PD 376/05 Rev. 2 (F,M)

TO DEVELOP AND PROMOTE A MONITORING INFORMATION SYSTEM TO SUPPORT THE SUSTAINABLE DEVELOPMENT OF TREE RESOURCES OUTSIDE FOREST AT THE SUB-DISTRICT LEVEL IN THAILAND

Technical Report 6 & 7

PILOT PROJECT RESULTS FOR THE INVENTORY AND MONITORING

ESTABLISHMENT OF PROJECT DEMONSTRATION AREAS FOR THE INVENTORY AND MONITORING OF TREE RESOURCES OUTSIDE FOREST IN THAILAND

Department of National Parks, Wildlife and Plant Conservation of Thailand
International T Organization

May, 2012
Bangkok, Thailand

Department of National Parks, Wildlife and Plant Conservation (DNP)

International Tropical Timber Organization (ITTO)

TECHNICAL REPORT

RESULTS OF THE REGIONAL AND NATIONAL STAKEHOLDER CONSULTATION WORKSHOPS ON THE DEFINITION, USES AND PATTERNS OF TREE RESOURCES OUTSIDE FOREST (TROF) IN THAILAND

EXECUTING AGENCY :

Department of The National Parks, Wildlife and Plant Conservation (DNP):

Thailand

ORDINAL NUMBER :
PD 376/05 Rev. 2 (F,M)

ITTO PROJECT TITLE :
"To Develop and Promote a Monitoring Information System to Support the Sustainable Management of Tree Resources Outside Forest at the Sub-District Level in Thailand"

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TECHNICAL REPORT No. 6

PILOT PROJECT RESULTS FOR THE INVENTORY AND MONITORING OF TREE RESOURCES OUTSIDE FOREST (TROF) IN THAILAND

ACRONYMS

DNP	Department of National Parks, Wildlife and Plant Conservation (Thailand)
FAO	United Nations Food and Agriculture Organization
GISTDA	Geo-Informatics and Space Technology Development Agency
GOT	Government of Thailand
IC	International Consultant
ITTO	International Tropical Timber Organization
RFD	Royal Forest Department (Thailand)
TAO	Tumbon (Sub-district) Administration Organization
TC	Tumbon (Sub-district) Council
TROF	Tree Resources Outside Forest

ABSTRACT

This report the pilot project results to inventory and monitor tree resources outside forest (TROF) at the sub-district level, for International Tropical Timber Organization (ITTO) Project PD 376/05 Rev. 2 (F,M). It outlines pilot project objectives, design, methodology, results and recommendations. The objectives of the pilot project were to: test the use of high-resolution satellite imagery and 1:10,000 aerial photos to map and classify TROF; test the application of Sector Sampling for TROF ground sampling; and compare the efficiency (time studies and statistical precision) of Sector Sampling and Fixed-grid Sampling methods for TROF ground sampling. The selected pilot project area was in the Kaeng Krachan sub-district, Kaeng Krachan District in Phetchaburi province. An area of approximately 4,205 ha was selected within the sub-district as the target population.

A TROF Land Classification System was proposed for classifying the TROF land cover in a sub-district or portion of sub-district. It is based on current TROF cover, and delineation and classification of uniform areas (polygons) on high-resolution satellite imagery. Two ground sampling approaches were tested: fixed-grid and sector sampling. For sector sampling, the selected portion of the sub-district was divided into 40 large polygons (blocks) using geographical features such as roads and land use. Then four sector plots were laid out in each large polygon in four cardinal directions, all emanating from one pivot point. For the fixed grid, a uniform square grid 1.5 km x 1.5 km was laid out in the pilot project area and the grid intersections formed the plot centre of the plot. The actual number of plots established was: 126 sector plots and 145 fixed-grid plot clusters.

In terms of statistical precision, sector plot sampling was more efficient that fixed-area plot sampling. In terms of time, however, the fixed-grid sampling faster than sector plot sampling. The combined relative efficiency of sector sampling was 819.84*0.39=316.57, i.e., sector sampling was about 316 times more efficient than fixed-area plot sampling. Sector sampling gives more precise volume estimates than the fixed-area, for a given sample size. As well, sector plots have no edge-effect bias. Therefore, considering statistical aspects and time, sector sampling is more preferable than the fixed-area (0.1-ha plots), for sampling the TROF non-forest areas with scattered trees. However, sector plot sampling requires more time and experience to develop the sample plan -- to create polygons and sub-sectors; requires more time to identify borderline trees, especially for long sectors, since the plot perimeter is large; is prone to compass-reading errors, especially for long sectors, unless small steps, e.g., 20m, are used; and is a relatively new technique to Thailand and this requires for training.

It was recommended to use the TROF mapping and classification system proposed here, and ground sampling using either sector sampling or fixed-grid sampling. The choice of ground sampling method depends on the TROF cover patterns in the sub-district (population): use sector sampling in populations with scattered trees and fixed-area sampling in forested populations.

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1. INTRODUCTION

1.1 Project Objectives

This report is concerned with the International Tropical Timber Organization (ITTO) Project PD 376/05 Rev. 2 (F,M); specifically, the inventory and monitoring of tree resources outside forest (TROF) in Thailand. The definition of TROF, for the purposes of this Project, is "Trees and other plants in the lands outside forest." (see Project Technical Report No. 2). Trees and Other plants include trees, bamboo, rattan, palm, climbers, shrubs, and herbs; excluding agronomic crops (e.g., cassava, rice). Land outside forest is areas where trees or other plants can be (destructively) used by the people within the existing laws or government cabinet resolution. The land outside forest is essentially land outside the conservation forests.

The project Specific Objective is "to develop and promote procedures to establish current and easily accessible baseline inventory and monitoring information on TROF cover, diversity and abundance, to support national policy decisions on TROF sustainable management and land use and economic development planning at the sub-district level." The intent of this project is to develop a simple inventory and monitoring system that can be operationally implemented smoothly by the local (sub-district) governments and land (TROF) owners.

1.2 Project Strategy

The project strategy involves four steps as follows:

1. Consult with a representative sample of sub-district leaders and private forest and land owners, national experts and other stakeholders, to determine TROF definition, patterns and uses across the country (Project Activities 1.1, 1.2 and 1.3).
2. Develop and pilot test a methodology to inventory and monitor existing TROF biomass, cover and diversity (Project Activities 2.1 and 2.2).
3. Develop GIS-based tools to access, integrate and use the TROF inventory and monitoring data (Project Activity 2.3).
4. Select two sub-districts as demonstration areas, to promote the use of the inventory and monitoring information system and sustainable TROF management (Project Activities 3.1, 3.2 and 3.3.

Steps 1 to 3 have been accomplished; the results of this stakeholder consultation are summarized in the project Technical Report No. 2.

1.3 Purpose of this Report

This report describes the design, implementation and results of a pilot project for the inventory and monitoring TROF at the sub-district level (Steps 2 and 3 in section 1.2). The pilot project design is given in Section 2, the implementation in Section 3, the results in Section 4 and the conclusions and recommendations in Section 5.

2. PILOT PROJECT DESIGN

2.1 Objectives

The objectives of the pilot project were to:

1. Test the use of high-resolution satellite imagery and 1:10,000 aerial photos to map and classify TROF.
2. Test the application of Sector Sampling for TROF ground sampling.
3. Compare the efficiency (time studies and statistical precision) of Sector Sampling and Fixed-grid Sampling methods for TROF ground sampling.

2.2 Pilot project area

The pilot project area was selected based on the following criteria:

1. The area should encompass at least three villages.
2. The village chiefs should be willing to participate in the pilot project.
3. The area should include examples of suitable size (e.g., > 2 km^2) of each of the three TROF patterns identified during the workshops: scattered, line and patch.
4. The total area should be relatively small, i.e., < 70 km^2.
5. The area should be close to Bangkok (e.g., < 200 km) so more RFD and DNP staff can participate in the pilot project, and to reduce travel cost.
6. High-resolution imagery (IKONOS or THEOS) and low resolution imagery (Landsat 5) should be available at Time 2 (recent, e.g., < 1 year old) and Time 1 (e.g., 3-4 years ago).
7. Socio-economic village survey data (e.g., population density, education, health status, economic status, GNP, GRP, GPP, rate of urbanization, infrastructure, rural development and agricultural expansion) should be available at Time 2 and Time 1.
8. Accommodation facilities for crew should be available.

The selected pilot project area was located about 200 km South-west of Bangkok at the Kaeng Krachan sub-district, Kaeng Krachan District in Phetchaburi province. The pilot project area is located near but outside the Kaeng Krachan National Park, one of the largest national parks in Thailand. An area of approximately 4,205 ha was selected within the sub-district as the target population.

2.3 Mapping and classification methods

2.3.1 TROF Land Cover Classification System

A TROF Land Classification System was proposed for classifying the TROF land cover in a sub-district or portion of sub-district. It is based on current TROF cover, and delineation and classification of uniform areas (polygons) on high-resolution satellite imagery (e.g., Quickbird) or other imagery. The TROF Land Cover Classification System is shown in Table 1 and flowchart in Figure 1 below.

Table 1. The TROF Land Cover Classification System.

Level I	Level II	Level III	Description	Code
V = Vegetated			Polygon is considered Vegetated when the total cover of trees, shrubs and herbs covers at least 5% of the total surface area of the polygon.	V
	T = Treed		Polygon is considered Treed if at least 10% of the polygon area, by tree crown cover; include perennial crops and orchards.	VT
		C = Tree stand	Polygon consists of a patch of trees at least 10% tree crown cover and area at least 0.5 ha (3 rai); and linear formation at least 20 m wide.	VTC
		S = Scattered	Polygon consists of individual trees; tree patches at least 10% tree cover and area less than 0.5 ha; and linear formations less than 20 m wide.	VTS
	N = Non-Treed		Polygon than 10% by tree crown cover. That is, it consists of mainly shrubs & herbs (e.g., abandoned paddy fields, grass plantation, rangeland, marsh, swamp), or non-perennial field crops (e.g., cassava, corn, sugarcane).	VN
N = Non-Vegetated			Polygon with total cover of trees, shrubs, and herbs less than 5% of the total surface area of the polygon; and includes water bodies.	N
	W = Water body		A naturally occurring, static body of water, two or more metres deep in some portion, or a watercourse formed when water flows (intermittently or perennially) between continuous, definable banks. Islands within streams that have definable banks are not part of the stream; gravel bars are part of the stream. Interpretation is based on the percentage area covered. Water bodies include lakes, reservoirs, rivers, streams and oceans.	NW
	L = Land		The portion of the landscape not covered by water based on the percentage cover area; land is more than 50% of polygon. The land may be rock outcrop, mines, or exposed land (e.g., beach, roads, urban and built-on land, village, salt flat, gravel pit and buildings)	NL

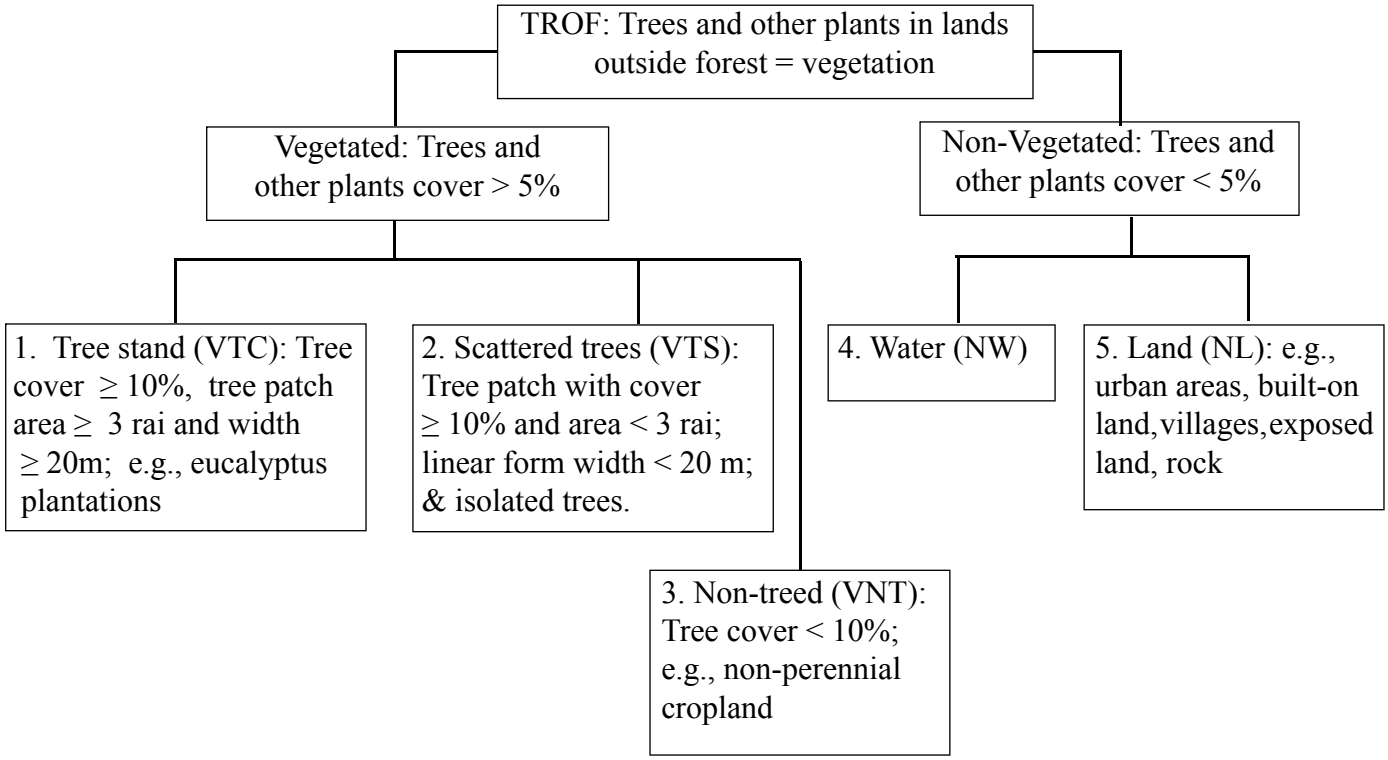

Figure 1. TROF land cover classification system.

2.3.2 Mapping

The Quickbird imagery was used to study monitoring methods at Time 1 and Time 2. The mapping and classification process involved the following steps:

1. Obtain imagery
2. Classify TROF area based on the TROF LCS.
3. Create spatial database linked to attribute database.

An example of the mapping is shown in Figure 2.

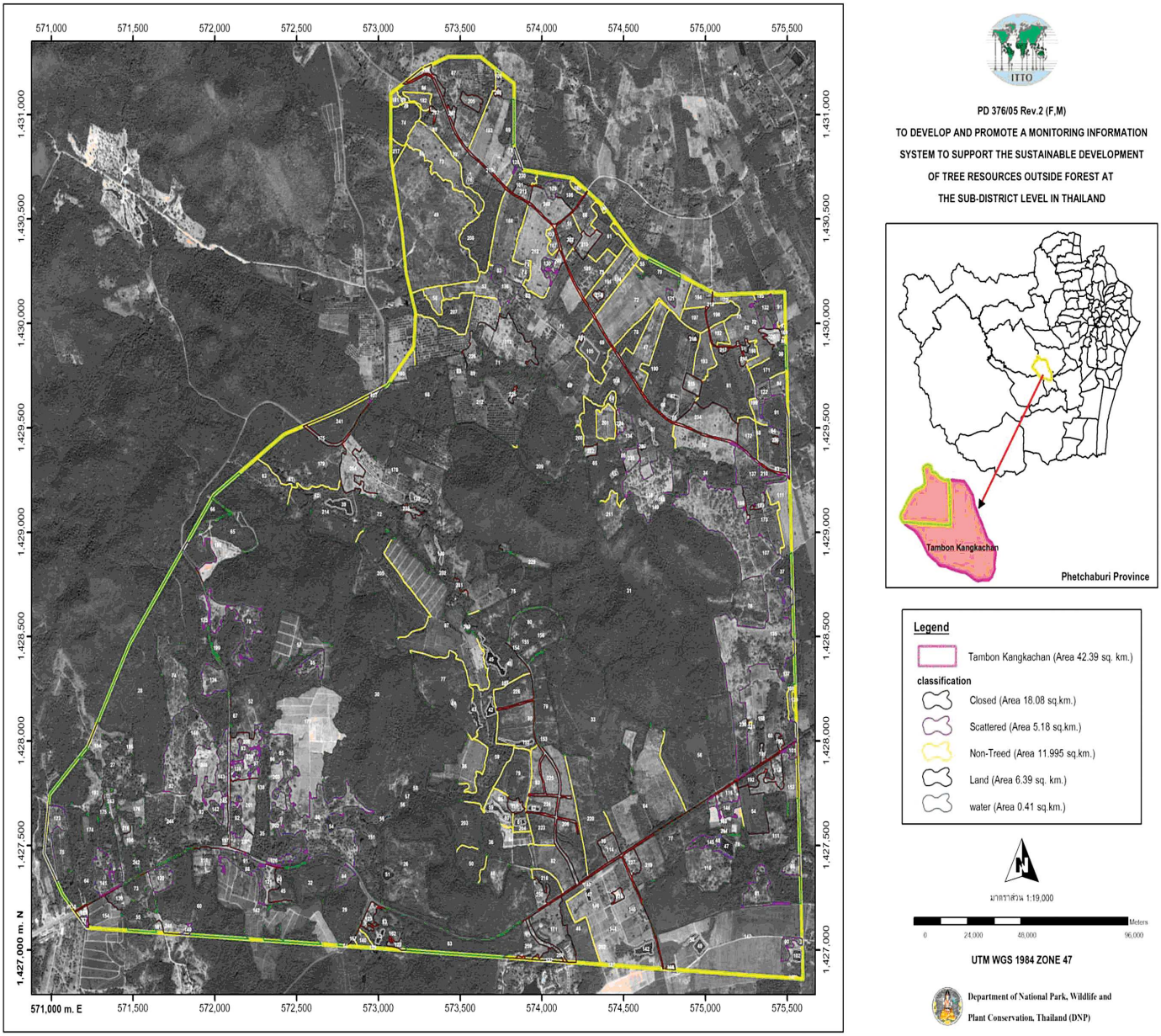

Figure 2. Example map of pilot project area using the TROF land cover classification system.

2.4 Ground sampling designs

Two ground sampling approaches were tested: fixed-grid and sector sampling. A detailed discussion of these methods is given in Annex I. A sample plan was developed for the target population (pilot project area). For sector sampling, the selected portion of the sub-district was divided into 40 large polygons (blocks) using geographical features such as roads and land use. Each polygon was, on average, about 105 ha; the minimum polygon area was 40 ha and maximum 163 ha. Then four sector plots were laid out in each large polygon in four cardinal directions, all emanating from one pivot point.

For the fixed grid, a uniform square grid 1.5 km x 1.5 km was laid out in the pilot project area and the grid intersections formed the plot centre of the plot. Thus, the nominal sample plan involved 160 sector plots and 169 fixed-grid plot clusters. This number of plots was deemed sufficient to enable meaningful comparison of the two methods within the available budget. The actual number of plots established was: 126 sector plots and 145 fixed-grid plot clusters.

The field procedures outlined in the Project Technical Reports No. 4 and 5 were followed. The field work involved 12 field crews, each with a crew chief, 5 students and 8 local labors. The fieldwork took approximately 16 days, and was conducted in March 2010. The actual number of sector and plot clusters established was 126 and 145, respectively. The number of sectors and plot clusters was reduced due to the available time and budget.

2.5 Data summaries and analysis

The individual tree measurement data were entered into the computer, edited and summarized into per-hectare values. Procedures for data summarization are given in Annex II. The relative efficiency (RE) of sector sampling relative to fixed-grid sampling was computed for tree volume using data from the plots that fell in the scattered area (i.e., non-forest areas). The RE was calculated in terms of precision (standard error, or SE), and time/plot (plot measurement, excluding travel time) using the following formulae:

$$\text{RE (Precision)} = \frac{(SE_{fixed})^2}{(SE_{sector})^2}$$

$$\text{RE (Time)} = \frac{(Time_{fixed})}{(Time_{sector})}$$

Note that the time per plot includes other measurements such as seedling and sapling count, CWD, etc. Only the non-forest areas were considered because it is known that sector sampling is not particularly efficient for sampling forested areas, unless it is combined with multi-stage or multiphase sampling. The data from 136 fixed-grid plots, and 114 sector plots in the TROF non-forest area of the pilot project area, were used for the comparison.

3. RESULTS

3.1 Data summaries

The overall estimated tree volume and number of stems population statistics, as well as the time studies, for the non-forst area of the pilot project area are given in Table 1 below. Summary statistics by polygon for fixed-area and sector plot are given in Tables 2 and 3, respectively. The time studies by fixed-area and sector plot are given in Tables 4 and 5, respectively. Summaries by tree species are given in Appendix III.

Table 1. Fixed-grid and sector sampling tree volume population statistics. Population is TROF non-forest pilot project area (3,454.48 ha)

Statistic	*Fixed-grid*	*Sector*
Number of plots (n)	136	114
Tree total volume (m^3)	63,011.4	43,849.8
Tree volume/ha (m^3/ha)	18.2	12.7
Standard error (m^3)	1,150.1	43.3
95% Sampling error (SE%)	2.1	0.1
95% Confidence Interval (CI)	± 2,339.8	± 88.1
Time per plot and 95% CI (minutes)*	38.9 ± 6.5	101.5 ± 15.6

* The number of plots for time studies in fixed area and sector were 121 and 110, respectively; times were not recorded in the tally sheets for some plots.

Table 2. Fixed-area plot total volume and number of stems summaries by polygon. SE is standard error.

Polygon No.	Area (m^2)	No. Plots	Total Volume (m^3)	Total No. Stems	SE Volume (m^3)	SE Stems (m^3)
1	1,246,638	4	497.7	8,726	445.2	7,917.2
2	967,373.8	4	0.0	0	0.0	0.0
3	1,070,109	4	862.2	21,937	505.3	11,562.6
4	1,197,107	5	704.7	33,758	202.3	12,591.8
5	910,140.2	5	1,385.9	31,491	861.4	16,462.2
6	980,578.9	4	1,795.9	31,133	727.5	13,273.3
7	768,095.8	3	411.8	16,386	79.3	3,328.4
8	1,126,342	5	3,085.6	24,780	1,627.4	3,526.0
9	819,781.2	4	1,229.2	22,954	700.5	14,468.6
10	904,134.8	3	269.7	1,808	269.7	1,808.3
11	1,201,607	4	1,121.1	20,127	626.8	12,917.3
12	1,107,251	5	853.1	17,052	652.1	10,959.0
13	1,061,828	5	2,154.3	7,858	1,288.4	2,548.4
14	1,020,081	3	443.6	27,882	299.0	20,708.2
15	827,882.5	3	3,937.2	88,032	1,859.0	58,349.2

Polygon No.	Area (m^2)	No. Plots	Total Volume (m^3)	Total No. Stems	SE Volume (m^3)	SE Stems (m^3)
16	1,132,201	4	3,876.6	28,871	2,437.7	10,884.3
17	911,209.2	3	26.1	2,734	26.1	2,733.6
18	1,335,551	6	6,428.5	55,203	2,663.4	28,560.5
20	1,094,944	5	1,244.8	21,023	770.9	14,244.4
21	955,980	3	3,382.4	41,426	840.5	22,415.2
22	1,032,304	4	2,498.2	32,001	1,636.3	26,023.5
23	879,340.6	3	4,220.5	73,425	2,988.5	13,629.8
25	1,275,087	5	828.5	7,396	452.6	4,080.3
27	537,569.5	2	80.0	4,032	80.0	4,031.8
29	1,236,864	5	1,462.0	41,064	304.8	9,390.4
30	1,147,037	6	871.6	24,088	468.7	14,563.3
31	1,073,865	5	539.5	35,867	232.2	25,733.8
32	1,268,231	5	1,458.6	30,945	761.2	19,051.3
33	1,144,882	4	1,235.5	36,636	704.2	22,725.3
34	919,651	3	749.5	11,649	310.1	4,291.7
35	809,543.1	3	1,998.6	16,191	1,263.0	3,993.4
36	1,144,255	4	920.9	25,174	595.6	11,413.9
37	701,131	2	629.1	3,856	518.6	1,051.7
39	736,223.5	3	1,937.4	36,811	1,648.2	34,240.3

Table 3. Sector plot volume and number of stems summaries by polygon. SE is standard error.

Polygon No.	Area (m^2)	No. Plots	Total Volume (m^3)	Total No. Stems	SE Volume (m^3)	SE Stems (m^3)
1	1,246,638	4	1,496.6	10,494	25.8	39.0
2	967,373	4	1,461.5	15,480	37.5	51.4
3	1,070,109	2	1,397.7	46,620	33.9	35.8
4	1,197,107	2	952.2	35,568	50.1	52
5	910,140	4	611.2	18,000	51.1	44.6
6	980,578	4	1,038.1	23,310	34.1	35.9
7	768,095	2	886.7	30,420	40.2	26.9
8	1,126,342	2	1,413.4	44,568	45.6	53.0
9	819,781	4	812.2	12,564	48.8	40.0
10	904,134	2	1,840.8	62,892	44	32.0
11	1,201,607	4	1,048.1	34,956	46.2	35.5
12	1,107,251	4	1,188.2	37,350	31.8	19.3
13	1,061,828	4	1,066.0	14,778	40.3	73.5
14	1,020,081	2	1,563.9	27,720	34.4	46.5
15	827,882	2	1,612.0	30,924	14.1	4.8
16	1,132,201	4	2,684.9	81,666	37.2	71.8
17	911,209	4	1,941.4	27,576	35.8	9.1
18	1,335,551	2	1,464.5	23,832	56.4	27.2
20	1,094,944	2	2,945.1	56,016	35.7	32.9
21	955,980	4	4,301.3	52,254	49.2	66.3
22	1,032,304	4	1,000.3	34,776	62.8	62.9
23	879,340	4	1,153.8	15,732	46.7	49.2
25	1,275,087	4	218.1	1,278	52.2	67.0
27	537,569	4	887.0	21,276	63.5	59.5
29	1,236,864	4	769.1	8,568	38.2	56.0
30	1,147,037	2	504.5	21,492	56.6	84.9
31	1,073,865	4	574.2	20,196	51.3	38.5
32	1,268,231	4	3,686.9	34,164	50	36.9
33	1,144,882	4	437.1	9,180	27.4	20.6
34	919,651	4	698.8	8,406	40.7	28.2
35	809,543	4	1,135.8	19,134	41.5	48.2
36	1,144,255	2	693.4	16,164	20.9	38.5
37	701,131	4	217.1	3,366	50.2	42.4
39	736,223	4	147.9	5,166	32.9	25.0

Table 4. Fixed-grid time studies for plot measurement (excludes travel time to plot).

Plot No.	***Fixed Grid ID***	***Time/plot (Minutes)***
1	475735014310	30
2	475735014305	10
3	475740014305	12
4	475735014300	77
5	475740014300	15
6	475745014300	10
7	475750014300	1
8	475755014300	23
10	475765014300	50
11	475730014295	50
13	475740014295	53
14	475745014295	27
15	475750014295	25
16	475755014295	21
17	475760014295	10
18	475765014295	25
19	475770014295	64
20	475720014290	50
21	475725014290	35
22	475730014290	10
23	475735014290	8
24	475740014290	30
26	475750014290	35
27	475755014290	10
28	475760014290	40
29	475765014290	5
30	475770014290	5
31	475775014290	5
32	475720014285	10
33	475725014285	5
34	475730014285	43
35	475735014285	10
36	475740014285	20
38	475750014285	11
39	475755014285	129
40	475760014285	40
41	475765014285	78
42	475770014285	50
43	475775014285	54
44	475715014280	27
45	475720014280	11

Plot No.	*Fixed Grid ID*	*Time/plot (Minutes)*
46	475725014280	30
49	475740014280	70
50	475745014280	11
51	475750014280	7
52	475755014280	50
53	475760014280	51
54	475765014280	27
55	475770014280	50
56	475775014280	15
61	475725014275	40
62	475730014275	37
63	475735014275	40
64	475740014275	29
65	475745014275	215
66	475750014275	7
67	475755014275	88
68	475760014275	195
71	475775014275	30
73	475715014270	33
75	475725014270	79
76	475730014270	25
77	475735014270	32
78	475740014270	20
79	475745014270	163
80	475750014270	55
81	475755014270	20
82	475760014270	17
84	475770014270	23
85	475775014270	25
86	475780014270	18
88	475725014265	61
90	475735014265	35
91	475740014265	60
92	475745014265	45
93	475750014265	25
94	475755014265	113
95	475760014265	66
96	475765014265	10
97	479770014265	40
98	475775014265	47
99	475780014265	84
100	475785014265	65

Plot No.	*Fixed Grid ID*	*Time/plot (Minutes)*
102	475735014260	37
103	475740014260	22
104	475745014260	30
105	475750014260	119
108	475765014260	13
111	475780014260	85
112	475785014260	20
117	475755014255	28
118	475760014255	40
119	475765014255	25
120	475770014255	15
121	475775014255	25
122	475780014255	20
123	475785014255	21
124	475790014255	49
129	475755014250	57
130	475760014250	71
132	475770014250	142
133	475775014250	10
134	475780014250	15
135	475785014250	15
136	475790014250	40
137	475795014250	7
139	475745014245	32
141	475755014245	21
142	475760014245	20
143	475765014245	26
144	475770014245	13
145	475775014245	32
146	475780014245	31
147	475785014245	25
148	475790014245	35
151	475755014240	80
152	475760014240	10
153	475765014240	15
155	475775014240	40
160	475765014235	31
161	475770014235	23

Table 5. Sector plot time for plot measurement (excludes travel time)

Sector	*Polygon ID*	*Time/sector (Minutes)*
1	475738171430209	75
2	475738171430209	135
3	475738171430209	80
4	475738171430209	100
1	475744221430251	222
2	475744221430251	55
3	475744221430251	63
4	475744221430251	42
1	475726271428931	200
2	475726271428931	270
1	475735481429187	150
2	475735481429187	270
1	475744901429169	4
2	475744901429169	65
3	475744901429169	100
4	475744901429169	80
1	475757501429686	114
2	475757501429686	82
3	475757501429686	55
4	475757501429686	99
1	475767251429646	71
2	475767251429646	264
1	475715941427932	177
2	475715941427932	180
1	475724011428013	90
2	475724011428013	90
3	475724011428013	45
4	475724011428013	95
1	475733061428137	18
2	475733061428137	393
1	475754581428572	63
2	475754581428572	66
3	475754581428572	88
4	475754581428572	91
1	475766241428917	65
2	475766241428917	55
3	475766241428917	69
4	475766241428917	99
1	475720751427097	175
2	475720751427097	128
1	475735501427475	70

Sector	*Polygon ID*	*Time/sector (Minutes)*
2	475735501427475	100
1	475755271427624	20
2	475755271427624	74
3	475755271427624	20
4	475755271427624	50
1	475767451427953	195
2	475767451427953	40
3	475767451427953	67
4	475767451427953	68
1	475775641428085	105
2	475775641428085	170
1	475734861426686	260
2	475734861426686	315
1	475745061426633	85
2	475745061426633	20
3	475745061426633	14
4	475745061426633	15
1	475753211426677	215
2	475753211426677	55
3	475753211426677	35
4	475753211426677	215
1	475760391426806	60
2	475760391426806	230
3	475760391426806	24
4	475760391426806	75
1	475776631426963	60
2	475776631426963	60
3	475776631426963	130
4	475776631426963	40
1	475743141425929	30
2	475743141425929	55
3	475743141425929	90
4	475743141425929	105
1	475757581425176	285
2	475757581425176	60
3	475757581425176	40
4	475757581425176	60
1	475764091425569	45
2	475764091425569	55
1	475775311426105	54
2	475775311426105	55
3	475775311426105	55

Sector	*Polygon ID*	*Time/sector (Minutes)*
4	475775311426105	129
1	475761151423996	89
2	475761151423996	12
3	475761151423996	152
4	475761151423996	72
1	475770251424842	131
2	475770251424842	80
3	475770251424842	56
4	475770251424842	70
1	475774801424031	75
2	475774801424031	120
3	475774801424031	11
4	475774801424031	200
1	475781911424706	25
2	475781911424706	78
3	475781911424706	385
4	475781911424706	385
1	475786331425399	150
2	475786331425399	4
1	475785491426087	125
2	475785491426087	90
3	475785491426087	55
4	475785491426087	30
1	475791541424799	33
2	475791541424799	50
3	475791541424799	45
4	475791541424799	53

3.2 Comparison of fixed-area sector plot sampling

The data summaries for volume in Table 1 were used to calculate the relative efficiency of sector sampling relative to fixed-grid sampling, in terms of precision and time. These were:

$$\text{RE (Precision)} = \frac{(1239.8)^2}{(43.3)^2} = 819.84 \qquad \text{RE (Time)} = \frac{39}{100} = 0.39$$

That is, in terms of statistical precision, sector plot sampling was more efficient that fixed-area plot sampling. In terms of time, however, the fixed-grid sampling faster than sector plot sampling. The combined relative efficiency of sector sampling was 819.84*0.39 = 316.57, i.e., sector sampling was about 316 times more efficient than fixed-area plot sampling. This is presumably because the sector plots were larger in size.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Mapping and classification

We recommend the TROF land cover classification scheme proposed here (Section 3.3) be used to classify TROF areas in the sub-districts. It is preferable to use high resolution satellite imagery.

4.2 Ground sampling

Sector sampling gives more precise volume estimates than the fixed-area, for a given sample size. As well, sector plots have no edge-effect bias. Therefore, considering statistical aspects and time, sector sampling is more preferable than the fixed-area (0.1 ha), for sampling the TROF non-forest areas with scattered trees. However, there are some practical issues with sector plot sampling, including:

1. Requires more time and experience to develop the sample plan to create polygons, sectors and sub-sectors.

2. Requires more time to identify borderline trees, especially for long sectors, since the plot perimeter is large.

3. Prone to compass-reading errors, especially for long sectors, unless small steps, e.g., 20m, are used.

4. It is a relatively new technique to Thailand, and this requires for training.

Preliminary recommendations for ground sampling design are as follows:

1. Use sector sampling or fixed-grid sampling depending on the TROF patterns in the sub-district (population).

2. Proceed as follows to choose sampling method:

   a) Stratify the area into Scattered and Tree Stand (forested) strata (see Section 3.3).

   b) Select one of the following options:

      - Mostly Scattered trees: use sector plot sampling
      - Mostly Treed Stand (forest): use fixed-area sampling
      - Mixed Scattered/Tree Stand: use sector sampling in Scattered stratum and the fixed-area in the Tree Stand stratum.

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6. APPENDIX I: OVERVIEW OF TROF INVENTRY & MONITORING METHODS

6.1 Inventory and monitoring methods

The proposed TROF inventory and monitoring method is a combination of satellite imagery and ground sampling. The satellite imagery is used to map and classify the TROF. The ground sampling is used to collect data on TROF. Thus, the proposed method involves two phases:

1. Mapping and classification
2. Ground sampling

These two phases are discussed further below.

6.2 Mapping and classification

TROF maps are needed to indicate the location of the TROF within a target area, and planning ground sampling. TROF classification is needed to enable presentation of the inventory results. TROF mapping and classification using high-resolution satellite imagery was tested. An example of the use of a combination of high and low-resolution imagery is what was done in India (Figure 1).

For this project, we propose to investigate the use of only high-resolution and a combination of high-and low-resolution imagery. The potential satellite imagery to be considered includes THEOS, IKONOS, and Landsat 5.

6.3 Ground sampling

Two approaches to ground sampling were tested:

1. Fixed-grid sampling, with fixed-area plots and transects.
2. Sector sampling, with sector plots and fixed-area sub-plots and transects.

These two sampling approaches are discussed further below.

6.3.1 Fixed-grid sampling with fixed-area plots and transects

This sampling approach is similar to that used in the ITTO project PD 195/03 Rev. 2 (F).[1] In that project ground sampling was needed to collect biophysical monitoring information especially on those resources that could be easily seen on traditional aerial photographs or other remote sensing media. For this Project the target population for the TROF monitoring system is a sub-district or a portion of it. This target population is assumed to consist of an infinite number of points. The fixed-grid sampling design is a probability sample of points in the sub-district, composed of a single systematic sample on, e.g., 2 km x 2 km uniform fixed grid.

1 Sampling design, plot establishment and estimation methods for Thailand's national forest resources monitoring information system. Technical Report No. 2, ITTO Project PD 195/03 Rev. 2 (F), June 2007, Department of National Parks, Wildlife and Plant Conservation of Thailand (DNP), Bangkok, Thailand.

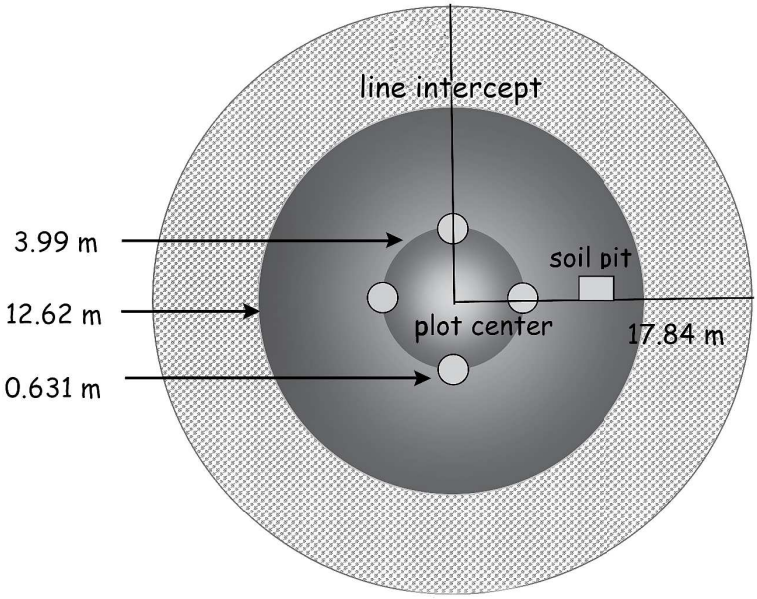


Figure 3. Plot design: a cluster of circular plots and transects line

A 'hidden' permanent sample plot (PSP) is established at each grid intersection (Figure 2). The permanent consist of circular fixed-area plots and line intercepts (Figure 2). They measure current status and changes over time in vegetation biodiversity, tree growing stock, coarse woody debris (CWD), soil properties, impact of human activities and natural causes on site and vegetation, and wildlife habitat use (Table 2).

Table 6. Fixed-grid plot types

Data Gathered	*Sampling Method*			
	Plot Type	*Number*	*Radius (m)*	*Total Area (ha)*
Seedling density	Circular	4	0.631	0.0005
Understory vegetation & sapling density	Circular	1	3.99	0.0050
Bamboo and erect rattan length & tree stump volume; site description	Circular	1	12.62	0.0500
Tree attributes; human & natural disturbance; wildlife habitat use	Circular	1		
CWD, rattan & climbers volume and length	17.84-m line-intersect	2	17.84	0.1000

The systematic grid lends itself easily to GIS modeling since a grid point represents a specific area whose attributes can be included in the GIS database. Furthermore, systematic sampling is simple to implement and maintain over time, and it is easier to re-locate the permanent plots over time. It has been tested, works well, and is operational. However, the fixed-grid sampling approach may not be suitable for sampling scattered items such as TROF. For example, sampling trees may require much larger plots than is feasible because of likely many plots with no trees. Thus, another sampling approach, such as sector sampling, may be desirable in this case.

6.3.2 Issues with the fixed-area plot ground sampling approach

The current approach (fixed-grid) uses 0.1 (17.84 m radius) plots to measure tree attributes. However, this size of plot has a high CV, typically 140%, in TROF areas. For example, the estimated CV of tree volume per hectare based on the 0.1-ha plots (centre plot of a five-plot cluster) established across the country in paddy fields was 142%, in urban areas/villages178% and in old clearings 103%. These high CV values imply a large sample size to achieve a specified allowable sampling error in a given TROF type; see Figure 4: **Increasing sample size as the tree volume CV increases.** For example, in the paddy fields we would need 200 plots to achieve an allowable sampling error of 20%..

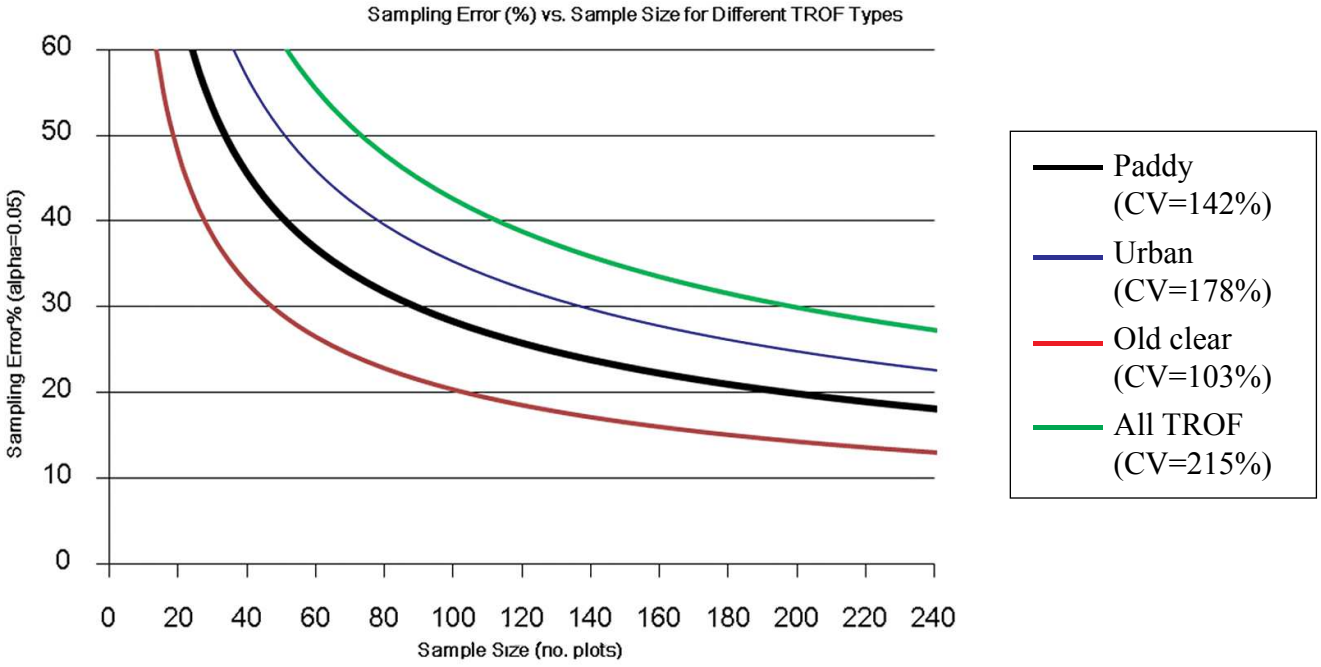


Figure 4: Increasing sample size as the tree volume CV increases.

Plot size has an effect on CV. Small plot sizes almost always result in larger CVs than the larger plots. Plot sizes of at least 1.0 ha would be needed to reduce the tree-volume CV in the different types of TROF to a reasonable level; see Figure 5. **Increasing optimum plot size as the CV increases in selected TROF types.** Lower CVs imply lower sample size; see Figure 5. The CVs of the different plot sizes (CV_2) shown in

Figure 4: Increasing sample size as the tree volume CV increases, were calculated using the approximate rule given by Freese (1962, page 27).[2] In this approximation rule, the CVs corresponding to a new plot size are calculated by varying P_2 (a plot size) and setting P_1 = 0.1 ha and CV_1 equal to the CV in the TROF type corresponding to P_1 in the following formula:

$$CV_2 = \sqrt{CV_1^2 \sqrt{\frac{P_1}{P_2}}}$$

2 F. Freese. 1962. Elementary forest sampling. Agric Handbook No. 232, US Dept. of Agriculture Forest Service.

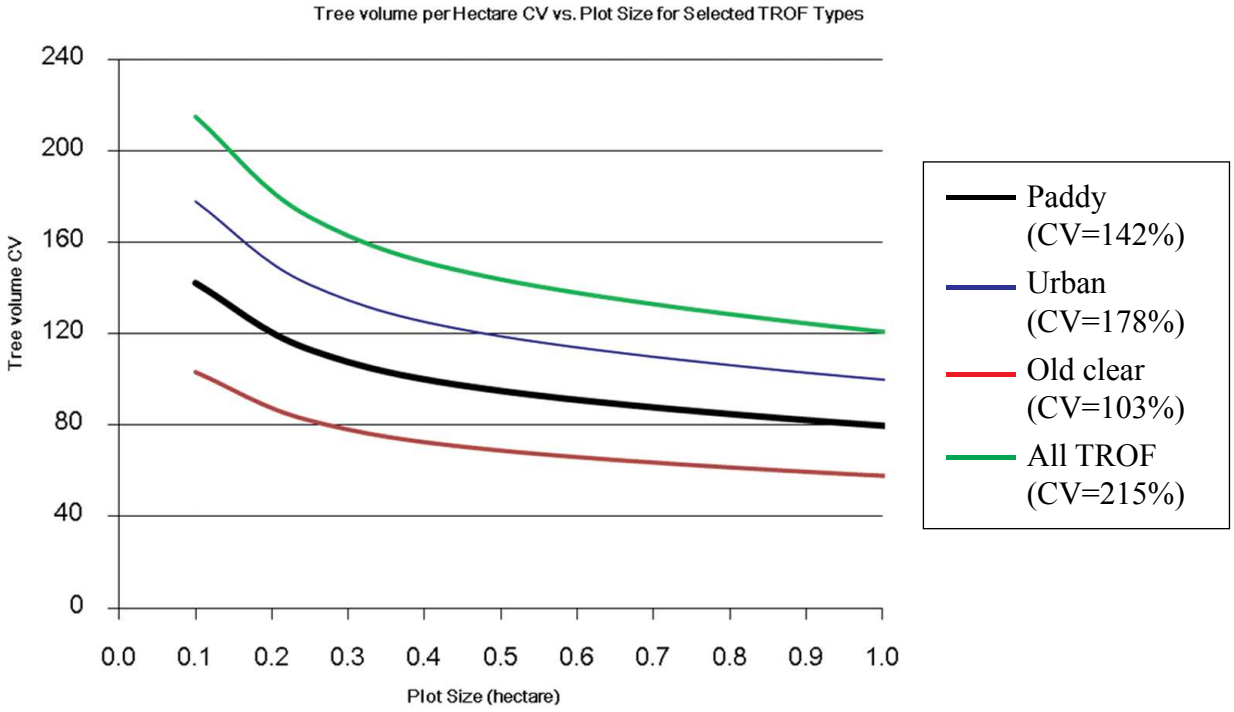


Figure 5. Increasing optimum plot size as the CV increases in selected TROF types.

The use of very large fixed-area plots, whether circular, rectangular, strip, or triangular, may not be suitable for TROF sampling. TROF increases the bias caused by edge effect. Edge effect is where parts of the plot fall outside the boundary of the sub-district, which is typically relatively small in area. As well, it may difficult to layout these large plots in the field for TROF, in single or cluster formation. Thus, a new plot type may be required for TROF inventory and monitoring.

6.3.3 Sector sampling with sector plots and fixed-area sub- plots and transects

Iles and Smith (2006) describe a method called sector sampling for sampling within clusters of objects, such as a patch of trees remaining in a harvested forest block (Figure 6). Sector sampling seems particularly suitable also for sampling scattered trees in TROF areas.

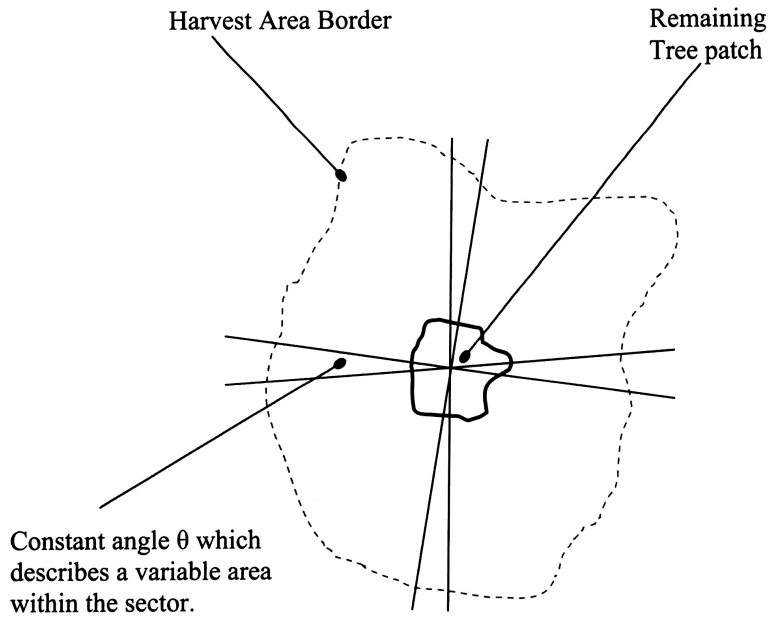


Figure 6. Sector sampling (Source: Iles and Smith 2006)

The theory of sector sampling is as follows (Iles and Smith 2006). Consider a polygon of arbitrary shape (Figure 7). From any pivot point inside or outside the polygon establish a sector with angle size α selected with equal probability for any orientation (θ*a*). An object included in the sector is sampled with probability = s/C, where s is the arc length within the sector and C is the circumference. The pivot point can be located anywhere based on operational convenience. That is, the pivot point can be as close or as far away from a given object as suits the field crew. Each object in the cluster is selected with the same probability because of the random orientation of the sector direction.

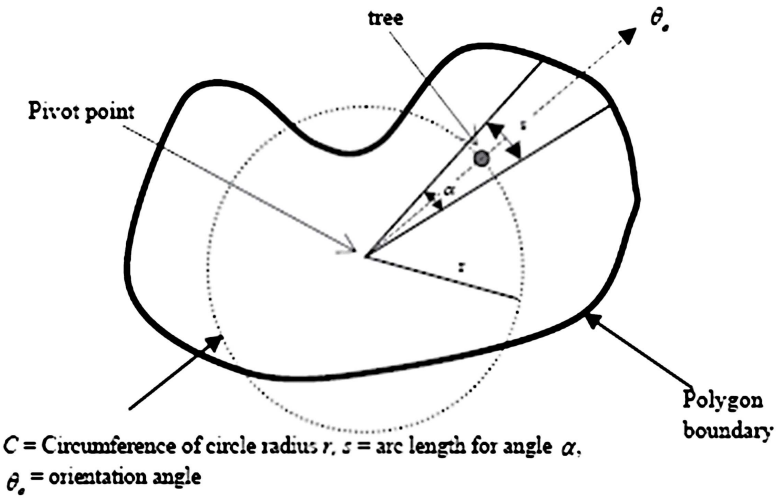


Figure 7. Schematic representation of sector sampling (Source: Iles and Smith, 2006).

Once the sector is established, the same information can be collected in the sector as in the fixed-grid sampling plots (Table 7). If the target population is large, the population can be sub-divided, and sectors established in each sub-division.

Table 7. Sector sampling plot types and attributes

Data Gathered	***Sampling Method***			
	Plot Type	***Number***	***Radius or angle***	***Total Area (ha)***
Seedlings	Circular	4	0.631	0.0005
Understory vegetation & saplings	Circular	4	3.99	0.0050
Bamboo, erect rattan, trees, palm, stumps, and site disturbance	Sector	4	5 or 10 degrees	--
CWD & climbers	transect line	4		

Sector sampling is proposed for TROF inventory and monitoring because of the scattered nature of TROF distribution. There is no need to know the population area, if interest is only in estimating population totals. However, sector sampling is a new inventory technique, and not tested extensively in Thailand. It is also not suited for GIS modeling. This technique shall be pilot tested and compared to the usual fixed-grid sampling.

7.APPENDIX II: DATA COMPILATION

7.1 Data compilation

7.1.1 Fixed-grid sampling

Tree volume

Individual tree volumes were calculated based on the local tree volume equations developed by the Royal Forest Department, using upper stem diameter measurements using a Spiegel Relascope (Pochai and Nanakorn, 1992).[3] These equations were developed for 7 species groups:

1. Dipterocarpaceae: Vol = exp{2.372083+ [2.443847 x ln(DBH)]}
2. Dalbergia: Vol = exp{2.134494+[2.363034 x ln(DBH)]}
3. Terminalia: Vol = exp{1.880578+[2.053321 x ln(DBH)]}
4. Afzelia: Vol = exp{1.789563+[2.025666 x ln(DBH)]}
5. Pterocarpus: Vol = exp{2.037096+[2.299618 x ln(DBH)]}
6. Tectona: Vol = exp{2.119907+[2.296511 x ln(DBH)]}
7. Others: Vol = exp{2.250111+[2.414209 x ln(DBH)]}

where DBH is tree diameter above breast height in m and Vol is tree volume in m^3.

The estimated individual tree volumes were summed to obtain the plot estimate, $\hat{V}_p$, of the population total volume. That is,

$$\hat{V}_p = \sum_{i=1}^{m} \left[v_i \times \left(\frac{A}{a_i} \right) \right] \qquad [1]$$

where:
m is the total number of trees in the plot
v_i is the individual tree volume
$\hat{V}_p$ is the plot estimate of the population total
a_i is plot size (ha)
A is size of the population (ha)

Then the average population total for the pilot project area is obtaimed as a simple arithmetic average of the plot total estimates. That is,

3 Pochai, B. and T. Nanakorn. 1992. Volume tables constructed by the Spiegel Relascocpe. Forest Management Division, Forest Research Office, Royal Forest Department, 61 Phaholyothin Road, Chatuchak, Bangkok, 10900, Thailand.

$$\hat{V}_1 = \frac{\sum_{p=1}^{n} \hat{V}_p}{n} \quad [2]$$

with standard error (SE):

$$SE(\hat{V}_1) = \sqrt{\frac{\sum_{p=1}^{n} \left[\left(\hat{V}_p - \hat{V}_1 \right)^2 \right]}{n \times (n-1)}} \quad [3]$$

where n is the number of sample fixed plots.

Tree biodversity

The Shannon-Weaver index of tree biodiveristy was calculated in each plot as follows:

$$\hat{D}_p = -\sum_{j=1}^{S_i} p_{ij} \ln(p_{ij}) \quad [4]$$

where:

N_i is the total number of individuals identified in the *i*th plot

S_i is the number of unique species (or species groups) observed at the *i*th plot

p_{ij} is the proportion of individuals (relative frequency) in the *j*th species or species group at the *i*th plot $= n_{ij}/N_i$

ln is natural logarithm

n_{ij} = Number of individuals for the *j*th species or species group at the *i*th plot

Then, the estimated indices for the target population are calculated as the plot avaerages estimate (and standard errors) for a simple random sample.

$$\hat{\overline{D}}_1 = \frac{\sum_{p=1}^{n} \hat{D}_p}{n} \quad [5]$$

with standard error (SE):

$$SE(\hat{\overline{D}}_1) = \sqrt{\frac{\sum_{p=1}^{n} \left[\left(\hat{D}_p - \hat{\overline{D}}_1 \right)^2 \right]}{n \times (n-1)}} \quad [6]$$

where n is the number of sample fixed plots.

7.1.2 Sector sampling

Tree volume

As in fixed-grid sampling, individual tree volumes) in a sector are summed to obtain a sector estimate of the population total of the values. That is,

$$\hat{V}_{hs} = \sum_{i=1}^{m_{hs}} \left[v_{hi} \times \left(\frac{360^{\circ}}{\theta_i} \right) \right] \qquad [7]$$

where:

θ_i is the sector angle in degrees for selecting the *i*th tree

m_{hs} is the total number of trees in the sector *s* in polygon *h*

v_{hi} is the individual tree volume in sector *i* in polygon *h*

$\hat{V}_{hs}$ is the sector estimate of the population total for polygon *h*

Then the sector estimates of the totals from the several sample sectors are averaged to obtain population average total for polygon h. That is:

$$\hat{V}_h = \frac{\sum_{s=1}^{n} \hat{V}_{hs}}{n_h} \qquad [8]$$

with variance

$$S_h^2 = \frac{\sum_{s=1}^{n} \left(\hat{V}_{hs} - \hat{V}_h \right)^2}{n_h - 1} \qquad [9]$$

The estimated total volume for the pilot project area is:

$$\hat{V}_2 = \sum_{h=1}^{L} \hat{V}_h \qquad [10]$$

with standard error (SE):

$$SE(\hat{V}_2) = \sqrt{\sum_{h=1}^{L} \left[\frac{S_h^2}{n_h} \right]} \qquad [11]$$

8. APPENDIX III. LISTING OF TREE SPECIES BY POLYGON

Table 8. Fixed-area tree species list by polygon, sorted by volume (unknown species excluded)

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
1	Garuga pinnata	284.2	312
1	Tamarindus indica	78.8	1247
1	Spondias pinnata	38.1	312
1	Leucaena leucocephala	33.6	3117
1	Albizia lebbeckoides	17.7	312
1	Millettia leucantha var. buteoide	12.5	1247
1	Pithecellobium dulce	11.7	623
1	Diospyros mollis	5.7	623
1	Senna garrettiana	2.5	312
3	Leucaena leucocephala	616.7	17657
3	Lagerstroemia duperreana	113.8	535
3	Diospyros mollis	47.9	268
3	Arfeuillea arborescens	25.8	803
3	Millettia leucantha var. buteoide	23.5	535
3	Streblus ilicifolius	9.1	535
3	Azadirachta indica var. siamensis	7.1	268
3	Blachia siamensis	3.6	535
3	Wrightia arborea	2.7	268
4	Leucaena leucocephala	386.5	27533
4	Artocarpus heterophyllus	237.1	2155
4	Antheroporum glaucum	36.7	2155
4	Arfeuillea arborescens	10.8	479
4	Maerua siamensis	8.5	239
4	Wrightia arborea	7.9	239
4	Albizia lebbeckoides	7.2	239
4	Mangifera indica	6.9	239
4	Vitex quinata	1.6	239
4	Streblus ilicifolius	1.5	239
5	Azadirachta indica var. siamensis	815.4	12742
5	Antheroporum glaucum	163.4	5097
5	Garuga pinnata	116.6	2002
5	Leucaena leucocephala	111.2	4915
5	Pterocymbium tinctorium	90.5	3277
5	Albizia lebbeckoides	35.3	182
5	Arfeuillea arborescens	15.6	364
5	Blachia siamensis	15.4	1820
5	Avicennia alba	9.0	182

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
5	Lagerstroemia duperreana	7.5	182
5	Diospyros mollis	5.0	546
5	Vitex quinata	1.1	182
6	Leucaena leucocephala	879.5	27456
6	Cocos nucifera var. Nucifera	370.5	245
6	Casuarina junghuhniana	220.6	1226
6	Streblus asper	209.0	1226
6	Mangifera indica	106.9	245
6	Streblus ilicifolius	4.4	245
6	Diospyros mollis	2.2	245
7	Pithecellobium dulce	118.2	5633
7	Spondias pinnata	70.3	1536
7	Streblus asper	54.6	2304
7	Millettia leucantha var. buteoide	40.9	768
7	Leucaena leucocephala	38.9	2048
7	Cleistanthus gracilis	26.7	1024
7	Diospyros mollis	22.4	1280
7	Antheroporum glaucum	12.1	512
7	Mangifera quadrifida var. longipet	11.5	256
7	Bombax anceps var. anceps	7.0	256
7	Azadirachta indica var. siamensis	5.1	512
8	Leucaena leucocephala	812.5	6983
8	Azadirachta indica var. siamensis	754.0	676
8	Tamarindus indica	472.5	2928
8	Ziziphus mauritiana	381.3	3830
8	Pithecellobium dulce	278.5	1126
8	Delonix regia	106.2	1352
8	Dalbergia cultrata	95.6	1802
8	Blachia siamensis	55.4	2478
8	Mangifera indica	45.5	225
8	Colona flagrocarpa	30.0	1352
8	Antheroporum glaucum	14.7	225
8	Senna garrettiana	3.6	225
8	Senna siamea	3.6	225
8	Stereospermum neuranthum	2.9	225
8	Bauhinia saccocalyx	1.9	225
8	Streblus asper	1.4	225
9	Samanea saman	297.3	205
9	Tabebuia rosea	242.7	1230
9	Leucaena leucocephala	203.0	11272
9	Senna siamea	149.4	410

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
9	Terminalia triptera	93.4	2869
9	Diospyros mollis	52.0	1025
9	Colona flagrocarpa	45.8	205
9	Wrightia arborea	34.0	410
9	Ficus sp.	27.6	615
9	Microcos tomentosa	19.6	1025
9	Maerua siamensis	16.0	1230
9	Azadirachta indica var. siamensis	10.1	820
9	Chukrasia tabularis	9.2	205
9	Albizia lebbeckoides	8.6	410
9	Lagerstroemia duperreana	6.8	410
9	Xylia xylocarpa var. kerri	5.3	205
10	Casuarina junghuhniana	269.7	1808
11	Tamarindus indica	531.1	1202
11	Albizia lebbeck	286.4	6609
11	Leucaena leucocephala	262.5	10814
11	Albizia odoratissima	27.7	300
11	Cleistanthus gracilis	6.1	601
11	Delonix regia	5.2	300
11	Arfeuillea arborescens	2.2	300
12	Pithecellobium dulce	514.1	443
12	Leucaena leucocephala	188.0	12623
12	Azadirachta indica var. siamensis	56.2	1107
12	Millingtonia hortensis	56.0	443
12	Ziziphus mauritiana	29.0	1772
12	Wrightia arborea	7.3	443
12	Streblus ilicifolius	2.6	221
13	Tamarindus indica	1442.7	1274
13	Dalbergia ovata	295.9	1487
13	Senna siamea	137.5	1487
13	Azadirachta indica var. siamensis	100.9	425
13	Eucalyptus camaldulensis	70.2	212
13	Pithecellobium dulce	58.5	1699
13	Leucaena leucocephala	45.0	1062
13	Diospyros rhodocalyx	3.5	212
14	Eucalyptus camaldulensis	330.8	22102
14	Antheroporum glaucum	100.6	4420
14	Leucaena leucocephala	6.8	680
14	Streblus ilicifolius	5.5	680
15	Leucaena leucocephala	1613.8	61263
15	Delonix regia	729.4	4415

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
15	Pithecellobium dulce	640.5	7451
15	Pterocarpus macrocarpus	262.7	1932
15	Albizia odoratissima	244.9	828
15	Azadirachta indica var. siamensis	232.8	8831
15	Ficus drupacea var. pubescens	60.9	1380
15	Diospyros rhodocalyx	46.8	1104
15	Combretum quadrangulare	2.8	276
16	Azadirachta indica var. siamensis	1975.1	4246
16	Samanea saman	551.0	283
16	Tamarindus indica	339.1	1415
16	Leucaena leucocephala	258.3	16700
16	Cocos nucifera var. Nucifera	220.2	566
16	Artocarpus heterophyllus	192.3	566
16	Pithecellobium dulce	178.3	3680
16	Dalbergia nigrescens	106.5	283
16	Diospyros rhodocalyx	55.8	1132
17	Eucalyptus camaldulensis	26.1	2734
18	Pithecellobium dulce	1305.0	1781
18	Arfeuillea arborescens	1016.0	2894
18	Antheroporum glaucum	625.5	3339
18	Ficus drupacea var. pubescens	522.6	668
18	Senna siamea	481.6	5787
18	Lagerstroemia calyculata	310.3	7346
18	Tamarindus indica	186.7	223
18	Hydnocarpus ilicifoli	135.0	7346
18	Tetrameles nudiflora	133.2	223
18	Combretum quadrangulare	103.2	1558
18	Mitrephora keithii	100.3	2003
18	Grewia eriocarpa	95.1	1336
18	Acacia catechu	94.6	445
18	Streblus asper	80.5	445
18	Streblus ilicifolius	74.7	1336
18	Sindora siamensis	68.5	445
18	Zollingeria dongnaiensis	60.7	1113
18	F.TILIACEAE	54.6	223
18	Diospyros mollis	53.2	890
18	Dalbergia oliveri	49.0	668
18	Cratoxylum formosum subsp. prunifl	43.7	445
18	Albizia odoratissima	40.4	1113
18	Memecylon sp.	30.6	668
18	Mansonia gagei	28.6	1336

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
18	Lagerstroemia tomentosa	28.5	445
18	Maerua siamensis	25.9	1558
18	Dalbergia nigrescens	25.5	445
18	Leucaena leucocephala	21.0	668
18	Sterculia foetida	21.0	223
18	Diospyros rhodocalyx	16.1	1336
18	Diospyros venosa	15.4	445
18	Barringtonia acutangula	14.7	223
18	Mallotus philippensis	13.3	668
18	Microcos tomentosa	12.9	445
18	Azadirachta indica var. siamensis	10.7	445
18	Sampantaea amentiflora	6.2	223
18	Diospyros sp.	5.5	223
18	Aphanamixis polystachya	2.4	223
18	Ziziphus mauritiana	2.0	223
18	Aporosa villosa	1.6	223
20	Alstonia scholaris	491.5	1095
20	Lagerstroemia cuspidata	352.9	1314
20	Leucaena leucocephala	161.5	11168
20	Tamarindus indica	46.5	219
20	Garuga pinnata	40.4	219
20	Pithecellobium dulce	35.3	657
20	Caesalpinia sappan	30.7	876
20	Maerua siamensis	27.0	1314
20	Millettia leucantha var. buteoide	18.6	1752
20	Roystonea oleracea	9.5	657
20	Antheroporum glaucum	9.2	438
20	Grewia eriocarpa	7.4	438
20	Plumeria rubra	1.9	219
21	Azadirachta indica var. siamensis	2331.0	9878
21	Leucaena leucocephala	238.5	9878
21	Cleistanthus gracilis	213.6	12109
21	Artocarpus heterophyllus	196.3	319
21	Garuga pinnata	140.9	319
21	Ziziphus mauritiana	99.9	1593
21	Tamarindus indica	51.3	956
21	Wrightia arborea	36.5	1275
21	Diospyros rhodocalyx	35.8	2231
21	F.LEGUMINOSAE-PAPILIONOIDEAE	12.8	956
21	Lagerstroemia cuspidata	9.7	637
21	Caesalpinia sappan	5.0	319

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
21	Maerua siamensis	4.7	319
21	Pithecellobium dulce	3.5	319
21	Cocos nucifera var. Nucifera	0.0	0
22	Mangifera indica	1770.0	3871
22	Leucaena leucocephala	431.5	22711
22	Pithecellobium dulce	129.0	3097
22	Ziziphus mauritiana	104.6	1548
22	Azadirachta indica var. siamensis	60.3	516
23	Diospyros rhodocalyx	1167.8	16707
23	Dalbergia oliveri	682.0	2052
23	Leucaena leucocephala	475.9	24328
23	Pterocarpus macrocarpus	251.5	586
23	Samanea saman	128.1	293
23	Mangifera indica	75.0	2638
23	Artocarpus heterophyllus	8.8	293
23	Streblus ilicifolius	7.5	879
23	Streblus asper	4.7	586
25	Azadirachta indica var. siamensis	367.4	1275
25	Diospyros rhodocalyx	324.0	3315
25	Albizia odoratissima	60.3	510
25	Senna siamea	37.9	1020
25	Vitex quinata	21.3	255
25	Plumeria rubra	13.6	765
25	Streblus ilicifolius	4.0	255
27	Cleistanthus gracilis	45.5	3494
27	Tamarindus indica	34.5	538
29	Millettia brandisiana	308.4	495
29	Leucaena leucocephala	214.5	6926
29	Spondias pinnata	191.6	1979
29	Antheroporum glaucum	117.2	5937
29	Pithecellobium dulce	103.4	2968
29	Ziziphus mauritiana	95.2	2474
29	Ormosia sumatrana	87.9	1979
29	Streblus asper	74.5	3216
29	Caesalpinia sappan	67.3	3958
29	Lagerstroemia duperreana	45.6	2226
29	Diospyros mollis	35.1	2226
29	Diospyros sp.	21.6	1237
29	Albizia odoratissima	17.6	247
29	Millettia leucantha var. buteoide	17.4	989
29	Dalbergia cultrata	11.9	495

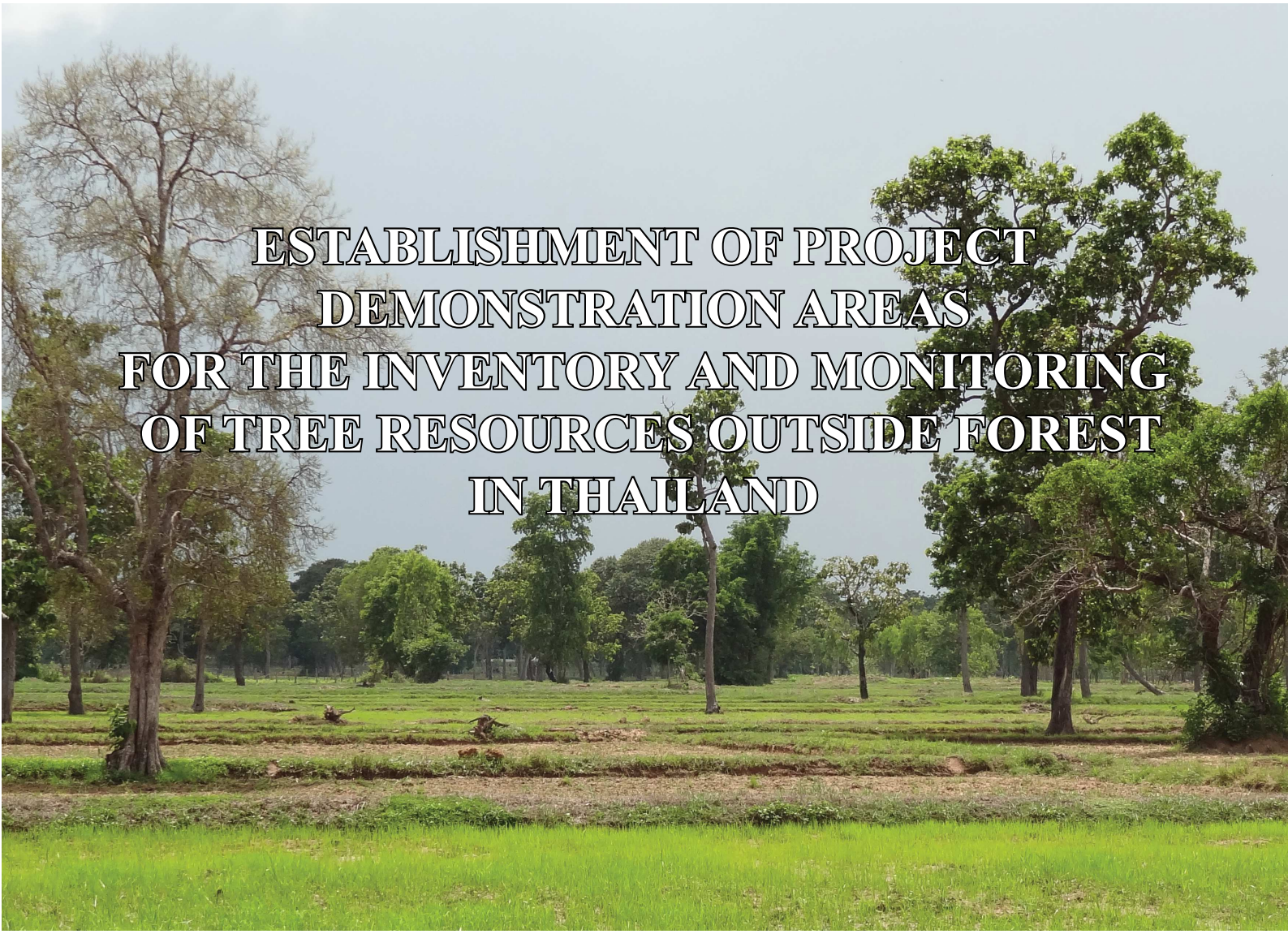
Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
29	Suregada multiflorum	5.1	495
29	Vitex quinata	4.8	247
29	Cleistanthus gracilis	4.2	495
29	Phyllanthus emblica	3.4	495
29	Siphonodon celastrineus	1.6	247
29	Grewia eriocarpa	1.5	247
30	Vitex quinata	168.9	3250
30	Sindora siamensis	151.2	765
30	Streblus asper	82.4	3632
30	Streblus ilicifolius	72.1	4206
30	Azadirachta indica var. siamensis	54.9	2485
30	Ziziphus mauritiana	46.6	382
30	Lagerstroemia duperreana	44.6	1721
30	Maerua siamensis	36.7	1721
30	Eucalyptus camaldulensis	35.8	956
30	Croton roxburghii	26.5	191
30	Bombax anceps var. anceps	18.4	574
30	Suregada multiflorum	15.0	765
30	Cratoxylum formosum subsp. prunifl	14.8	574
30	Diospyros mollis	12.0	191
30	Garuga pinnata	7.7	191
30	Antheroporum glaucum	6.3	382
30	Leucaena leucocephala	6.0	765
30	Caesalpinia sappan	3.1	191
30	Fernandoa adenophylla	3.0	382
30	Albizia lebbeck	2.4	191
30	Memecylon sp.	2.1	191
31	Eucalyptus camaldulensis	246.0	27706
31	Bombax anceps var. anceps	114.8	859
31	Croton roxburghii	41.6	2792
31	Sindora siamensis	37.2	430
31	Wrightia arborea	30.6	215
31	Leucaena leucocephala	21.7	1503
31	Ziziphus mauritiana	18.1	644
31	Spondias pinnata	6.0	430
31	Cleistanthus gracilis	2.0	215
31	Aporosa villosa	1.8	215
32	Afzelia xylocarpa	417.7	1015
32	Spondias pinnata	304.1	2029
32	Diospyros rhodocalyx	206.7	5834
32	Millettia brandisiana	101.0	4058

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
32	Cleistanthus gracilis	73.8	4312
32	Berrya mollis	69.2	507
32	Caesalpinia sappan	56.8	3297
32	Millettia leucantha var. buteoide	43.8	2536
32	Cratoxylum formosum subsp. prunifl	25.0	507
32	Grewia eriocarpa	17.9	254
32	Croton roxburghii	16.6	1268
32	Symingtoniasp.	13.6	507
32	Syzygium sp.	10.4	507
32	Lagerstroemia duperreana	5.5	254
32	Arfeuillea arborescens	4.8	254
32	Diospyros mollis	4.1	254
33	Dalbergia oliveri	374.8	286
33	Lagerstroemia duperreana	152.0	4866
33	Lannea coromandelica	139.7	7156
33	Bombax anceps var. anceps	88.1	1717
33	Millettia brandisiana	59.3	2290
33	Millettia leucantha var. buteoide	58.5	2576
33	Afzelia xylocarpa	51.5	859
33	Caesalpinia sappan	29.1	1145
33	Ormosia sumatrana	23.6	1717
33	Sindora siamensis	21.9	572
33	Dalbergia ovata	17.9	859
33	Garuga pinnata	17.7	286
33	Xylia xylocarpa var. kerri	16.3	859
33	Vitex quinata	16.2	1717
33	Buchanania lanzan	14.5	286
33	Spondias pinnata	14.1	572
33	Cratoxylum cochinchinense	13.9	859
33	Albizia lebbeckoides	12.8	859
33	Siphonodon celastrineus	11.2	859
33	Dalbergia assamica	10.2	286
33	Bauhinia saccocalyx	10.0	572
33	Croton roxburghii	8.3	859
33	Sesbania grandiflora	8.2	572
33	Maerua siamensis	6.8	572
33	Lagerstroemia cuspidata	6.3	859
33	Mangifera indica	5.3	572
33	Pterocarpus macrocarpus	5.1	286
33	Azadirachta indica var. siamensis	5.0	286
33	Pithecellobium dulce	3.0	286

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
33	Morinda tomentosa	2.5	286
34	Albizia lebbeck	305.0	1226
34	Mangifera indica	171.7	4292
34	Wrightia arborea	93.9	1226
34	Delonix regia	66.3	307
34	Pithecellobium dulce	56.8	920
34	Croton roxburghii	24.9	1533
34	Millettia brandisiana	15.6	920
34	Spondias pinnata	7.8	307
34	Caesalpinia sappan	5.5	613
34	Combretum quadrangulare	1.9	307
35	Cassia fistula	386.6	1889
35	Pterocymbium tinctorium	328.0	540
35	Pterocarpus macrocarpus	276.7	1889
35	Pithecellobium dulce	237.7	810
35	Streblus asper	162.1	540
35	Lagerstroemia duperreana	161.2	540
35	Millingtonia hortensis	125.1	810
35	Moringa oleifera	75.4	810
35	Leucaena leucocephala	49.5	1349
35	Croton roxburghii	49.2	3238
35	Bridelia ovata	43.2	1619
35	Artocarpus heterophyllus	38.1	270
35	Azadirachta indica var. siamensis	34.6	270
35	Michelia alba	13.7	540
35	Barringtonia acutangula	13.3	810
35	Araucaria cookii	4.2	270
36	Azadirachta indica var. siamensis	656.9	12587
36	Pithecellobium dulce	47.5	858
36	Lagerstroemia duperreana	36.5	1430
36	Leucaena leucocephala	32.5	1430
36	Atalantia monophylla	32.1	1716
36	Croton roxburghii	18.9	1430
36	Memecylon sp.	18.4	1430
36	Arfeuillea arborescens	14.5	572
36	Diospyros rhodocalyx	8.6	286
36	Combretum quadrangulare	7.9	572
36	Pterocymbium tinctorium	7.9	286
36	Antheroporum glaucum	7.6	286
36	Wrightia arborea	6.0	286
36	Ziziphus mauritiana	5.9	286

Polygon No.	Species Name	Total Volume (m3)	Total No. Stems
36	Garuga pinnata	5.6	286
36	Grewia eriocarpa	3.9	286
36	Phyllanthus emblica	3.7	572
36	Aphanamixis polystachya	3.4	286
36	F.STERCULIACEAE	2.9	286
37	Tamarindus indica	411.1	701
37	Cocos nucifera var. Nucifera	120.4	351
37	Leucaena leucocephala	49.7	701
37	Streblus asper	23.8	1052
37	Ziziphus mauritiana	9.7	351
37	Combretum quadrangulare	8.3	351
39	Mangifera indica	1500.1	29940
39	Dalbergia cultrata	194.7	1718
39	Sandoricum koetjape	108.0	1963
39	Tamarindus indica	106.1	2699

TECHNICAL REPORT No. 7



ESTABLISHMENT OF PROJECT DEMONSTRATION AREAS FOR THE INVENTORY AND MONITORING OF TREE RESOURCES OUTSIDE FOREST IN THAILAND

ACRONYMS

DNP	Department of National Parks, Wildlife and Plant Conservation (Thailand)
ITTO	International Tropical Timber Organization
RFD	Royal Forest Department (Thailand)
TAO	Tumbon (Sub-district) Administration Organization
TC	Tumbon (Sub-district) Council
TROF	Tree Resources Outside Forest

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1. INTRODUCTION

1.1 Project Objectives

This report is concerned with the International Tropical Timber Organization (ITTO) Project PD 376/05 Rev. 2 (F,M); specifically, the inventory and monitoring of tree resources outside forest (TROF) in Thailand. The definition of TROF, for the purposes of this Project, is "Trees and other plants in the lands outside forest." (see Project Technical Report No. 2). Trees and Other plants include trees, bamboo, rattan, palm, climbers, shrubs, and herbs; excluding agronomic crops (e.g., cassava, rice). Land outside forest is areas where trees or other plants can be (destructively) used by the people within the existing laws or government cabinet resolution. The land outside forest is essentially land outside the conservation forests.

The project Specific Objective is "to develop and promote procedures to establish current and easily accessible baseline inventory and monitoring information on TROF cover, diversity and abundance, to support national policy decisions on TROF sustainable management and land use and economic development planning at the sub-district level." The intent of this project is to develop a simple inventory and monitoring system that can be implemented by the local people, sub-district governments and land (TROF) owners.

1.2 Project Strategy

The Project strategy involved four steps as follows:

1. Consult with a representative sample of sub-district leaders and private forest and land owners, national experts and other stakeholders, to determine TROF definition, patterns and uses across the country (Project Activities 1.1, 1.2 and 1.3).
2. Develop and pilot test a methodology to inventory and monitor existing TROF biomass, cover and diversity (Project Activities 2.1 and 2.2).
3. Develop GIS-based tools to access, integrate and use the TROF inventory and monitoring data (Project Activity 2.3).
4. Select two sub-districts as demonstration areas, to promote the use of the inventory and monitoring information system and sustainable TROF management (Project Activities 3.1, 3.2 and 3.3.

1.3 Purpose of this Report

This report describes the design and implementation of the establishment of demonstration areas for the inventory and monitoring TROF at the sub-district level (Step 4 in Section 1.2 above). The demonstration areas project design is given in Section 2, the results in Section 3, and the conclusions and recommendations in Section 4.

2. DEMONSTRATION AREAS

Two Project demonstration areas have been selected: one in the Northeastern province of Ubon Ratchatani and the other in the Southern province of Chumpon; see the maps in Annex I. The Northeast demonstration area consists of one sub-district (Nonglao), and the South two sub-districts (Pato and Paksong). A combination of sector sampling (areas with scattered trees) and fixed-area plot sampling (community forest areas and private plantations) were established in the Nonglao sub-district. Only fixed-area plot sampling was applied in the Pato and Paksong sub-districts, because most of the TROF area was covered with coconut, rubber and oil palm plantations.

The following criteria were used to select the Project demonstration areas:

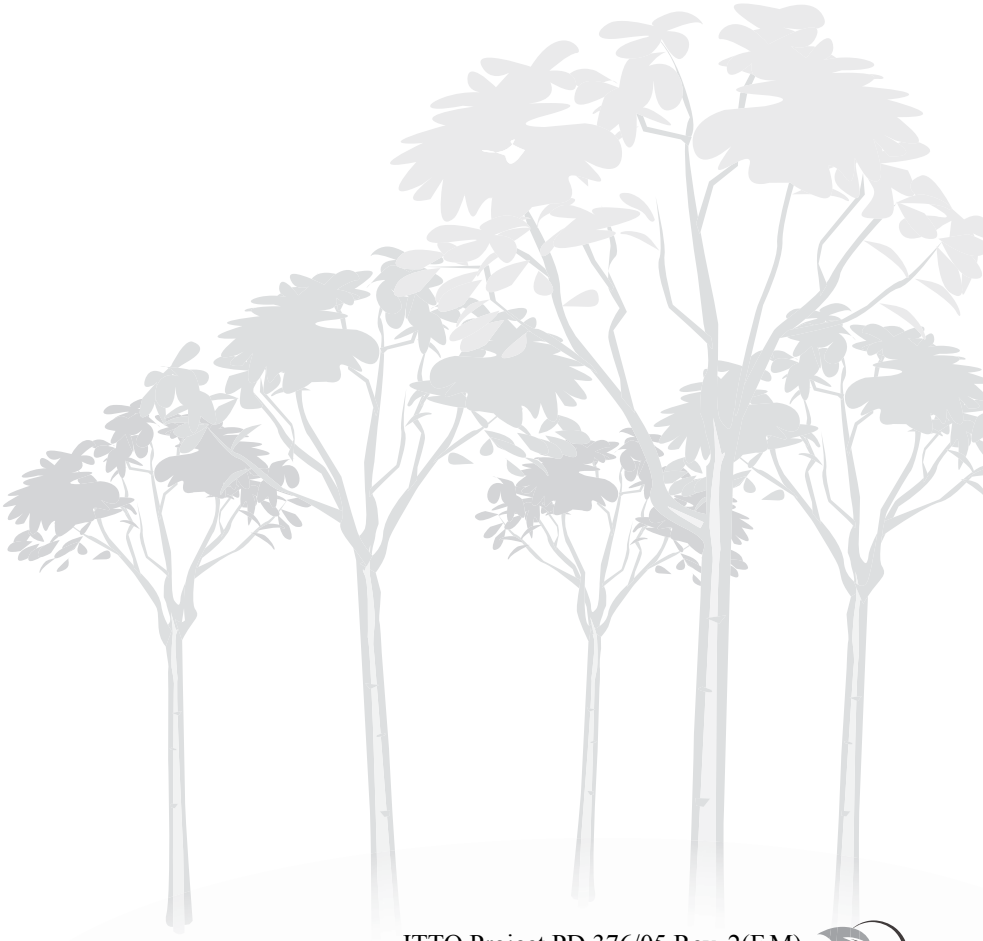
1. Should be a whole sub-district.
2. Heads of villages should be willing to participate.
3. Many pattern of TROF represented in the area.
4. Estimated area approximately 70 km^2 (average size of sub-districts in the country).
5. Located in the South or the Northeast parts of the country.
6. Arial photos available for two time periods.
7. Sociocomic data available for two time periods.
8. Should be linked to an existing RFD or DNP Training Center.
9. The RFD staff should be involved in the establishment.

The process for selecting and establishing demonstration sites involved the following steps (see Appendix I for pictures of some activities):

1. Find potential TROF demonstration sites in the South and Northeast of Thailand using aerial photographs or other existing information, which meet the required criteria.
2. Present an outline and concept of the TROF project to the local authorities and tambon chiefs.
3. Project staff discusses priority areas and select the area where there is high potential for success. The success criteria include high interest in the concept of TROF project by the local people, and good relationship between the local people and government officials.
4. Project staff invites tambon chief and local officers for meeting to share, comment, discuss and clarify the details of purpose and goals of the TROF.
5. Confirm establishment of the demonstration area of the project.
6. Appoint demonstration area staff, which includes people from the local community, and local officials.
7. Project staff and the demonstration area staff jointly plan implementation of the demonstration area.
8. Project national experts and staff train the demonstration staff and local field crew about the method and how to survey and collect the biophysical data in the demonstration area.
9. The demonstration area staff report on the progress of implementation after about 50% of the work is completed, and again after amost 80% or 90% of the work is completed.
10. Demonstration staff submit the raw data for analysis and quality assurance.
11. Project staff conduct a field quality assurance.
12. Finally, hold workshops at the demo site location to present and transfer the knowledge about the results of the project implementation, as well to know opinions and receive advice and recommendation from the participants.

3. RESULTS

Maps of the demonstration areas are shown in Appendix II. The biophysical data summaries are given in the project reports "Preliminary statistics of tree resources outside forest in the Nonglao sub-district, Ubon Ratchasima province" and "Preliminary statistics of tree resources outside forest in the Pato and Paksong sub-districts, Chumphon provinc", available from the DNP. Brief summaries of the statistics are given in Appendices III and IV, for the northeast and south demonstration areas, respectively. The feedbacks from the workshops are given in Appendices V and VI, for the northeast and south areas, respectively.



4. CONCLUSIONS AND RECOMMENDATIONS

This Project has developed and demonstrated procedures that can be deployed for proper monitoring mechanism/ information system to support the sustainable development of tree resources outside forests at the subdistrict level. This would fill the gap of "data badly lacking on the biological and socioeconomic importance of TROF as a strategic natural resource" (ITTO Mission Report, 2006). The Project recommends a follow-up new project as follows:

1. Adjust reforestation programs and extension services, to incorporpte TROF inventory and monitoring.

2. Capacity building and more demonstration areas are created to promote awareness of TROF land sustainable management for multiple uses, including biodiversity and climate change, at the local and sub-district levels.

The primary stakeholders (PSH) for this proposed new project include the rural communities and the sub-district administration (TAO). The secondary stakeholders (SSH) are the provincial administration organization, and the related central government departments or agencies. Tertiary stakeholders: related NGOs (e.g. natural resources, health, etc.). The PSH will benefit from better management of their natural resources, through improved land use and economic development planning at the sub-district level. This in turn will lead to sustainable supply of TROF, which many local people are now dependent for sustaining and uplifting their household incomes. The SSH will benefit:

1. Increased TROF cover for carbon sequestration and biodiversity conservation; reclamation of degraded forest and other lands; and in providing corridors for wildlife in TROF areas near wildlife sanctuaries

2. Assist the central government to achieve its goals of improving the livelihoods of local people, and formulate national TROF policies.

3. Improved networking between related government agencies and the TAO.

Tertiary stakeholders benefit by helping protect/conserve forest; and participation of NGOs. As well, other ITTO producer countries may also benefit from the Project development of sustainable TROF management plans.

Some of the outputs and activities for the proposed follow-up project are described further below.

Output 1: Two TROF awareness demonstration areas are established in each of the five regions, targeting school children, individual TROF land owners and sub-district level planners

Activity 1.1 - Stakeholder consultations

1. Hold workshop involving all stakeholders.
2. Pre-survey to select demonstration area.

Activity 1.2 – Establish 14 project demonstration areas.

This includes selecting two sub-districts of area about 70 km^2 each in each of five regions, and

1. Equip demo areas with GIS software and hardware, and field equipment.
2. Acquire Quickbird satellite imagery, and classify and map TROF.
3. Collect ground data, involve the establishment of ground plots as part of the ITTO project PD 376/05 Rev. 2 (F,M).
4. Produce spatial and attribute database on TROF for each area.

Activity 1.3 – Train 12 persons in TROF inventory planning and field operations.

This involves training of four GIS/Database staff in the demonstration areas on use of the developed GIS database and analysis tools. Train planning tools

Activity 1.4 – Conduct five regional seminars to promote use of the monitoring information.
This involves developing and implementing an extension strategy to disseminate demonstration area activities and results, and holding a regional seminar at each demonstration site to promote use of the monitoring information and to explain how the monitoring information can be used in TROF sustainable management decision-making. For example, it will be demonstrated how soil and site information from the project could be used to select prime tree species for planting in TROF areas. Thirty participants, including sub-district and regional decision-makers and planners, would be invited to attend the seminar at each demonstration area. The seminar participants will be encouraged to provide feedback on possible national incentives that the government could use to promote tree planting to support TROF sustainable management. Study tour.

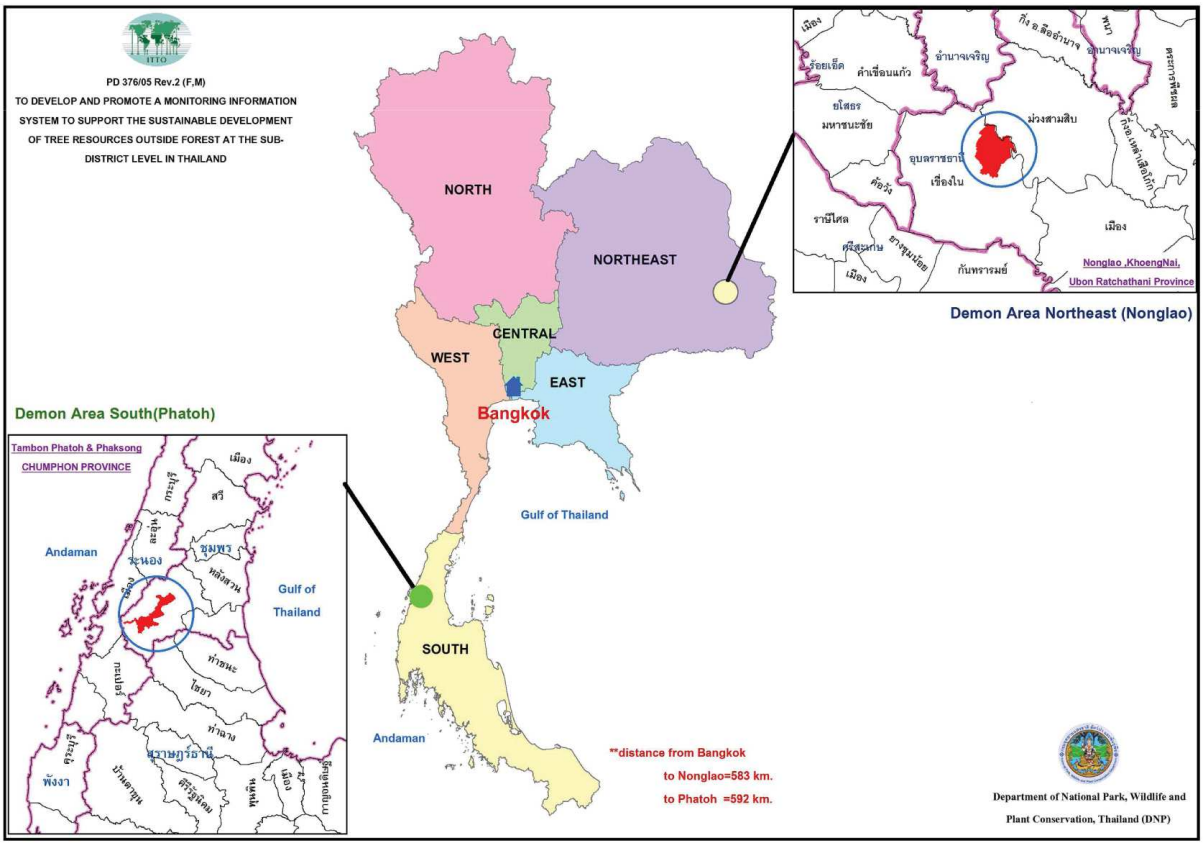
Output 2: TROF land management planning training and support strategies for high schools, individual TROF land owners and the wider communities are operational.

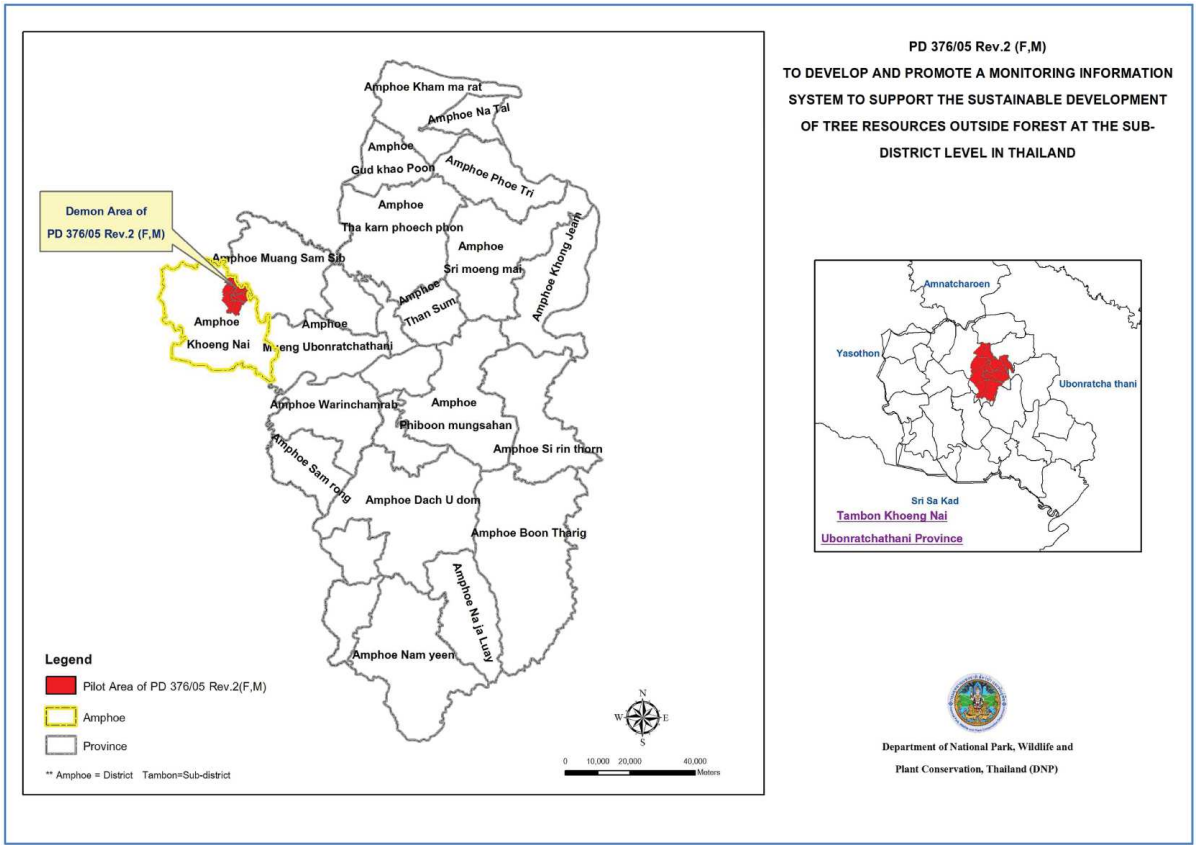
Activity 2.1 - Develop and publish TROF land management planning tools.
Activity 2.2 - Establish TROF land sustainable management planning training program.
Activity 2.3 - Establish TROF land management information center.

Output 3: Consensus between related government departments and TAO for TROF land management is established

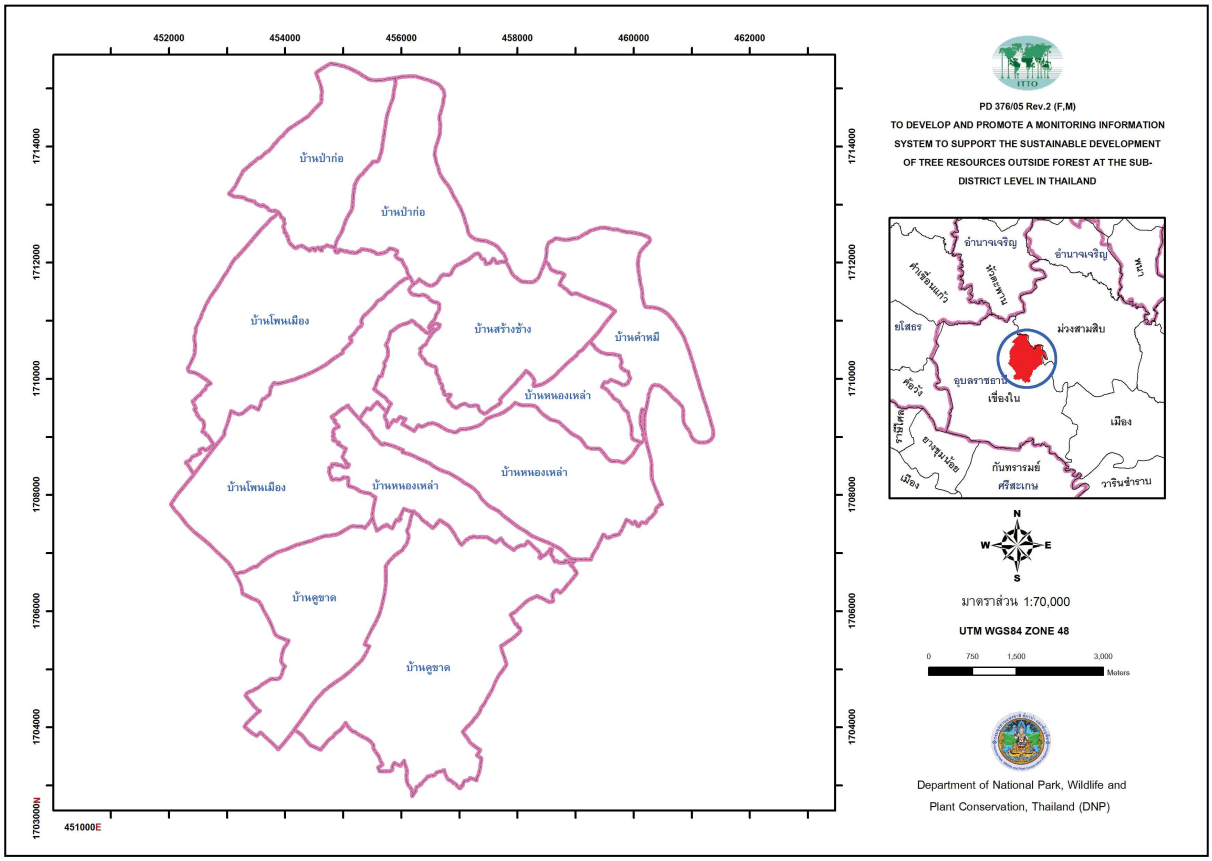
Activity 3.1 - Inter-agency coordination strengthened and stakeholder consultative structures created
Acfivity 3.2 - Training and extension capacity in the regions and headquarters DNP and RFD strengthened.
Activity 3.3 - Networking among related agencies promoted.

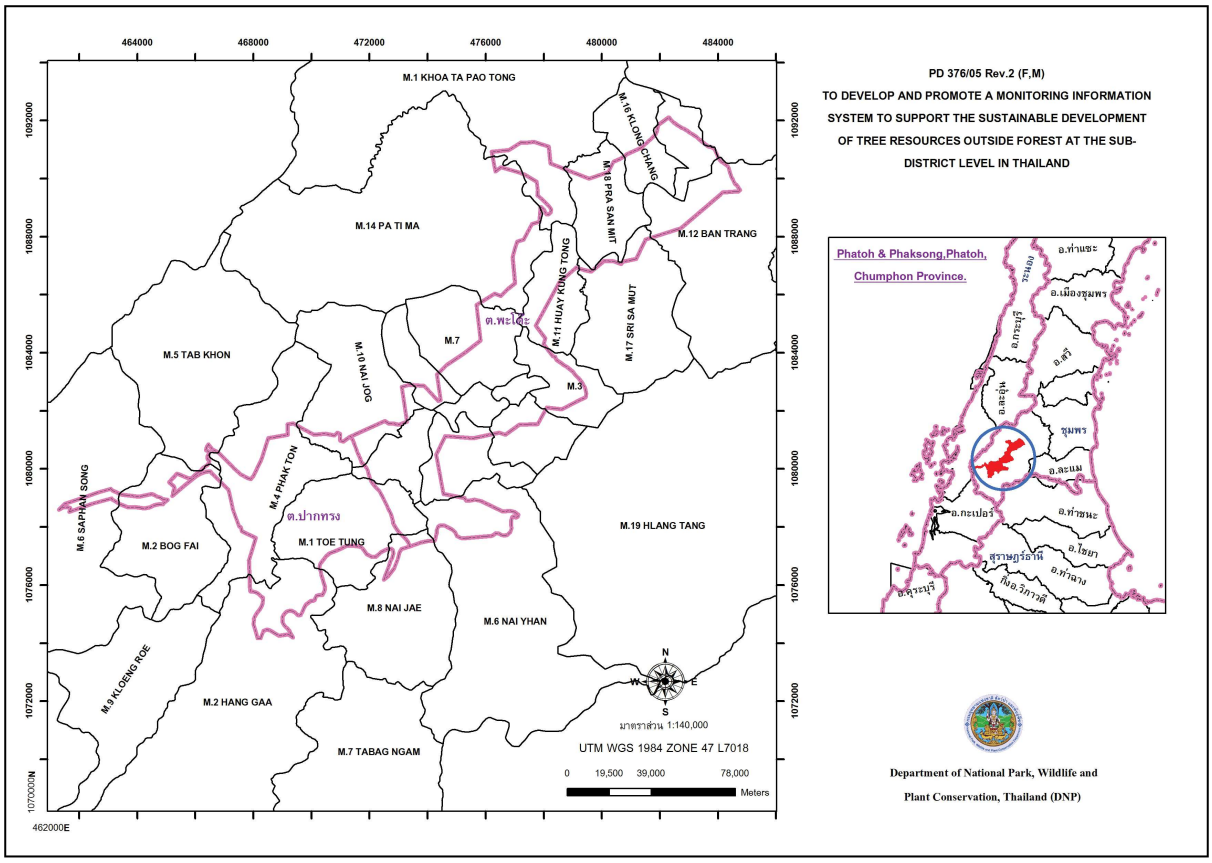
APPENDIX I: PICTURES OF DEMONSTRATION AREA SELECTION AND ESTABLISHMENT





APPENDIX II: MAPS OF THE NORTHEAST AND SOUTH DEMONSTRATION AREAS





APPENDIX III: PRELIMINARY STATISTICS FOR THE NORTHEAST DEMONSTRATION AREA

Fixed-Grid Sampling in the Forested TROF Area

TROF area and number of plots

Forth-eight plots were established in the forested TROF areas (Table 1). There were no plots in Village 3 and Village 6 (no forested areas). The village labelled "Special" was a residual area as a result of unclear boundary definitions.

Table 1. Number of plots and forested TROF area by village.

Village	Village Area (ha)	Forested TROF Area		No of Plots
		ha	%	
1	659	35	5	6
2	1,061	123	12	5
4	732	164	22	10
5	870	68	8	2
7	550	97	18	4
8	430	144	34	6
9	477	106	22	6
10	325	92	28	4
Special	886	68	8	5
Total	**5,990**	**896**	**15**	**48**

Statistics

The estimated population statistics for the Nonglao Sub-district forested TROF area are given in Table 2 below.

Table 2. Estimated population statistics in the Nonglao forested TROF area

Atribute	Nonglao Sub-District	
	Total	Std. Error (%)
Total volume (m^3)	56,020	17
Number of trees	549,707	13
Volume of stumps (m^3)	885	28
Volume of CWD (m^3)	51,155	32
Length of bamboo (m)	31,575	56

Sector sampling in the non-forested TROF area

Number of sectors and TROF area

A total of 98 sector plots were established in the non-forested TROF area (Table 3). The village labelled "Special" in Table 1 was a residual area asa result of unclear boundary definitions.

Table 3. Village area, and number of polygons and sectors in the non-forested TROF area by village in the Nonglao sub-district.

Village	Village Area (ha)	Non-forested TROF Area		No of Plots	No. Sectors (2 per polygon)
		ha	%		
1	659	624	95	3	6
2	1,061	938	88	8	18
3	587	587	100	4	8
4	732	568	78	5	10
5	870	802	92	6	12
6	462	462	100	3	6
7	550	453	82	2	4
8	430	286	67	2	4
9	477	371	78	2	4
10	325	233	72	2	4
11	409	409	100	4	8
Special	886	818	92	7	14
Total	**7,448**	**6,551**	**88**	**48**	**98**

Statistics

The estimated population statistics for the NonglaoSsub-district non-forested TROF area are given in Table 4 below. There was little CWD in the area; it occurred in only three sectors, thus, no CWD statistics are provided. Editing of the bamboo, sampling and seedling data was not completed in time for preparation of this preliminary report.

Table 4. Estimated population statistics in the Nonglao non-forested TROF area

Attribute	Nonglao Sub-District	
	Total	Std. Error (%)
Total volume (m^3)	225,658	10
Number of trees	997,128	9
Volume of stumps (m^3)	24,650	22

APPENDIX IV: PRELIMINARY STATISTICS FOR THE SOUTH DEMONSTRATION AREA

Introduction

This report presents the results of the inventory of TROF areas in two sub-districts in Chumphon province. Sample plots were systematically established using a fixed grid in the Pato and Paksong sub-districts. Out of a planned total of 203 plots that were selected, 138 plots were established and 65 were dropped (Table 5). The plots were dropped because they either fell in non-TROF areas or water, or were unsafe to establish.

Table 5. TROF area and number of sample plots in Pato and Paksong sub-districts

Sub-District	TROF Area (ha)	Number of Plots		
		Established	Dropped	Total
Pato	5,320	79	21	100
Paksong	2,620	59	44	103
Total	**7,944**	**138**	**65**	**203**

The number of plots from the fixed-grid that fell into each village, along with the TROF area in each village, are given in Table 6. The plots were established and data collected by the Project Demonstration Area staff and crew at Pato following the procedures laid out in the Project Technical Report No. 5.

Table 6. Number of plots and TROF area by village.

Sub-District	Village	TROF Area (ha)	No of Plots
Paksong	M.1 TOE TUNG	1,111	25
Paksong	M.2 HANG GAA	401	8
Paksong	M.3 BOG FAI	103	3
Paksong	M.4 PHAK TON	951	21
Paksong	M.6 SAPHAN SONG	58	2
Pato	M.1 KHOA TA PAO	357	5
Pato	M.2 THA SAI	111	2
Pato	M.3 SAI NGO	324	5
Pato	M.4 KUAN DOG MAI	139	3
Pato	M.5 BUENG KHUD	241	5
Pato	M.6 NAI YHAN	334	2
Pato	M.7 THA THIN	507	7
Pato	M.8 PATO	208	1
Pato	M.9 BAAN PAK LEKK	432	5
Pato	M.10 NAI JOG	262	8
Pato	M.11 HUAY KUNG THONG	375	5
Pato	M.12 BAN TRANG	380	5
Pato	M.13 HUAY KHON	276	5
Pato	M.14 NAI JUNE	96	1
Pato	M.15 PA TI MA	291	6
Pato	M.16 KLONG CHANGG	257	3
Pato	M.17 SRI SA MUT	89	1
Pato	M.18 PRASAN MI	641	10

Statistical analysis

Crew plot data were analysed to produce basic descriptive statistics and estimated population totals and means, and presented in statistical summary tables. The population totals and means were estimated based on a post-stratified sample design, where the post-strata were the villages. Detailed statistics by sub-district, village and species, including volume estimates of totals, averages and their approximate standard errors (SE), were calculated. Standard error is a measure of the precision of the estimated attribute mean or total. The lower the SE%, the more precise the estimated total. The SE can be used, along with the number of plots, to construct confidence intervals around the estimated attribute totals. A confidence interval expresses the range within which we expect the true population total or mean of the attribute to lie, with a given probability level.

Results

The overall TROF estimated population statistics for each sub-district are given in Table 7 below.

Table 7. TROF estimated population statistics by sub-district.

Attribute	Paksong		Pato	
	Total	**Std. Error (%)**	**Total**	**Std. Error (%)**
Total volume of trees (m^3)	350,154	18	571,383	21
Number of live trees	608,767	14	1,160,999	14
Volume of stumps (m^3)	1,827	39	3,492	27
Volume of CWD (m^3)	4,692	55	17,427	46
Length of bamboo (m)	338,912	48	387,607	42

APPENDIX V: NORTHEAST DEMONSTRATION AREA WORKSHOP FEEDBACK

Table 8. BENEFITS (USES) OF TROF INVENTORY & MONITORING INFORMATION

A. Individual TROF owners	B. Sub-district Administration	C. Central Government
1.To conserve and give the importance to trees for, e.g., planting for replacement.	1.Getting the information from research to publicize to the public.	1.Planning the management plannning by participation.
2.To get more advantage from TROF for livelihood such as to be a seasonal food source (mushroom, bamboo, shoots, vegetable, insects), which is like a local supermarket.	2.Setting up the village community to respond to the villager needs.	2.Receive the true information which can apply to develop areas in many ways.
3.Know how many tree species are in an area.	3.Rearrange and reprocess trees data to be a new information such as information in comparative statistic form.	3.Conduct the project continually and extend result to show the benefit of other species in forest.
4.Know how many trees are in an area.	4.Making a forest conservation project such as rehabilitation planting depending on the local need.	4.Study and research to promote and increase value of TROF product.
5.Know if trees are suitable with area or not. If not suitable, how to solve the unsuitable problem.	5.Extension of the non-forest product and knowledge importance to the local community.	5.Develop and extend activities continually and sustainably especially in local and product markets.
6.Know the trees exist in the plan of the local community.	6.Enable community network to exchange knowledge.	6.Economic valuation of local resource.
7.Know about species and their use such as alternative energy source, food and herb source.	7.Setup in the plan of the local community.	7.Using tree data in community as an indicator in funds allocation, to be database in community economics mechanism development.
8.Sharing and allocating resources usefulness with neighbors.	8.Extend to the neighboring district.	
9.Be a knowledge of community exchanged between landowners, village and sub - district .	9.Get the data from this Project and expand to other part to give benefit to the entire public.	
10.Knowing the worth and price of land, to realization a sense of belonging and feeling.	10.Used as the basic data for area management such as using public land.	
11.Be a public food source (4 factor of life : food ,habitats , clothes and medicine)	11. Give information about living condition, economic and life being depend on trees.	

A. Individual TROF owners	B. Sub-district Administration	C. Central Government
	12.Develop as learning place and source for increasing income of local people for example making fertilizer, charcoal, raft and OTOP product.	
	13.Be a focal point of community for doing activities.	

Table 9 : TROF INVENTORY AND MONITORING IMPLEMENTATION STRATEGY

A. Who to implement?	B. Suggested government incentives for TROF inventory & monitoring	C. Other remarks
1.Continually collecting data.	1.Overseeing	1.Inventory should use standard measuring tool, don't use self – expectation or eye estimation.
2.Replacement planting.	2.Field training	
3.Trees maintainance.	3.Incentive forces creation to make forest love mind and have knowledge about forest in current to the community.	
4.Wise use.	4.Set up afforestation activities during important days, to create vision of forest value.	
5. Sub-district Administration	5.Find budget source for data collection.	
6. Other government's division	6.Training and giving knowledge in TROF inventory. Overseeing and create network in TROF inventory & monitoring.	
7. Community's leaders and people.	7.Competition and rewarding to be an indicator in local funds allocation.	
8.School / Educational place as a centre of the operation	8.Find market, where supplier meet consumer, to promote local product.	
9.Community members		
10.The community		
11.Sub – district Administration		
12.Relevant government division at provincial level		
13.NGOs / Foundations / Private / Company.		

Table 10. COMMENTS ON TROF INVENTORY AND MONITORING SYSTEM

A. Fix grid	B. Sector	C. Other comment
It is suitable in inventory because it is easy in field working and calculation.	It is suitable in inventory although it looks complicate because it give fine data in each sampling plot.	1.Inventory, villager survey their own area , government division survey public area. If in jungle, should survey with government and village participation.
Difficult and want high technology. Villager has not enough experience to use tool in inventory.	Difficult to do, both method and tool using.	2.Expand area to nearby area or sub – district which attend to do and expand network.
		3. Communication / public relation between villager and neighboring community, beware conflict and misunderstanding.

APPENDIX VI: SOUTH DEMONSTRATION AREA WORKSHOP FEEDBACK

Table 11: BENEFITS (USES) OF TROF INVENTORY & MONITORING INFORMATION

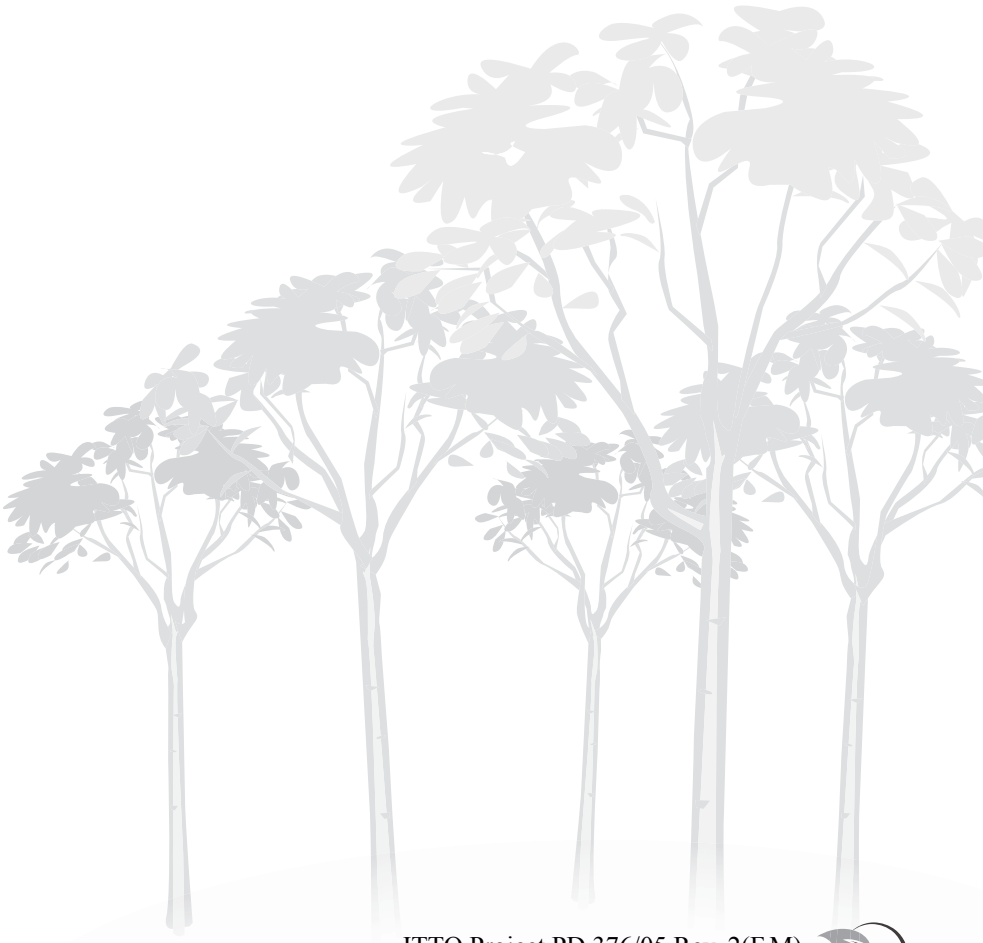
1. Individual TROF owners	2. Sub-district Administration	3. Central Government
1. Quantities of tree are known.	1. Planning for local development policy.	1. Concept promotion and guidelines for activities are identified.
2. Tree species are known.	2. Provide suitable tree seedling for soil and water conservation.	2. Scenarios analysis for changes.
3. Appropriate treatment for tree in the area.	3. Data for taxation.	3. Promotion and extension to public.
4. Find out best way for inventory.	4. Suitable tree planting for soil.	
5. Forest increment such as species, quantity and quantity will be known.	5.Tree management for community.	
6. Tree species in land tenure, forest are known.	6. Preservation/ conservation	
7. Fast growing species increase/ decrease.	7. Sources and tree products located.	
8. Which tree species suitable for particular soil.	8. Comparison of tree species in the area.	
9. Alteranative job for farmers.	9. Land use changes are detected.	
10. Stimulate nationwide idea of sustainable development through multicrop-trees planting.	10. Data can be use for local development planning.	
	11. Data can be compared with other areas.	

Table 12 : TROF INVENTORY AND MONITORING IMPLEMENTATION STRATEGY

1. Who to implement?	2.Suggested government incentives for TROF inventory & monitoring	3. Other remarks
1. Expert in tree species and codes.	1. Tree bank	1. Tree inventory planning is annually performed.
2. Inventory regularly done by farmers themselves.	2. Sustainable management for bamboo uses.	2. All stakeholders participate in inventory.
3. Hiring workers.	3. There will be cooperation between governments agencies to provide budget and knowledge of inventory, while private sector perform the activities on the field.	3. Next inventory, land owners should lead the inventory and community committee should be involved in verification phase.
4. Land owners.		
5. Data can be used for future management on tree supply for community uses.		

Table 13: COMMENTS ON TROF INVENTORY AND MONITORING SYSTEM

1. Fix grid	**2. Other comment**
1. Biodiversity is identified.	1. Promote TROF to be a pilot project for each Tambon.
2. Inventory database should emphasize more details.	2. Elaborate TROF to local people and government staff, to gain some understanding of TROF benefits.
3. Promote youth to participate and gain knowledge from the project.	



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Tree Resources Outside Forest

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