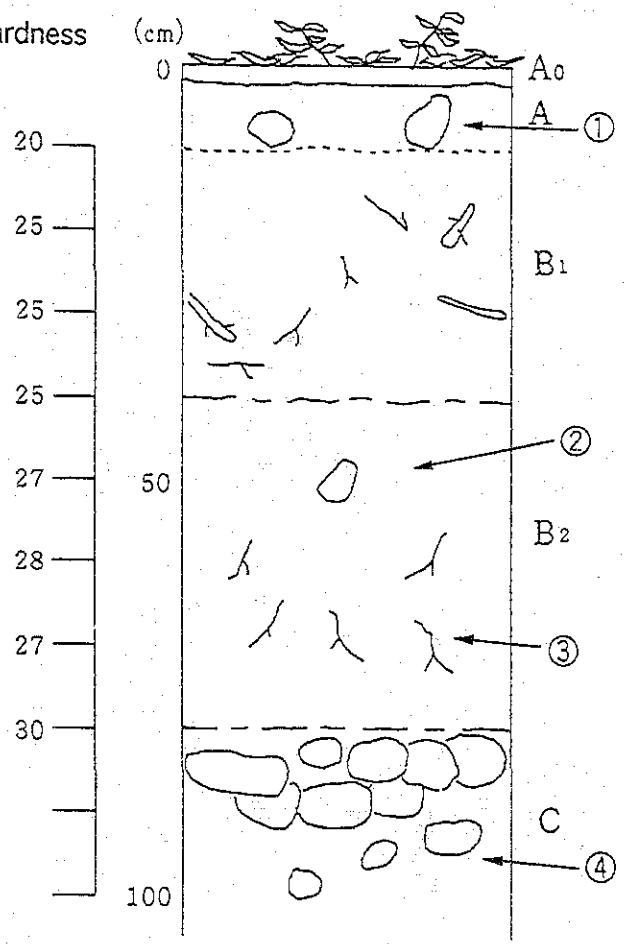
Plot No,16 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

Plot No,17 Result of artificial forest survey

Date	8/9/93	Plot size	20m×20m 0.04ha
Plot No,	17	Planted year	Regeneration for forest fire at1983
Area	Ulu Kukut	Planted species	Acacia mangium
Compartment	P/1/1	Planted interval	10ft×10ft
Elevation	90m	Crown density	Middle
Inclination	Slope land	Tending	
Remarks	Original stand was planted at 1971,which was damaged forest fire at 1983 No,19 Pinas caribaea, No,20 & 25 are other species.		

No,	DBH (m)	Tree height (m)	Volume equation (m3)
1	24	17	0.29626
2	30	20	0.50052
3	19	15	0.17719
4	11	12	0.05619
5	28	18	0.40776
6	21	18	0.24407
7	21	17	0.23347
8	18	14	0.15249
9	10	13	0.05045
10	11	11	0.05252
11	9	7	0.02584
12	14	16	0.10805
13	6	6	0.01112
14	8	9	0.02546
15	26	20	0.38775
16	26	16	0.32601
17	11	8	0.04100
18	7	7	0.01650
○19	26	23	0.43224
△20	7	9	0.02006
21	30	20	0.50052
22	16	14	0.12359
23	22	23	0.32085
24	27	21	0.43078
△25	8	7	0.02094
26	8	7	0.02094
27	17	18	0.16742
28	26	21	0.40274
Total	487	407	5.55273
Average	17.39286	15	
		Volume/ha (m3)	138.81828
		MAI(m3)	13.88183
		Total (m3)	5.07949
		Volume of only A.mangium/ha (m3)	126.98718
		MAI of only A.mangium (m3)	12.69872

○ : Pinas caribaea
△ : Other species

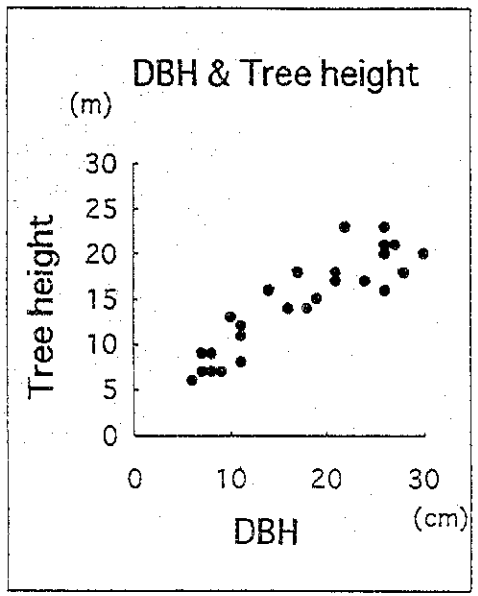


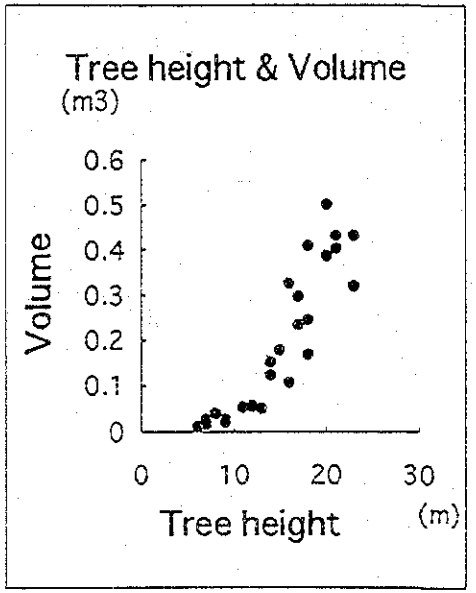
①Mudstone
②Ferrous integration
③Root of A.mangium
④Mudstone

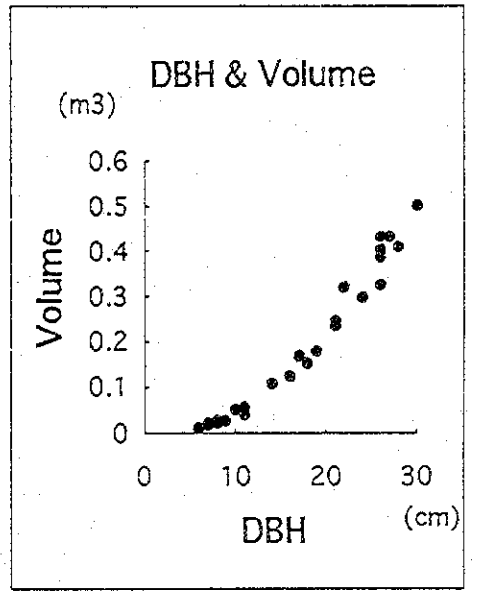
Date	8/7/93
Plot No,	17
Area	Ulu Kukut
Compartment	P/1/1
inclination	Slope land (gently) /8°

Horizon	Colour	Humus	Gravel	Structure	Moisture	Illuvation	Mycorrhiza	Root	pH	Remark
A	10YR7/4	Middle	Rich	Nutty	Wet	Nil	Nil	Rich	5.4	
B1	2.5Y6/4	Nil	Rich	Massive	Wet	Fe	Nil	Poor	5.2	
B2	2.5Y6/2	Nil	Rich	Massive	Wet	Fe	Nil	Poor	5.2	
C	2.5Y5/2	Nil	Very rich	Massive	Wet	Nil	Nil	Nil	5.2	

Plot No,17 Soil profile and Result of soil survey (Artificial forest)







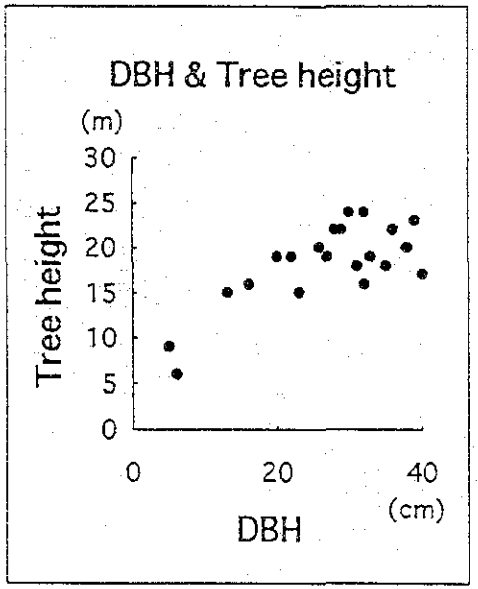
r= 0.9051241 r= 0.8971036 r= 0.9794633

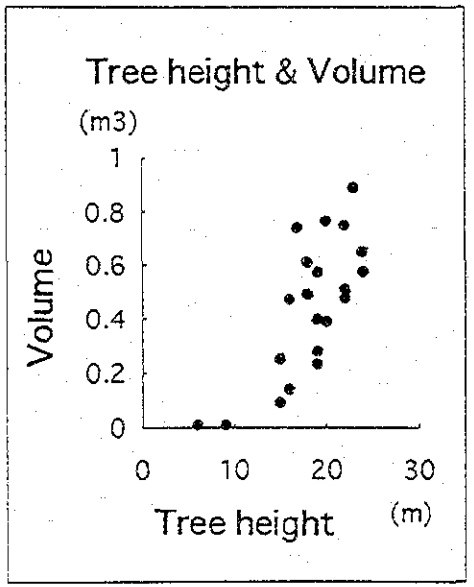
Plot No,17 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

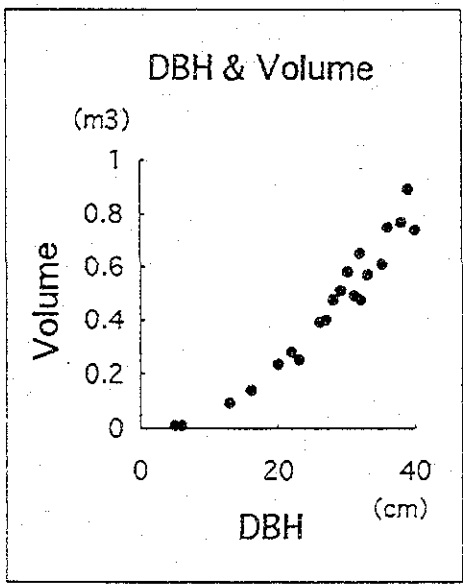
Plot No,18 Result of artificial forest survey

Date	8/9/93	Plot size	20m×20m 0.04ha
Plot No.	18	Planted year	1971~2. (21.6years)
Area	Ulu Kukut	Planted species	Acacia mangium (Hybrid)
Compartment	P/2/2	Planted interval	10ft×10ft
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks	Some tree died at forest fire 1983.		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	32	16	0.47218
2	35	18	0.60715
3	33	19	0.57010
4	22	19	0.27657
5	6	6	0.01112
6	29	22	0.50737
7	40	17	0.73698
8	36	22	0.74620
9	26	20	0.38775
10	30	24	0.57672
11	28	22	0.47658
12	31	18	0.48895
13	20	19	0.23333
14	13	15	0.09004
15	39	23	0.89099
16	38	20	0.76308
17	16	16	0.13711
18	23	15	0.24915
19	5	9	0.01101
20	32	24	0.64709
21	27	19	0.39855
Total	561	383	9.27802
Average	26.71429	18	
		Volue/ha (m3)	231.95048
		MAI(m3)	10.78839







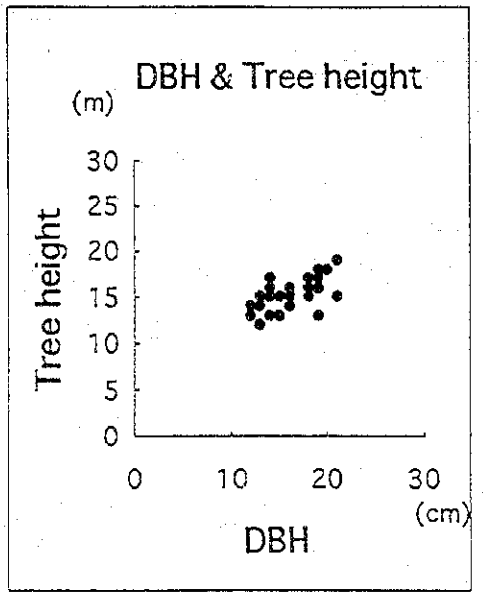
r= 0.7419198 r= 0.7425728 r= 0.9640634

Plot No,18 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

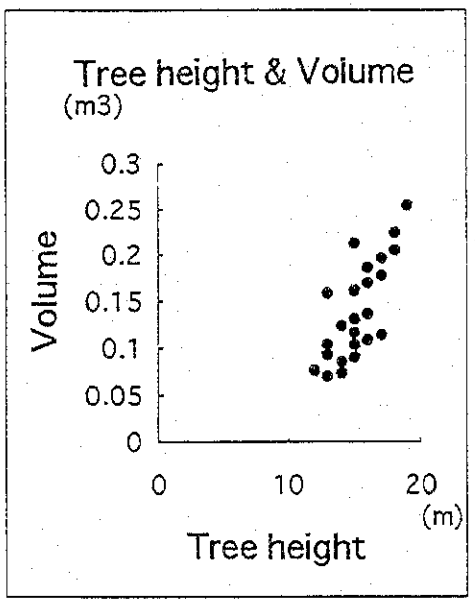
Plot No,19 Result of artificial forest survey

Date	8/9/93	Plot size	20m×20m 0.04ha
Plot No,	19	Planted year	1985.Oct. (7.10years)
Area	Ulu Kukut	Planted species	Acacia mangium
Compartment	B-29	Planted interval	10ft×10ft
Elevation	120m	Crown density	Middle
Inclination	Slope land (gently) /7°	Tending	
Remarks	A part of this plot was damaged forest fire at april,1992.		

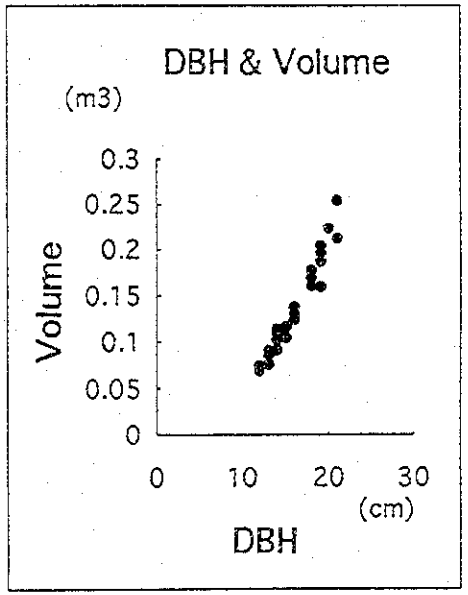
No,	DBH (cm)	Tree heiht (m)	Volume equation (m3)
1	16	14	0.12359
2	16	14	0.12359
3	14	13	0.09194
4	13	12	0.07570
5	19	13	0.15854
6	13	14	0.08533
7	18	15	0.16090
8	14	15	0.10276
9	15	13	0.10399
10	12	13	0.06984
11	21	15	0.21182
12	12	14	0.07398
13	18	17	0.17733
14	14	16	0.10805
15	18	15	0.16090
16	18	16	0.16917
17	12	13	0.06984
18	13	12	0.07570
19	16	14	0.12359
20	14	16	0.10805
21	16	16	0.13711
22	18	17	0.17733
23	19	17	0.19529
24	21	19	0.25455
25	14	15	0.10276
26	15	15	0.11622
27	16	15	0.13040
28	19	16	0.18630
29	20	18	0.22372
30	13	15	0.09004
31	14	16	0.10805
32	18	17	0.17733
33	19	18	0.20416
34	14	17	0.11326
Total	542	515	4.59114
Average	15.94118	15	
		volume/ha (m3)	114.77855
		MAI(m3)	14.65320



r= 0.6084208



r= 0.7542008



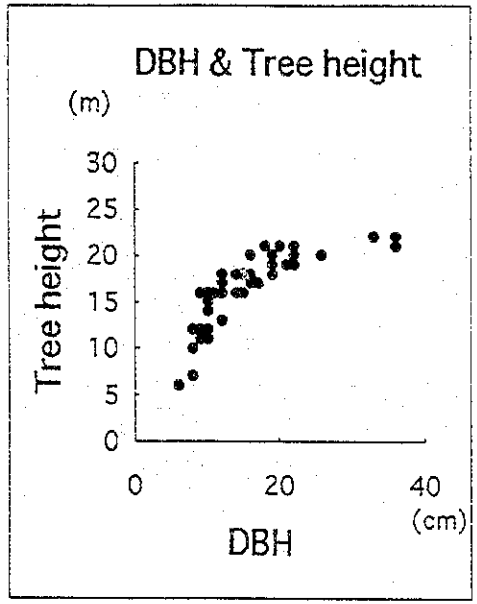
r= 0.972728

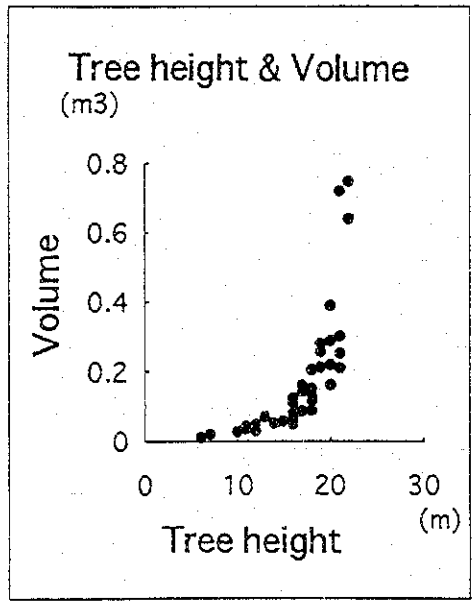
Plot No,19 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

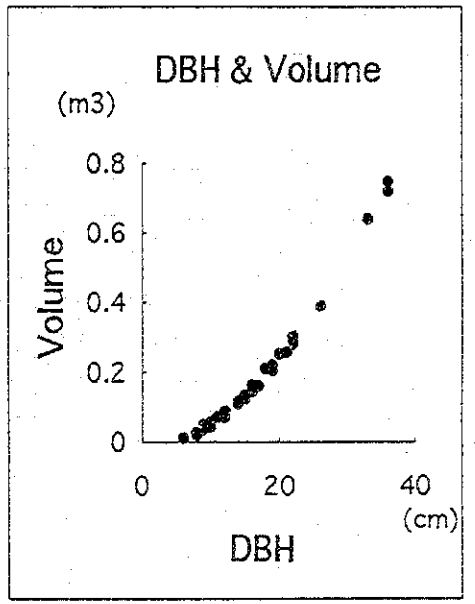
Plot No,20 Result of artificial forest survey

Date	8/9/93	Plot size	20m×20m 0.04ha
Plot No,	20	Planted year	Regeneration for forest fire at1983
Area	Ulu Kukut	Planted species	Acacia mangium
Compartment	C0-9	Planted interval	10ft×10ft
Elevation		Crown density	Middle
Inclination	Slope land (gently) /5°	Tending	
Remarks	Original stand was planted at 1969,which was damaged forest fire at 1983 Now stand regenerated after 1983.		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	22	19	0.27657
2	19	18	0.20416
3	26	20	0.38775
4	8	7	0.02094
5	6	6	0.01112
6	19	19	0.21292
7	15	16	0.12220
8	21	19	0.25455
9	8	12	0.03184
10	21	19	0.25455
11	16	17	0.14373
12	33	22	0.63891
13	9	16	0.04912
14	10	15	0.05638
15	9	12	0.03928
16	36	21	0.71970
17	15	18	0.13391
18	14	18	0.11840
19	12	17	0.08603
20	10	12	0.04740
21	11	16	0.07027
22	17	17	0.16014
23	14	16	0.10805
24	20	21	0.25220
25	10	11	0.04430
26	9	11	0.03671
27	10	14	0.05344
28	10	14	0.05344
29	12	13	0.06984
30	12	16	0.08207
31	22	20	0.28782
32	8	12	0.03184
33	10	16	0.05928
34	12	18	0.08994
35	22	21	0.29894
36	15	18	0.13391
37	19	20	0.22158
38	8	10	0.02763
39	16	18	0.15025
40	18	21	0.20898
41	16	20	0.16308
42	36	22	0.74620
Total	656	688	7.15937
Average	15.61905	16	
		Volume/ha (m3)	178.98436
		MAI(m3)	17.89844





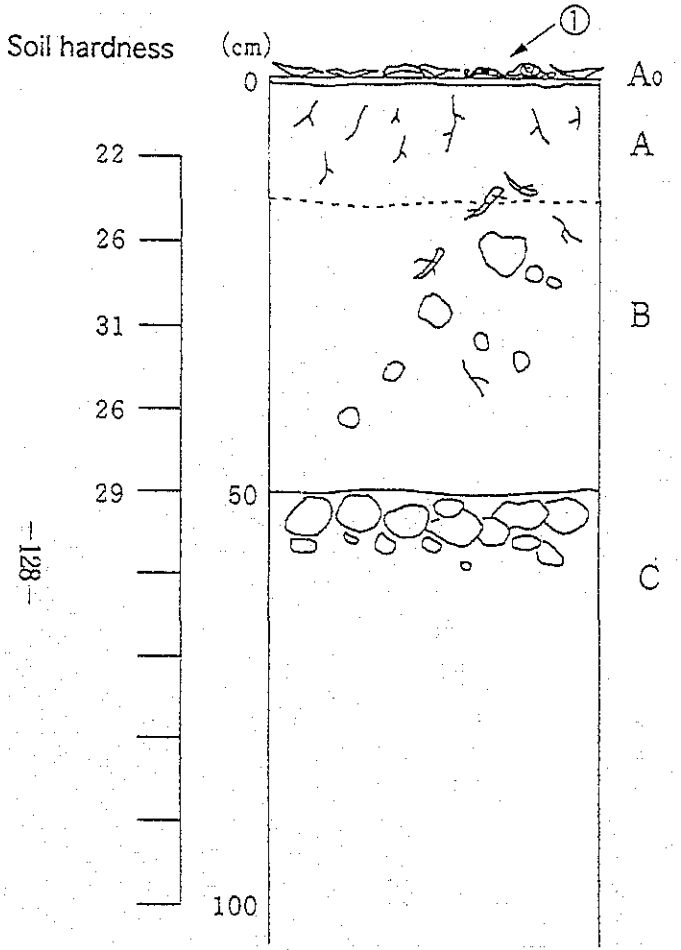


r= 0.7989113

r= 0.7133479

r= 0.9793797

Plot No,20 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume



①Litter and seed of A.mangium

Date	8/9/93
Plot No,	20
Area	Ulu Kukut
Compartment	CO2
inclination	Slope land (gently) /5°

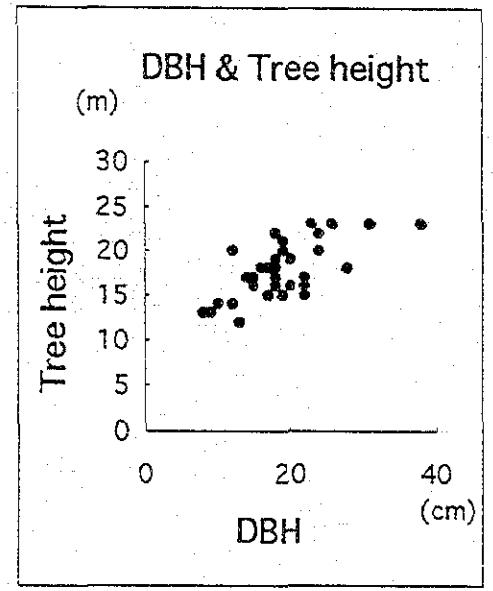
Horizon	Colour	Humus	Gravel	Structure	Moisture	Illuvation	Mycorrhiza	Root	pH	Remark
A	7.5YR4/4	Rich	Nil	Little crumb	Little dry	Nil	Nil	Very rich	5.4	
B	10YR5/4	Poor	Rich	Massive	Little dry	Fe	Nil	Poor	5.4	
C	2.5Y6/6	Nil	Rich	Massive	Little dry	Fe	Nil	Nil	5.2	

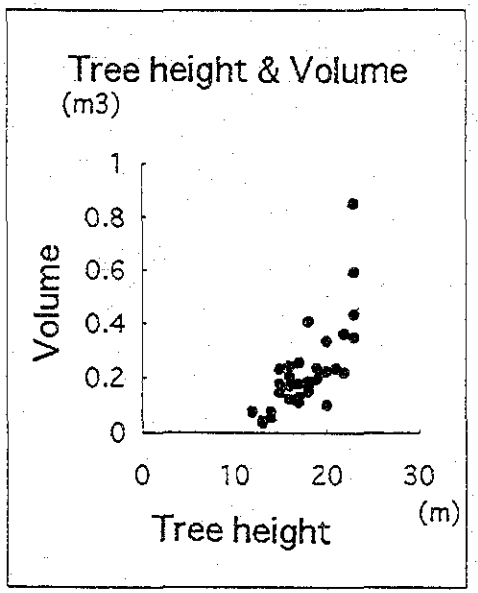
Plot No,20 Soil profile and Result of soil survey (Artificial forest)

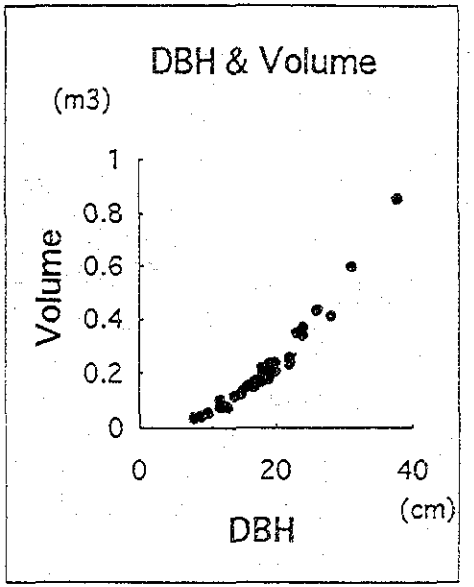
Plot No,21 Result of artificial forest survey

Date	8/17/93	Plot size	30m×30m 0.09ha
Plot No.	21	Planted year	1986.Oct.~Dec. (6.9years)
Area	Ulu Kukut	Planted species	Acacia mangium
Compartment		Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Slope land /17°	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	20	16	0.20415
2	18	18	0.18539
3	18	16	0.16917
4	22	15	0.23015
5	22	17	0.25367
6	22	16	0.24199
7	19	15	0.17719
8	28	18	0.40776
9	17	15	0.14530
10	20	19	0.23333
11	18	17	0.17733
12	18	17	0.17733
13	31	23	0.59157
14	24	20	0.33615
15	38	23	0.85064
16	19	21	0.23015
17	26	23	0.43224
18	14	17	0.11326
19	23	23	0.34732
20	12	14	0.07398
21	15	17	0.12809
22	15	17	0.12809
23	10	14	0.05344
24	18	22	0.21668
25	9	13	0.04180
26	12	20	0.09761
27	13	12	0.07570
28	24	22	0.36200
29	8	13	0.03388
30	15	16	0.12220
31	18	19	0.19334
32	19	20	0.22158
33	17	18	0.16742
34	18	19	0.19334
35	16	18	0.15025
Total	656	623	7.76351
Average	18.74286	18	
		Volume/ha (m3)	86.26041
		MAI(m3)	12.77932







r= 0.6834826

r= 0.7214541

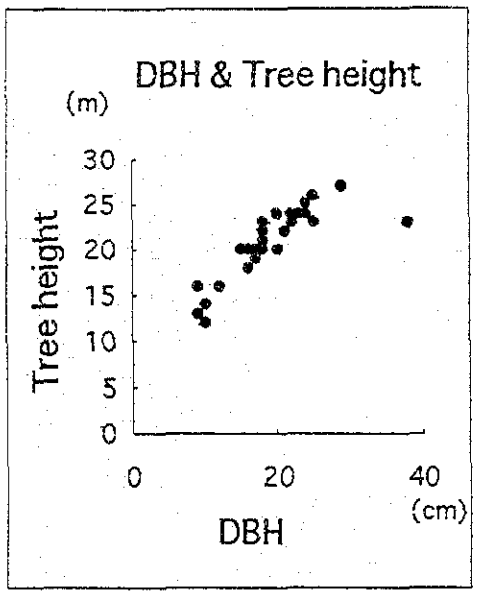
r= 0.9617124

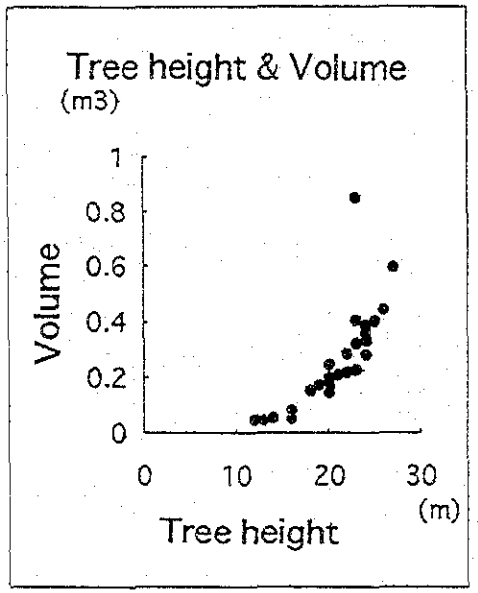
Plot No,21 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

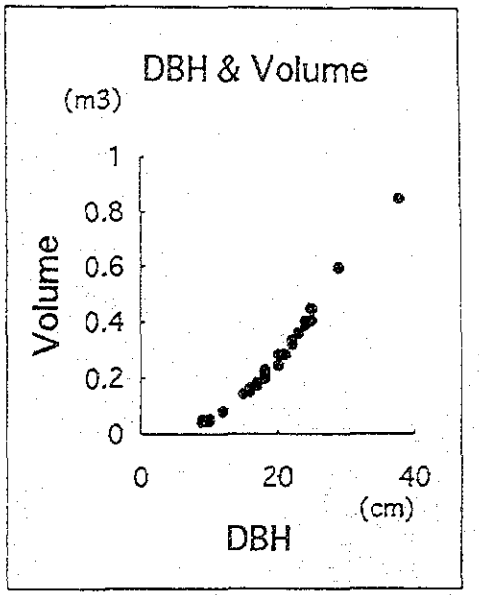
Plot No,22 Result of artificial forest survey

Date	8/17/93	Plot size	20m×20m 0.04ha
Plot No,	22	Planted year	Regeneration for forest fire at1983
Area	Ulu Kukut	Planted species	Acacia mangium (Hybrid)
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks	Original stand was planted at 1971,which was damaged forest fire at 1983 Mother tree of Acacia auricaliformis live near by this plot. Undergrowth are Alpinia spp, and party of Lygodium spp.		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	17	19	0.17460
2	22	23	0.32085
3	25	23	0.40303
4	18	20	0.20121
5	9	16	0.04912
6	20	24	0.27978
7	24	24	0.38732
8	21	22	0.28527
9	29	27	0.59491
10	18	23	0.22429
11	16	20	0.16308
12	15	20	0.14534
13	9	13	0.04180
14	17	19	0.17460
15	20	24	0.27978
16	22	24	0.33164
17	12	16	0.08207
18	23	24	0.35901
19	20	20	0.24282
20	16	18	0.15025
21	25	26	0.44332
22	18	22	0.21668
23	18	21	0.20898
24	9	13	0.04180
25	10	12	0.04740
26	25	26	0.44332
27	10	14	0.05344
28	38	23	0.85064
29	21	22	0.28527
30	25	23	0.40303
31	24	25	0.39981
32	17	20	0.18170
33	12	16	0.08207
Total	625	682	8.54824
Average	18.93939	21	
		Volume/ha (m3)	213.70594
		MAI(m3)	21.37059







r= 0.847484

r= 0.7929905

r= 0.9829454

Plot No,22 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

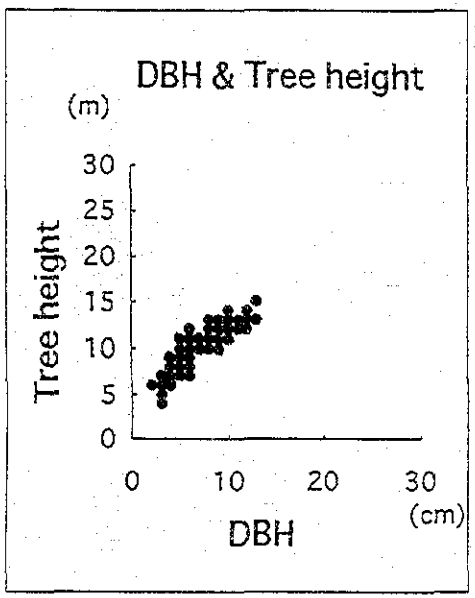
Plot No,23 Result of artificial forest survey

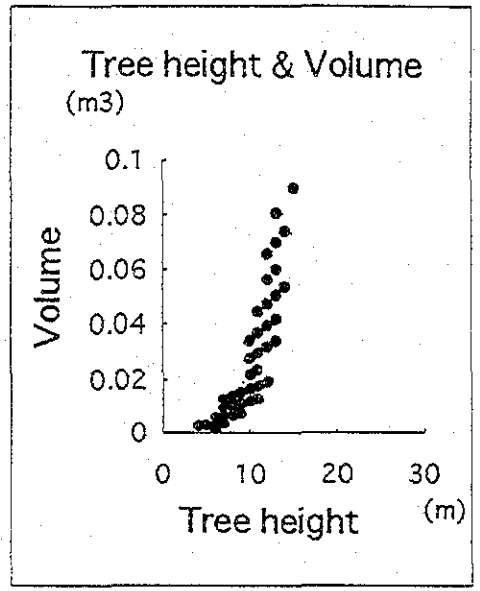
Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No.	23	Planted year	Regeneration at 1990 (3years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Thick
Inclination	Flat	Tending	
Remarks	Now stand regenerated after log at 1988～1989		

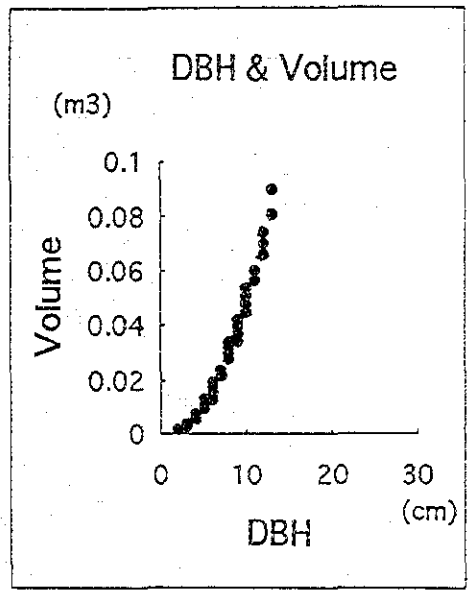
No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	6	9	0.01524
2	8	10	0.02763
3	9	11	0.03671
4	6	9	0.01524
5	5	10	0.01195
6	4	8	0.00675
7	6	10	0.01654
8	6	11	0.01781
9	3	5	0.00280
10	7	11	0.02345
11	6	12	0.01906
12	10	13	0.05045
13	5	8	0.01004
14	5	10	0.01195
15	6	8	0.01391
16	11	12	0.05619
17	5	9	0.01101
18	9	13	0.04180
19	9	10	0.03409
20	5	8	0.01004
21	10	14	0.05344
22	9	13	0.04180
23	11	13	0.05980
24	6	8	0.01391
25	8	10	0.02763
26	9	10	0.03409
27	6	7	0.01253
28	10	12	0.04740
29	8	13	0.03388
30	12	14	0.07398
31	10	13	0.05045
32	8	12	0.03184
33	10	12	0.04740
34	5	10	0.01195
35	4	8	0.00675
36	8	11	0.02976
37	13	13	0.08056
38	9	11	0.03671
39	4	6	0.00539
40	6	11	0.01781
41	8	12	0.03184
42	8	10	0.02763
43	8	11	0.02976
44	6	10	0.01654
45	9	11	0.03671
46	3	7	0.00364

47	4	8	0.00675
48	7	10	0.02177
49	10	12	0.04740
50	7	10	0.02177
51	8	12	0.03184
52	5	8	0.01004
53	4	8	0.00675
54	3	7	0.00364
55	8	12	0.03184
56	5	10	0.01195
57	8	12	0.03184
58	6	12	0.01906
59	6	10	0.01654
60	5	10	0.01195
61	9	12	0.03928
62	7	11	0.02345
63	5	9	0.01101
64	6	11	0.01781
65	5	10	0.01195
66	8	12	0.03184
67	13	15	0.09004
68	4	9	0.00739
69	8	11	0.02976
70	8	12	0.03184
71	9	12	0.03928
72	13	13	0.08056
73	10	11	0.04430
74	11	13	0.05980
75	7	10	0.02177
76	8	12	0.03184
77	10	11	0.04430
78	4	6	0.00539
79	12	13	0.06984
80	5	8	0.01004
81	4	6	0.00539
82	12	12	0.06563
83	5	7	0.00905
84	4	7	0.00608
85	3	6	0.00323
86	3	5	0.00280
87	10	12	0.04740
88	10	13	0.05045
89	3	5	0.00280
90	7	10	0.02177
91	7	10	0.02177
92	6	9	0.01524
93	6	8	0.01391
94	7	10	0.02177

95	3	5	0.00280
96	5	10	0.01195
97	3	5	0.00280
98	4	9	0.00739
99	6	10	0.01654
100	6	11	0.01781
101	6	11	0.01781
102	8	10	0.02763
103	3	7	0.00364
104	3	5	0.00280
105	10	13	0.05045
106	9	12	0.03928
107	11	13	0.05980
108	8	13	0.03388
109	6	11	0.01781
110	4	9	0.00739
111	5	10	0.01195
112	8	11	0.02976
113	5	9	0.01101
114	4	8	0.00675
115	6	10	0.01654
116	6	10	0.01654
117	5	9	0.01101
118	5	10	0.01195
119	8	12	0.03184
120	4	9	0.00739
121	6	11	0.01781
122	3	7	0.00364
123	4	9	0.00739
124	6	9	0.01524
125	7	10	0.02177
126	3	4	0.00236
127	2	6	0.00157
128	7	11	0.02345
129	8	12	0.03184
130	5	11	0.01287
131	10	12	0.04740
132	7	11	0.02345
133	4	7	0.00608
134	9	12	0.03928
Total	906	1345	3.28639
Average	6.76119	10	
		Volume/ha (m3)	82.15977
		MAI(m3)	20.53994





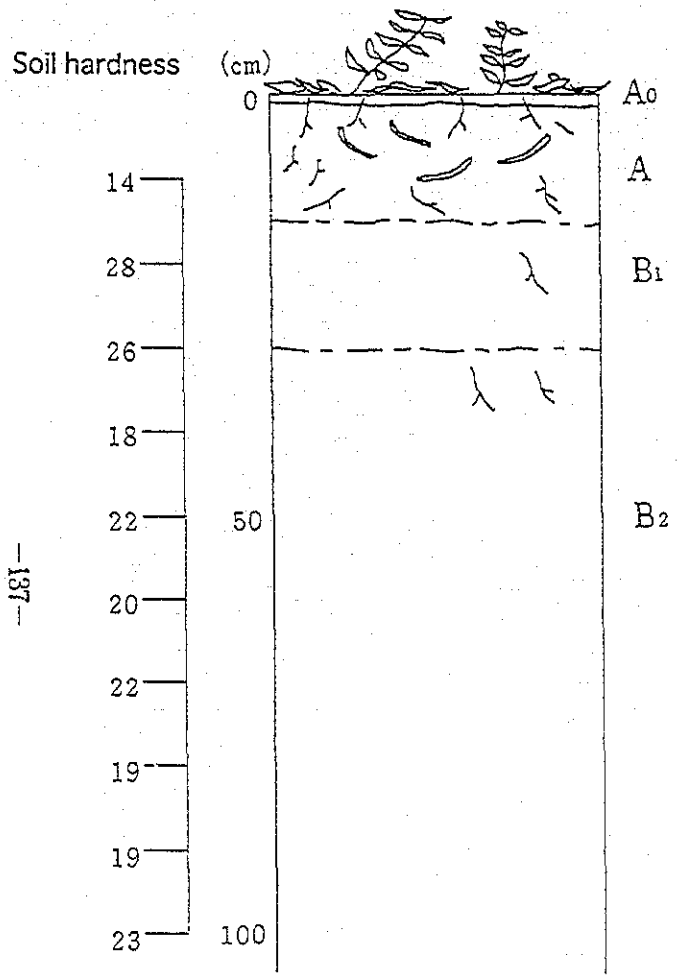


r= 0.8541831

r= 0.8239533

r= 0.9743819

Plot No,23 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume



Date	8/18/93
Plot No,	23
Area	Kudat/Kota Marudu Boundary
Compartment	
inclination	Flat

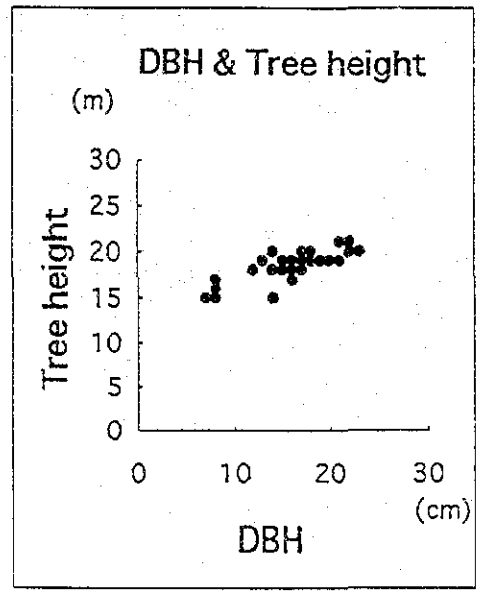
Horizon	Colour	Humus	Gravel	Structure	Moisture	Illuvation	Mycorrhiza	Root	pH	Remark
A	10YR5/3	Poor	Nil	Massive	Dry	Nil	Nil	Rich	5.4	
B1	10YR5/6	Nil	Nil	Massive	Dry	Nil	Nil	Poor	5.4	
B2	10YR8/6	Nil	Nil	Massive	Dry	Nil	Nil	Nil	5.4	

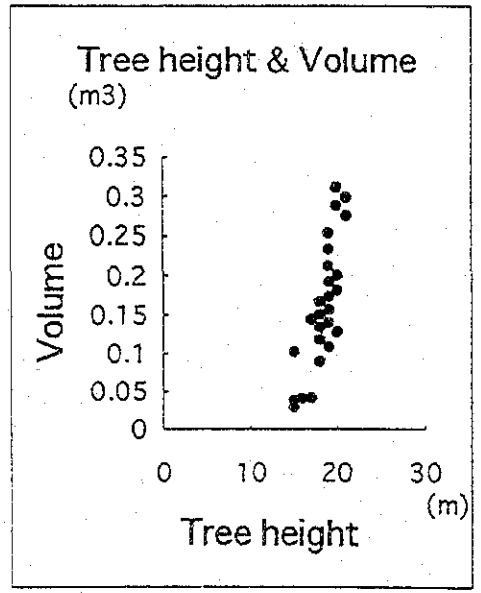
Plot No,23 Soil profile and Result of soil survey (Artificial forest)

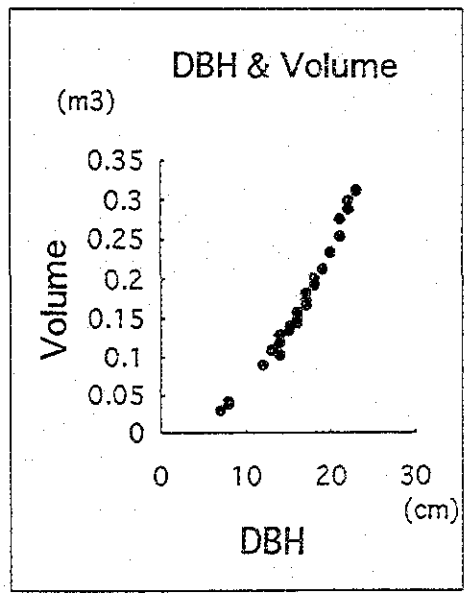
Plot No,24 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	24	Planted year	1986.Dec. (6.7years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment	44	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	14	15	0.10276
2	15	18	0.13391
3	20	19	0.23333
4	16	18	0.15025
5	14	20	0.12851
6	18	19	0.19334
7	19	19	0.21292
8	14	18	0.11840
9	22	20	0.28782
10	16	19	0.15670
11	8	16	0.03981
12	15	19	0.13966
13	18	20	0.20121
14	17	19	0.17460
15	23	20	0.31157
16	16	18	0.15025
17	14	18	0.11840
18	17	20	0.18170
19	16	19	0.15670
20	12	18	0.08994
21	17	18	0.16742
22	15	18	0.13391
23	8	17	0.04173
24	13	19	0.10819
25	8	15	0.03787
26	7	15	0.02984
27	18	20	0.20121
28	21	21	0.27514
29	12	18	0.08994
30	22	21	0.29894
31	17	18	0.16742
32	21	19	0.25455
33	18	19	0.19334
34	19	19	0.21292
35	16	18	0.15025
36	19	19	0.21292
37	17	18	0.16742
38	16	17	0.14373
Total	608	701	6.16855
Average	16	18	
		Volume/ha (m3)	154.21367
		MAI(m3)	23.42605







r= 0.7769873 r= 0.8010431 r= 0.9813443

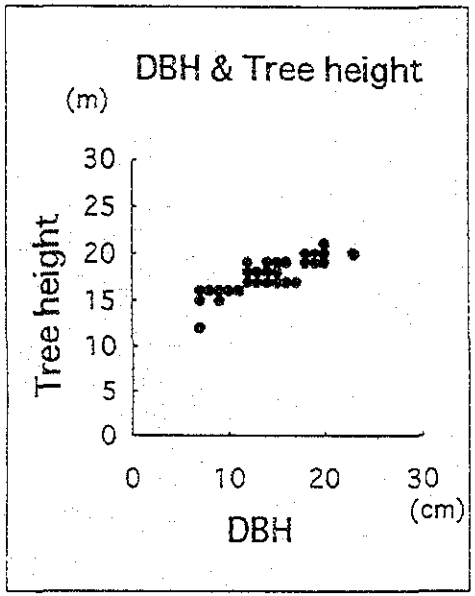
Plot No,24 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

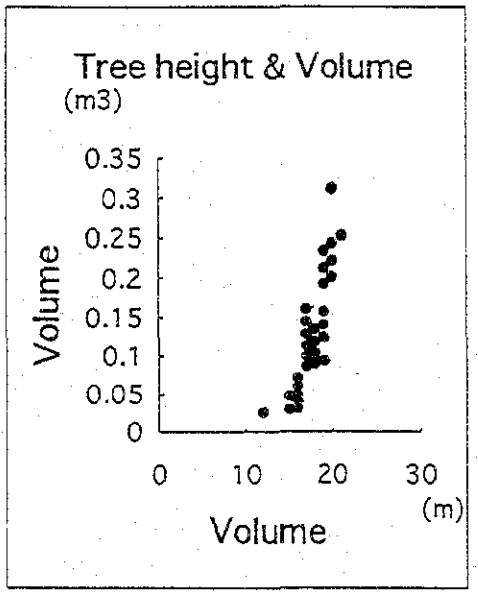
Plot No,25 Result of artificial forest survey

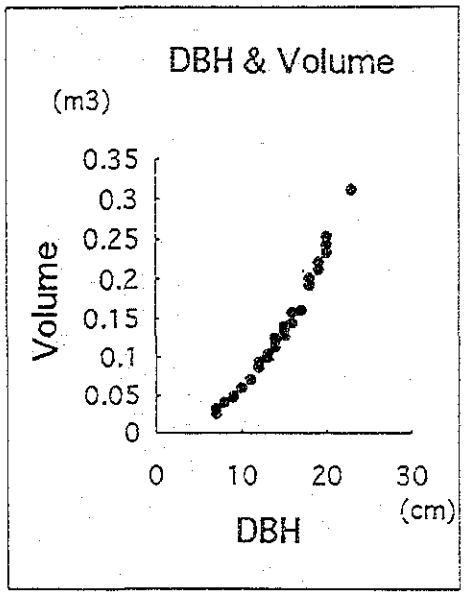
Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	25	Planted year	1986.Dec. (6.7years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment	44	Planted interval	3m×3m
Elevation		Crown density	Middle
Inclination	Flat	Tending	weeding every a half year (total 3 times)
Remarks	Planted distance is disturbed.		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	14	18	0.11840
2	16	19	0.15670
3	20	20	0.24282
4	14	18	0.11840
5	9	15	0.04672
6	15	17	0.12809
7	15	18	0.13391
8	19	19	0.21292
9	13	17	0.09923
10	12	18	0.08994
11	12	19	0.09380
12	15	19	0.13966
13	17	17	0.16014
14	14	18	0.11840
15	19	20	0.22158
16	20	21	0.25220
17	13	17	0.09923
18	16	19	0.15670
19	7	12	0.02509
20	16	17	0.14373
21	8	16	0.03981
22	9	16	0.04912
23	14	17	0.11326
24	12	17	0.08603
25	23	20	0.31157
26	14	18	0.11840
27	12	17	0.08603
28	12	18	0.08994
29	13	17	0.09923
30	14	18	0.11840
31	10	16	0.05928
32	8	16	0.03981
33	15	18	0.13391
34	12	17	0.08603
35	14	19	0.12349
36	20	20	0.24282
37	19	19	0.21292
38	7	15	0.02984
39	11	16	0.07027
40	20	19	0.23333

41	18	19	0.19334
42	15	18	0.13391
43	18	20	0.20121
44	7	16	0.03137
45	13	18	0.10374
Total	634	798	5.76477
Average	14.08889	18	
		Volume/ha (m3)	144.11918
		MAI(m3)	21.89263







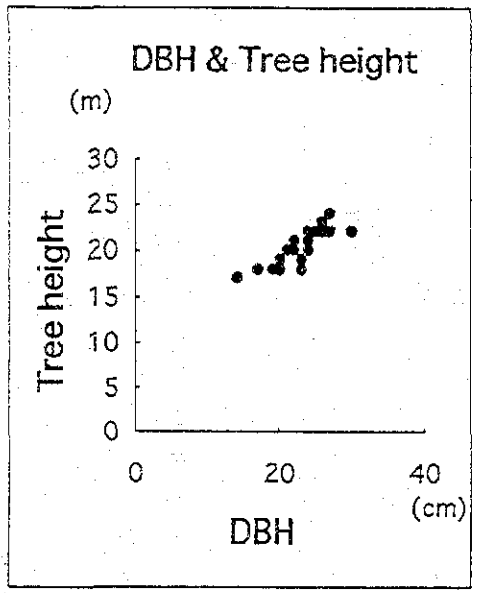
r= 0.8482897 r= 0.8431735 r= 0.9843182

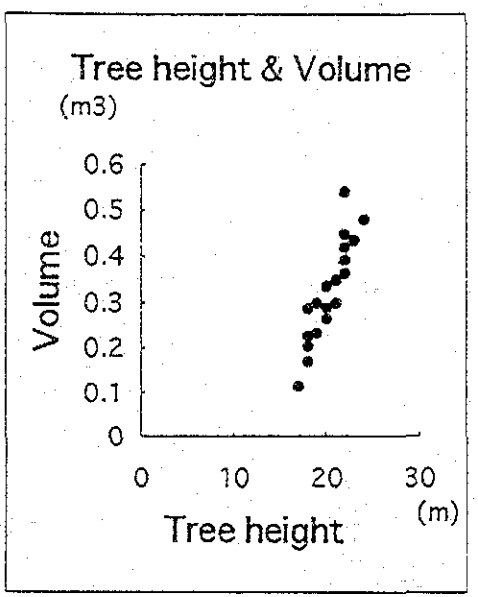
Plot No,25 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

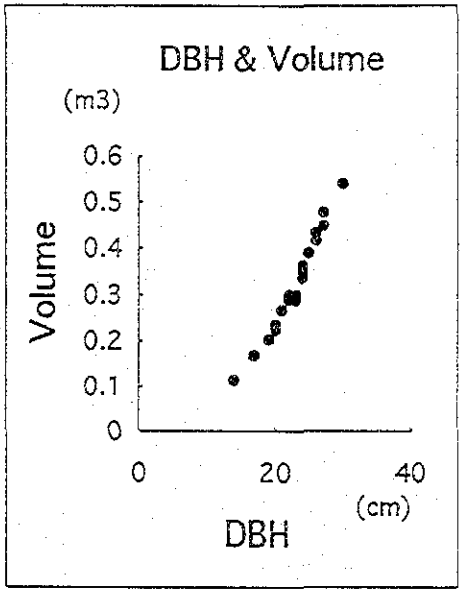
Plot No,26 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	26	Planted year	1984 Jan. (9.6years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment	28	Planted interval	10ft×10ft
Elevation		Crown density	Middle
Inclination	Slope land (gently) /6°	Tending	weeding every a half year (total 3 times)
Remarks	A part of this plot was damaged forest fire at 1986 and 1989		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	25	22	0.38934
2	27	24	0.47789
3	30	22	0.53901
4	22	20	0.28782
5	23	19	0.29940
6	24	22	0.36200
7	26	23	0.43224
8	17	18	0.16742
9	23	18	0.28708
10	14	17	0.11326
11	24	20	0.33615
12	24	21	0.34914
13	26	22	0.41756
14	20	19	0.23333
15	24	21	0.34914
16	26	22	0.41756
17	20	19	0.23333
18	24	20	0.33615
19	20	18	0.22372
20	19	18	0.20416
21	24	22	0.36200
22	26	23	0.43224
23	24	22	0.36200
24	22	21	0.29894
25	27	22	0.44664
26	21	20	0.26490
Total	602	535	8.62243
Average	23.15385	21	
		Volume/ha (m3)	215.56080
		MAI(m3)	22.69061







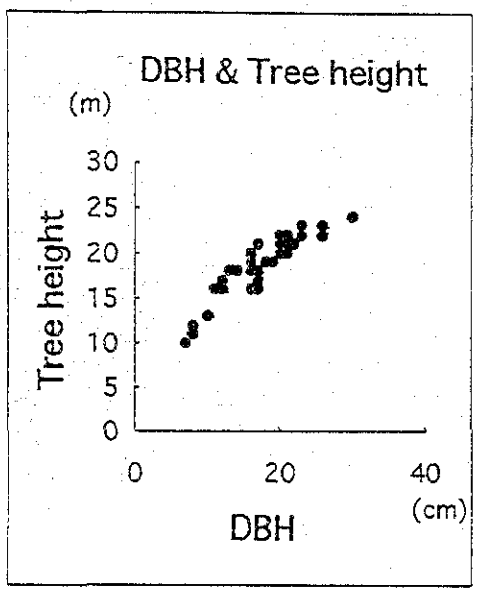
r= 0.8428353 r= 0.9010927 r= 0.9833382

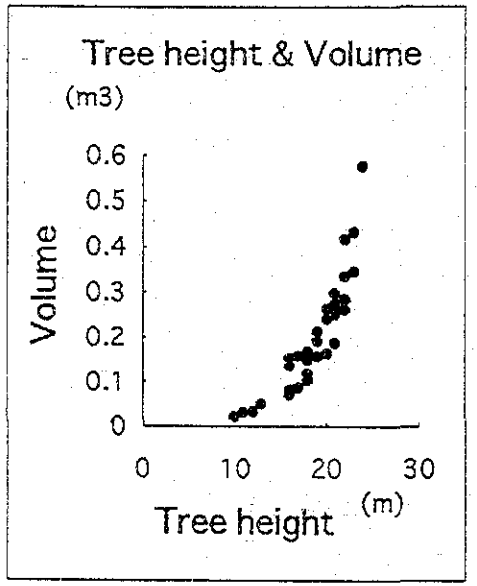
Plot No,26 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

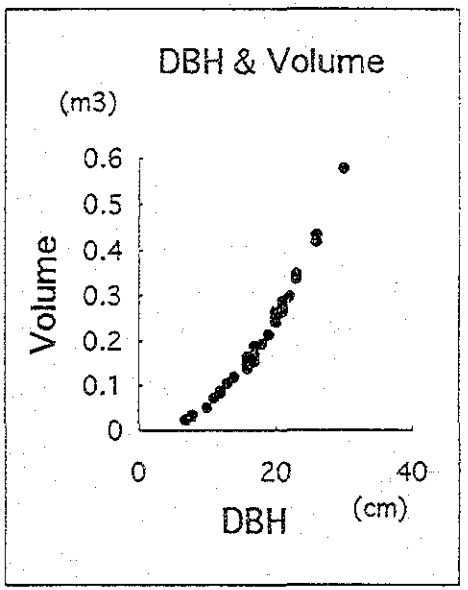
Plot No,27 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	27	Planted year	Regeneration for forest fire at1983
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks	Underbrowth are Alpinia spp. and party of Oplismenus undulatifolius		

No,	DBH (cm)	Tree height (m)	Volume equation(m3)
1	23	23	0.34732
2	20	21	0.25220
3	16	18	0.15025
4	17	18	0.16742
5	18	19	0.19334
6	19	19	0.21292
7	16	16	0.13711
8	17	16	0.15277
9	17	17	0.16014
10	21	22	0.28527
11	10	13	0.05045
12	8	11	0.02976
13	30	24	0.57672
14	23	23	0.34732
15	16	20	0.16308
16	8	12	0.03184
17	17	16	0.15277
18	18	19	0.19334
19	16	19	0.15670
20	20	20	0.24282
21	21	20	0.26490
22	16	18	0.15025
23	26	23	0.43224
24	17	21	0.18872
25	20	22	0.26149
26	7	10	0.02177
27	12	16	0.08207
28	12	17	0.08603
29	22	21	0.29894
30	26	22	0.41756
31	14	18	0.11840
32	21	21	0.27514
33	11	16	0.07027
34	16	19	0.15670
35	18	19	0.19334
36	13	18	0.10374
37	23	22	0.33553
38	12	17	0.08603
Total	657	706	7.54668
Average	17.28947	19	
		Volume/ha (m3)	188.66692
		MAI(m3)	18.86669

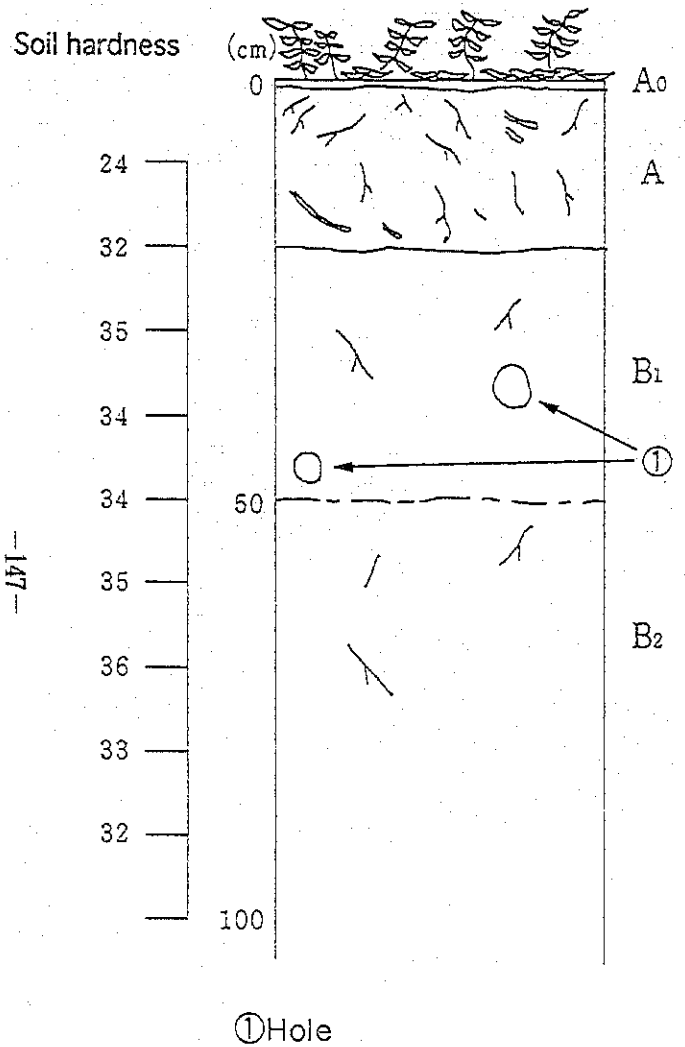






r= 0.9066614 r= 0.8703092 r= 0.9742473

Plot No,27 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume



Date	8/18/93
Plot No,	27
Area	Kudat/Kota Marudu Boundary
Compartment	
inclination	Flat

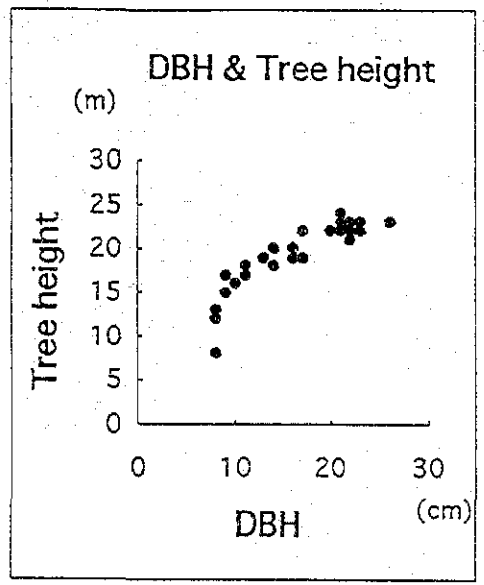
Horizon	Colour	Humus	Gravel	Structure	Moisture	Illuvation	Mycorrhiza	Root	pH	Remark
A	10YR6/3	Poor	Nil	Massive	Dry	Nil	Nil	Middle	5.6	
B1	7.5YR7/8	Nil	Nil	Massive	Dry	Nil	Nil	Poor	5.4	
B2	5YR5/8	Nil	Nil	Massive	Dry	Nil	Nil	Poor	5.4	

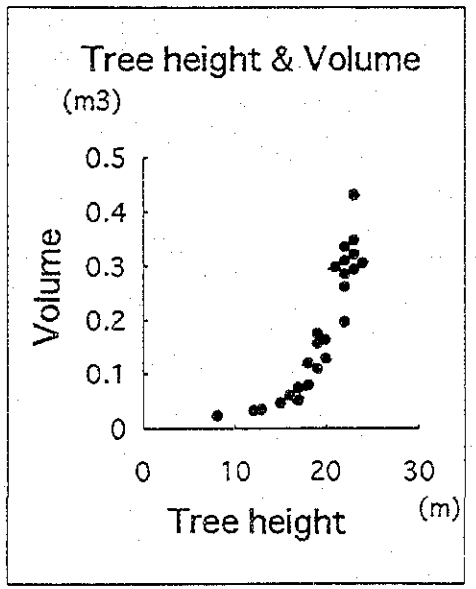
Plot No,27 Soil profile and Result of soil survey (Artificial forest)

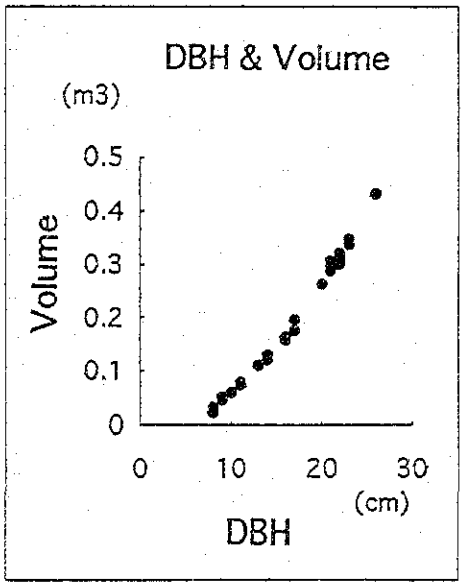
Plot No,28 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No.	28	Planted year	Regeneration for forest fire at1983
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks	Penatan, Puri (local name)		

No.	DBH (cm)	Tree height (m)	Volume equation (m3)
1	14	18	0.11840
2	26	23	0.43224
3	23	22	0.33553
4	21	22	0.28527
5	11	18	0.07701
6	17	22	0.19567
7	22	23	0.32085
8	11	17	0.07366
9	16	20	0.16308
10	17	19	0.17460
11	21	22	0.28527
12	22	22	0.30995
13	8	8	0.02323
14	21	23	0.29529
15	13	19	0.10819
16	16	19	0.15670
17	16	19	0.15670
18	9	17	0.05149
19	11	17	0.07366
20	22	21	0.29894
21	14	20	0.12851
22	16	19	0.15670
23	10	16	0.05928
24	9	15	0.04672
25	21	23	0.29529
26	8	13	0.03388
27	8	12	0.03184
28	21	24	0.30522
29	14	18	0.11840
30	20	22	0.26149
31	16	20	0.16308
32	23	23	0.34732
33	16	20	0.16308
Total	533	636	6.04654
Average	16.15152	19	
		Volume/ha (m3)	151.16362
		MAI(m3)	15.11636







r= 0.8877614

r= 0.8616926

r= 0.9891048

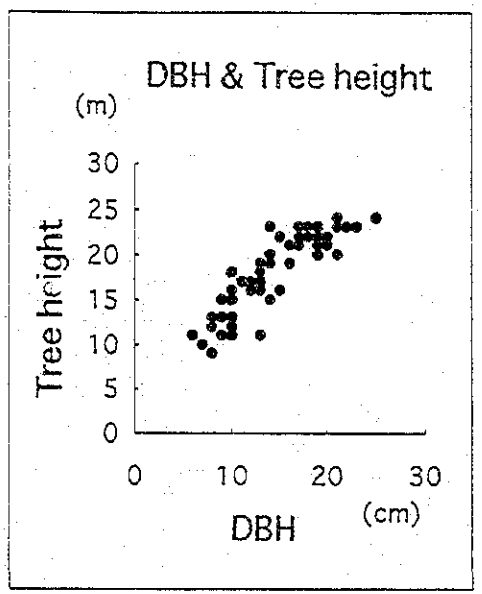
Plot No,28 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

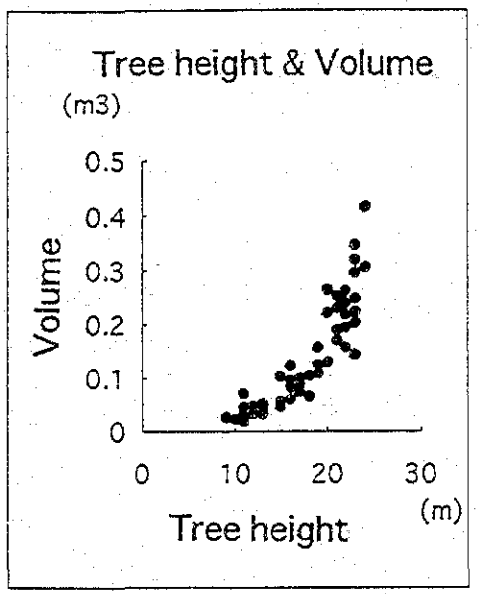
Plot No,29 Result of artificial forest survey

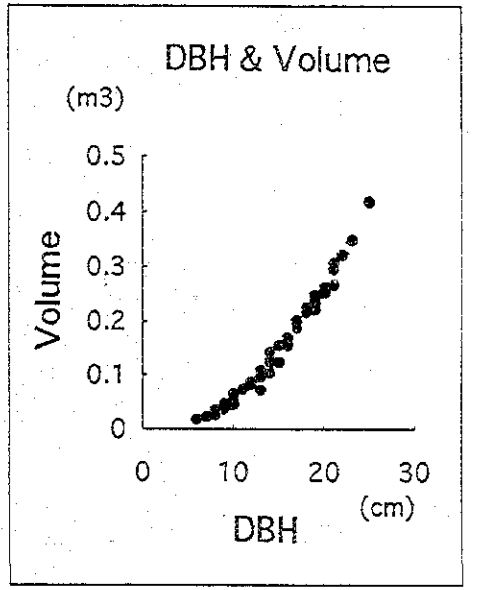
Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	29	Planted year	Regeneration for forest fire at1983
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks	A mark of forest fire at 1983		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	19	20	0.22158
2	13	19	0.10819
3	13	19	0.10819
4	8	9	0.02546
5	19	22	0.23862
6	10	13	0.05045
7	17	23	0.20255
8	18	23	0.22429
9	21	24	0.30522
10	14	20	0.12851
11	13	18	0.10374
12	16	21	0.16938
13	10	15	0.05638
14	17	22	0.19567
15	14	23	0.14325
16	15	16	0.12220
17	25	24	0.41658
18	12	17	0.08603
19	21	23	0.29529
20	10	12	0.04740
21	8	12	0.03184
22	22	23	0.32085
23	6	11	0.01781
24	7	10	0.02177
25	9	11	0.03671
26	14	19	0.12349
27	13	16	0.09467
28	14	15	0.10276
29	9	13	0.04180
30	20	21	0.25220
31	20	21	0.25220
32	21	20	0.26490
33	12	16	0.08207
34	21	23	0.29529
35	13	17	0.09923
36	13	17	0.09923
37	23	23	0.34732
38	11	17	0.07366
39	13	11	0.07075
40	10	15	0.05638

41	16	19	0.15670
42	10	16	0.05928
43	19	21	0.23015
44	9	15	0.04672
45	17	21	0.18872
46	17	21	0.18872
47	18	22	0.21668
48	15	22	0.15652
49	8	12	0.03184
50	8	13	0.03388
51	16	19	0.15670
52	10	18	0.06496
53	10	11	0.04430
54	19	23	0.24701
55	18	22	0.21668
56	18	22	0.21668
57	20	21	0.25220
58	10	16	0.05928
59	19	22	0.23862
60	20	22	0.26149
Total	881	1092	9.00108
Average	14.68333	18	
		Volume/ha (m3)	225.02690
		MAI(m3)	22.50269







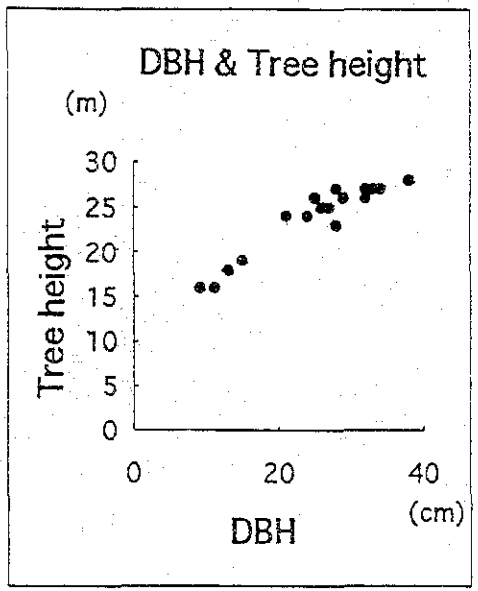
0.8805218 0.8781818 0.9838269

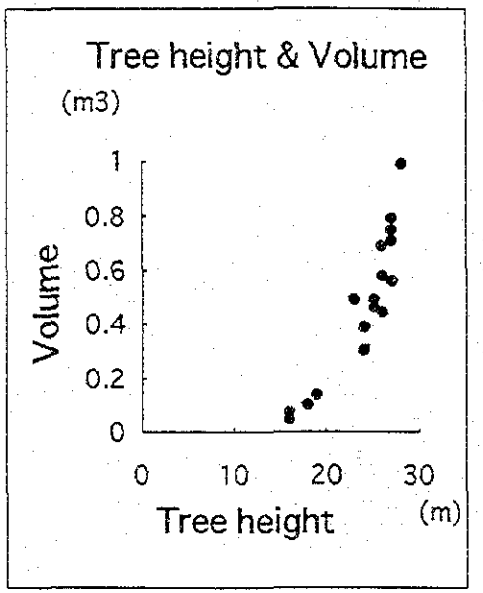
Plot No,29 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

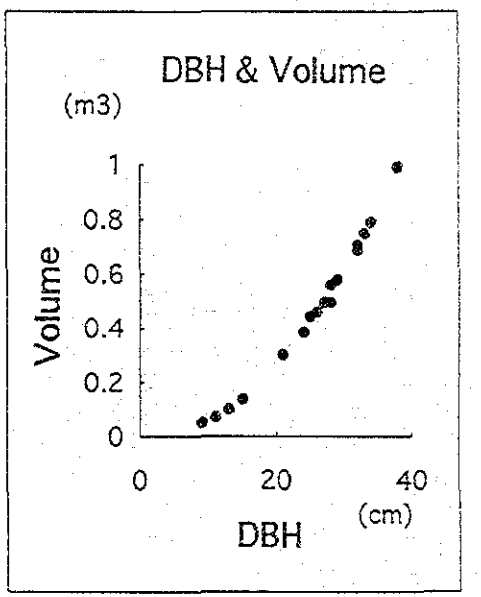
Plot No,30 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No.	30	Planted year	1980 (13years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			
Undergrowth	Geronggang geronggang	(Cratoxylum sp.)	
	Kudok kudok	(Colubrina anomala)	
	Kulimpapa	(Vitex pubescens)	
	Obah	(Eugenia sp.)	
	Pakudika	(Alphitonia incana)	
	Pulai	(Alstonia angustiloba)	
	Simpor bini	(Dillenia sp.)	

No,	DBH (cm)	Tree height (m)	Volume equation(m3)
1	21	24	0.30522
2	13	18	0.10374
3	33	27	0.74914
4	38	28	0.99116
5	26	25	0.46118
6	32	26	0.68863
7	28	23	0.49334
8	21	24	0.30522
9	25	26	0.44332
10	32	27	0.70912
11	24	24	0.38732
12	29	26	0.57772
13	27	25	0.49330
14	25	26	0.44332
15	28	27	0.55881
16	15	19	0.13966
17	9	16	0.04912
18	34	27	0.79012
19	11	16	0.07027
Total	471	454	8.75972
Average	24.78947	24	
		Volume/ha (m3)	218.99305
		MAI(m3)	16.84562







r= 0.9333401

r= 0.8878833

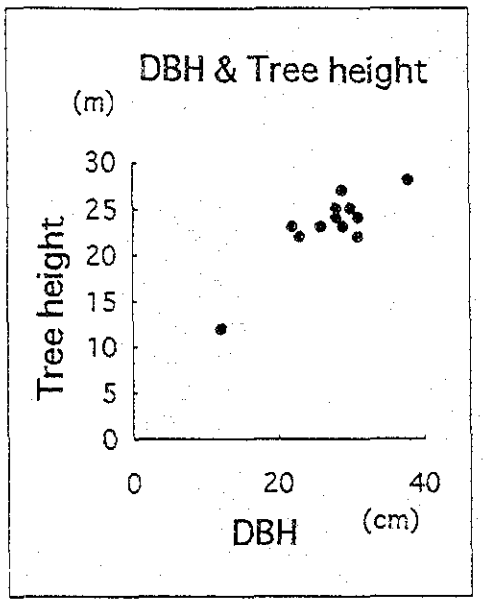
r= 0.9836871

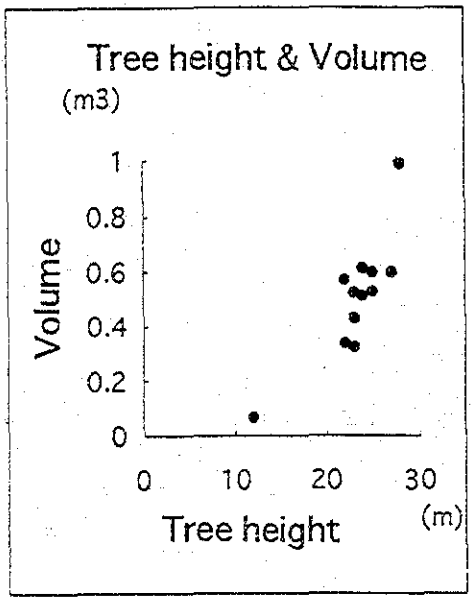
Plot No,30 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

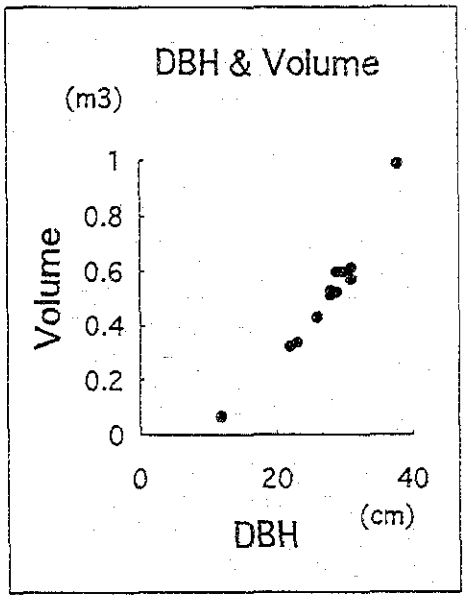
Plot No,31 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	31	Planted year	1980 (13years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			
Undergrowth	Beruni		
	Bintangor	(Calophyllum sp.)	
	Kamu maram	(Diospyros sp.)	
	Kopi kopi(Koping-koping?)	(Aglaia argentea)	
	Magkulat		
	Medang	(Cinnamomum parthenoxylon)	
	Pahit pahit	(Eurycoma longifolia)	
	Resak	(Vatica or Cotylelobium sp.)	
	Simpor bini	(Dillenia sp.)	
	tabarus	(Sarcotheca diversifolia)	
	Toroi toroi		

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	31	22	0.57148
2	29	23	0.52521
3	31	24	0.61146
4	23	22	0.33553
5	28	24	0.50993
6	22	23	0.32085
7	30	25	0.59531
8	26	23	0.43224
9	28	25	0.52637
10	29	27	0.59491
11	38	28	0.99116
12	12	12	0.06563
Total	327	278	6.08006
Average	27.25	23	
		Volume/ha (m3)	152.00148
		MAI(m3)	11.69242







r= 0.8717579

r= 0.8397615

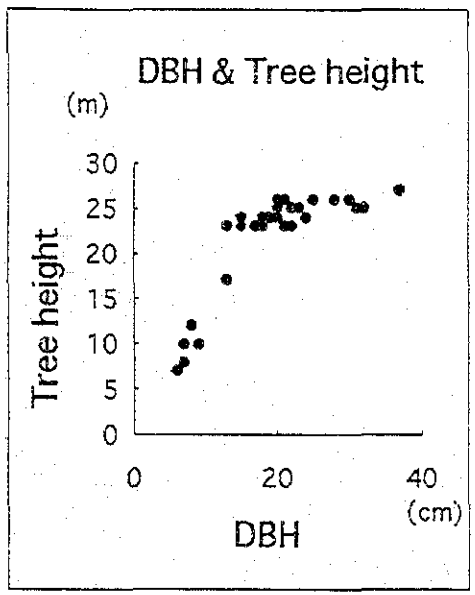
r= 0.9718528

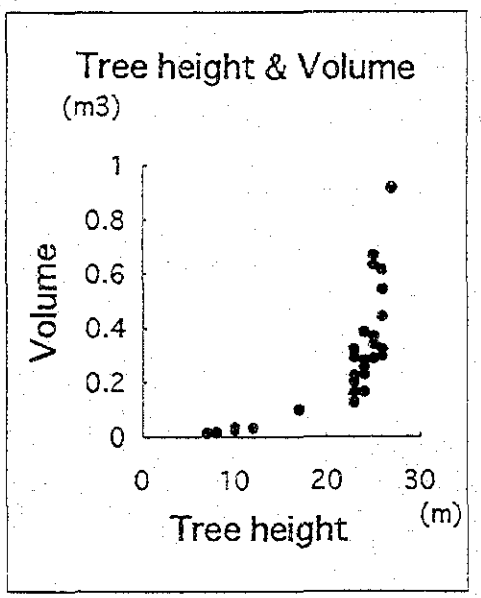
Plot No,31 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

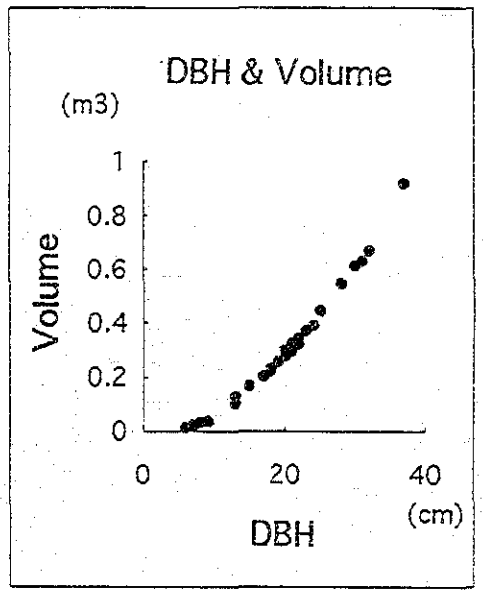
Plot No,32 Result of artificial forest survey

Date	8/18/93	Plot size	20m×20m 0.04ha
Plot No,	32	Planted year	1980 (13years)
Area	Langkon/Sampir	Planted species	Acacia mangium
Compartment		Planted interval	
Elevation		Crown density	Middle
Inclination	Flat	Tending	
Remarks			
Undergrowth	Beruni		
	Bintangor	(Calophyllum sp.)	
	Kopi kopi(Koping-koping?)	(Aglaia argentea)	
	Langkas		
	Obah	(Eugenia sp.)	
	Odak odak merah		
	Pahit pahit	(Eurycoma longifolia)	
	Pauh pauh paya	(Euodia roxburghiana)	
	Simpor bini	(Dillenia sp.)	

No,	DBH (cm)	Tree height (m)	Volume equation (m3)
1	21	23	0.29529
2	22	25	0.34233
3	20	25	0.28880
4	20	26	0.29774
5	15	23	0.16202
6	37	27	0.91877
7	9	10	0.03409
8	17	23	0.20255
9	6	7	0.01253
10	31	25	0.63117
11	21	26	0.32481
12	19	24	0.25531
13	7	10	0.02177
14	20	25	0.28880
15	13	17	0.09923
16	18	24	0.23184
17	28	26	0.54266
18	20	26	0.29774
19	21	23	0.29529
20	25	26	0.44332
21	32	25	0.66795
22	30	26	0.61373
23	24	24	0.38732
24	23	25	0.37058
25	22	23	0.32085
26	13	23	0.12551
27	8	12	0.03184
28	21	26	0.32481
29	20	24	0.27978
30	18	23	0.22429
31	15	24	0.16747
32	22	25	0.34233
33	7	8	0.01831
Total	645	729	9.86084
Average	19.54545	22	
		Volume/ha (m3)	246.52101
		MAI(m3)	18.96315







r= 0.8020894

r= 0.6964273

r= 0.978871

Plot No,32 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

Table 4 Collected Plants in Survey Site

No,	family	scientific name	place	characteristic	remarks
1	Pteridaceae	Pteridium esculentum	Plot No,15	a party of bracken	roadside
2	Gleicheniaceae	Dicronopteris curranii	Plot No,15	a party of fern	roadside
3	Melastomataceae	Melastoma	near by Plot No,15		roadside
4	Ulmaceae	Trema cannabina	near by Plot No,15	pionner	logging roadside
5	Zingibaraceae	Alpinia?	out of Plot No,15		forest floor
6	Orchidaceae	Malaxis	out of Plot No,15		forest floor
7	Thelypteridaceae	Pronephrium nitidum	near by Plot No,15	a party of fern , compound leaf	forest floor
8	Blechnaceae	Blechnum orientale	near by Plot No,15	a party of fern , This leaves are bigger than No,7	forest floor
9	Cyatheaceae	Cyathea latebrosa	Plot No,15	a party of fern , bipinnate	forest floor (dry)
10	Cyperaceae	Sclena	Plot No,15		forest floor (gap)
11	Lindsaeaceae	Lindsaea borneensis	Plot No,15	a party of fern	
12	Melastomataceae	Sonerila	Plot No,15		forest floor
13	Dryopteridaceae	Diplazium crenaoserratum	Plot No,15	a party of fern	forest floor
14	Acanthaceae		Plot No,15	liana	forest floor
15	Marantaceae	Phrynium	Plot No,1		inside of B type forest
16	Araceae	Homalomena rubra?	Plot No,1		inside of B type forest
17	Hanguanaceae	Hanguana malayana	Plot No,17		inside of B type forest
18	(fern)	Tectaria beccariana?	Plot No,1	leaves are thin	inside of B type forest
19	(fern)	Taenitis blechnoides	Plot No,1	a party of Fern , compound leaf ,Petiole is black.	inside of B type forest
20	Leguminosae	Spatholobus	Plot No,1	liana , looklike arrowroot	inside of B type forest
21	Gramineae	Dinochloa trichogona	Plot No,1	aparty of bamboo	inside of B type forest
22	Hypoxidaceae	Curculigo	Plot No,1		inside of B type forest
23	Araceae	Raphidophora	Plot No,1	liana	inside of B type forest
24	Lygodiaceae/Schizeaeceae	Lygodiun circinnatum	near by Plot No,16	liana	Bed is a little wet.
25	Selaginellaceae	Selaginella sp.	Plot No,16		inside gap
26	(fern)	Pleocnemia irregularis	Plot No,16	a party of fern	inside gap
27	same No,30		Plot No,16		inside gap
28	Palmae	Caryota mitis	Plot No,16	a party of palm	near by small stream
29	Zingiberaceae	Alpinia?	Plot No,16		
30	Zingiberaceae	Costus speciosus	Plot No,16		
31	Saurauiaceae	Saurauia	Plot No,16		
32	Leguminosae	Bauhinia	Plot No,16		
33	Tiliaceae	Microcos	Plot No,16		
34	Araceae	Scindapsis	Plot No,16		
35	a missing number				
36	Leguminosae	Mezoneuron	Plot No,16		

37	Zingiberaceae	Alpinia	Plot No,16		
38	Palmae	Arenga	Plot No,16		
39	Dryopteridaceae	Tectaria angulata?	Plot No,16		
40	Cyatheaceae	Cyathea sp.	Plot No,2	a party of palm (bigger than others)	inside forest
41	Leguminosae	Spatholobus	Plot No,2	liana	inside forest (Soil is wet)
42	Rubiaceae	Acranthera	Plot No,2		inside forest
43	Araceae	Epipremnum?	Plot No,2		inside forest
44	Pandanaceae	Pandanus	Plot No,2		inside forest
45	Asclepiadaceae	Cynanchum			shrub forest near Kg.Marak Parak
46	Rhizophoraceae	Anisophyllea disticha			shrub forest near Kg.Marak Parak
47	Euphorbiaceae	Croton argyratum			shrub forest near Kg.Marak Parak
48	Meliaceae	Aglaia			shrub forest near Kg.Marak Parak
49	Simaroubaceae	Eurycoma longifolia			shrub forest near Kg.Marak Parak
50	Apocyraceae	Alstonia macrophylla			shrub forest near Kg.Marak Parak
51	Verberaceae	Callicarpa			shrub forest near Kg.Marak Parak
52	Urticaceae?				shrub forest near Kg.Marak Parak
53	Tiliaceae	Pentace			shrub forest near Kg.Marak Parak
54	Euphorbiaceae	Macaranga tanarius			shrub forest near Kg.Marak Parak
55	Compositae	Blunea balsamifera			shrub forest near Kg.Marak Parak
56	Ulmaceae	Alphitonia philippinense			shrub forest near Kg.Marak Parak
57	Cyperaceae	Scleria			shrub forest near Kg.Marak Parak
58	Myrtaceae	Eugenia			shrub forest near Kg.Marak Parak
59	Euphorbiaceae	Sapium baccatum			shrub forest near Kg.Marak Parak
60	Rhizophoraceae	Pellacalyx saccardianus			shrub forest near Kg.Marak Parak
61	Moraceae	Ficus fulva			shrub forest near Kg.Marak Parak
71	Blechnaceae	Blechnum orientale	Plot No,24	a party of fern	logging roadside
72	Lycopodiaceae	Lycopodium cernuum	Plot No,24		logging roadside
73	Palmae	Licuala	Plot No,24		
74	Compositae	Eupatorium odoratum	Plot No,24		a mark of shifting cultivation

Results of Sectional Measurement of Planted Timber

1. Species and Method of Survey

Sample trees of *Acacia mangium* were collected in the sample plots (20 m x 20 m each). To choose sample trees, the DBHs and heights of all standing trees in the plots were measured, and trees whose DBH and height are equal or approximate to the average DBH and height were chosen as sample trees.

2. Purpose of Sectional Measurement

1) To calculate stand volume based on the volume of sample trees in a stand.

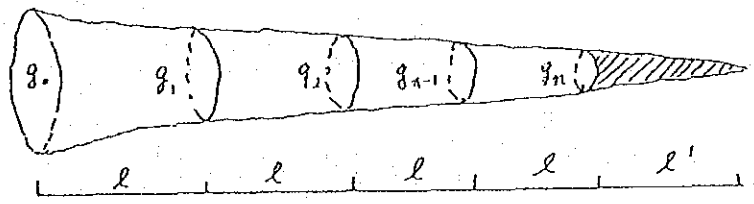
2) To calculate the mean annual increment (MAI) and the current annual increment (CAI) to determine the proper cutting age of the stand.

3) To calculate the breast height form facter (F) necessary for calculating single tree and stand volumes.

4) To estimate the site quality of the stand to use it for preparing a yield table.

3. Method of Sectional Measurement

The Smallian Method was used.



(1) As shown in the above figure, fell a sample tree at the base, and divide it into equal sections at certain intervals (2 m) from the base.

(2) Measure the basal area at both ends of the equally divided log.

(3) Call the basal areas of each log g_0, g_1, g_2, g_3 ....g_{n-1}, g_n from the base.

(4) Calculate the volume of each log. Use the average value of butt-end basal area and the top-end basal area.

That is, the volume of the first log is:

$$V = \left(\frac{g_0 + g_1}{2}\right) \times 2\ m$$

(5) Add up the volume of every log calculated by the above formula to determine the total volume. This is formulated as follows:

$$V = \left(\frac{g_0 + g_1}{2} + \frac{g_1 + g_2}{2} + \frac{g_2 + g_3}{2} + \cdots\cdots + \frac{g_{n-1} + g_n}{2}\right) \times L + V'$$

$$= \left(\frac{g_0 + g_n}{2} + g_1 + g_2 + g_3 + \cdots\cdots + g_{n-1}\right) \times L + V'$$

Notes: 1) Assuming that the top end is a cone, $V' = (1/3\ g_n \times L')$.

2) L is the total length of the divided stem, and L' is the length of the top end.

3) The basal area (g) is determined by the following formula.

$$g = \frac{\pi}{4} D^2 \quad \text{where D is diameter.}$$

4. Results of the Survey

1) Sample Trees Collected for Sectional Measurement

No.	Planting Year	Age	DBH (cm)	Height			Remarks
				Stem (m)	Top (m)	Total	
1	1986	7	13.3	12.0	5.7	17.7	Fertilized at planting
2	1987	6	15.8	14.0	4.7	18.7	Fertilized at planting
3	1985	8	13.3	14.0	4.8	18.8	Fertilized at planting.
4	1983	10	14.8	16.0	4.0	20.0	
5	1984	9	16.3	16.0	4.2	20.2	50% thinned in 1987.
6	1988	5	12.0	8.0	5.2	13.2	
7	1981	12	13.5	14.0	4.8	18.8	
8	1983	10	13.5	14.0	4.6	18.6	Damage by diseases & insects.
9	1986	7	12.5	10.0	3.1	13.1	
10	1981	12	18.5	14.0	6.2	20.2	50% thinned in 1987.
11	1982	11	18.5	16.0	5.4	21.4	
12	1984	9	17.0	18.0	4.3	22.3	50% thinned in 1987.
13	1987	6	16.3	12.0	5.2	17.2	50% thinned in 1987.
14	1982	11	13.5	14.0	4.4	18.4	

2) Results of Sectional Measurement (in m^3)

No.	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V'	Total volume
1	0.031	0.028	0.026	0.020	0.012	0.008				0.006	0.131
2	0.045	0.033	0.029	0.026	0.022	0.016	0.008			0.004	0.183
3	0.033	0.024	0.021	0.017	0.015	0.011	0.007			0.004	0.132
4	0.037	0.030	0.026	0.023	0.018	0.012	0.009	0.006		0.003	0.164
5	0.047	0.037	0.028	0.021	0.017	0.015	0.013	0.008		0.004	0.190
6	0.023	0.021	0.018	0.010						0.006	0.078
7	0.038	0.027	0.025	0.022	0.019	0.014	0.008			0.004	0.157
8	0.034	0.025	0.023	0.019	0.013	0.010	0.006			0.003	0.133
9	0.030	0.022	0.018	0.013	0.006					0.001	0.090
10	0.074	0.045	0.041	0.036	0.030	0.022	0.011			0.006	0.265
11	0.064	0.044	0.041	0.037	0.030	0.021	0.013	0.011		0.008	0.269
12	0.053	0.042	0.037	0.032	0.027	0.024	0.020	0.014	0.009	0.008	0.266
13	0.045	0.036	0.031	0.025	0.018	0.013				0.008	0.176
14	0.037	0.027	0.024	0.020	0.017	0.013	0.007			0.003	0.148

Note: The volume of each section (V_n) is calcualted as follows:

$$V_1 = \left(\frac{g_0 + g_1}{2}\right) \times L\ (2m)$$

Where $g_0 = \frac{\pi}{4} D^2$

The volume of the top end:

$V' = 1/3\ (g_n \times L)$

where L is the length of the top end.

3) Breast height form factor of Sample Trees and Stand Volume per Sample Plot or ha. (in m^3)

No.	Cylindrical volume (Vy)			Sectional volume (V_D)	Breast-height Form-factor (F) (V_D/Vy)	No. of trees (N)	Volume in sample plot (Vs)	Area of plot (S)	Volume per ha (Vg)
	Gy (m^2)	Hy (m)	Vy (m^3)						
1	0.014	17.7	0.248	0.131	0.526	45	5.895	0.04	147.38
2	0.020	18.7	0.374	0.183	0.489	34	6.222		155.55
3	0.014	18.8	0.263	0.132	0.502	43	5.676		141.90
4	0.017	20.0	0.340	0.164	0.482	43	7.052		176.30
5	0.021	20.2	0.424	0.190	0.448	33	6.270		156.75
6	0.011	13.2	0.145	0.078	0.506	28	2.184		54.64
7	0.014	18.8	0.263	0.157	0.596	35	5.495		137.38
8	0.014	18.6	0.260	0.133	0.511	40	5.320		133.00
9	0.012	13.1	0.157	0.090	0.573	31	2.790		69.75
10	0.027	20.2	0.545	0.265	0.486	21	5.565		139.12
11	0.027	21.4	0.578	0.269	0.465	22	5.918		147.95
12	0.023	22.3	0.513	0.266	0.519	18	4.788		119.70
13	0.021	17.2	0.361	0.176	0.488	21	3.696		92.40
14	0.014	18.4	0.258	0.148	0.573	25	3.700		92.50

Notes: 1) Cylindricl volume is determined by multiplying the the basal area (Gy) of the sectionally measured tree by height (Hy). However, it is not consistent with the figure determined by multiplying the automatically doubled DBH by $\pi/4$ and then by height to the third decimal.
If the figure is calculated in this way, the value of Vy for No.1 will be 0.246.

2) Breast height form factor (F) is a ratio of the volume of the sectionally measured standing tree (V_D) to the above-mentioned cylindrical volume (Vy). (V_D/Vy)

3) The number of trees is that of living trees (excluding dead trees and standing trees 5 cm or less in DBH) in a sample plot (20 m x 20 m).

4) Tree volume in the sample plot (Vs) means volume inside the bark in the above-mentioned plot and determined by the formula V_D x N.

5) The area of the sample plot (S) is 20 m x 20 m = 0.04 ha.

6) Volume per ha (Vg) means volume inside the bark per ha and is determined by the formula Vs x 25 (1/0.04).

7) Single tree volume is calculated by multiplying basal area by height by breast height form factor, while stand volume is calculated by multiplying total basal area by average height by the above-mentioned factor. (V = G x H x F).

4) General Evaluation of the Sample Plots (volume and MAI in m^3)

No.	Age of plot (N)	Volume of sample tree (V_T)	Breast-height Form-factor (F)	No. of planted trees Thinning ◎	No. of trees in plot (N)	Volume per ha (Vg)	Mean annula increment (MAI)	Evaluation
1	7	0.131	0.526	3×3	45	147.38	21.05	2
2	6	0.183	0.489	3×3	34	155.55	25.95	1
3	8	0.132	0.502	3×3	43	141.90	17.73	3
4	10	0.164	0.482		43	176.30	17.63	3
5	9	0.190	0.448	3×3 ◎	33	156.75		1
6	5	0.078	0.506	2×5	28	54.64	10.92	3
7	12	0.157	0.596	3×3	35	137.38	11.45	3
8	10	0.133	0.511	3×3	40	133.00	13.00	3
9	7	0.090	0.573	3×3	31	69.75	9.96	3
10	12	0.265	0.486	3×3 ◎	21	139.12		3
11	11	0.269	0.465	3×3	22	147.95	13.45	2
12	9	0.266	0.519	3×3 ◎	18	119.70		1
13	6	0.176	0.488	3×3 ◎	21	92.40		2
14	11	0.148	0.573	3×3	25	92.50	8.40	3

Note: Mean annual increment (MAI) = Vg/N

5) MAI Calculation

Mean annual increment (MAI) will be calculated from the breast height form factors of standard trees and the stand volume table by test plot or per hectare with the following corrections.

i) Thinned stands are Plots 5, 10, 12 and 13.
ii) Stands with poor results are Plots 6, 9 and 14.
iii) As for the four thinned plots, the figure is based on what the present stands would have been if they had not been thinned. In this case, the sectional measurement of volume of standard trees is assumed to be 0.85 of the thinned stands. Since the proportion of thinned trees is 50%, the number of the present stands would have doubled if they had not been thinned.
iv) The three plots with poor results will be excluded from the calculation of MAI.

Based on these assumptions, breast height form factors of standard trees and stand volume by plot and per hectare are shown in the following table.

	Cylindrical volume			Sectionally measured volume	Breast height form factor	Number	Volume of test plot	Area of test plot	Volume per ha
	$Gy(m^2)$	Hy(m)	$Vy(m^3)$	(V^D)	(V^D/Vy)	(N)	(Vs)	(Ha)	(m^3)
1	0.014	17.7	0.248	0.131	0.526	45	5.895	0.04	147.38
2	0.020	18.7	0.374	0.183	0.489	34	6,222		155.55
3	0.014	18.8	0.263	0.132	0.502	43	5.676		141.90
4	0.017	20.0	0.340	0.152	0.482	43	7.052		176.30
5	0.021	20.2	0.424	0.161	0.448	66	10.626		265.65
6	0.011	13.2	0.145	0.078	0.506	28	2.184		54.64
7	0.014	18.8	0.263	0.157	0.596	35	5.495		137.38
8	0.014	18.6	0.260	0.133	0.511	40	5.320		133.00
9	0.012	13.1	0.157	0.090	0.573	31	2.790		69.75
10	0.027	20.2	0.545	0.225	0.486	42	9.461		236.51
11	0.027	21.4	0.578	0.269	0.465	22	5.918		147.95
12	0.023	22.3	0.513	0.225	0.519	36	7.668		202.50
13	0.021	17.2	0.361	0.150	0.488	42	6.283		157.08
14	0.014	18.4	0.258	0.148	0.573	25	3.700		92.50

	Age of stand (years)	Volume per ha m^3	MAI m^3	
1	7	147.38	21.05	
2	6	155.55	25.95	
3	8	141.90	17.73	
4	10	176.30	17.63	
5	9	265.65	29.63	
6	5	54.64	(10.92)	Excluded
7	12	137.38	11.45	
8	10	133.00	13.00	
9	7	69.75	(9.96)	Excluded
10	12	236.51	19.71	
11	11	147.95	13.45	
12	9	202.50	22.50	
13	6	157.08	26.18	
14	11	92.50	(8.40)	Excluded
Average			19.84 (20.00)	

6) Summary of Results of the Survey

(1) The average breast height form factor was approximately 0.5. Breast height form factor indicates the numerical value of tapering of the trunk. The figure of about 0.5 shows that trees do not taper. However, a high form factor does not always mean large volume because many low trees had high form factors according to the results.

(2) As thinned stands showed good results, the MAI of test plots is 19.88 m^3 or about 20 m^3 on the assumption that they had not been thinned.

(3) The minimum level of profitability is 200 m^3 per ha for pulpwood. There were no stands whose volume exceeded 200 m^3 if they had not been thinned.

(4) Thinning and pruning are necessary for sawwood but not for pulpwood. Accordingly, it is necessary to urgently establish techniques for tending stands on a usage basis. The relationship between the number of planted trees and the percentage of thinned trees and the thinning time will raise problems for planters to produce sawwood. Thinned stands show good stock and growth, the highest in the stands surveyed. Six- or seven-year-old stands which were fertilized at the time of planting also showed good growth compared with other stands.

(5) The ratio of the volume of unbarked stands to that of barked stands was about 100 to 85. That is, the volume of bark accounts for about 15% of unbarked stand volume. The average accretion of unbarked stand volume in Plot 2 (six years old), which showed relatively good results, was 30.53 m^3, and the stand volume per ha was 183.00 m^3.

(6) Current annual increment (CAI) could not be measured because data on fixed plots was not available. In the case of pulpwood, CAI is generally estimated to cross MAI at six or seven years, which may provide a standard of regular cutting period.

(7) Both newly planted and thinned stands showed good growth. Numbers 1 and 2 in the column "Evaluation" in the above table correspond to Sites 1 and 2, respectively, in the expected yield table for Acacia mangium which covers northern Sabah State.

Functions of Tropical Rain Forests

1. General Consideration on Functions of Tropical Rain Forests

Tropical rain forests have a variety of functions which can be roughly grouped into (1) those that support human life, and (2) those that maintain the natural environment.

(1) Functions Supporting Human Life

1) Food Supply

Forests supply food such as fruits, mushrooms and honey.

2) Fuel Supply

Forest supply fuel such as firewood and charcoal.

3) Supply of Materials in Life and Medicines

Forests supply materials for buildings and furniture (including lumber, veneer, fiberboard, particle board, laminated lumber, floor boards and LVL), rot- and insect-proof materials (sleepers, utility poles, etc.), improve lumber, chemically processed lumber (such as WPC and thermal insulation lumber), and wood chips for manufacturing paper and pulp.

They also supply by-products like rubber, oils and fats, tannin, Japanese lacquer, dyes and medicines.

4) Scene Maintenance

Forests are part of the geographical features, lakes and marshes, and other natural characteristics that are closely related to them, forests maintain beautiful landscapes, contributing to recreational activities.

5) Living Environment for Wild Birds and Animals

Forests offer a comfortable living environment for wild birds and animals.

6) Land marks for navigation of ships

Forests can be appropriate landmarks for safe navigation of ships.

7) Inhabitation of Fish

Forests form locations for inhabitation and reproduction of fish

(2) Functions Maintaining the Natural Environment

1) Anti-disaster Functions

◎ Forests have the following functions on the land.
Reducing wind velocity (windbreak forests, sandbreak forests)
Functions as a guard fence due to tree trunks (tide-break forests, flood prevention forests)
Action as barriers by groups of crowns (fire prevention forests)

◎ Forests offer the following functions on the ground surface and underground.
Fixation of surface soil (prevention of landslides, surface erosions)
Ground surface protection by fallen leaves and branches (protection of surface erosion)
Controlling water flow rate (control of floods, water yield, purification of water)

2) Control the Natural Environment

Forests absorb carbon dioxide from the air and supply oxygen. They also fix solar energy to form organic substances.

3) Preservation of Gene Resources in Plant Ecosystems

As a cycle in the chain of plant ecosystems, forests preserve various gene resources.

4) Conservation of Soil Nutrients

Forests make soil more fertile by improving the aggregated structure of soil and preventing loss of soil nutrients.

2. Significance of Retaining of Tropical Rain Forests (natural forests)

(1) Coexistence of Public-service Functions and Economic Functions of Tropical Rain Forests

There is strong public opinion on the destruction of tropical rain forests and many suggestions have been proposed to stop the progress of such destruction by prohibiting tree-felling, but prohibiting tree-felling will not necessarily prevent the exhibition of functions of forests. According to T.C. Whitmore[1] there is a law for tropical rain forests starting that the quantity of dying trees is equal to that of growing trees. This is a theory in which felling old trees that have stopped growing accelerates the growth of young trees and thus rejuvenating forests. Furthermore, it has been shown that,

[1] T.C. Whitmore: Tropical Rain Forest of the Far East (Oxford Univ.), 1986

because the absorption of carbon dioxide is proportional to the growth of forests, double the forest growth will results in twice the absorption of carbon dioxide and twice the emission of oxygen.

Thus, it is important that a certain volume of trees in a forest corresponding to the growth volume of trees should be felled to allow young trees to grow rapidly to support the natural adjustment function (air purification function) of the forest.

Meanwhile, tropical rain forests are characterized by the fact that high temperature and activities of microbes in the topical zone shorten the term for the decomposition of fallen leaves to three months. This has been shown by a survey conducted by Tatsuo Kira[2], which demonstrated that up to 80% of the organic carbon contained in the tropical rain forests is stored in trees, and the amount of organic carbon accumulated in the Soil during the decomposition of fallen leaves and branches is less than 20% (this ratio is reversed in coniferous forests, i.e. 36:63).

In other words, in tropical rain forests, a large portion organic substances are locked in trees and less in present in soil and, therefore, intense tree-felling will result in a sudden loss of nutriments in the soil, making it difficult to reactivate such forests again. This is one reason for the fact that even though tropical rain forests are environmentally favored with temperature and rainfall, the restoring force of these forests is very low when compared with that of forests in temperate and the cold regions.

As mentioned above, in consideration of the balance in public-benefit functions of tropical rain forests, intense loggings destroys these functions, and reasonable tree-felling results in stronger exhibition of such functions, so the coexistence of public-service functions and economic functions of tropical rain forests is important.

(2) New Direction in Technologies for Tropical Rain Forests

Like forests in other regions, tropical rain forests are a reproducible and sustainable resource. Therefore, as mentioned in the previous item (1), tropical rain forests, while exhibiting public-benefit functions, can fulfil economic needs for lumber production at the same time, depending on the management method.

Recently, the supply of large diameter logs from natural forests has been overlooked because of the development of wood processing technology. In reality, however, there are a considerable number of factories with machines for manufacturing lumber and veneer from large diameter logs. These are contributing to regional economies in their own ways and therefore they cannot be ignored.

The status quo is, however, that production of these lumber industries depends greatly on tropical rain forests, and the secondary and tertiary logging are carried out a few years after the primary logging, causing deterioration and lowered public-benefit

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2 Tatsuo Kira: "Thoughts on Conservation of Nature", published by Jinbun Shoin, 1980

functions.

As such, tropical rain forests have been exposed to excessive loggings. However, it is noteworthy that in Peninsular Malaysia, lumber production is being conducted under selected cutting method which aims at full-fledged sustainable management of forests with a Selective Management System (SMS)[3]. Moreover, for the promotion of this method, discussions on how to link this with the results of artificial forests are expected to make progress rapidly from now.

3. Necessity of Artificial Afforestation in Tropical Zones

(1) Artificial Afforestation with the Functions of Forests

The characteristics of the ecosystem in tropical rain forests is multiple plant species. Establishing artificial afforestation with a single plant species indicates simplification of the complicated nature of human intervention. Tropical rain forest zones, each of which is a biosphere consisting of many kinds of living things, exist based on a complicated relationships of interdependence so that their ecological viability is very high, like machines provided with many safeguards. Addition of an artificial single storied forest of one specific species of plant to the ecosystem existing in such a balance of versatility will yield many risk factors.

Single storied forests in tropical zones are appropriate to the mass production of lumber with high profitability, but cause excess utilization of soil nutrients. In contrast to tropical forests, which are mixtures of many types of plant species, single storied forests have imbalanced ecosystems poor resistance to damage caused by blight and harmful insects, and lowered anti-disaster functions.

Accordingly, ideal artificial afforestation in mountainous areas is an artificial regeneration or an artificial forest having functions of a natural forest.

The following three methods may be useful in the above.

1) A devastated natural forest is reinforced by artificial forestation to reform it into a normal natural forest. (This method corresponds to enrichment planting that has been achieved in some areas.);

2) A management method by which a bare land area caused by logging or the shifting cultivation is subjected to repeated artificial forestation of a multilayered forest, and;

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[3] In Peninsular Malaysia, the SMS was adopted in place of the improved Malayan Uniform System (MUS) from 1990. The SMS features the following; (1) the cutting cycle has been 30 years, (2) the harvesting permissible under-limit for felling of Dipterocarpaceae has been raised from DBH45 cm to 50 cm, and (3) it has been decided that all Dipterocarpaceae trees must be preserved as a useful and succeeding tree.

3) A bare land area caused by logging or the shifting cultivation is first subjected to artificial forestation of a multilayered forest, which is then grown into a natural forest.

It cannot be denied that these methods have the following disadvantages to demonstrate industrial forestation; complicated technologies for forestation and lumber production, long periods of investment, unsolved methods to cope with massive demand of lumber, and insecure payments.

It is desirable, however, that these methods be applied at places where public-benefit functions are strongly needed to aim at establishing management methods and technologies for artificial forestation with functions of the natural forest, and to demonstrate forestation for promoting coexistence of public-benefit functions and economic functions of the natural forest in the future.

(2) Relationship between Artificial Afforestation and Estates such as Rubber Estates

In areas of this project, the main form of modern agriculture other than rice paddy crop is cultivation of "trees" for rubber, oil palm, coconut palm, cacao and others. Such artificial afforestation exist in various areas, so that local inhabitants have no resistance to the cultivation of "trees", even such cultivation belongs to the category of forestry.

The management methods and technologies for the rubber plantation have many helpful aspects for execution of artificial forestation, because working processes for the rubber plantation are similar to those for the artificial forestation. For instance, full-face plowing is common for the land preparation for rubber plantation and is worth consideration for land preparation for artificial forestation in some areas, though there may be some topographical restrictions from place to place, such as abandoned shifting cultivation and areas left after forest fires where organic substances have been lost in the surface layer, and places where lalang (*Imperata cylindrica*) may intrude. Furthermore the planting rate of rubber trees is so low that only 500 per hectare, and *Centrosema pubescens, Calopogonum mucunoides* and *Pueraria phasceloides* are planted in the forest bed to cover the ground surface, aiming at protection of the surface and prevention of invasion by weed. This system may be useful for artificial afforestation.

(3) Artificial Forests and Labour Force

With artificial forests, unlike natural forests, sufficient nursing and adequate management are indispensable to realize the coexistence of the lumber produced from artificial forests with those from natural forests, and to maintain the level of usefulness as a commodity. Fortunately, "trees" for rubber, oil palm and coconut have been cultivated in the vicinity of this project, which will facilitate operations such as forestation and nursing, which require high skill, and securing of labour.

The Malaysian Timber Industry Board[4] has reported trial computation results in which the forestry labour force needed for raising seedlings, forestation, raising forests and lumber production is 800 persons per 10,000 hectare (200 actual working days per year). This figure, when seen as an effect on the efficient use of local labour force and regional economies, is never worse that from the modern agriculture of rubber, oil palm and coconut.

4. Main Factors Deteriorating the Functions of Forests

(1) Shifting Cultivation

1) Present State of Shifting Cultivation

Shifting cultivation has prevailed in the tropical rain forest zones within this studied area.

Spenser J. F.[5] has pointed out that, as seen in Fig. 1, about 1/3 of the farmland in the tropical rain forests in Southeast Asia is shifting cultivation fields. Dobby I. H. G.[6] has shown, in his report on Sarawak, that shifting cultivation fields in the state comprise 2.8 million hectares, corresponding to 1/5 of the whole area of the state, which is expanding by 100,000 hectares annually. Lau B. I.[7] has reported that the population of Sarawak is increasing at an annual rate of three percent, and the yearly increment of shifting cultivation fields in 105,000 hectares in total, 30 percent of which (34,000 hectares) comes from primary forestland, and the remaining 70 percent (79,000 hectares) from secondary forestland. This means that a 1% increment in the population creates new shifting cultivation fields of some 35,000 hectares. In particular, the large conversion from secondary forest land is stable and the report says that blocks of shifting cultivation fields are distribute along the roads for carrying out the felled logs, like the meshes of a net.

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4 Malayan Timber Industry Board: Investment guideline for the woodbased industry 1990

5 Spenser J.E.: Shifting Cultivation in Southeastern Asia, 1966

6 Dobby E.H.G.: South east Asia. 1950

7 Lau B.T.: The effect of shifting cultivation on sustained yield management for Sawrawak national forests, 1979

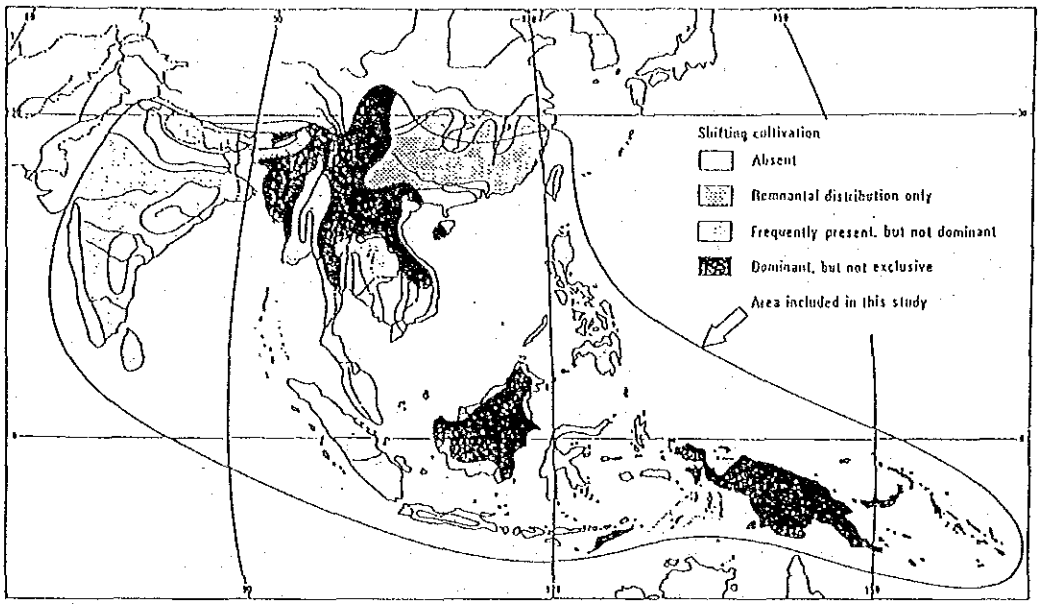

Fig. 20 Distribution of Shifting Cultivation in Southeast Asia

The ratio in area between Sarawak and Sabah is 63:37, and the ratio in population as of 1992 is 52:48. The real state of shifting cultivation in Sarawak cannot be directly applied to Sabah, because Sabah is higher than Sarawak in terms of population density and agricultural output, but the whole area and the annual increment of shifting cultivation fields can be considered to be marked.

2) Real State and Problem Points of Shifting Cultivation

According to a.survey conducted by Verboon W. C. in Peninsular Malaysia[8], an indication for the primary progress in changes after logging includes the emergence of lalang (*Imperata cylindrica*) in shifting cultivation fields and of *Axonopus conpressus*, which belongs to the same Gramineae, in areas to be used as meadows (see Fig.21).

[8] Verboom W.C.: Grassland succession and association in Pahang, Central Malaysia, 1968

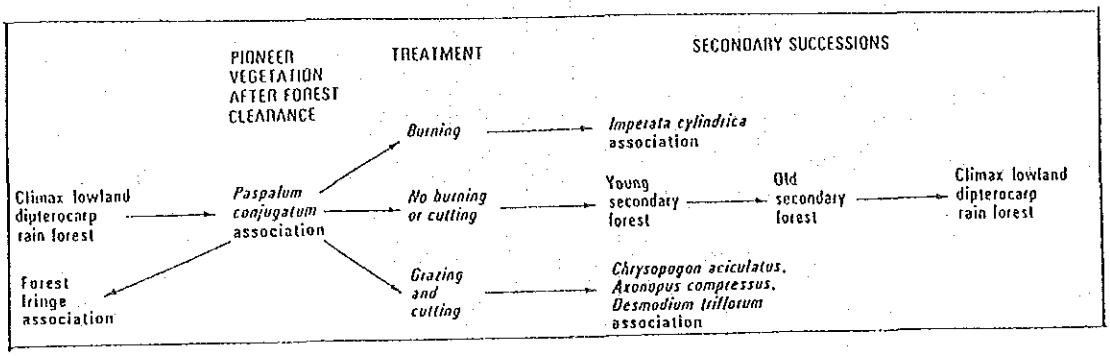

Fig. 21 Progress of Vegetation after Tree-felling

Cogon is a troublesome perennial plant, which is well adapted to poor land conditions and spreads underground with its subterranean stem, and can be expected to be a big obstructing element in executing artificial afforestation. The invasion of cogon into shifting cultivation fields can be prevented by simple plowing immediately after burning dead grass and sowing seeds of target crops.

The survey conducted by Dryessen P. M. in Kalimantan[9] has reported that, with repeated shifting cultivation on the same spot, the harvest per unit of 1–5 ha reached the peak in the third year after the start of shifting cultivation and has decreased thereafter (see Fig.22), and therefore the limit for shifting cultivation on the same spot is four years. However, another block of forests is burnt in the third year, because no crops can be expected in the first year.

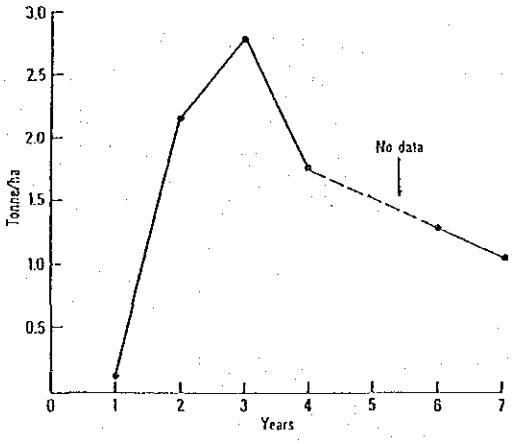

Fig. 22 Changes in Harvest from Shifting Cultivation Fields

9 Driessen P.M.: The influence of shifting cultivation on podzolic soil from Central Kalimantan, 1976

The self-supporting food production on the burnt farm is usually 60 percent, and the remaining 40 percent is satisfied by income from cultivation of cash crops, and the income also used for buying daily commodities including clothing.

The shifting cultivation is characterized by securing fallow. The fallow is apt to be misunderstood as a cause of acceleration of the destruction of forests.

Boserup E.[10], based on results of analyzing the labour intensity and the profitability of rice, the major crop, proposed the fixation of shifting cultivation fields, and has also urged that shifting cultivation farmers consider their options by forecasting that the pressure from the increasing population will lead shifting cultivation to collapse.

It has been revealed, however, that the existence of this fallow keeps the soil fertile in the shifting cultivation fields. The reason for this is that the presence of forests as follow makes it possible to continue the cultivation of crops without letting arable land become temporarily bare land, resulting in prevention of excessive alkalinization of the land. With shifting cultivation, which, differs from flatland farming, is executed on slopes, the surface soil is washed away to some extent. Accordingly, a lot of fertilizer is needed to conduct fixed farming. However shifting cultivation farmers cannot afford to buy fertilizers. It was a good move for shifting cultivation farmers to utilize forests as favorable places to secure fallow, which is necessary to maintain the fertility of the soil. Therefore, as long as slash-and-burn is carried out in a certain cycle, destruction does not extend given limit, and as such forests have taken root as a stable agricultural form combined with the life style of the shifting cultivation farmer. Recently, however, the population of mountainous villages has been increasing. Densely populated are as in the lower areas cannot sufficiently absorb the surplus labour force, so that the strain is being shifted to forests, destroying the rotation of utilization of forests with a follow period. Shifting cultivation farming is spreading widely along roads for carrying out logs at an increased speed with shifting cultivation.

It cannot be said that all of shifting cultivation areas accelerate the destruction of forests, but one viewpoint is that forests will be reduced at a considerable rate it burnt fields increase widely with such progress.

(2) Effects of Intensified Logging of Tropical Rain Forests in Mountainous Villages

An intense logging of forests will change the material cycling maintained under the existence of such forests. The strongest change is caused in A_0 layer, the organic sedimentary layer of the surface layer of the forest.

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[10] Boserup E.: The conditions of agricultural growth, 1965

Even in this survey, A_0 layers in remaining places left after intense logging were 1 – 2 cm thick at most.

Furthermore, advanced decomposition of organic matter in A_0 layer causes an increase in pH.

Ikuhisa Mashimo[11], Hideo Takehara and Tadashi Kuroshima[12], and Eyles R. J. et al[13] have pointed out that organic matter in laterite, a typical kind of soil for tropical rain forests, are rapidly decomposed without forming acid humus, and the soil rather shows weak alkalinity. However, this survey has pH data of the soil were 5 – 6, which cannot be regarded as alkaline.

Another effect caused by intensified logging of forests on slopes is rapid erosion of the fertile soil in the surface layer. This trend is especially strong in places that have been taken out of rotation due to slash-and burn after logging (abandoned lots) and meadow. The soil in these vacant areas must be improved before executing artificial forestation.

(3) Degradation of Functions of Forests due to Construction of Forest Roads

In the tropical rain forests found in this project, many roads for carrying out logs constructed at the time of logging have been developed, like the meshes of a net. The topography includes valleys at various locations, and these valleys are surrounded by relatively steep slopes.

Most of these forest roads are now out of use with advanced devastation. It is clear that these abandoned roads have adverse effects, but the bad effects of "waste soil" created at the time of construction of these roads are described in the following. That is to say, dumping of cut soil under roads bury roots of trees, and rolling stones severely damage trunks. Moreover, waste soil kills plants created in the final stage of vegetation in many cases, while heliophytic species, an intermediate phase, tend to be relatively strong in resistance, and thus the diversity of plants deteriorates.

Another had effect is that while living trees were felled at construction of a road, standing trees of a certain width in each of the forest borders facing both sides of the road have been killed or are undergrown. The reason for this is that the wind blowing along the road accelerates evaporation of water and diffusion of moisture from forests and they dry up.

In establishing artificial forestation, a reduction in costs for forestation and lumber production is realized by constructing roads of high density. Especially for steep

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11 Ikuhisa Mashimo: Ringyo Jitsumu Hikkei (Handbook for Practical Business of Forestry), Edited by Tokyo University of Agriculture and Industry 1979

12 Hideo Takehara and Tadashi Kuroshima: Soil, Ikurin Soten 1958

13 Eyles R.J.: Laterite at Kerudau, Pahang, Malaya 1967

slopes, however, it is ideal that priority should be given to ridges where possible as locations for construction of roads, to reduce cut-off areas of forests and amount of waste soil as much as possible, aiming at prevention of deterioration of the functions forests.

(4) Deterioration of Functions of Forests due to Fires

For farmlands of rubber and oil palm trees on flatlands with houses in their vicinities, preventive measures can readily be provided, and fire fighting actions can be rapidly taken if a fire starts. In mountainous zones, however, establishment of preventive measures for forest fires is difficult, and no means can be taken for fire fighting when a fire has broken out.

When a forest fire has occurred, the loss of the burnt forest is of course a great, but adverse effects remaining cannot be ignored. It is said that, in an area left after a forest fire, the infiltration of water is degraded, and therefore the overland flow of soil erosion and soil runoff are heightened.

After a forest fire, some trees are not killed and recover, but such trees are inferior in quality, and thus they cannot be used as lumber. They also cannot be used as pulp, which is processed wood, because the carbonized lignum disturbs digestion.

Results of Artificial Forest Survey at High Altitudes in Phase II

An increment survey of artificial forests (mainly *A. mangium*) was carried out from July to August last year in order to determine tree species adaptable to the project area in northern part of Sabah State. The results were shown in the attachment to Progress Report (I).

Based on the results of the previous survey, plantations of *A. mangium* at an altitude of 2000 f (about 600 m) or higher were surveyed this time in respect to their increment in order to verify the adaptability of this species to high altitudes. Although plantations of *A. mangium* at an altitude of 2000 f or higher were sought on the land use and vegetation map, they were absent at such a high altitude in this area. For this reason, the coverage of this survey was extended to Tambunan and Keningau in the south, beyond the project area.

The increment of *A. mangium* was therefore able to be surveyed at high altitudes from about 2300 f to about 3500 f. Kg. Patau and Kg. Tanaki in Tambunan were chosen for this survey. The increment of *A. mangium* and soil were surveyed at four sites in these districts. The location of the survey sites is shown in the following map.

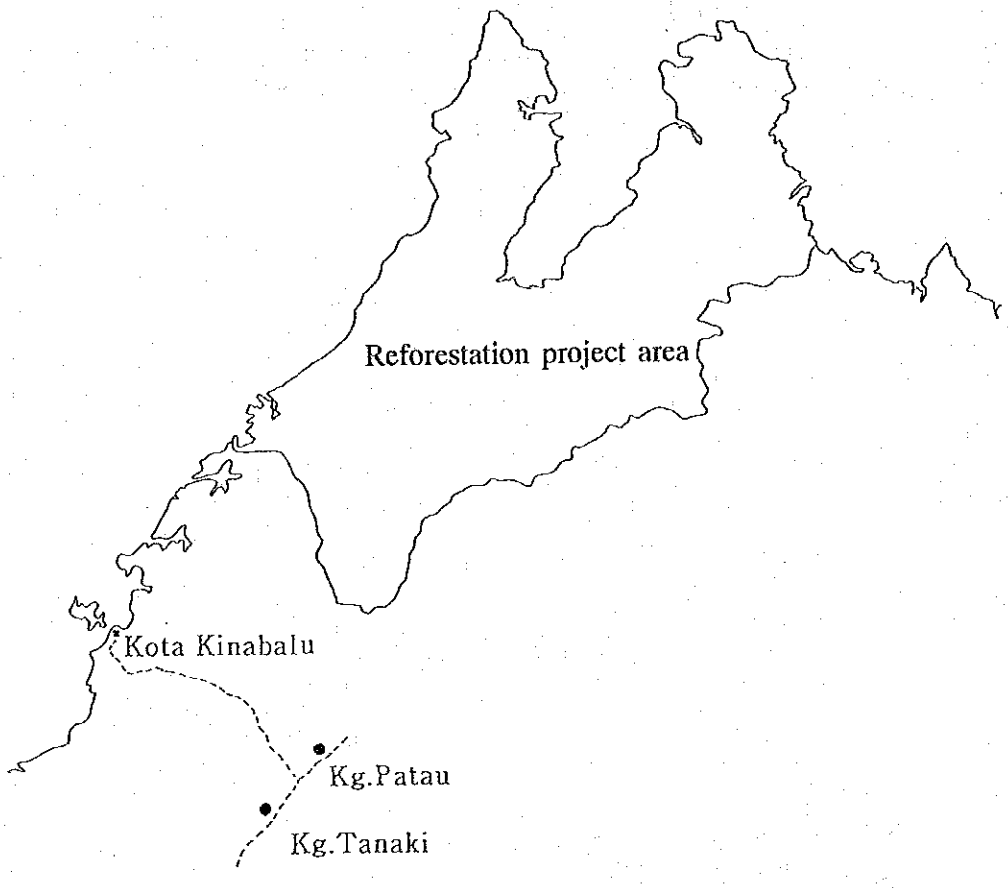


Fig. 23 Location of Sites for Surveying Increment of *A. mangium* at High Altitudes

There are differences in climatic conditions between northern Sabah and Tambunan or Keningau (rainfall is heavy in the latter two areas, judging from the present condition of vegetation). Data on these areas cannot be simply compared, and the results of this survey are regarded as only indicative for reference. According to the results, the average of MAIs in four plantations of *A. mangium* was 13.64 m^3/year in Bengkoka surveyed last year. In terms of quality, there were many trees with split fork-like trunks in these four plantations of *A. mangium*.

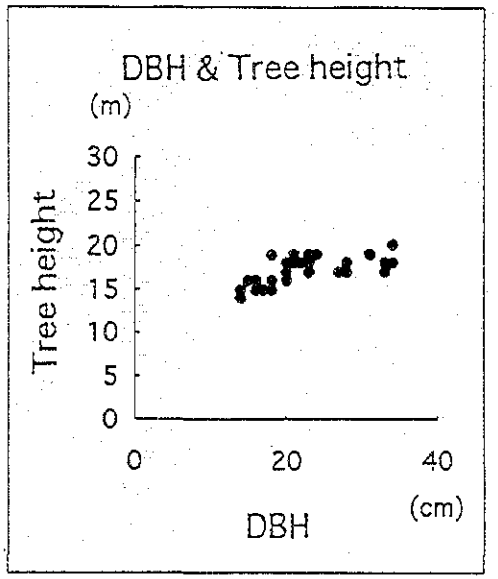
Thus, as conventionally recommended, it is best to choose sites less than 2000 f above sea level for planting *A. mangium* and introduce other species, such as *P. falcataria* into sites 2000 f or more above sea level.

Data obtained from this survey are shown in the following.

Plot No,1 Result of artificial forest survey

Date	1/14/94	Plot size	20m×20m 0.04ha
Plot No,	1	Planted year	1981(13years)
Area	Kg.Patau(A)	Planted species	Acacia mangium
Compartment	No,4	Planted interval	10ft×10ft
Elevation	3500ft	Crown density	Middle
Inclination	Steep/30°	Tending	Hardly tending
Remarks	Apart of this plot was damaged forest fire at 1992.Undergrowth are party of Oplismenus undlatifolius. Couse of very steep,Almost planted tree cline to lower direction.		

No,	DBH(cm)	Tree height(m)	Volume equation(m3)
1	18	15	0.16090
2	34	20	0.62574
3	20	16	0.20415
4	33	17	0.52289
5	33	18	0.54664
6	18	16	0.16917
7	18	29	0.26857
8	14	15	0.10276
9	28	17	0.39004
10	14	15	0.10276
11	33	18	0.54664
12	28	18	0.40776
13	23	17	0.27460
14	20	17	0.21400
15	16	15	0.13040
16	15	16	0.12220
17	27	17	0.36554
18	18	15	0.16090
19	21	18	0.24407
20	31	19	0.50994
21	20	18	0.22372
22	24	19	0.32301
23	23	18	0.28708
24	14	15	0.10276
25	21	18	0.24407
26	23	19	0.29940
27	34	18	0.57655
28	14	14	0.09740
29	21	19	0.25455
30	17	15	0.14530
31	16	16	0.13711
32	22	18	0.26519
Total	711	555	9.02583
Average	22.21875	17.34375	0.28206
		Volume/ha(m3)	225.64573
		MAI(m3)	17.35736



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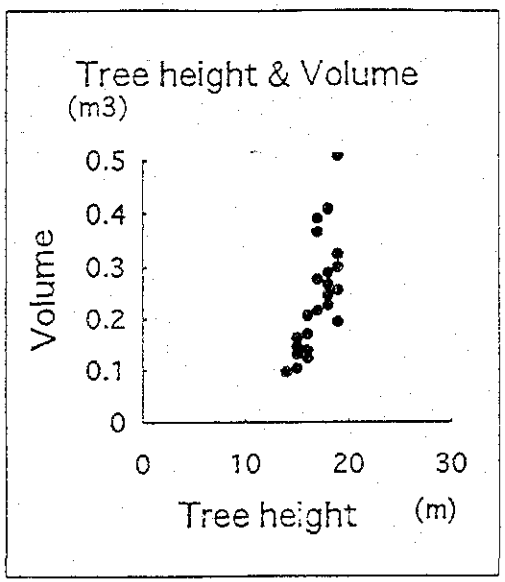

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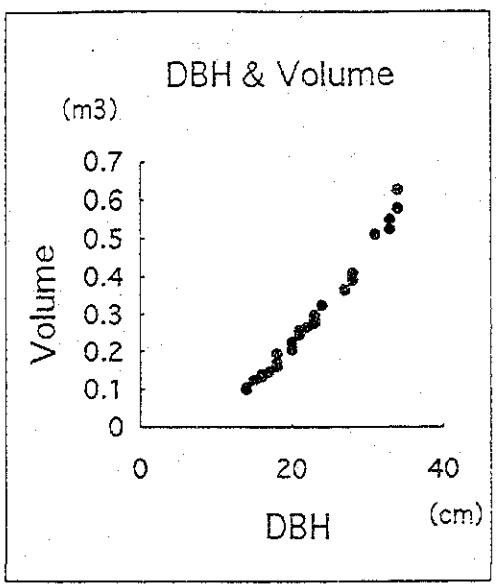

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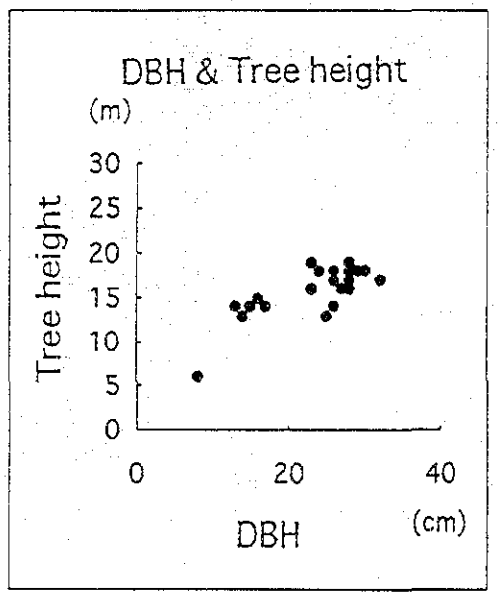
Plot No,1 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

Plot No,2 Result of artificial forest survey

Date	1/14/94	Plot size	20m×20m 0.04ha
Plot No,	2	Planted year	1981(13years)
Area	Kg.Patau(A)	Planted species	Acacia mangium
Compartment	No,4	Planted interval	10ft×10ft
Elevation	3500ft	Crown density	Thin
Inclination	Steep/26°	Tending	Hardly tending
Remarks	Apart of this plot was damaged forest fire at 1992.Undergrowth are party of Oplismenus undlatifolius. Couse of very steep,Almost planted tree cline to lower direction.		

No,	DBH(cm)	Tree height(m)	Volume equation(m3)
1	23	19	0.29940
2	26	18	0.35726
3	26	18	0.35726
4	27	16	0.34872
5	26	14	0.29387
6	14	13	0.09194
7	28	18	0.40776
8	28	19	0.42526
9	17	14	0.13771
10	26	17	0.34174
11	15	14	0.11015
12	23	16	0.26196
13	16	15	0.13040
14	24	18	0.30972
15	25	13	0.25868
16	29	18	0.43410
17	13	14	0.08533
18	15	14	0.11015
19	28	17	0.39004
20	8	6	0.01858
21	28	16	0.37209
22	32	17	0.49496
23	30	18	0.46117
Total	527	362	6.49829
Average	22.913043	15.73913043	0.28253
		Volume/ha(m3)	162.45728
		MAI(m3)	12.49671



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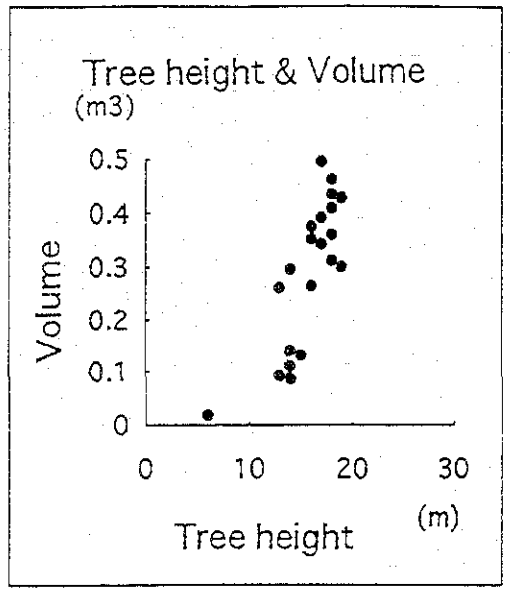

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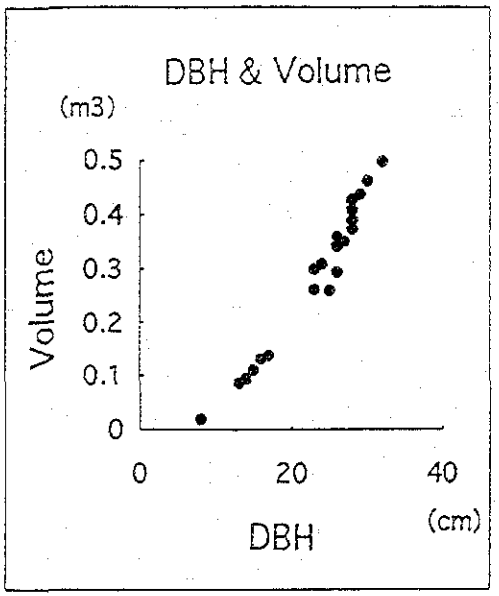


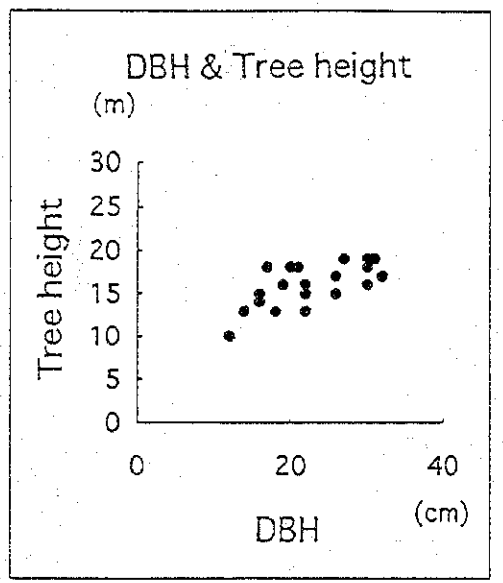
r= 0.98133

Plot No,2 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

Plot No,3 Result of artificial forest survey

Date	1/15/94	Plot size	20m×20m 0.04ha
Plot No,	3	Planted year	1985(9years)
Area	Kg.Patau(B)	Planted species	Acacia mangium
Compartment		Planted interval	10ft×10ft
Elevation	3000ft	Crown density	Middle
Inclination	Slope land/19°	Tending	Hardly tending
Remarks	Original stand was planted at 1980,which was damaged forest fire at 1983. Now stand replanted at 1985. Undergrowth are party of Oplismenus undlatifolius. Some kind of species are trespassing in this plot.		

No,	DBH(cm)	Tree height(m)	Volume equation(m3)
1	26	15	0.31006
2	30	16	0.42083
3	22	15	0.23015
4	22	16	0.24199
5	32	17	0.49496
6	18	13	0.14396
7	12	10	0.05696
8	30	18	0.46117
9	16	14	0.12359
10	22	13	0.20593
11	14	13	0.09194
12	19	16	0.18630
13	16	15	0.13040
14	30	19	0.48096
15	27	19	0.39855
16	17	18	0.16742
17	20	18	0.22372
18	31	19	0.50994
19	26	17	0.34174
20	21	18	0.24407
Total	451	319	5.46465
Average	22.55	15.95	0.27323
		Volume/ha(m3)	136.61625
		MAI(m3)	15.17958



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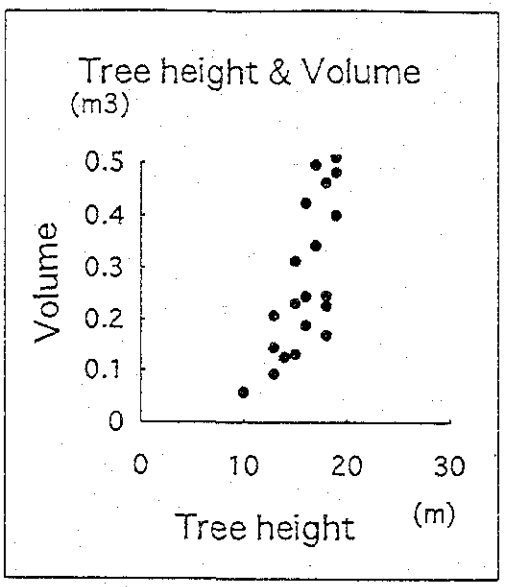

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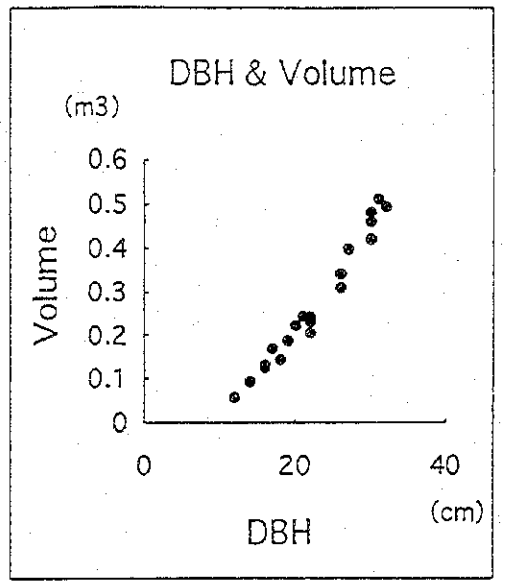

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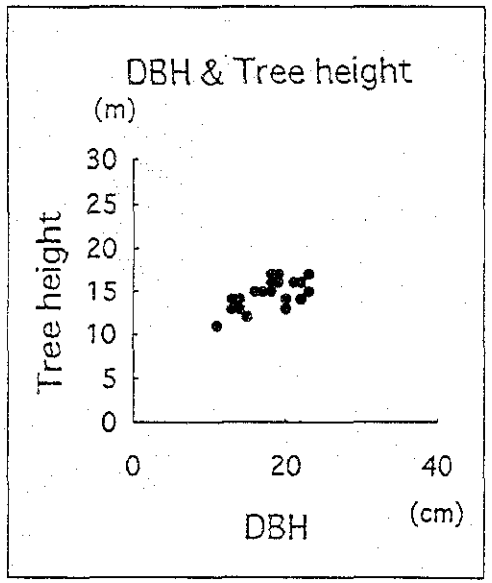
Plot No,3 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume

Plot No,4 Result of artificial forest survey

Date	1/14/94	Plot size	20m×20m 0.04ha
Plot No.	4	Planted year	1984(10years)
Area	Kg.Tanaki	Planted species	Acacia mangium
Compartment	A	Planted interval	10ft×10ft
Elevation	2300ft	Crown density	Middle
Inclination	Slope land/17°	Tending	Hardly tending
Remarks	Original stand was planted at 1983,which was damaged forest fire at 1984. Now standing replanted immediately forest fire. Undergrowth are a kind of fern. Meny stock of Bamboo are standing near in this plot.		

No,	DBH(cm)	Tree height(m)	Volume equation(m3)
1	19	16	0.18630
2	16	15	0.13040
3	23	17	0.27460
4	11	11	0.05252
5	11	11	0.05252
6	20	13	0.17373
7	14	14	0.09740
8	21	16	0.22272
9	13	14	0.08533
10	18	16	0.16917
11	13	14	0.08533
12	18	17	0.17733
13	19	17	0.19529
14	14	13	0.09194
15	14	13	0.09194
16	15	12	0.09772
17	22	14	0.21814
18	18	15	0.16090
19	20	14	0.18403
20	23	15	0.24915
21	13	14	0.08533
22	22	16	0.24199
23	19	16	0.18630
24	13	14	0.08533
25	17	15	0.14530
26	13	13	0.08056
Total	439	375	3.82128
Average	16.884615	14.42307692	0.14697
		Volume/ha(m3)	95.53211
		MAI(m3)	9.55321



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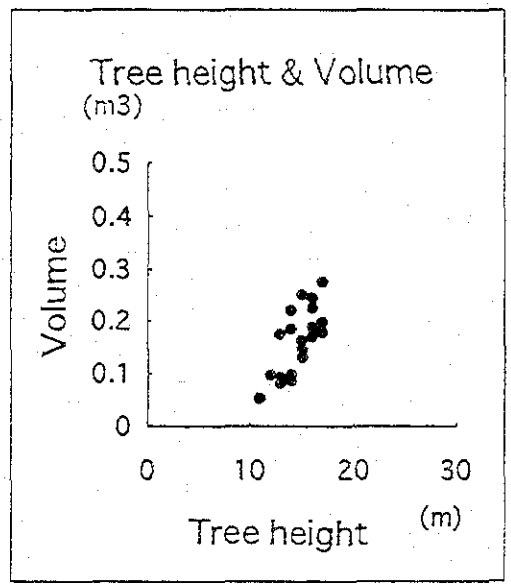

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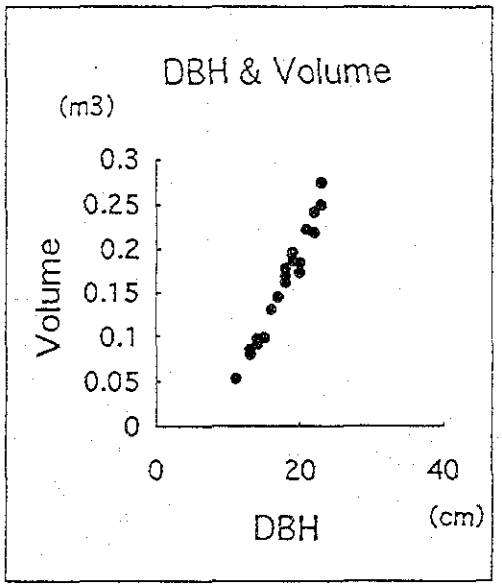

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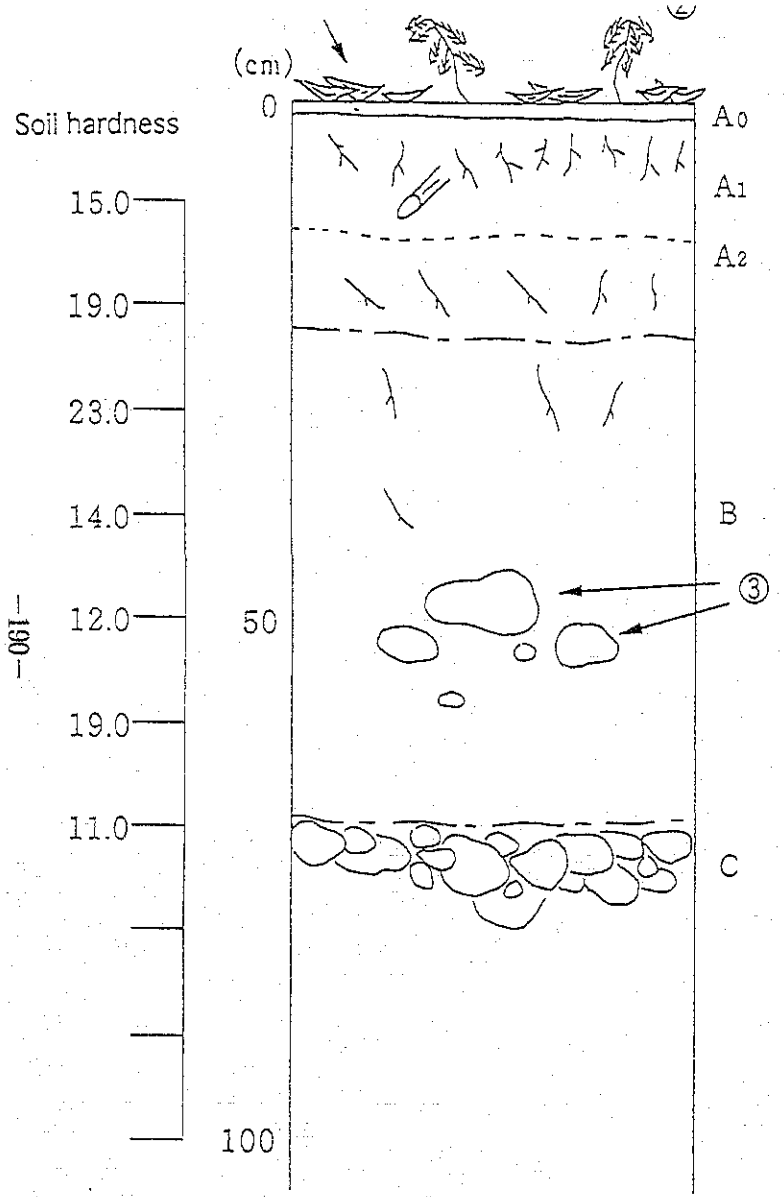
Plot No,4 Correlation of between DBH & Tree height , Tree height & Volume , DBH & Volume



Date	1/15/94
Plot No,	4
Elevation	2300ft
Inclination	Slope land/22°

Horizon	Colour	Humus	Gravel	Structure	moisture	Illuvation	Mycorrhiza	Root	pH	Remarks
A1	7.5YR2/3	Rich	Nil	Little Crumb	Middle	Nil	Nil	Rich	5.0	
A2	7.5YR5/6	Rich/Middle	Nil	Massive	Middle	Nil	Nil	Rich	4.6	
B	7.5YR6/8	Nil	Middle	Massive	Middle	Nil	Nil	Poor	4.4	
C	2.5Y6/6	Nil	Rich	Massive	Middle	Nil	Nil	Nil	4.4	

① Litter and seed of A.mangium
② Fern
③ Sandstone

Plot No,4 Soil profile and Result of soil survey (Natunal forest)