การประเมินการเปลี่ยนแปลงการใช้ที่ดินและการกักเก็บคาร์บอน ในป่าไม้ของอุทยานแห่งชาติทับลาน

นางวาสนา ภานุรักษ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
สาขาวิชาชีววิทยาสิ่งแวดล้อม
มหาวิทยาลัยเทคโนโลยีสุรนารี
ปีการศึกษา 2555

THE ASSESSMENT OF LAND USE CHANGE AND FOREST CARBON SEQUESTRATION AT THAP LAN NATIONAL PARK

Wassana Phanurak

A Thesis Submitted in Partial Fulfillment of the Requirements for the

Degree of Doctor of Philosophy in Environmental Biology

Suranaree University of Technology

Academic Year 2012

THE ASSESSMENT OF LAND USE CHANGE AND FOREST CARBON SEQUESTRATION AT THAP LAN NATIONAL PARK

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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วาสนา ภานุรักษ์ : การประเมินการเปลี่ยนแปลงการใช้ที่ดินและการกักเก็บคาร์บอนในป่าไม้ของอุทยานแห่งชาติทับลาน (THE ASSESSMENT OF LAND USE CHANGE AND FOREST CARBON SEQUESTRATION AT THAP LAN NATIONAL PARK) อาจารย์ที่ปรึกษา : ผู้ช่วยศาสตราจารย์ ดร.พงศ์เทพ สุวรรณวารี, 243 หน้า.

อุทยานแห่งชาติทับลาน มีขนาดใหญ่เป็นอันดับสองของอุทยานแห่งชาติในประเทศไทย มีบทบาทสำคัญต่อการอนุรักษ์ความหลากหลายทางชีวภาพ และการกักเก็บคาร์บอน ในประเทศไทยและเอเชียตะวันออกเฉียงใต้ การลดลงของพื้นที่ป่าและการกักเก็บคาร์บอนในพื้นที่นี้อาจมีผลต่อภูมิอากาศและความเป็นอยู่ของคนในท้องถิ่นได้ ดังนั้นการศึกษานี้จึงมีวัตถุประสงค์เพื่อ ติดตามการเปลี่ยนแปลงการใช้พื้นที่ของอุทยานแห่งชาติทับลานและเขตแนวกันชน 5 กิโลเมตร ระหว่างปี 2530-2549 ประเมินโครงสร้างของป่าไม้ และความสามารถในการกักเก็บคาร์บอนในรูปมวลชีวภาพและในดิน ผลที่ได้แสดงให้เห็นว่าพื้นที่ป่าของอุทยานแห่งชาติทับลานลดลงร้อยละ 3.0 จาก 1,948.73 ตารางกิโลเมตร (ตร.กม.) ในปี 2530 เหลือ 1,890.20 ตร.กม. ในปี 2549 ป่าเต็งรังมีการลดลงมากที่สุดคิดเป็นร้อยละ 17.9 ตามด้วยป่าเบญจพรรณคิดเป็นร้อยละ 4.8 ซึ่งลดลงจากพื้นที่ 197.15 และ 550.58 ตร.กม. ในปี 2530 เหลือ 161.72 และ 476.35 ตร.กม. ในปี 2549 ตามลำดับ การลดลงของพื้นที่ป่าไม้ในปี 2530-2540 มีความสัมพันธ์กับการเพิ่มขึ้นของพื้นน้ำ ซึ่งเกิดจากการสร้างเขื่อนลำปลายมาศ นอกจากนั้น พื้นที่เกษตรกรรมและพื้นที่ที่เหลืออื่น ๆ เพิ่มขึ้น ร้อยละ 12.9 จาก 248.50 ตร.กม. ในปี 2530 เป็น 280.69 ตร.กม. ในปี 2549 ซึ่งดูเหมือนว่าเป็นการบุกรุกเข้าไปในพื้นที่ป่าไม้ ส่วนพื้นที่เพาะปลูก ทุ่งหญ้า และพื้นที่อื่น ๆ มีแนวโน้มเพิ่มขึ้นตามการลดลงของพื้นที่ปลูกข้าว ไม้ยืนต้น และดอกไม้ ระหว่างปี 2530-2549 พื้นที่บ้านเรือนและสิ่งก่อสร้างเพิ่มขึ้นถึงร้อยละ 35 จาก 11.11 ไปถึง 15.00 ตร.กม. ในทำนองเดียวกัน การเปลี่ยนแปลงการใช้พื้นที่ในแนวกันชน 5 กม. มีแนวโน้มคล้ายกันกับในเขตอุทยานแห่งชาติทับลาน แต่ในอัตราส่วนที่มากกว่า ระหว่างปี 2530 ถึง 2549 พื้นที่ป่าไม้ในแนวกันชนลดลงร้อยละ 6.5 จากพื้นที่ทั้งหมด 1,041.35 เหลือ 973.28 ตร.กม. สำหรับการสำรวจ โครงสร้างป่าไม้ พบว่า ป่าทั้งสามชนิดประกอบด้วยพันธุ์พืชและสังคมพืชที่แตกต่างกัน พันธุ์พืชทั้งหมดที่พบในป่าไม้ทั้งสามมีจำนวน 141 ชนิด ป่าดิบแล้งมีความหลากหลายของพืชมากที่สุด ตามด้วยป่าเบญจพรรณและป่าเต็งรัง โดยมีพันธุ์พืชจำนวน 81 63 และ 32 ชนิด ตามลำดับ ไทรหิน (*Ficus curtipes* Cornr) ประดู่ (*Pterocarpus macrocarpus* Kurz) และเต็ง (*Shorea obtusa* Wall. Ex Blume) เป็นพันธุ์พืชหลักที่พบมากในป่าดิบแล้ง ป่าเบญจพรรณและป่าเต็งรัง ตามลำดับ โดยมีค่าดัชนีความสำคัญที่ 13.63 26.42 และ 91.00 ตามลำดับ นอกจากนั้นการกักเก็บคาร์บอนในรูปชีวมวลของป่าดิบแล้งมีค่าสูงกว่าป่าเบญจพรรณและป่าเต็งรัง ซึ่งมีค่า 113.89 64.61 และ 27.91 ตันคาร์บอนต่อเฮกแตร์ ตามลำดับ เมื่อรวมกับผลการสำรวจข้อมูล

ระยะไกล พบว่าค่าประมาณการการกักเก็บคาร์บอนทั้งหมดของป่า ในเขตอุทยานแห่งชาติทับลาน เท่ากับ 18.03 ล้านตันคาร์บอนต่อเฮกแตร์ในปี 2530 ขณะที่ลดลงร้อยละ 1.3 เหลือ 17.79 ล้านตันคาร์บอนต่อเฮกแตร์ในปี 2549 โดยมีอัตราการสูญเสีย 12,631.58 ตันคาร์บอนต่อปี การกักเก็บคาร์บอนทั้งหมดในเขตอุทยานแห่งชาติทับลานและเขตแนวกันชนสามารถทำนายได้ตามสมการ $y = -0.0144x + 46.574$ $R^2 = 0.920$ และ $y = -0.0166x + 41.457$ $R^2 = 0.976$ เมื่อ y = การกักเก็บคาร์บอนทั้งหมด และ x = ปี (คริสตศักราช) นอกจากนั้น คาร์บอนอินทรีย์สะสมสูงสุดในดินที่ลึก 10 ซม. และลดลงอย่างมีนัยสำคัญทางสถิติกับความลึกของดิน ($p < 0.05$) ถึงแม้ว่าปริมาณคาร์บอนในดินของป่าไม้ทั้งสามชนิด ไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ แต่คาร์บอนในป่าดิบแล้งที่ระดับความลึก 0-10 ซม. มีค่ามากกว่าป่าเบญจพรรณ และป่าเต็งรัง ซึ่งมีค่าร้อยละ 3.90 3.10 และ 2.77 ตามลำดับ การศึกษาครั้งนี้แสดงให้เห็นการลดลงอย่างมีนัยสำคัญทั้งพื้นที่ป่าไม้ธรรมชาติและการกักเก็บคาร์บอนในเขตอุทยานแห่งชาติทับลานและเขตแนวกันชน 5 กม. ถ้าปราศจากมาตรการที่สำคัญ การลดลงนี้จะส่งผลกระทบอย่างต่อเนื่องกับการเปลี่ยนแปลงสภาพภูมิอากาศทั้งในระดับท้องถิ่นและภูมิภาค

สาขาวิชาชีววิทยา ลายมือชื่อนักศึกษา _____

ปีการศึกษา 2555 ลายมือชื่ออาจารย์ที่ปรึกษา _____

ลายมือชื่ออาจารย์ที่ปรึกษาร่วม _____

WASSANA PHANURAK : THE ASSESSMENT OF LAND USE CHANGE AND FOREST CARBON SEQUESTRATION AT THAP LAN NATIONAL PARK. THESIS ADVISOR : ASST. PROF. DR. PONGTHEP SUWANWAREE, Ph.D. 243 PP.

LAND USE CHANGE/ CARBON SINK/ THAP LAN NATIONAL PARK

Thap Lan National Park, the second largest national park of Thailand, has an important role in conserving biodiversity and carbon sequestration in Thailand and Southeast Asia. The decline of forest and carbon storage of this area can affect climate and livelihood of local people. Therefore, the objectives of this study were to observe land use change of Thap Lan National Park and its 5 km buffer zone during 1987-2006, to assess forest community, and to estimate carbon storage in forest biomass and in soil. The results revealed that forestland of Thap Lan National Park decreased 3.0% from 1,948.73 km^2 in 1987 to 1,890.20 km^2 in 2006. Dry Dipterocarp Forest (DDF) was the most decreasing land use (17.9%), followed by Mixed Deciduous Forest (MDF) 4.8%, which decreased from 197.15 and 500.58 km^2 in 1987 to 161.72 and 476.35 km^2 in 2006, respectively. The decreasing of forestland during 1987-1997 correlated with the increment of water body by the construction of Lam Plai Mat dam. Furthermore, agricultural and other lands were increased 12.9% from 248.50 km^2 in 1987 to 280.69 km^2 in 2006, which seem to expand into forest area. Field crop, grassland, and other lands tended to increase along with the decreasing of paddy fields and perennials and orchards. During 1987-2006, urban and built-up gradually increased 35.0% from 11.11 to 15.00 km^2. In addition, the changing of each land use in 5 km buffer zone had the similar trend as inside Thap Lan National Park, but the percent changing was higher. In the 5 km buffer zone between 1987 and 2006, the

forestland also decreased 6.5% from 1,041.35 to 973.28 km^2. The forest structure survey revealed three forest types composed of different plant species and composition. A total of 141 species were found in three forests. Dry Evergreen Forest (DEF) had the most diverse plants, followed by MDF and DDF at 81, 63 and 32 species, respectively. *Ficus curtipes* Corner, *Pterocarpus macrocarpus* Kurz, and *Shorea obtusa* Wall. ex Blume were the most dominant species in DEF, MDF and DDF with important value index of 13.63, 26.42 and 91.00, respectively. Although there was no significant difference, carbon sequestration in plant biomass of DEF was higher than those of MDF and DDF which were 113.89, 64.61, and 27.91 tC/ha, respectively. Combining with forest area, the estimated total forest carbon sequestration in Thap Lan National Park was 18.03 million tC in 1987, while it declined 1.3% to 17.79 million tC in 2006, losing 12,631.58 tC/yr. The total carbon sequestration in Thap Lan National Park and its 5 km buffer zone could be predicted as $y = -0.0144x + 46.573$, $R^2 = 0.920$ and $y = -0.0166x + 41.457$, $R^2 = 0.976$, where y = total carbon sequestration, x = year (Christian Era), respectively. Furthermore, soil organic carbon (SOC) significantly accumulated in the top 10 cm and decreased with soil depth ($p < 0.05$). The soil organic carbon was not significantly different among the three forest types, but DEF had slightly higher SOC at 0-10 cm depth than those of MDF and DDF which were 3.90, 3.10 and 2.77%, respectively. Finally, this study shows a significant loss of both natural forest area and carbon storage in Thap Lan National Park and 5 km buffer zone. Without any intervention, this loss will continue affecting climate change of both local and regional areas.

School of Biology

Academic Year 2012

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ACKNOWLEDGEMENTS

I would like to express my deepest appreciation and sincere gratitude to my thesis advisor, Asst. Prof. Dr. Pongthep Suwanwaree for his valuable advice, morale support and time spent discussing my concerned matters during the study at Suranaree University of Technology. Additionally, I am also grateful to have valuable comments and suggestion from the thesis co-advisor, Asst. Prof. Dr. Sapit Diloksumpun, and the thesis examining committee, Assoc. Prof. Dr. Nathsuda Pumijumnong and Dr. Surachai Ratanasermpong. I would also extend my thanks to Assoc. Prof. Dr. Yupaporn Chaiseha, chairperson and chair of the School, for her generous help and suggestions on my thesis writing.

I am especially thankful to Nakhon Ratchasima Rajabhat University for providing funds in this course study and thesis period. I would like to thank Thap Lan National Park for permission of this thesis and providing personal and park rangers to support the field work and data collection.

Finally, I would like to thank my family for financial support and great care. This thesis is dedicated to my parents, all former teachers and professors who have taught, guided and paved my way.

Wassana Phanuruk

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LIST OF ABBREVIATIONS

Ar	=	Arboretum
BG	=	Botanical Garden
C	=	Carbon
Ca	=	Calcium
CO_2	=	Carbon Dioxide
DBH	=	Diameter at Breast Height
DDF	=	Dry Dipterocarp Forest
DEF	=	Dry Evergreen Forest
DNP	=	Department of National Park, Wildlife and Plant Conservation
DPKY-FCWH	=	Dong Phra Yayen-KKhao Yai Forest Complex World Heritage
FAO	=	Food and Agriculture Organization
FC	=	Field Crop
FP	=	Forest Park
FRA	=	Forest Resources Assessment
GIS	=	Geographic Information System
GL	=	Grassland
Gt	=	Giga Tonnes
H	=	Height of the Tree
ha	=	Hectare
IPCC	=	Intergovernmental Panel on Climate Change
IVI	=	Importance Value Index

LIST OF ABBREVIATIONS (Continued)

K	=	Potassium
Landsat-TM	=	Landsat-Thermatic Mapper
LDD	=	Land Development Department
LULC	=	Land Use and Land Cover Change
m	=	Meter
MDF	=	Mixed Deciduous Forest
mg	=	Milligram
MNRE	=	Ministry of Natural Resources and Environment
NASA	=	National Aeronautics and Space Administration
NHA	=	No-Hunting Area
No.	=	Number
NP	=	National Park
NPP	=	Net Primary Production
OL	=	Other Lands
P	=	Phosphorus
PA	=	Protected Area
PF	=	Paddy Field
PO	=	Perennial and Orchard
RD	=	Relative Density
RDo	=	Relative Dominance
RF	=	Relative Frequency
RFD	=	The Royal Forest Department

LIST OF ABBREVIATIONS (Continued)

SEM	=	Standard Error of Mean
SERS	=	Sakaerat Environmental Research Station
SOC	=	Soil Organic Carbon
SOM	=	Soil Organic Matter
SPSS	=	Statistical Package for Social Science
t	=	Tonnes
UB	=	Urban and Built-up
UNFCCC	=	United Nations Framework Convention on Climate Change
W_B	=	Biomass of Branch
WB	=	Water Body
WISE	=	World Inventory of Soil Emission Potentials
W_L	=	Biomass of Leaf
W_R	=	Biomass of Root
W_S	=	Biomass of Stem
WS	=	Wildlife Sanctuary

CHAPTER I

INTRODUCTION

1.1 Significance of the Problem

Tropical forests are the center of the plant photosynthesis because the biomass as well as diversity of places is much higher than in other forest types such as temperate or broadleaf forest. Many recent researchers highlight the importance of understanding terrestrial carbon exchange in tropical forest, particularly the role of tropical forest acting as a carbon sink (Schimel *et al*., 2001; Intergovernmental Panel on Climate Change (IPCC), 2002). Tropical forest ecosystems play dominant roles in the carbon cycle because they store a large amount of carbon in vegetation and soil, and interact with atmospheric processes through the absorption and respiration of CO_2 (Brown and Schroeder, 1999; Houghton *et al*., 1999; Goodale *et al*., 2002). Moreover, growing stock and carbon storage were assessed to determine relevant trends to climate change, while sustainable management and planting of forest can conserve or increase forest carbon stocks, but deforestation, forest degradation and poor management practices reduce them.

Yet, there are still many uncertainties about the workings of the carbon cycle. According to the 2001 report, IPCC estimates that the amount of carbon absorbed in the soil and vegetation amounts between 0.9 and 4.3 giga tonnes (Gt) annually on a global scale. Recent research suggests tropical forests play an even more important role in absorbing carbon than previously thought, taking up 1 Gt of carbon every year,

or about 40% of the total for land based absorption (Britton *et al*., 2007). On the other hand, NASA satellite data create the most precise map ever produced depicting the amount and location of carbon stored in Earth's tropical forests (Saatchi *et al*., 2011). The new map, created from ground and space-based data shows, for the first time, the distribution of carbon stored in forests across more than 75 tropical countries. Most of that carbon is stored in the extensive forests of Latin America that account for 49% of the total carbon stock, followed by forests of Southeast Asia (26%), and Africa (25%). Brazil's forests accounted for nearly a quarter of total biomass measured in the study. Republic of the Congo (9.8%), Indonesia (9.3%), Peru (4.9%), and Colombia (4.1%) rounded out the top five countries, which together accounted for more than half (52.8%) of tropical forest biomass.

However, total carbon storage in forest biomass was 44 Gt in Asia and the Pacific region as a whole. Carbon stock in forest biomass decreased by an estimated 156 million tonnes annually during 2000 to 2010 (Food and Agriculture Organization (FAO), 2011). A high percentage of carbon stock in Southeast Asia was also a negative trend over the period 1990-2010. Carbon stock in living forest biomass reduces by alarming rate of soil degradation, deforestation and land use change in tropical forest. Therefore, estimating of carbon stock across heterogeneous regions and land-use change will allow us to better understand the function of the forests not only as a reservoir of biodiversity, but also as an important CO_2 sink.

Thap Lan National Park, one of the Dong Phra Yayen - Khao Yai Forest Complex World Heritage (DPKY - FCWH), was inscribed in 2005. This world heritage contains more than 800 fauna species, including 112 species of mammals, 392 species of birds and 200 species of reptiles and amphibians. It is internationally

important for the conservation of globally threatened and endangered mammal, bird and reptile species that are recognized as being of outstanding universal value. This includes 1 critically endangered, 4 endangered and 19 vulnerable species. The area contains the last substantial area of globally important tropical forest ecosystems of Thailand Monsoon Forest biogeographic province in Northeast Thailand.

Thap Lan National Park has the important roles in conserving biodiversity and carbon storage in Thailand and Southeast Asia. It is now facing serious problems from deforestation and wildlife hunting. Since, there is an expansion of communities into the National Park zone for the tourist attraction in Khon Buri district, Wang Nam Khiaw district, Soeng Sang district in Nakhon Ratchasima province and Na Dee district in Prachin Buri province, the 5 km buffer zone around Thap Lan National Park was also taken into account. Therefore, the changes of land use in Thap Lan National Park and its 5 km buffer zone and carbon sequestration in the forest are greatly of concern. The reason is that the land use change around and in the area would affect carbon sequestration. This matter must be reconsidered and solved to slow down the greenhouse effect and the global climate change at the present time.

1.2 Research Objectives

1.2.1 To assess land use change within Thap Lan National Park and the 5 km buffer zone from 1987 to 2006 by remote sensing technique.

1.2.2 To estimate above/below ground and soil forest carbon sequestration in Dry Evergreen Forest (DEF), Mixed Deciduous Forest (MDF) and Dry Dipterocarp Forest (DDF) in Thap Lan National Park.

1.2.3 To predict the trend of forest carbon loss of Thap Lan National Park by using these observed data.

1.3 Scope and Limitations of the Study

1.3.1 The land use classification and its change in Thap Lan National Park and 5 km buffer zone were performed by using 1987, 1997, 2003, and 2006 Landsat-TM data. In this study, ten land use types were classified, including Dry Evergreen Forest (DEF), Mixed Deciduous Forest (MDF), Dry Dipterocarp Forest (DDF), paddy field, field crop, perennial and orchard, grassland, water body, urban and built-up, and other lands (old clearing, uncultivated land, barren land/bare land) based on the classification of Land Development Department (LDD) and the Royal Forest Department (RFD).

1.3.2 Importance value index (IVI) is used to determine the overall importance of each species in the community structure and compare the species dominance of the 17 plots.

1.3.3 The allometric equations of Tsutsumi *et al*. (1983) were used to estimate forest biomass for DEF while Ogawa *et al*. (1961, 1965)'s equations were used for both MDF and DDF.

1.3.4 To estimate soil carbon storage, disturbed and undisturbed soil samples were collected by using a soil sampler on 3 forest types from each plot, 3 soil layers were collected (0-10, 10-20, and 20-30 cm) in the soil profile.

1.3.5 The results were presented as mean ± standard error of mean (SEM). Data of carbon storage were analyzed by one-way analysis of variance (ANOVA), followed by Duncan's multiple range tests. Data of soil properties were analyzed by

two-way ANOVA, followed by Duncan's multiple range tests. The regression equations were analyzed by fitting the linear regression. All data analysis and correlations were analyzed using Statistical Package for Social Sciences (SPSS) program for Windows, v.17.

1.4 Expected Results

1.4.1 Know the decrease and increase of any particular land use type both inside Thap Lan National Park and 5 km buffer zone.

1.4.2 Know the change of any forest and where is the most vulnerable.

1.4.3 Gain the estimated amount of carbon storage in major forests of Thap Lan National Park and how much it loss during the study period.

1.4.4. The results can be further applied for protection, monitoring and restoration of forest resources in Dong Phra Yayen - Khao Yai Forest Complex World Heritage.

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CHAPTER II

LITERATURE REVIEW

2.1 Global Carbon Cycle and Carbon Stock of Tropical Forest

Photosynthetic uptake of carbon from the atmosphere and oceans provides the fuel for most biotic processes. This reduced carbon makes up about half of the mass of Earth's organic matter. Biological systems, in turn, respire CO_2 when they use organic carbon for growth and metabolism. The controls over the carbon cycle depend on the time scale, ranging from the years, by which photosynthetic rate and surface air exchange (Houghton, 2007; Gorte, 2009).

On land, the carbon gain by vegetation is slightly greater than the carbon loss in respiration, leading to net carbon storage on land. The net carbon input to the oceans is also slightly greater than the net carbon return to the atmosphere. The terrestrial biosphere accounts for 50 to 60% of global net primary production (NPP). Whereas, most (80%) of the marine NPP is released to environment by heterotrophic respiration and the remaining 20% goes to the deep oceans by the biological pump. Ocean upwelling returns most of this carbon to the surface ocean waters (Farquhar *et al*., 1993; Ciais *et al*., 1997).

Since 1980, researchers have estimated the uptake of carbon by the world's oceans and terrestrial ecosystems at the global level, with an emphasis on terrestrial ecosystems. The world's terrestrial ecosystems were a net source of 40 giga tonnes carbon (GtC) to the atmosphere over the period 1850-2000 (Table 2.1). Total

emissions to the atmosphere were, thus, 315 GtC (275 from fossil fuels and cement production plus 40 from land), and the airborne fraction, defined relative to total emissions. The flux of carbon from changes in land use depends on the area of land affected, the carbon stocks before and after change, and the rates of decay and recovery following disturbance or management. Over the past 300 years, forests have been replaced with agricultural lands and thus, the amount of carbon on land has decreased. Although carbon has accumulated on land in some regions (Houghton *et al*., 1999), the change resulting from direct human activity over the 150-year period from 1850 to 2000 is estimated to have been a release of 156 GtC (Houghton, 2003).

Table 2.1 The global carbon budget for 1850-2000 (GtC).

Carbon budget	**1850-2000**
Emissions from fossil fuels and cement production	275
Atmospheric increase	-175
Oceanic uptake	-140
Net terrestrial flux	40
Land-use change	156
Residual terrestrial flux	-116

Source: Houghton (2003)

Tropical forests are the center of the plant photosynthesis because the biomass as well as diversity of places is much higher than the other forest types such as temperate or board forest. Many recent researchers highlight the importance of understanding terrestrial carbon exchange in tropical forest, particularly the role of tropical forest acting as a carbon sink (Schimel *et al*., 2001; IPCC, 2002). Tropical forest ecosystems play dominant roles in the carbon cycle because they store a large

amount of carbon in vegetation and soil, and interact with atmospheric processes through the absorption and respiration of CO_2 (Brown and Schroeder, 1999; Houghton *et al*., 1999; Goodale *et al*., 2002). Moreover, growing stock and carbon storage were assessed to determine relevant trends to climate change while sustainable management and planting of forest can conserve or increase forest carbon stocks but deforestation, forest degradation and poor management practices reduce them.

Yet, there are still many uncertainties about the workings of the carbon cycle. According to the 2001 report, IPCC estimate that the amount of carbon absorbed in the soil and vegetation amounts to anything between 0.9 and 4.3 Gt annually on a global scale. Recent research suggests tropical forests play an even more important role in absorbing carbon than previously thought, taking up 1 Gt of carbon every year, or about 40% of the total for land based absorption (Britton *et al*., 2007).

On the other hand, NASA satellite data create the most precise map ever produced depicting the amount and location of carbon stored in Earth's tropical forests (Saatchi *et al*., 2011). The new map, created from ground- and space-based data, shows, for the first time, the distribution of carbon stored in forests across more than 75 tropical countries (Figure 2.1). Most of that carbon is stored in the extensive forests of Latin America that account for 49% of the total carbon stock, followed by forests of Southeast Asia (26%), and Africa (25%). Brazil's forests accounted for nearly a quarter of total biomass measured in this study. Democratic Republic of Congo (9.8%), Indonesia (9.3%), Peru (4.9%), and Colombia (4.1%) rounded out the top five countries, which together accounted for more than half (52.8%) of tropical forest biomass.

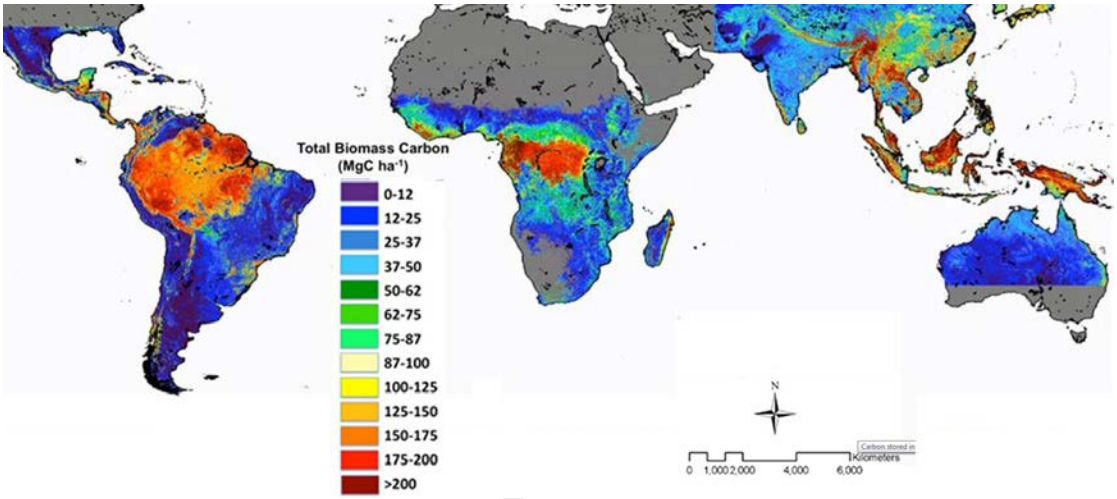

Figure 2.1 Carbon stored in Earth's tropical forests (Saatchi *et al*., 2011).

However, total carbon storage in forest biomass was 44 Gt in Asia and the Pacific region as a whole. Carbon stock in forest biomass decreased by an estimated 156 million tonnes annually during 2000 to 2010 (FAO, 2011). As high percentage of carbon stock is in Southeast Asia, but the trend of forest carbon stock was a negative trend over the period 1990-2010 (Figure 2.2). In Southeast Asia, carbon stock in living forest biomass in each country shows the increasing or decreasing rate and alarming trend of degradation, deforestation and land use change in tropical forest (Table 2.2). In Southeast Asia, Indonesia's forest showed a highest carbon stock of 16,335 million tonnes while lowest value of carbon stock of 609 million tonnes was observed in Cambodia's forest in 1999. Thailand's forest had the total carbon stock of 908 million tonnes in 1999 and decreased to 881 million tonnes in 2000, then showed unchanged values until 2010. Therefore, estimating of carbon stock across heterogeneous regions, and are statistically representative of land-use change and disturbance will allow us to better understand the function of the forests not only as a reservoir of biodiversity, but also as an important CO_2 sink.

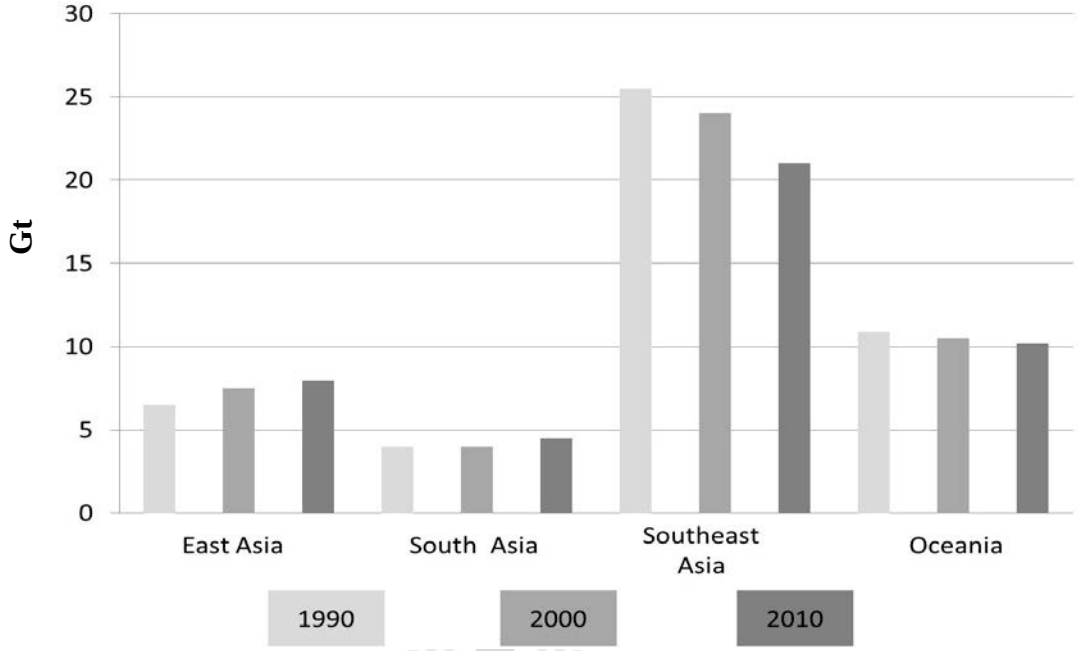

Figure 2.2 Carbon stock in forest biomass in Asia and Pacific during 1990-2010 periods (FAO, 2011).

Table 2.2 Carbon stock and stock change in living forest biomass in Southeast Asia.

Country	Carbon stock in living forest biomass					Annual change rate	
	million tonnes				t/ha	1000 tonnes	
	1999	2000	2005	2010	2010	1999-2000	2000-2010
Cambodia	609	537	495	464	46	-7	-7
Indonesia	16,335	15,182	14,299	13,017	138	-115	-217
Laos	1,186	1,133	1,106	1,074	68	-5	-6
Malaysia	2,822	3,558	3,362	3,212	157	74	-35
Philippines	2,040	1,814	1,734	1,654	52	-23	-16
Singapore	-	-	-	-	-	-	-
Thailand	908	881	877	880	46	-3	0
Timor-Leste	-	-	-	-	-	-	-
Vietnam	778	927	960	992	72	15	7

Source: FAO (2011)

2.2 Carbon Sequestration in Forest Ecosystems

Forest ecosystems absorb large amounts of CO_2 from the atmosphere via photosynthesis, and return a large part of the fixed carbon back to the atmosphere through respiration. However, a small fraction of assimilated carbon is stored in net primary productions. Forest ecosystems are open systems and exchange carbon, energy and material with other systems including neighbor forests, aquatic ecosystems and the atmosphere. Thus, a forest ecosystem is never in equilibrium (Lorenz and Lal, 2010).

As this forest-atmosphere interaction leads to the view that controlling land use change practices involving forests might prevent some of the increase in atmospheric greenhouse gases, and additionally that some forest management activities might effectively reduce the rate of CO_2 accumulation in the atmosphere. The main carbon stock in tropical forest ecosystems are the living biomass of trees and understory vegetation and the dead mass of litter, woody debris and soil organic matter. The carbon stored in the aboveground living biomass of trees is typically the largest pool and the most directly impacted by deforestation and degradation. Thus, estimating aboveground forest biomass carbon is the most critical step in quantifying carbon stocks and fluxes from tropical forests (Post, Izaurralde, Mann, and Bliss, 1999; Brown and Masera, 2003; Pearson *et al*., 2005; IPCC, 2007).

Moreover, the most direct way to quantify the carbon stored in aboveground living forest biomass (forest carbon stock) is to harvest all trees in a known area, dry them and weigh the biomass. The dry biomass can be converted to carbon content by taking half of the biomass weight with carbon content around 50% of biomass (Westlake, 1966) as well as approximately carbon stored in root can calculated as 25%

of aboveground biomass (Cairns, Brown, Helmer, and Baumgardner, 1997). Also the measurement of organic carbon in each part of the tree such as stem, leave, branch, and root can make us to better estimating in detail of carbon in each forest ecosystems.

The effect on aboveground carbon depends on stand productivity, which is often already maximized in regions with a tradition of forest management, such as in the temperate zone. The effect of tree species on soil carbon depends on the chemical quality of litter, rooting depth, and rooting density. Some investigations on the influence of tree species on soil properties exist. Due to the multiple interactions of tree species and site properties, comprehensive information is, unfortunately, unavailable (Jandl *et al*., 2006). It is well known that tree species selection can quickly modify forest floor carbon stocks. Therefore, tropical forest structure and biomass are known to vary with soil type, climate and topographic condition (Iverson, Brown, Grainger, Prasad, and Liu, 1994; Vieira *et al*., 2004; de Castilho *et al*., 2006; Hertel *et al*., 2009), as well as different in carbon sequestration potential of forest ecosystems.

Aboveground biomass distribution and carbon storage depend on different diameter at breast height (DBH) size classes of the tree. Terakunpisut *et al*. (2007) compared the size class distribution and aboveground biomass of Tropical forest, Dry Evergreen Forest and Mixed Deciduous Forest in Thong Pha Phum National Forest, Thailand. The result showed that carbon sequestration potential in the different forest types seems to be related to DBH size class (Table 2.3).

Table 2.3 Comparison of tree density and carbon sequestration potential in each size class in the different forest in Thong Pha Phum National Forest, Thailand.

Size class DBH (cm)	Tropical Rain Forest		Dry Evergreen Forest		Mixed Deciduous Forest	
	Density (%)	C-storage (%)	Density (%)	C-storage (%)	Density (%)	C-storage (%)
≥ 4.5-20	62.0	4.2	76.22	6.71	85.88	4.49
> 20-40	25.2	16.5	15.74	16.05	7.50	8.82
> 40-60	7.4	20.7	5.01	21.42	4.56	20.83
> 60-80	2.4	12.1	1.64	17.03	1.18	11.31
> 80-100	1.3	11.4	0.82	15.19	0.59	10.89
> 100	1.7	35.2	0.58	23.61	0.30	43.67

Source: Terakunpisut *et al*. (2007)

According to Piyaphongkul *et al*. (2011), carbon sequestration potential in Khao Yai National Park, showed that the distribution of DBH size classes and the total carbon storage in each size class varied between the primary and secondary forest. About 80% of the carbon stock was presented in DBH size class at 4.5-20 cm and 20-40 cm in secondary forest, but contributed only 20% of total carbon stock in primary forest. The carbon storage was highest in DBH size class at 60-80 cm and 80-100 cm in primary forest (Table 2.4).

Table 2.4 A comparison of the percentage of tree density and carbon sequestration potential between the primary forest and the secondary forest.

Size class (DBH, cm)	The primary forest		The secondary forest	
	Tree density (%)	Carbon stock (%)	Tree density (%)	Carbon stock (%)
4.5-20	76.20	6.93	85.30	38.18
20-40	20.00	13.43	14.37	39.96
40-60	3.04	6.37	0.19	1.48
60-80	0.44	26.73	0.05	0.62
80-100	0.33	46.53	-	-
> 100	-	-	0.09	19.75

Source: Piyaphongkul *et al*. (2011)

Diloksumpun *et al*. (2008) reported that Dry Evergreen Forest at Sakaerat Environmental Research Station in Nakhon Ratchasima sequestrated more carbon (1.54 tC/ha/yr) than those of Mixed Deciduous Forest at Maeklong Watershed Research Station in Kanchana Buri (0.20 tC/ha/yr) (Figure 2.3).

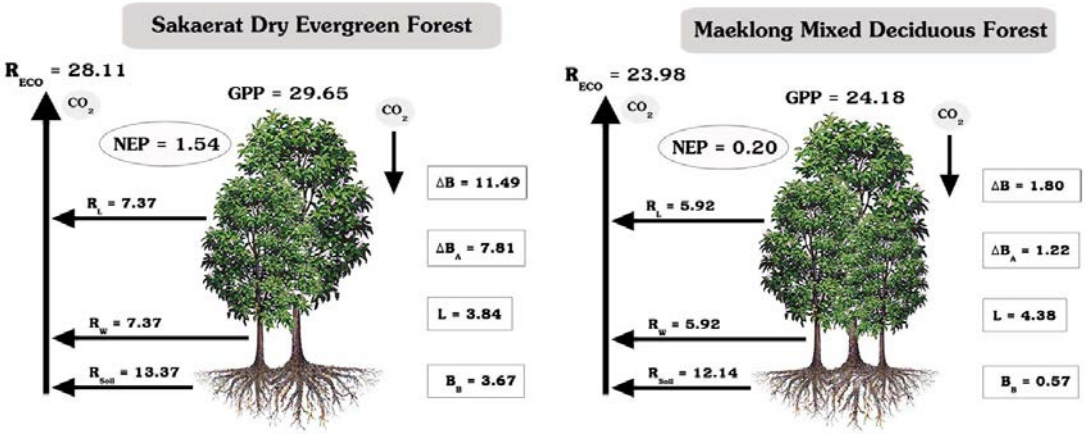

Figure 2.3 Carbon sequestration of DEF at Sakaerat, Nakhon Ratchasima and MDF at Maeklong, Kanchana Buri (Diloksumpun *et al*., 2008).

In Thailand, previous studies showed various aboveground carbon storages reported in different forest types (Table 2.5). The highest amount of carbon was stored in Moist Evergreen Forest, ranging from 137 to 179 tC/ha.

Table 2.5 The carbon stock in living trees of difference forest types in Thailand.

Forest types	**Locations**	**Carbon stock (tC/ha)**	**Sources**
Hill Evergreen Forest	Kaeng Krachan NP	128.32	Jampanin and Gajaseni (2005)
Moist Evergreen Forest	Kaeng Krachan NP	168.04	Nuanurai (2005)
	Thong Pha Phum NP	137.73	Terakunpisut *et al*. (2007)
	Northeast, Thailand	179.00	Ogawa *et al*. (1965)
Dry Evergreen Forest	Kaeng Krachan NP	103.85	Nuanurai (2005)
	Kaeng Krachan NP	35.40	Jampanin and Gajaseni (2005)
	Thong Pha Phum NP	70.29	Terakunpisut *et al*. (2004)
	Sakaerat Environmental Research Station	135.00	Boonraksa (1989)
	Sang Khom, Nong Khai	196.51	Senpaseuth *et al*. (2009)
	Northeast, Thailand	60.30	Ogawa *et al*. (1965)
Mixed Deciduous Forest	Lower Northern, Thailand	51.58	Kaewkrom *et al*. (2011)
	Kaeng Krachan NP	34.26	Nuanurai (2005)
	Thong Pha Phum NP	93.00	Terakunpisut *et al*. (2004)
	Khun Korn Waterfall FP, Chiang Rai	99.14	Nukool (2002)
	Doi Suthep, Chiang Mai	95.73	Viriyabuncha *et al*. (2002)
	Nam Prom Basin, Chaiyaphoom	140.83	Handechanon (1990)
	Chiang Mai	67.00	Yamakura *et al*. (1976)

Table 2.5 (Continued).

Forest types	Locations	Carbon stock (tC/ha)	Sources
	Northeast, Thailand	155.50	Ogawa *et al*. (1965)
Secondary Mixed Deciduous Forest	Lower Northern, Thailand	30.74	Kaewkrom *et al*. (2011)
Dry Dipterocarp Forest	Kaeng Krachan NP	29.31	Nuanurai (2005)
	Nam Prom Basin, Chaiyaphoom	70.78	Handechanon (1990)
	Sang Khom, Nong Khai	94.35	Senpaseuth (2009)

Note: NP, National Park; FP, Forest Park

2.3 Soil Carbon Storage

Soil carbon is one of the important pools constituting global carbon budget and plays a key role in crop production and management. The amount of carbon storage is related to land use and soil management. The changing of land use from forest to agriculture in Thailand has increased rapidly in many parts of the country. This forest conversion to crop may lead to decreased or increased soil carbon storage, depending on the management techniques employed (Cerri and Andreux, 1990; van Noordwijk, Cerri, Woomer, Nugroho, and Bernoux, 1997; Tan and Lal, 2005). Improving soil management has great potential to increase the amount of carbon sequestered in cropland soil.

Recently, the soil carbon status of Thailand project was carried out in 2004-2008 by Land Development Department (Jaiarree, 2010). From 2,443 soil samples, soil organic carbon (SOC) contents map of Thailand has been eventually drawn (Figure 2.4).

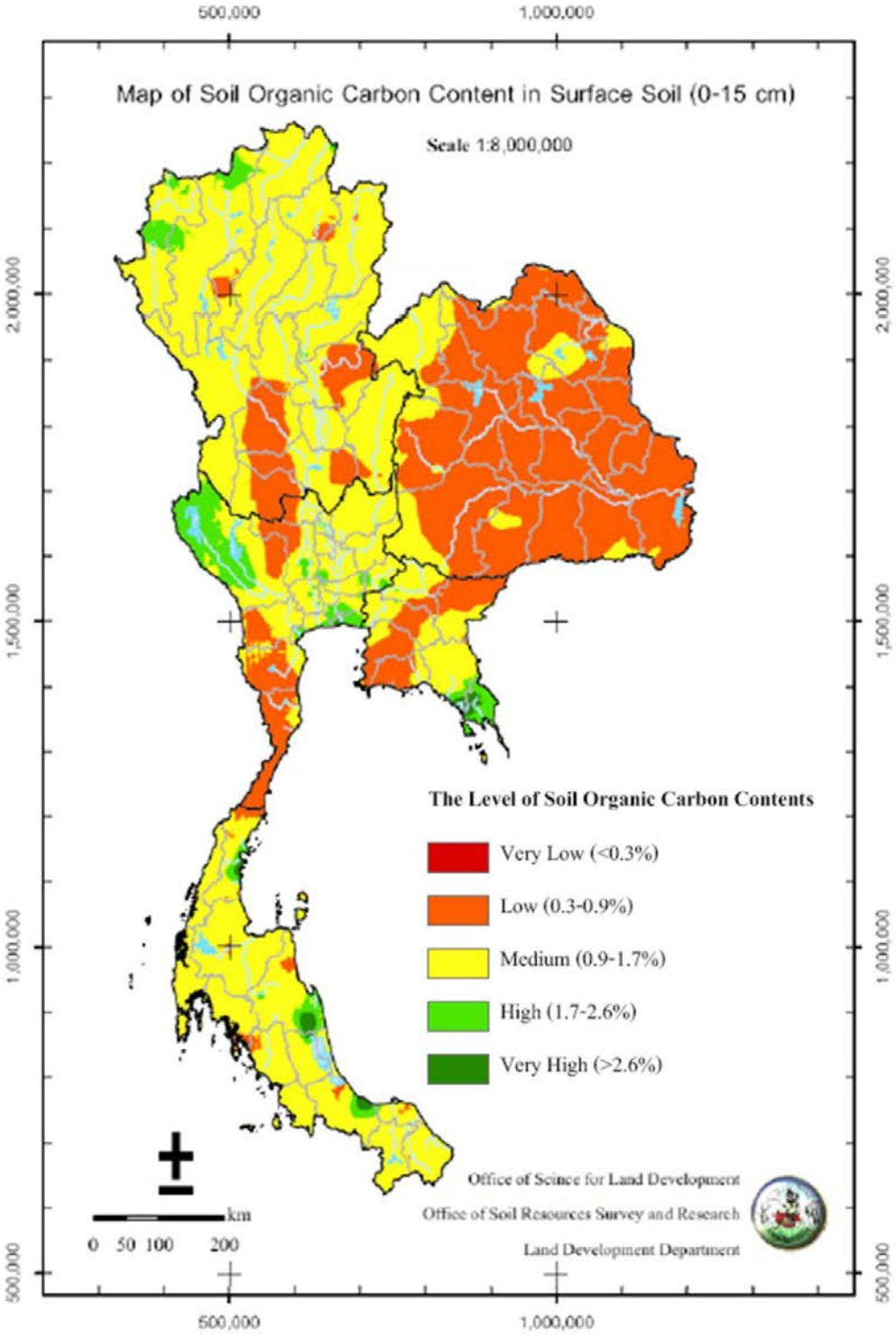

Figure 2.4 The soil organic carbon status of Thailand in 2008 (Jaiarree, 2010).

SOC content estimates of different soil depth in various forest types have been determined (Table 2.6). The results indicate that the accumulation of SOC in the 0-25 cm was around 10.27 kg/m^2 in the surface soil. It is somewhat higher in Evergreen Forests than other types of forest. Because this types of forest has a high density of vegetation that covers the soil. SOC accumulation in the 0-25 cm layer was around 6.99 kg/m^2 in Mixed Deciduous Forest and it increased to 14.17 kg/m^2 in the 0-100 cm layer. In Dry Dipterocarp Forest, the content of SOC in the 0-25 cm is quite low, around 3.66 kg/m^2 (Moncharoen and Viensilp, 2001).

Table 2.6 Estimated SOC in different types of forest in Thailand.

Forest types	**Area**		**Organic carbon (kg/m^2)**		
	hectares	**%**	**0-25 cm**	**0-50 cm**	**0-100 cm**
Dry Dipterocarp	434.07	8.46	3.66	4.94	6.56
Evergreen	740.89	14.44	10.27	15.78	20.82
Mixed Deciduous	243.08	4.74	6.99	10.25	14.17
Pine	9.51	0.19	9.20	12.21	14.33
Deforestation area	71.37	1.39	5.70	8.75	11.99

Source: Moncharoen and Viensilp (2001)

Lichaikun *et al*. (2006) found that SOC accumulated in native forest was higher than those in reforestation and agriculture land (corn), respectively. Concentration of carbon stored in soil under native forest was 15-30 mgC/g of soil at 0-20 depth (Figure 2.5). While carbon stored in soil under reforestation and agriculture land (corn) were 10-15 and < 10 mgC/g of soil, respectively. By multiplying with the

bulk density, the total carbon stock for 50 cm of soil depth under native forest, reforestation, and agriculture land, were 118, 66, and 57 tC/ha, respectively.

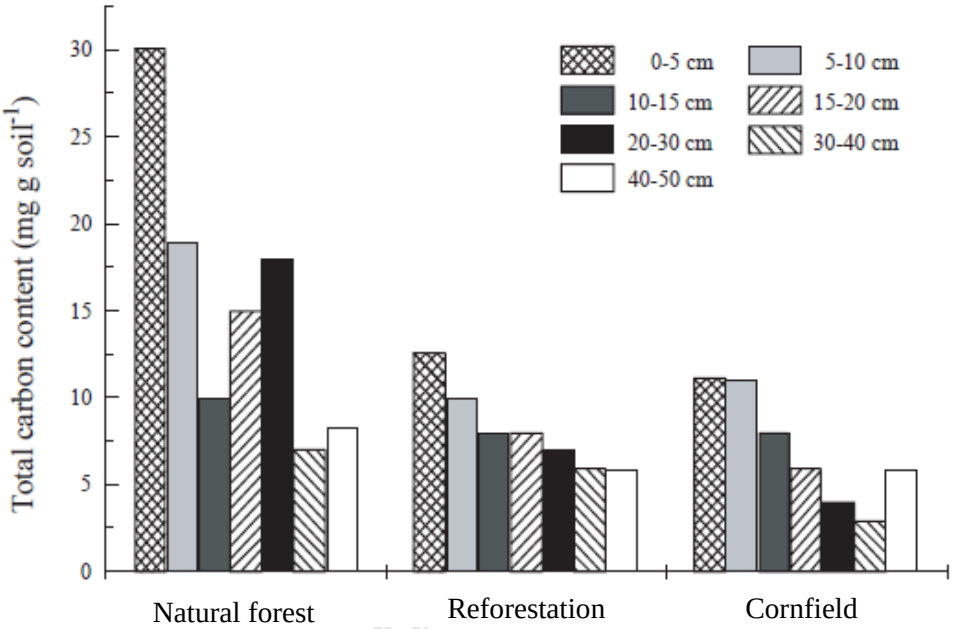

Figure 2.5 Soil carbon stock under different land use type and at different depth (Lichaikun *et al*., 2006).

More than 60% of organic carbon was found in the topsoil (0-10 cm). When the values of soil carbon content were plotted against number of years after deforestation, it was found that soil carbon was reduced at the rate of 6.97 tC/ha/yr (Jaiarree *et al*., 2006). The turnover time of surface soil carbon was 8.67 years, while in the subsurface soil (40-50 cm) the turnover rate was 0.29 tC/ha/yr and turnover time was 44.05 years. However, other interesting researches in soil carbon are showed in Table 2.7.

Table 2.7 The researches of soil carbon in Thailand.

Study area	Year	Details	C stock (t/ha)	References
Abondoned agricultural land	2008	Depth 0-15 cm Depth 15-30 cm	10.50 6.20	Chaun *et al*. (2010)
Organic tapioca Nakhon Ratchasima	2007	Depth 0-20 cm	7.11	Fungladda *et al*. (2010)
Tropical upland soils (0-50 cm)	2003-2004	Natural forest Reforestation Agriculture	118 66 57	Lichaikun *et al*. (2006)
Agro-ecosystems (0-100 cm)	2004-2005	Natural forest Intensive Conventional	23.54 41.55 26.47	Jaiarree (2009)

Sources: Jaiarree (2010)

2.4 Forest Types of Thailand

Basically the forest of Thailand can be classified into two categories: Evergreen Forest and Deciduous Forest (MNRE, 2008; FAO, 2009).

2.4.1 Evergreen Forests

The Evergreen Forest is composed of a great proportion of the non-leave shedding species and forming about 60% of the total forested area. Evergreen Forest can be sub-divided into Tropical Evergreen Forest, Pine Forest, Mangrove Forest and Beach Forest.

1) Tropical Evergreen Forest is found all over the moist part of the country. This type of forest is also subdivided into the tropical rain forest, the Semi-Evergreen Forest and the Hill Evergreen Forest.

Tropical Rain Forest is characterized by a very rich flora and very dense undergrowth. This type of forest is commonly found in the Southern and the Eastern regions where rainfall is above 2,000 mm. It is also found along rivers and/or in valleys in other parts of the country. The predominant genera (the top storey species) are, for example, *Dipterocarpus*, *Hopea*, *Lagerstroemia*, and *Shorea*, whereas the lower storey species are bamboos, palms and rattans.

Semi-Evergreen Forest is scattered all over the country where the rainfall is between 1,000-2,000 mm. The predominant genera are *Dipterocarpus*, *Hopea*, *Diospyros*, *Afzelia*, *Terminalia*, and *Artocarpus*. The main undergrowth species consist of bamboos and rattans.

Hill Evergreen Forest is found on the highlands (above 1,000 m from the sea level) where the climatic condition is the humid subtropical type. The presence of mosses and lichens on trees and rocks is the indicator of this forest type. The

predominant species are oaks (*Quercus* spp.) and chestnuts (*Castanopsis* spp. and *Lithocarpus* spp.).

2) Pine Forest has two species of tropical pines, *Pinus merkusii* locally called Son Song Bi (the two-needlepine) and *P. kesiya* locally called Son Sam Bi (the three-needle pine). *P. merkusii* is found in the northern and the western part of the Central region, where the soil is poor (grave) lateritic and podzolic. *P. kesiya* is found only in the highlands of the Northern and Northeastern regions.

3) Mangrove Forests occur along the coastal areas of the Eastern, Central and Southern regions. The Mangrove Forest is scattered along the estuaries of rivers and seashores where the soil is muddy and influenced by the tide. The predominant genera are *Rhizophora, Xylocarpus, Avecennia, Bruguiers* and *Nypa*.

4) Beach Forests occur along the sandy coastal plains especially in the eastern coast of the Southern region. The main genera in this type of forest are *Diospyros, Croton, Lagerstroemia* and *Casuarinas*.

2.4.2 Deciduous Forests

The Deciduous Forest is composed of species with leafless periods. Tree growing in this types of forest tend to develop growth or annual ring, a feature not often found in the species of the Evergreen Forest. This forest is more or less subjected to ground fire during the dry season.

Mixed Deciduous Forest is commercially among the most valuable forest of Thailand. In the Northern Region, this type of forest is called the teak forest with *Tectona grandis, Xylia kerrii, Pterocarpus marcrocarpus, Afzelia xylocarpus* and *Dalbergia* spp. (rose wood) as dominant/common species.

Dry Dipterocarp Forest is commonly found in the dry area (rainfall below 1,000 mm) with sandy or gravely lateritic interfertile soils. The predominant species are mainly *Dipterocarpaceae* such as *Diptercarpus tuberculatus, D. obtusifolius, Shorea obtusa, S. siamensis* with the presence of *Dalbergia* spp., *Lagerstroemia* spp., *Terminalia* spp. and other species.

The description of forest types and areas are given below (Table 2.7).

Table 2.7 Forest types and areas of Thailand in 2000.

Forest ecosystem	**km^2**	**1,000 ha**
Tropical Rain Evergreen Forest	15,448.85	1,544.89
Semi-Evergreen Forest	22,903.16	2,290.32
Hill Evergreen Forest	14,327.04	1,432.70
Pine Forest	462.08	46.21
Swamp	560.79	56.08
Mangrove Forest	2,452.55	245.25
Beach Forest	124.96	12.50
Mixed Deciduous Forest	87,444.74	8,744.47
Dry Deciduous Forest	18,569.52	1,856.95
Bamboo Forest	1,503.50	150.35
Eucalyptus Plantation	1,510.28	151.03
Other (forest spp.) Plantation[a]	1,966.72	196.67
Rehabilitated Forest	2,836.59	283.66
Total	170,110.78	17,011.08

Note: [a]excludes rubber plantations, which is considered a commercial agricultural crop
Source: MNRE (2008)

2.5 Forest Structure

Importance value index (IVI) is used to determine the overall importance of each species in the community structure. It is a measure often used to describe and compare the species dominance of the plots (Cottam and Curtis, 1956). The IVI for a species is calculated as the sum of its relative dominance, its relative frequency and its relative density (Curtis, 1959). Certain points have to be acknowledged, to understand the arguments the IVI is providing. Species occurring singular but with a high basal area may be given the same rank as widely spread but small species. Also some species may be dominant in one site but do not occur at other sites. Therefore their local dominance is not displayed in the overall statistics. Still, the IVI is giving a figure with the overall importance of a species.

Lamotte *et al*. (1998) described structure of three tropical forests at Sakaerat Environmental Research Station (SERS), Thailand. Species composition of both Dry Dipterocarp Forest and Dry Evergreen Forest together with their IVI for the 10 most important families are shown in Tables 2.8 and 2.9. The dominant family was *Dipterocarpaceae* in both DDF and DEF. The IVI of this family for each forest were 155.4 and 85.0, respectively.

Table 2.8 Importance value index (IVI) for the 10 ecologically most important families of DDF in SERS.

Family	Number of species	Basal area (m^2)	RF	RD	RDo	IVI
Dipterocarpaceae	4	9.5351	37.84	50.17	67.36	155.4
Fabaceae	4	1.1440	13.28	11.13	8.08	32.5
Mimosaceae	2	0.8098	13.03	9.97	5.72	28.7
Rubiaceae	3	0.5013	10.53	8.14	3.54	22.2
Caesalpinaceae	3	0.8741	5.26	4.65	6.18	16.1
Anacardiaceae	2	0.2421	5.01	4.32	1.71	11.0
Fagaceae	1	0.5342	3.76	3.49	3.77	11.0
Euphorbiaceae	3	0.1442	4.01	2.99	1.02	8.0
Verbenaceae	1	0.0531	1.00	0.66	0.38	2.0
Chrysobalanaceae	1	0.1285	0.50	0.50	0.91	1.9
Remaining families	13	0.1835	5.76	3.99	1.33	11.1
Total	37	14.154	100.00	100.00	100.00	300.0

Note: RF, Relative Frequency; RD, Relative Density; RDo, Relative Dominance

Source: Lamotte *et al*. (1998)

Table 2.9 Importance value index (IVI) for the 10 ecologically most important families of DEF in SERS.

Family	Number of species	Basal area (m^2)	RF	RD	RDo	IVI
Dipterocarpaceae	2	15.137	14.81	18.04	52.19	85.0
Meliaceae	2	1.6074	15.98	17.54	5.54	39.1
Memecylaceae	2	1.6446	14.37	14.92	5.67	35.0
Flacourtiaceae	1	1.3560	9.53	9.98	4.68	24.2
unknown	1	1.0963	4.99	4.03	3.78	12.8
Lythraceae	1	2.2620	1.61	1.11	7.80	10.5
Rubiaceae	2	0.2802	4.40	4.74	0.97	10.1
Aquifoliaceae	1	0.6903	4.11	3.23	2.38	9.7
Rhizophoraceae	1	0.5439	3.81	3.33	1.88	9.0
Clusiaceae	2	0.2364	3.37	2.92	0.82	7.1
Remaining families	33	4.1493	23.02	20.16	14.31	57.5
Total	48	14.154	100.00	100.00	100.00	300.00

Note: RF, Relative Frequency; RD, Relative Density; RDo, Relative Dominance

Source: Lamotte *et al*. (1998)

Jampanin and Gajaseni (2005) found that a few dominant species with high aboveground biomass also had high IVI. At Kaeng Krachan National Park, the dominant species in Mixed Deciduous Forest were *Tetrameles nudiflora* R. Br., *Largerstomia* spp., *Hydnocarpus ilicifolius* King and *Afzelia xylocarpa* Roxb. While the dominant species in hill evergreen forest were *Castanopsis diversifolia* King., *Quercus lamellosa* Smith, *Dipterocarpus* spp., *Aphanamixis polystachya* Parker,

Syzegium cumini (L.) Skeels, *Eugenia aequea* Burm.f. and *Xerospermum intermedium* Radlk.

Piyaphongkul *et al*. (2011) compared the dominant species between primary forest and secondary forest in Khao Yai National Park. The result indicated that common species in the primary forest were *Ardisia nervosa* (127 tree/ha, IVI = 56.08), followed by *Mastixia pentandra*, *Gonocaryum lobbianum*, *Dipterocarpus gracilis*, *Cinnamomum subavenium* and *Aglaiae laeagnoidea*, respectively. The contribution of the dominant species in the secondary forest was *Schima wallichii* (505 trees/ ha, IVI = 71.94) and 2 co-dominant species were *Machilus odoratissima* and *Eurya nitida*.

2.6 Land Use and Land Cover Change in Thailand

In tropical countries, like Thailand, one of the prominent characteristics of Land Use and Land Cover Change (LUCC) is the decline in forest and woodlands due to land conversion, in particular from agricultural expansion for cash crop production (FAO, 1997, 2003; Barbier and Burgess, 2001). Research conducted by the FAO (2001) suggested that large-scale agriculture is the major cause of deforestation (about 32%), followed by small-scale agriculture (about 26%). Intensification and expansion of the agriculture in shifting cultivation practice comprise about 15% of tropical deforestation.

In 2001, the land use of the country was divided between agriculture or farm holdings (41%), forest (31%) and unclassified area (28%) (Table 2.10). This pattern was the result of rapid expansion of agriculture on what was previously forest land. There were significant differences in the land-use pattern by region; the North had more than 50% underforest cover, while the other regions were predominantly

agricultural. One-third of the total land in the other three regions remained "unclassified". This included urban, peri-urban area and infrastructure but obviously also degraded areas which were in the past under forest cover.

Table 2.10 Land-use patterns by region in 2001.

Region	Forest (%)	Farm holding land (%)	Unclassified (%)
North	54.0	26.4	19.6
Northeast	15.0	55.0	30.0
Central	27.1	30.9	33.0
Southern	22.5	43.4	34.1
Total	31.4	40.9	27.7

Source: Agricultural Statistics of Thailand (2004)

2.6.1 Forestry

Forest cover in Thailand has decreased substantially during the last 30 years (1961-1991) due to heavy commercial logging of trees, followed by large-scale conversion of forest land to non-forest uses. Forest cover in Thailand has decreased from 53.33% in 1961 to 25.28% in 1995 (FAO, 1999) and 17.00% by 1999 (Prayurasiddhi, Chiwatana, and Naporn, 1999), which may have resulted in greatly reduced forest biodiversity.

In 1961, the total forest area of Thailand was 273,629 km^2 or about 27 million ha or 171,017,812 rai, covering over 53.33% of the country. Subsequently, forest areas were encroached for the purpose of slash-and-burn, shifting cultivation, land resettlement, dam and road construction, and land reform for agriculture. As a

result, the share of forest area declined to 25.28% in 1998. From 2000 onwards, the forest has been assessed from Landsat-5 interpretation imageries at the scale of 1:50,000, while the earlier assessments were made using imageries of 1:200,000. Due to the change of scale and method of calculation, a new benchmark was established for forest area (Table 2.11). The annual rate of deforestation has been about 63,000 ha/yr since 2000, or higher than in the 1990s. The 2004 forest area is estimated at 16.8 million ha (32.66%) (FAO, 2009).

By 2006, the total forest cover in Thailand is estimated at 15.8 million ha, representing over 30.92% of the total land area of 513,000 km^2 or 51.31 million ha compared to 1961, which had an estimated forest cover of over 50% of total land area. After submission of the Initial National Communication in 2000 by Thailand to the UNFCCC covering 1990-1994 data, the mapping (benchmarking) of forest cover and areas deforested using GIS technology has been produced for the years: 1995, 2000 and 2005. The deforestation rate estimated between 2000 and 2005 is at 1.07%, which is higher than what has been so far assumed 0.73% in the period 1991-1998 (FAO, 2009). However, FRA (2010) used Landsat-5 TM data with scale 1:50,000 as basis to estimate trend of forest area in 1990, 2000, 2005 and 2010 (Table 2.12). They found that forest cover of 19.55 million ha or 38.10% of total area were observed in 1990, while only 18.97 million ha or 36.97% of total area was found in 2010.

Table 2.11 Forest cover from 1961 to 2006.

Year	Forest cover	
	1,000 ha	**% of the country area**
1961	27,369	53.33
1973	22,172	43.21
1976	19,841	38.67
1978	17,522	34.15
1982	15,680	30.56
1985	15,087	29.40
1988	14,380	28.02
1989	14,343	27.95
1991	13,670	26.64
1993	13,355	26.03
1995	13,148	25.62
1998	12,972	25.28
2000*	17,011	33.15
2004	16,759	32.66
2005	16,100	31.38
2006	15,865	30.92

Note: *Change image resolution from 1 : 200,000 to 1 : 50,000

Source: FAO (2009)

Table 2.12 The extent of forest and other wooded land during 1990-2010.

FRA 2010 categories	Area (1000 ha)			
	1990	**2000**	**2005**	**2010**
Forest	19,549	19,004	18,898	18,972
Other land	31,540	32,085	32,191	32,117
Inland water body	223	223	223	223
Total	51,312	51,312	51,312	51,312

Source: FRA (2010)

2.6.2 Protected Area

Since the enactment of the National Park Act in 1961, the areas under legal protection have expanded rapidly and they presently cover 17% of the total nation territory. The protected area (PA) system consists of national parks, or local government-controlled forest parks, wildlife sanctuaries, no-hunting areas (mostly private lands), botanical gardens and arboretums (FRA, 2010). The existing 227 protected areas amount to 11.3 million ha and they are under the control of Department of National Parks Wildlife and Plant Conservation (Lakanavichian, 2001).

Although extensive, the PA system contains disproportionate amounts of upland forest but very little lowland evergreen forest. Apart from this, MacKinnon (1997) rated habitat coverage as “quite satisfactory” and reported “no obvious gaps”. All bio units and subunits were represented. Already prior to the logging ban it was widely believed that the PA network in Thailand was one of the best in Southeast Asia (Parr, 1996).

In 1979, Thailand had only 16 national parks covering an area of 935,700 ha. But by 2010, they are 426 protected area covering 103.8 million ha (Table 2.13).

Whereas, 123 National Parks (NP), covering an area of 6.03 million ha, had been established. All the 58 wildlife sanctuaries (WS) (conservation areas) are gazetted, covering area of 36.9 million ha. In addition, 113 forest parks (FP) have been created covering an area of 1.2 million ha. There are 60 no-hunting areas (NHA) covering 5.2 million ha. Botanical Garden (BG) and Arboretum (Ar) are covering area of 4,540 and 4,300 ha, respectively. However, out of which about 17,000 ha are on private lands, and the rest on public lands, probably with more effective control for hunting risks in the latter case (FAO, 2009).

Besides taking stringent efforts in covering a total of 9.3 million ha as protected areas, Thailand has also created 1,221 National Forest Reserves spread over 23.4 million ha (Figure 2.6). Out of the five regions in Thailand, the North has the largest area under National Forest Reserves with 11.2 million ha. It is highly significant for policy design that National Forest Reserves together with protected areas cover about 63.2% of the total area of the country. However, about 20% of the country's 56,000 villages are also located within forest reserves (FRA, 2010). This would be very challenged to conserve the forest area from local people.

Table 2.13 Number and area of natural conservation and recreation by type in 2006-2010.

Type	2006		2007		2008		2009		2010	
	unit	area (1000 ha)	unit	area (1000 ha)	unit	area (1000 ha)	unit	area (1000 ha)	unit	area (1000 ha)
NP	103	52,773.7	108	54,725.5	110	55,135.3	123	60,323.8	123	60,320.1
FP	112	1,298.9	113	1,238.8	113	1,236.7	112	1,238.0	113	1,239.0
WS	55	35,748.8	57	36,203.2	57	36,578.7	58	36,929.4	58	36,929.4
NHA	56	4,346.5	51	3,776.2	60	5,233.0	53	4,060.4	60	5,233.0
BG	16	46.3	51	46.3	16	41.4	16	41.4	16	45.4
Ar	55	41.9	16	41.9	55	42.8	56	43.0	56	43.0
Total	397	94,256.1	400	96.031.9	410	98,267.9	418	102,636.3	426	103,809.9

Note: NP, National Park; FP, Forest park; WS, Wildlife sanctuary; NHA, No-hunting area; BG, Botanical garden; Ar, Arboretum

Source: DNP (2011)

Luangjame (2005) reported the forest decline in all but one of the western protected areas from 2000 to 2004 (Table 2.14). Umpang wildlife sanctuary suffered the worse, losing 8,147 ha in 4 years.

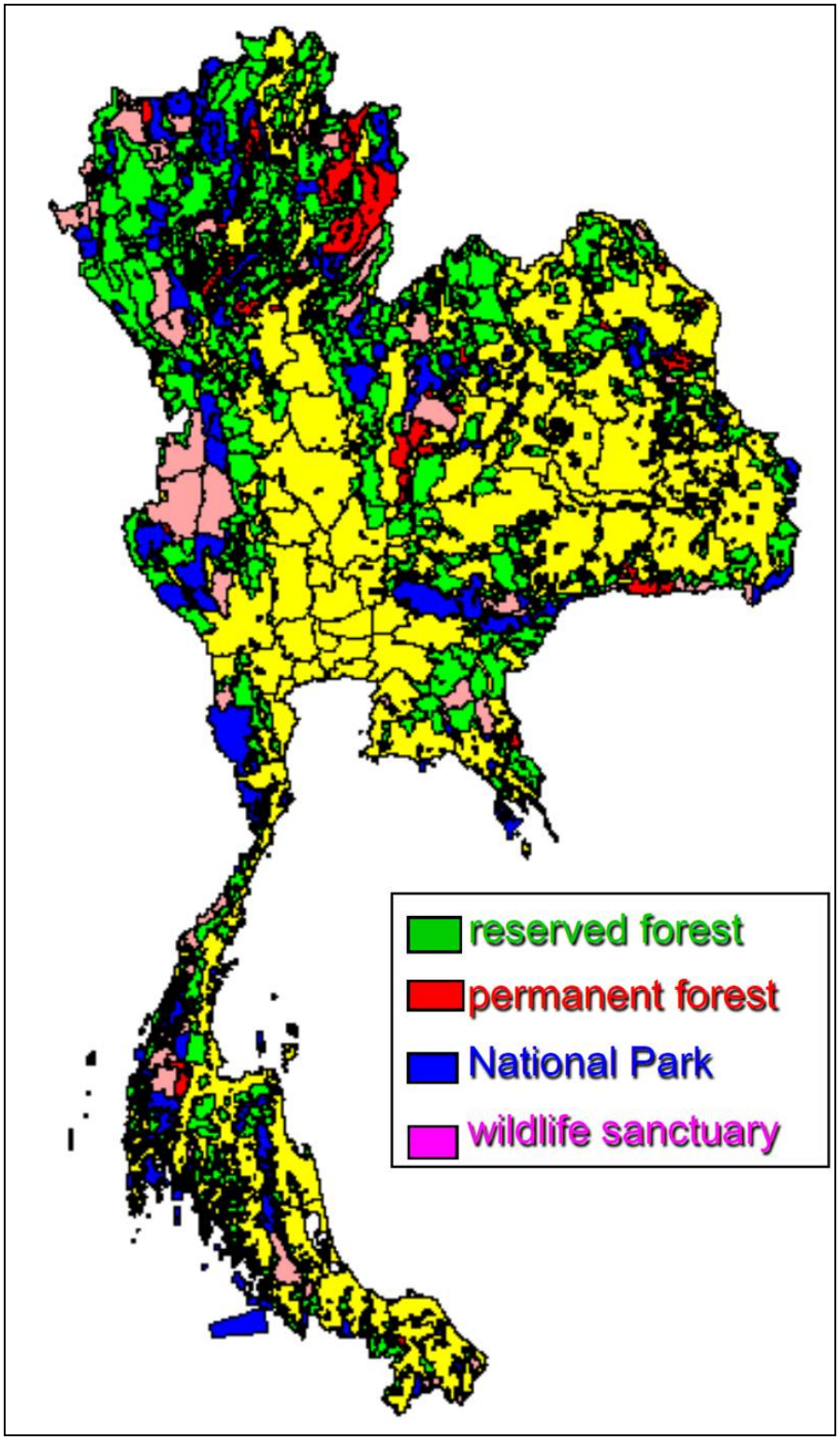

Figure 2.6 National Forest Reserves in Thailand (FRA, 2010).

Table 2.14 Land use changes in the western protected areas in 2000-2004.

Study area	Forest area (ha)		Total change (ha)	Annual change (ha)
	2000	2004		
Khao Sanam Priang WS	9,772.83	9,415.80	-357.03	-89.25
Khlong Wang Chao NP	70,069.76	69,089.66	-980.10	-245.02
Salak Phra WS	88,839.19	87,305.65	-1,531.41	-383.38
Erawan NP	49,148.35	46,879.22	-2,269.13	-567.28
Lam Khlong Ngu NP	64,483.10	64,021.55	-461.55	-115.38
SaiYok NP	91,041.92	89,991.74	-1,050.18	-262.54
Thong Pha Phum NP	107,418.52	107,917.31	557.66	139.41
Umphang WS	245,804.00	237,657.23	-8,146.77	-2036.69

Note: WS, Wildlife Sanctuary; NP, National Park

Source: Luangjame (2005)

2.7 Thap Lan National Park

2.7.1 Location and Administration

Thap Lan National Park, one of DPKY - FCWH, was declared as Thailand's 40th national park in December 1981. It is situated in Nakhon Ratchasima, Buri Ram and Prachin Buri Provinces (Figure 2.7), located between latitude 14°05′ to 14°33′ N and longitude 101°50′ to 102°40′ E. It is the country's second largest national park, covering an area of 2,235.80 km^2. It is comprised of continuous mountain ranges with naturally created valleys, chasms and waterfalls. The highest peak of the park is Khao Lamang, at a height of 992 m above sea level. Thap Lan National Park extends across two provinces: Nakhon Ratchasima and Pranchin Buri. The park headquarter is situated 197 km from Bangkok.

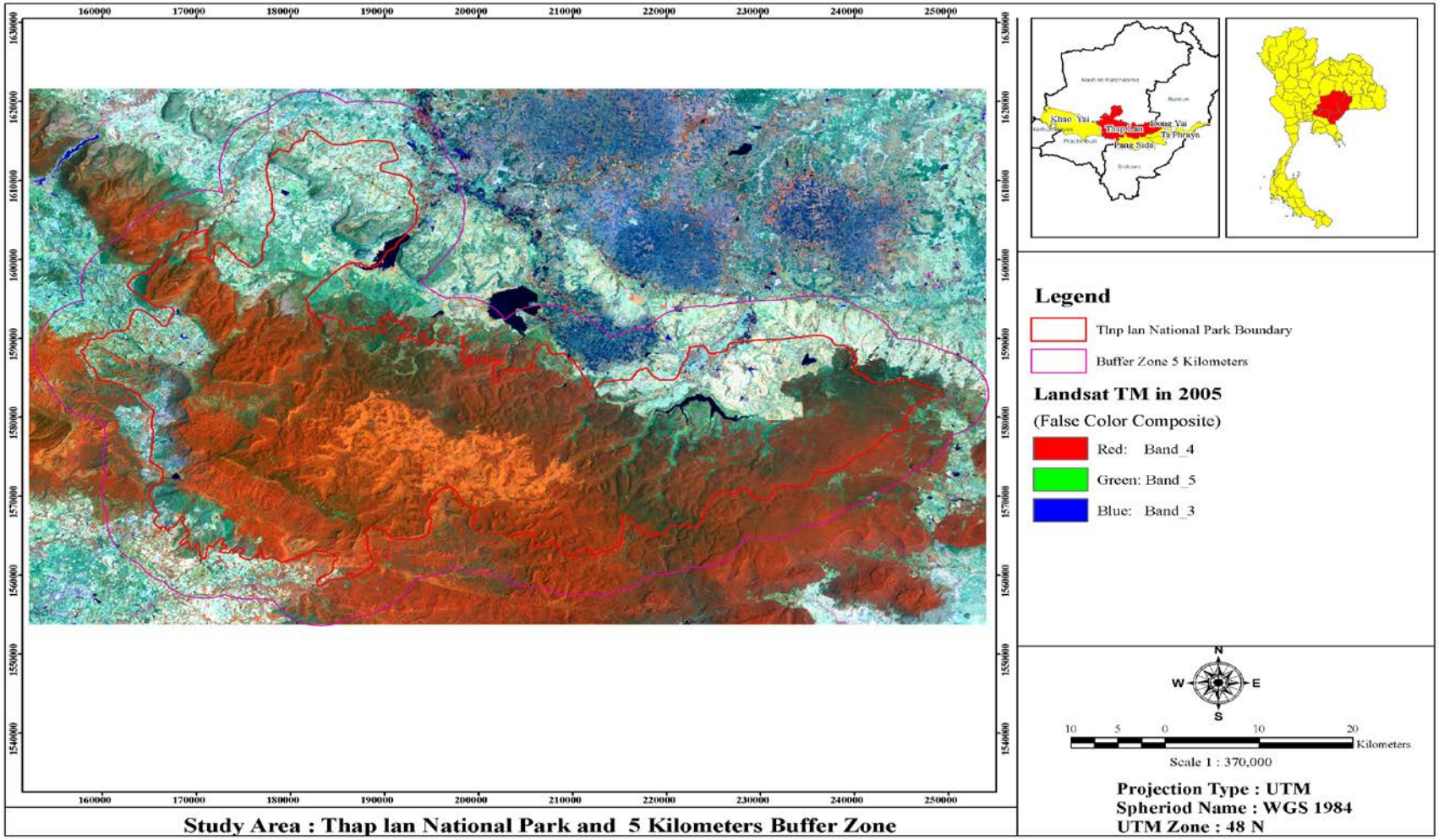

Figure 2.7 Location and administration.

2.7.2 Management

Park headquarter is located close to the 304 road in Na Dee district, Prachin Buri province. Thap Lan National Park has 14 ranger stations which are distributed around the park namely, Klong Num Mun, Lam Ply Mas, Lam Plang, Khao Ma Ca, Hui Toei, Wang Ta Lu, Khao Mai Plong, Ta Ling Chun, Lam Ma Phai, Phu Lam Yai, Thai Sa Mak Kee, Sub Sa Dao, Suan Hom, and Lam Phiak. The location and distribution of each station is shown in Figure 2.8.

2.7.3 Topography

The park comprises of great mountain range in the west (e.g. Khao Lamang, Phu Sam Ngam, and Phu Sung mountains). The Phu Sam Ngam is the highest mountain approximately 992 m above mean sea level (Figure 2.9). This national park is important as the origin of Mon and Bang-Pa-Kong rivers.

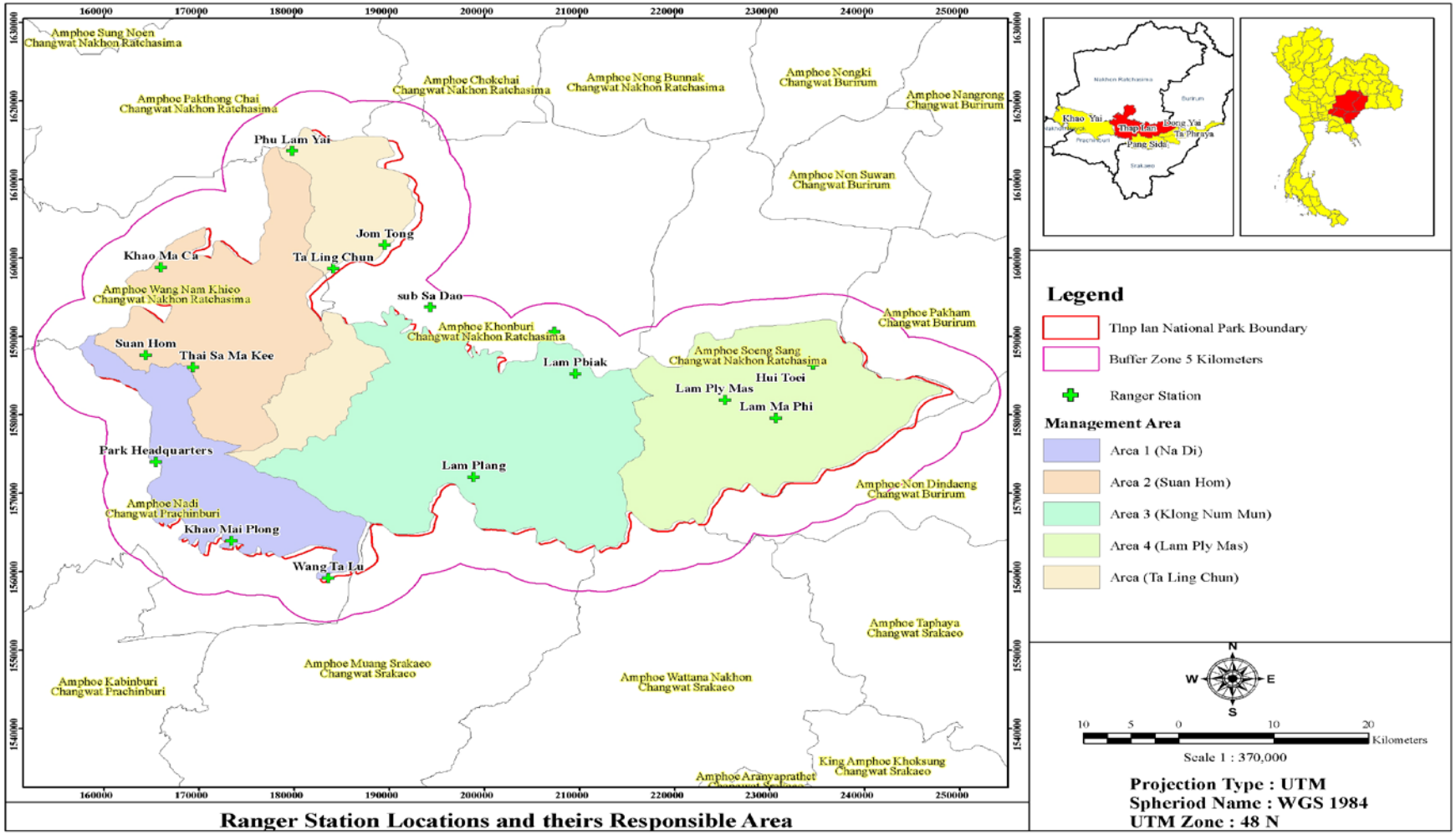

Figure 2.8 Ranger station and management areas of Thap Lan National Park.

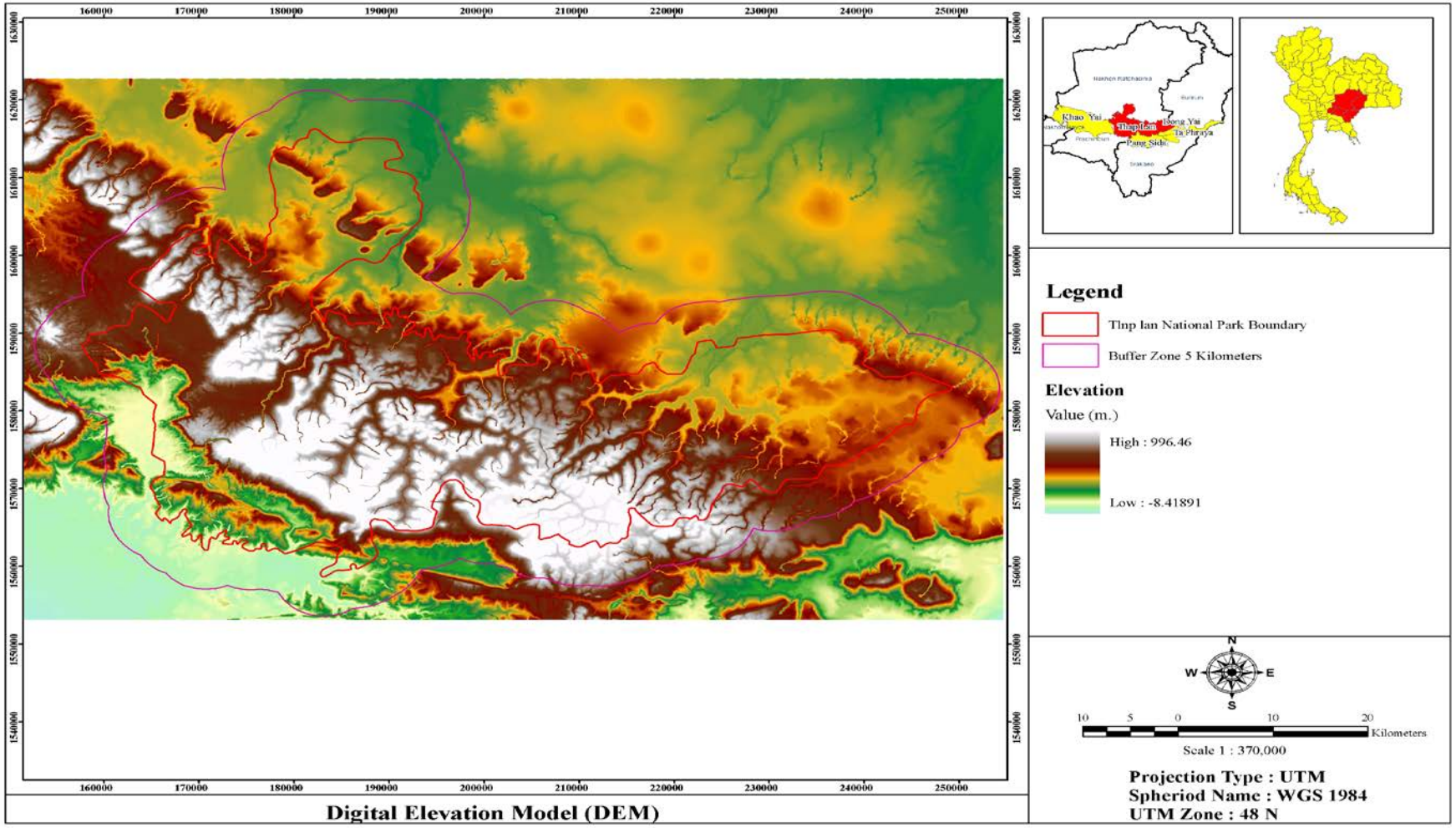

Figure 2.9 Topography of Thap Lan National Park.

2.7.4 Climate, Temperature and Rainfall

In general, there are three seasons in the region; hot season (mid February to mid May), rainy season (mid May to mid October) and cool dry season (mid October to mid February). Rainy season is under the influence of the southwest monsoons, while cool-dry season is influenced by the northeast monsoon carrying cold air from China.

The annual average temperature ranges from 27.0 to 27.7°C. The highest temperature in April varies from 35.7 to 36.9°C. The lowest temperature in January varies from 16.9 to 19.4°C.

The annual average rainfall ranges from 1,096.6 to 1662.2 mm. The highest rainfall in September varies from 231.1 to 303.2 mm. The lowest rainfall in December varies from 1.8 to 5.3 mm.

2.7.5 Land Use and Land Cover

In 1999, Land Development Department (LDD) classified land use types in Thap Lan National Park into 6 categories including: urban and built-up area (4.35 km^2), forest land (1,646.07 km^2), forest plantation (43.38 km^2), grassland and shrub (85.92 km^2), water bodies (18.44 km^2), and miscellaneous land (390.00 km^2).

In 2000, Royal Forest Department (RFD) classified forest types of Thap Lan National Park into 4 categories including 1) Dry Evergreen Forest, 2) Mixed Deciduous Forest, 3) Dry Dipterocarp Forest and, 4) Bamboo Forest (Figure 2.10).

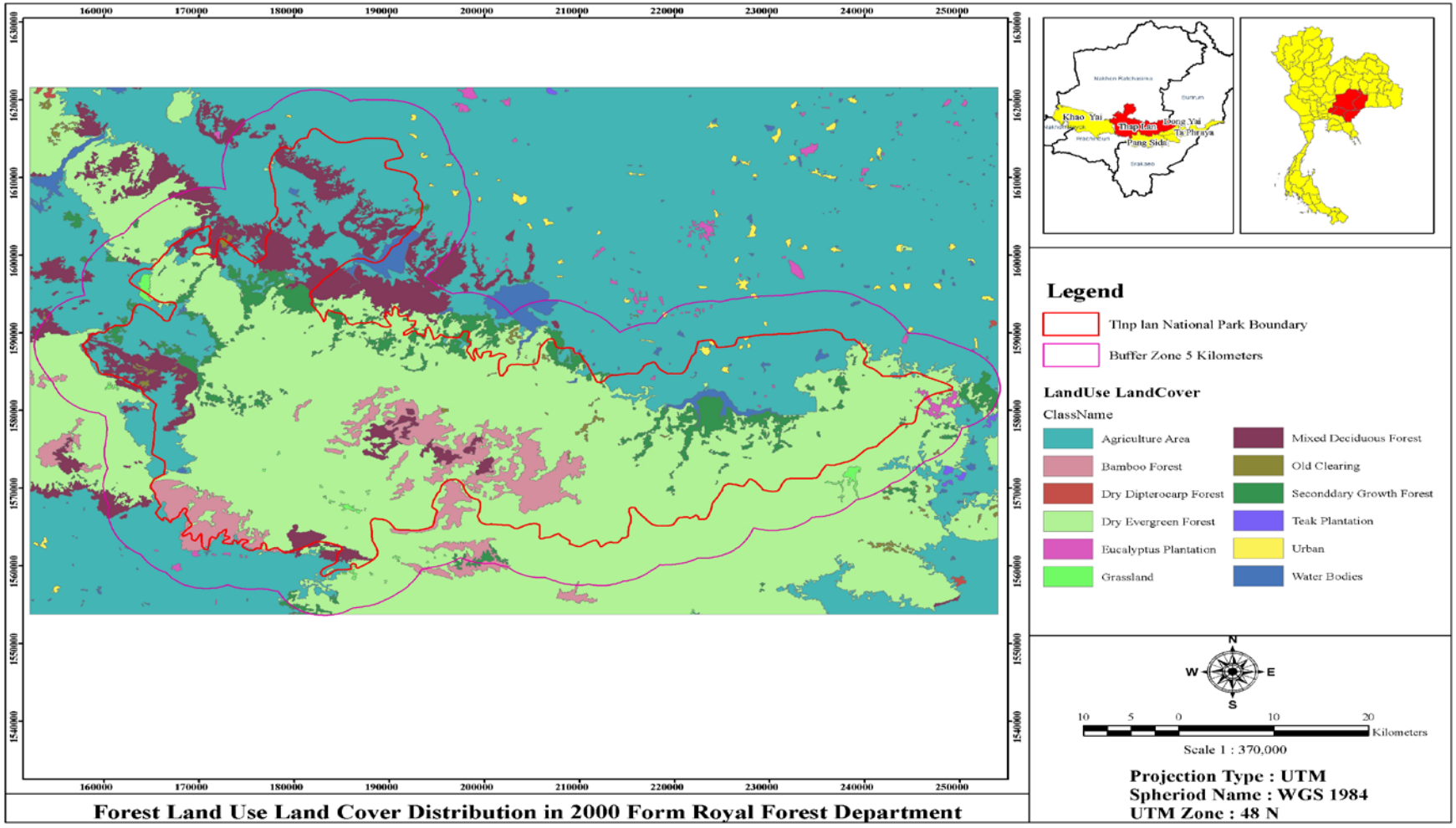

Figure 2.10 Forest land use and land cover in 2000 from Royal Forest Department of Thap Lan National Park.

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CHAPTER III

MATERIALS AND METHODS

The research is about the assessment of land use change and the forest carbon sequestration in Thap Lan National Park. The study has recognized the following procedures and instruments.

3.1 Study Area

The total study area of 3,824.15 km^2, the area of 2,219.47 km^2 for the Thap Lan Natioinal Park and 1604.68 km^2 for the 5 km buffer zone around the national park, were observed in this study. This study area also has 25 sub-districts (Tambol) and consists of 246 villages (Table 3.1) (DNP, 2007).

Table 3.1 List of provinces, districts, sub-districts and number of villages in Thap Lan National Park and the 5 km buffer zone.

Province	**District**	**Sub-district**	**No. of villages**
Nakhon Ratchasima	Khon Buri	1. Khon Buri	19
		2. Khon Buri Tai	4
		3. Chorakhe Hin	2
		4. Khok Krachai	7
		5. Lam Phiak	17
		6. Oraphim	11
		7. Khon Buri	19
		8. Khon Buri Tai	4
		9. Chorakhe Hin	2
		10. Khok Krachai	7
		11. Lam Phiak	17
		12. Oraphim	11
	Pak Thong Chai	13. Ngio	3
		14. Don	1
		15. Phu Luang	6
		16. Samrong	2
		17. Sakaerat	14
		18. Sa Takhian	8
		19. Non Sombun	9
		20. Wang Nam Khiaw	22
		21. Udom Sap	31
	Chok Chai	22. Thung Arun	4
Prachin Buri	Na Dee	23. Bu Phram	7
		24. Kaeng Dinso	15
		25. Thung Pho	4
Total			**246**

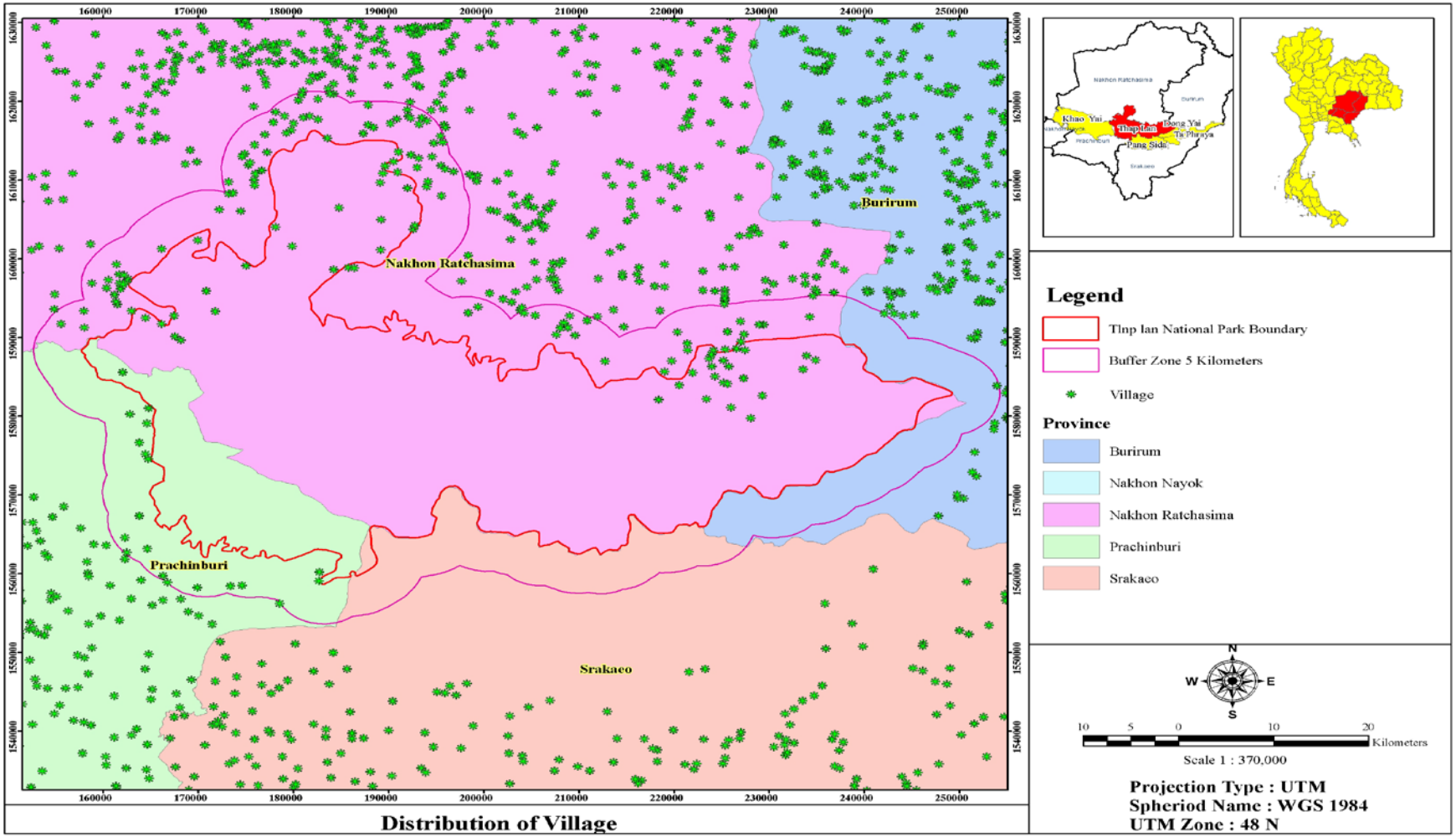

Figure 3.1 Study area and the villages in Thap Lan National Park and it 5 km buffer zone.

3.2 Materials

The study is an exploring-oriented area including primary and secondary data presented in Table 3.2.

Table 3.2 Data and maps.

Data and maps	Year	Scale	Source/Remarks
1. Maps and images			
- Topographic data**:** Sheet Number 5338 II, 5438 III, 5337 I, 5337 II 5537 III, and 5537 IV	2000	1:50,000	Royal Thai Survey Department
- Landsat TM**:** Path 129, Row 50	12/1987 12/1997 12/2003 12/2006		GISTDA
2**.** Secondary datasets			
- Forest cover data	2000 2004	1:50,000	Royal Forest Department
- Land use data	2006	1:25,000	Land Development
- National park boundary	2000		Royal Forest Department

Note: GISTDA, Geo-Informatics and Space Technology Development Agency

3.3 Classification of Land Use

The 1987, 1997, 2003, and 2006 Landsat-TM data (Path 129 Row 50) were major data sources for land use classification in this study. In addition, the 2006 land use data of Land Development Department and the 2000 and 2004 forest data of Royal Forest Department were compiled and used as ancillary data for land use classification. The major steps are 1) geometric correction of remotely sensed data 2) land use classification and 3) accuracy assessment. The detail of each step can be summarized as follows:

3.3.1 Geometric Correction

The 1987, 1997, 2003, and 2006 Landsat-TM data were geometrically corrected with image to map rectification based on topographic map of the Royal Thai Survey Department. Herein, polynomial second order transformation for spatial interpolation and nearest neighbor resampling for intensity interpolation were conducted with root mean square (RMS) errors less than 0.5 pixel (12.5 m).

3.3.2 Land Use Classification

Band 3, 4, and 5 of Landsat-TM data in 1987, 1997, 2003, and 2006 were used to classify land use using supervised classification of Maximum Likelihood algorithm. In practice, training areas were identified from ground survey and land use map from Land Development Department and the Royal Forest Department. In addition, visual interpretation for land use on the screen cover was also performed for correction of land use classes. In this study, 10 land use categories based on Land Development Department and the Royal Forest Department classification were extracted from remotely sensed data including: 1) Dry Evergreen Forest, 2) Mixed

Deciduous Forest, 3) Dry Dipterocarp Forest, 4) paddy field, 5) field crop, 6) perennial and orchard, 7) grassland, 8) water body, 9) urban and built-up, and 10) other lands.

3.3.3 Accuracy Assessment

In practice, number of sample size was firstly calculated based on statistics and sampling design, then selected for locating the observing points for accuracy assessment. Finally, error matrix was constructed to assess accuracy.

1) Number of Sample Size Calculation

Number of sample size was firstly identified based on multinomial distribution with desired level of confidence of 90% and a precision of 10% as following equation:

$$n = \frac{BII_i\left(1 - II_i\right)}{b_i^2}$$

where B is the upper $\left(\alpha / k\right) \times 100^{th}$ percentile of the chi square $\left(\chi^2\right)$ distribution with one degree of freedom, $II_i\,(i = 1, 2, ...k)$ is the proportion of the population in the i^{th} category, b is the absolute precision of the sample and k is the number of classes (Congalton and Green, 2009).

2) Sampling Design Selection

In this study, stratified random sampling technique was applied for locating observing points for accuracy assessment.

3) Accuracy Assessment

In practice, the 2006 classified land use and land cover was compared with the 2009 ground information as matrix error for accuracy assessment with overall accuracy and kappa hat coefficient of agreement as following.

Overall accuracy is compute:

$$\textbf{Overall accuracy} = \frac{\sum_{i=1}^{k} x_{ii}}{N}$$

where k is the number of rows in the matrix, x_{ii} is the number of observation in row i and column i and N is the total number of observations (Congalton and Green, 2009).

Kappa hat coefficient, $\hat{K}$**,** is computed:

$$\hat{K} = \frac{N\sum_{i=1}^{k} x_{ii} - \sum_{i=1}^{k}\left(x_{i+} \times x_{+i}\right)}{N^2 - \sum_{i=1}^{k}\left(x_{i+} \times x_{+i}\right)}$$

where k is the number of rows in the matrix, x_{ii} is the number of observation in row i and column i, x_{i+} and x_{+i} are the marginal totals for row i and column i, respectively and N is the total number of observations (Jensen, 2005).

Classified land use and land cover in 2006 was compared with ground information in 2009 for accuracy assessment using overall accuracy and kappa hat coefficient of agreement. In practice, error matrix between land use type in 2006 and the reference land use types from field survey in 2009 is firstly constructed. In this

study, 168 randomly stratified sampling points based on multinomial distribution theory with desired level of confident 90 % and a precision of 10 % were used for accuracy assessment. It was found that the overall accuracy was 87.50% and Kappa hat coefficient of agreement was 0.87.

3.3.4 Assessment of Land Use and Its Change

The 1987, 1997, 2003, and 2006 land use data of Thap Lan National Park and 5 km buffer area were assessed under GIS environment. Herein, the area and percentage of the land use categories was calculated and compared between classes.

Furthermore, post-classification comparison change detection which was a heavily used quantitative change detection method (Jensen, 2005) were used to quantify the change of land use of 1987-1997, 1997-2005, 2005-2006, and 1987-2006 in term of “from-to situation of land use class information”. This method was preferred because data from the two periods were separately classified, thereby minimizing the problems of normalizing the atmosphere and sensor differences between these dates. As a result, the credibility of the comparison was principally subject to the accuracy of the individual classification of the used images (Jensen, 2005).

3.4 Forest Structure Study

Three major types of Dry Evergreen, Mixed Deciduous and Dry Dipterocarp Forest were classified from 2006 Landsat TM data. Then 17 sampling plots were chosen for ground forest inventory study (Table 3.3 and Figure 3.2). In each plot, 40 x 40 m^2 quadrat were placed. Plant species was identified and counted. The height and

DBH (1.3 m) of trees equal or greater than 4.5 cm were measured**.** Then plant density, frequency, basal area and important value index were calculated.

Table 3.3 Sampling plots locations.

Forest type	X	Y	Elevation Average
1. Dry Dipterocarp Forest	180,140.00	1,613,579.00	277.69
2. Dry Dipterocarp Forest	190,737.00	1,603,870.00	253.80
3. Dry Dipterocarp Forest	182,535.00	1,597,876.00	251.18
4. Dry Evergreen Forest	171,248.00	1,576,061.00	534.16
5. Dry Evergreen Forest	808,926.00	1,575,908.00	571.86
6. Dry Evergreen Forest	821,999.00	1,581,354.00	229.99
7. Dry Evergreen Forest	821,999.00	1,581,357.00	344.34
8. Dry Evergreen Forest	820,335.00	1,564,050.00	68.99
9. Dry Evergreen Forest	822,586.00	1,566,014.00	419.10
10. Dry Evergreen Forest	185,906.00	1,559,996.00	433.33
11. Mixed Deciduous Forest	185,906.00	1,559,996.00	97.40
12. Mixed Deciduous Forest	813,235.00	1,569,715.00	332.19
13. Mixed Deciduous Forest	813,499.00	1,569,827.00	531.68
14. Mixed Deciduous Forest	815,676.00	1,579,179.00	533.06
15. Mixed Deciduous Forest	811,923.00	1,582,681.00	106.88
16. Mixed Deciduous Forest	198,969.00	1,572,232.00	83.50
17. Mixed Deciduous Forest	201,707.00	1,574,829.00	170.20

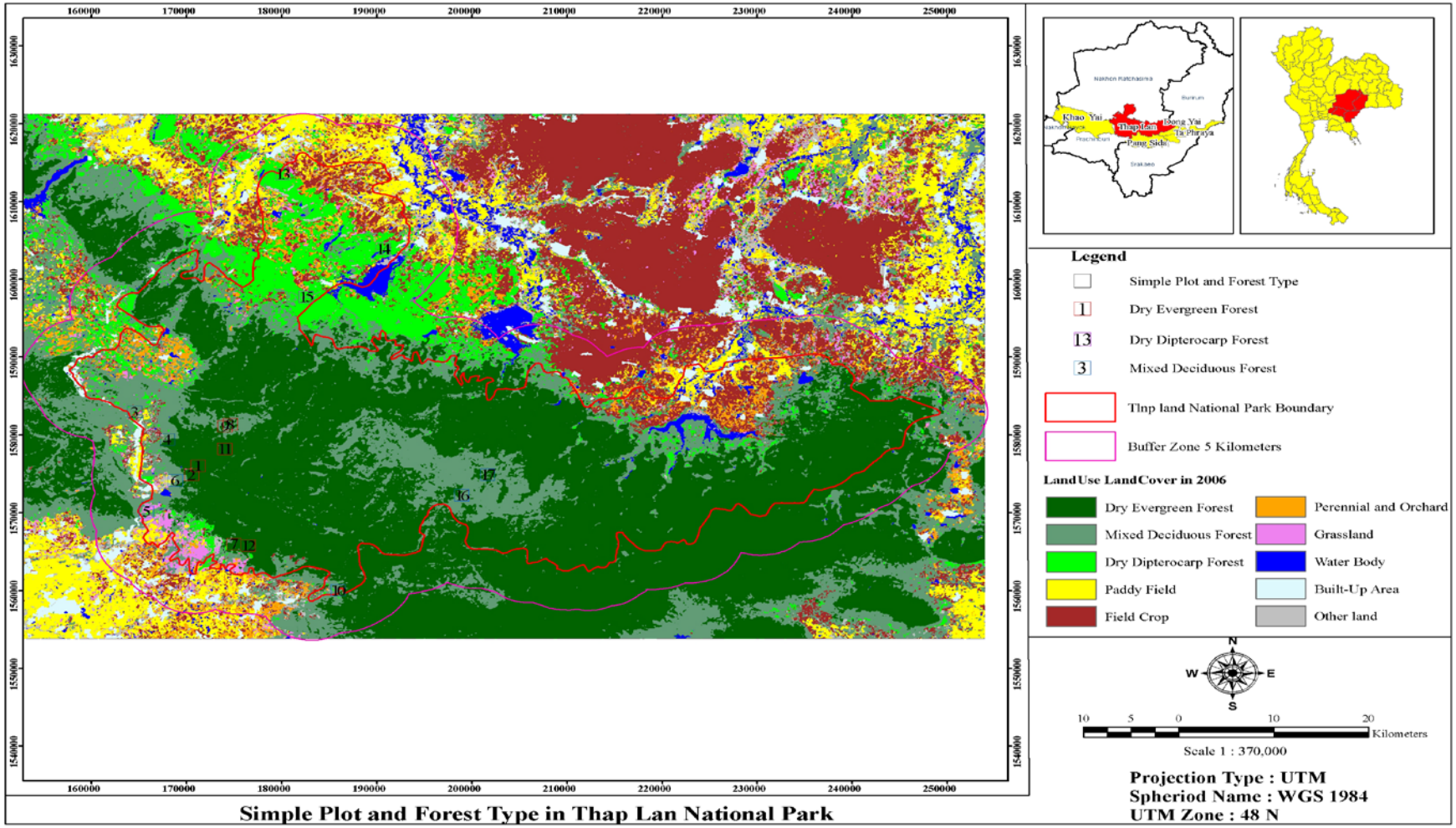

Figure 3.2 Sampling plots locations.

3.4.1 Importance Value Index

Importance value index (IVI) is used to determine the overall importance of each species in the community structure and compare the species dominance of the plots (Cottam and Curtis, 1956). The IVI for a species is calculated as the sum of is relative dominance, its relative frequency and its relative density (Curtis, 1959).

1) Relative density

Relative density is the study of numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Relative density (RD)} = \frac{\text{Number of individual of the species} \times 100}{\text{Number of individual of all species}}$$

2) Relative frequency

The degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Relative frequency (RF)} = \frac{\text{Number of occurrence of the species} \times 100}{\text{Number of occurrence of all the species}}$$

3) Relative dominance

Dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

$$\text{Relative dominance (RD)} = \frac{\text{Total basal area of the species} \times 100}{\text{Total basal area of all the species}}$$

All of them were combined to be IVI of each plant species and family.

3.5 Forest Carbon Sequestration

The allometric equations of Tsutsumi *et al*. (1983) were used for Dry Evergreen Forest while Ogawa *et al*. (1961, 1965) were used for both Mixed Deciduous and Dry Dipterocarp Forest.

The Dry Evergreen Forest allometric equations of Tsutsumi *et al*. (1983).

Stem (W_S) = $0.0509(D^2 H)^{0.919}$

Branch (W_B) = $0.00893(D^2 H)^{0.977}$

Leaf (W_L) = $0.0140(D^2 H)^{0.669}$

Root (W_R) = $0.0313(D^2H)^{0.805}$

The Mixed Deciduous Forest allometric equations of Ogawa *et al*. (1965).

Stem (W_S) = $0.0396(D^2 H)^{0.9326}$

Branch (W_B) = $0.003487(D^2 H)^{1.027}$

Leaf (W_L) = $((28.0/ WS + WB) + 0.025)^{-1}$

Root (W_R) = $0.0264(D^2H)^{0.775}$

The Dry Dipterocarp Forest allometric equations of Ogawa *et al*. (1961).

Stem (W_S) = $0.0396(D^2H)^{0.9326}$

Branch (W_B) = $0.003487(D^2H)^{1.027}$

Leaf (W_L) = $22.5/W_s+0.025$

Root (W_R) = $0.0264(D^2H)^{0.775}$

where W_S = biomass of stem (kg)

W_B = biomass of branch (kg)

W_L = biomass of leaf (kg)

W_R = biomass of root (kg)

H = The height of the tree (m)

D = Diameter of the stem (cm) at 1.30 m high (Diameter at breast height, DBH)

After forest biomass was calculated, it was then multiplied by 0.47 carbon fraction to become carbon sequestration in each forest type (IPCC, 2006).

3.6 Estimation of Soil Carbon Storage

At soil sample pits, disturbed and undisturbed soil samples were collected by using a soil sampler from 17 plots of 3 forest types, 3 soil layers (0-10, 10-20, and 20-30 cm) were collected in December 2008 and March to May 2009. There wee three replications per site. Soil sample (500 g) were taken to measure pH, moisture, organic matter, P, K and Ca. Soil pH were determined in a water suspension at a 2 : 5 of soil : water ratio, on fresh samples. Soil moisture was determined by percent of the weight of fresh soil sample after dried at 105°C for 24 hours (Buurman *et al*., 1996). The organic matter was determined following Walkey and Black (1934). Available phosphorus was measured colourimetrically, based on the reaction with ammonium molybdate and development of the ‘Molybdenum Blue’ colour (Brey and Kurtz, 1945). Exchangeable K and Ca were determined by atomic absorption spectrophotometry and flame emission (Tran and Simard, 1993).

3.7 Statistical Analysis

Results were presented as mean ± SEM. Carbon sequestration among forest were analyzed by one-way ANOVA, followed by Duncan's multiple range tests. Data of soil properties among soil depths were analyzed by two-way ANOVA, followed by Duncan's multiple range tests. The regression equations were analyzed by fitting the linear regression. All data analysis and correlations were analyzed using Statistical Package for Social Sciences (SPSS) program for Window, v.17.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Land Use Change of Thap Lan National Park between 1987 and 2006

Land use and land cover change in the Thap Lan National Park were analyzed by the data obtained from Landsat-5 TM imagery in 1987, 1997, 2003, and 2006, which can systematically be classified into 10 categories: Dry Evergreen Forest, Mixed Deciduous Forest, Dry Dipterocarp Forest, paddy field, field crop, perennial and orchard, grassland, water body, urban and built-up, and other lands (old clearing, uncultivated land, barren/bare land). The images were geometrically corrected using topographic maps with the scale of 1:370,000. Post-classification was applied for accurate classification.

4.1.1 Land Use Change of Dry Evergreen Forest

Dry Evergreen Forest (DEF) was the most significant forest of Thap Lan National Park. DEF was translucently and dispersedly forest which cover throughout the Thap Lan National Park, except for the North-Western region (Khon Buri district) (Figures 4.1-4.4), accounting for 1,249.71-1,252.14 km^2or 56.31-56.42% of total area between 1987 and 2006 (Table 4.1). Although, DEF area was rarely unchanged over the study period, but it showed some fluctuated results. DEF land use changes were 0.77, -2.06, and 2.43 km^2 or 0.03%, -0.09%, and 0.11% change when compared in year 1987-1997, 1997-2003, and 2003-2006, respectively (Tables 4.2-4.4). Therefore,

the overview changing of DEF between 1987 and 2006 showed that DEF was slightly increased 1.14 km^2 which obtained from the changing of MDF to DEF (Table 4.5). As the results, the change of DEF could be explained in the regression model, but it is not a good model for predicting the future change of DEF ($p > 0.05$) (Table 4.6 and Figure 4.5A). The fluctuated results of DEF area might be due to the error of satellite images (Landsat), data interpreting, and also climatic and atmospheric error during the remote sensing operation.

Table 4.1 Land use of the Thap Lan National Park in 1987, 1997, 2003, and 2006.

Land use type	**Area (km^2)**			
	1987	**1997**	**2003**	**2006**
Dry Evergreen Forest	1,251.00	1,251.77	1,249.71	1,252.14
Mixed Deciduous Forest	500.58	484.22	473.11	476.35
Dry Dipterocarp Forest	197.15	182.81	167.60	161.72
Paddy Field	49.54	43.20	28.53	40.78
Field Crop	95.02	89.05	82.81	108.54
Perennial and Orchard	79.68	67.44	68.09	76.73
Grassland	14.79	27.71	24.42	27.53
Water Body	11.13	31.72	27.87	33.58
Urban and Built-Up	11.11	12.88	13.15	15.00
Other Land	9.47	28.69	84.19	27.12
Total	**2,219.47**	**2,219.47**	**2,219.47**	**2,219.47**

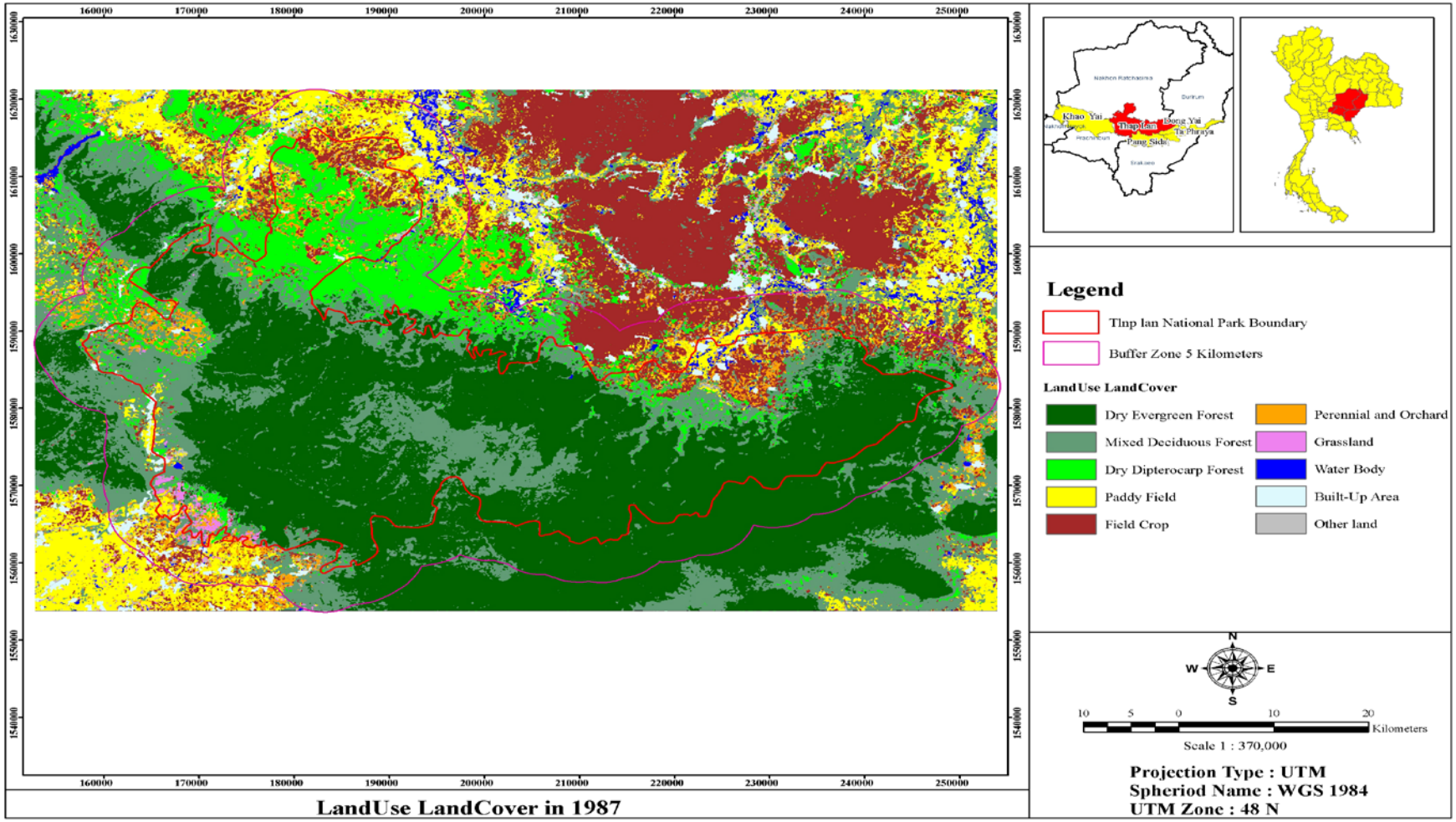

Figure 4.1 Land use of Thap Lan National Park in 1987.

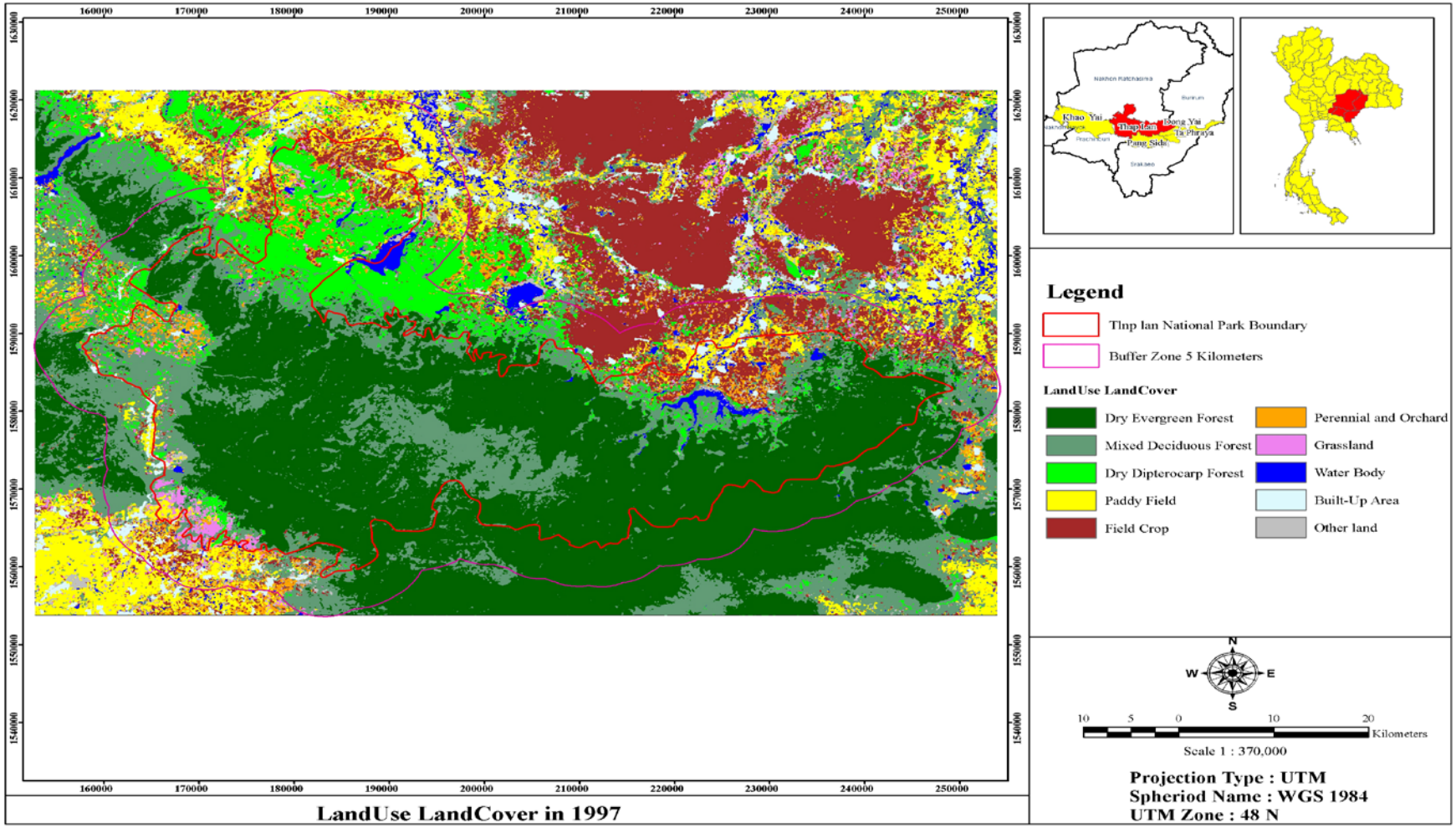

Figure 4.2 Land use of Thap Lan National Park in 1997.

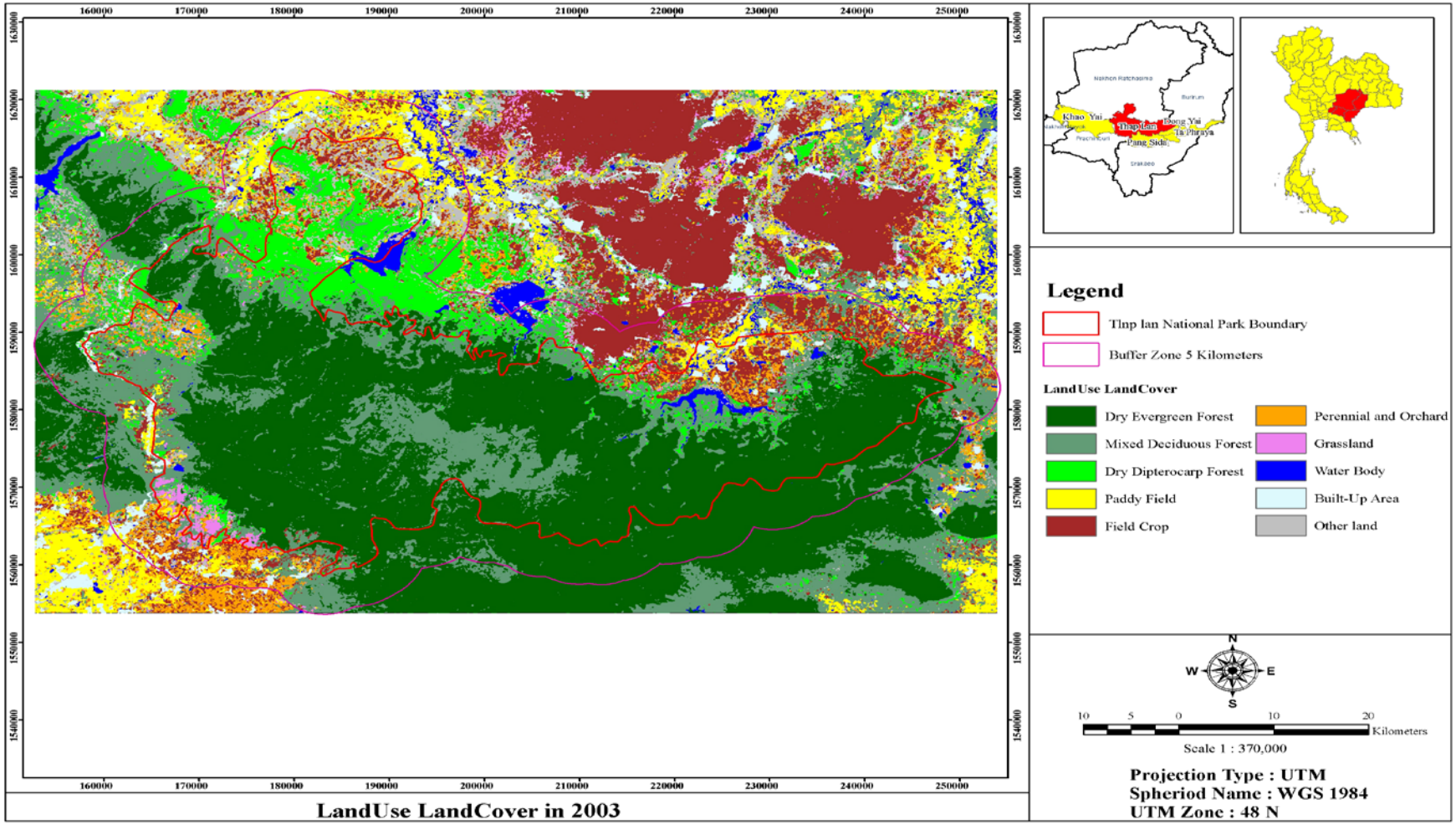

Figure 4.3 Land use of Thap Lan National Park in 2003.

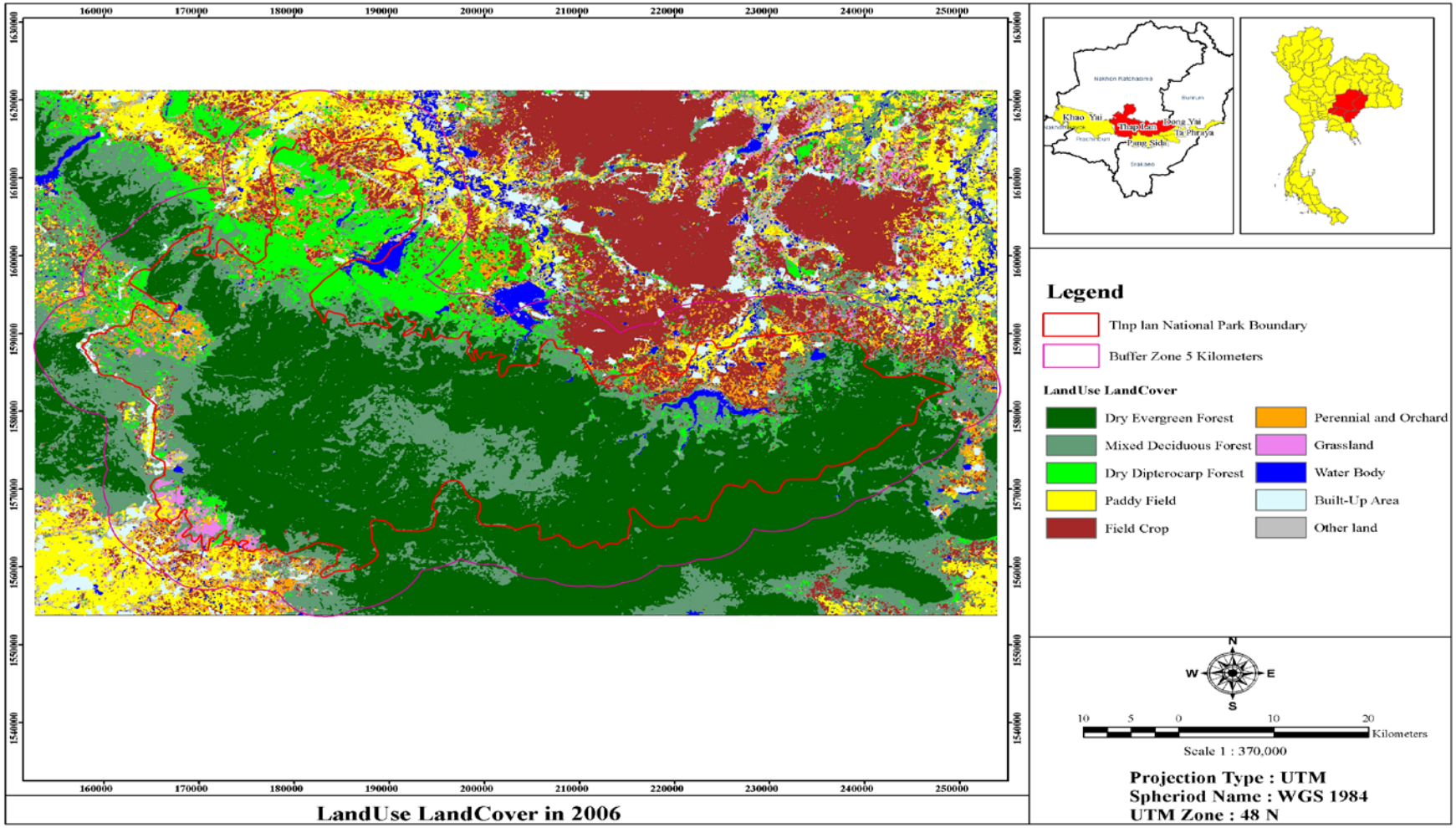

Figure 4.4 Land use of Thap Lan National Park in 2006.

Table 4.2 Land use change matrix in Thap Lan National Park, between 1987 and 1997.

LULC in 1987	LULC in 1997 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	1234.8035	15.4649	0.5542	-	0.0454	0.0177	0.0364	0.0566	0.0005	0.0185	1250.9977
MDF	16.0235	455.1117	8.2462	0.7809	2.5697	2.3031	0.7407	12.2546	0.2728	2.2809	500.5840
DDF	0.7770	7.9627	169.9850	0.4560	3.8525	2.1149	0.6170	5.5498	0.1468	5.6835	197.1452
PF	0.0012	0.9915	0.4048	39.8539	1.6374	1.7653	0.4810	2.2977	0.2797	1.8320	49.5446
FC	0.0626	1.2784	0.7292	0.6130	76.3510	3.9344	5.2185	1.5033	0.5705	4.7548	95.0157
PO	0.0269	2.3492	2.1491	0.6960	4.0356	56.1001	7.6047	1.1341	0.5981	4.9887	79.6825
GL	0.0539	0.6643	0.4455	0.1483	0.0914	0.2463	12.9020	0.0414	0.0139	0.1848	14.7918
WB	0.0187	0.1860	0.0829	0.5022	0.3106	0.6933	0.0152	8.5429	0.1070	0.6741	11.1329
UB	-	0.1140	0.0741	0.0665	0.0622	0.1075	0.0134	0.0644	10.3744	0.2361	11.1127
OL	0.0007	0.0976	0.1350	0.0790	0.0949	0.1562	0.0801	0.2716	0.5128	8.0376	9.4653
Total	1251.7679	484.2203	182.8061	43.1959	89.0506	67.4387	27.7090	31.7164	12.8767	28.6909	2219.4724
Area/total area (%)	56.40	21.82	8.24	1.95	4.01	3.04	1.25	1.43	0.58	1.29	
Area change (km^2)*	0.77	-16.36	-14.34	-6.35	-5.97	-12.24	12.92	20.58	1.76	19.23	
Area change/ total area (%)*	0.03	-0.74	-0.65	-0.29	-0.27	-0.55	0.58	0.93	0.08	0.87	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.3 Land use change matrix in Thap Lan National Park, between 1997 and 2003.

LULC in 1997	LULC in 2003 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	1225.9216	23.9457	1.1058	0.0006	0.1205	0.0260	0.1049	0.1424	0.0037	0.3967	1251.7679
MDF	22.7742	426.1511	10.7994	0.9344	6.4205	2.6180	1.5438	2.1837	1.1242	9.6710	484.2203
DDF	0.7604	10.8582	142.3565	0.3811	2.5481	2.2174	0.9696	0.8639	0.1521	21.6987	182.8061
PF	0.0005	0.8179	0.4483	23.0686	1.6544	5.8756	0.3397	0.7295	0.1384	10.1232	43.1959
FC	0.0812	2.3974	3.0126	0.6930	59.4180	5.5861	2.5032	0.5442	0.3660	14.4487	89.0506
PO	0.0335	2.4873	2.1960	1.0013	4.6656	41.5465	2.6642	0.6679	0.4131	11.7634	67.4387
GL	0.0598	1.1067	0.9128	0.8569	3.3716	4.5053	15.1705	0.0542	0.0515	1.6198	27.7090
WB	0.0558	3.2793	1.8840	0.5930	0.4810	1.2283	0.1882	21.7654	0.1461	2.0952	31.7164
UB	0.0008	0.1821	0.1846	0.1402	0.4630	0.4826	0.0737	0.0733	10.0214	1.2550	12.8767
OL	0.0188	1.8823	4.7011	0.8599	3.6716	4.0015	0.8596	0.8497	0.7321	11.1142	28.6909
Total	1249.7066	473.1080	167.6010	28.5291	82.8143	68.0873	24.4176	27.8743	13.1484	84.1859	2219.4724
Area/total area (%)	56.31	21.32	7.55	1.29	3.73	3.07	1.10	1.26	0.59	3.79	
Area change (km^2)*	-2.06	-11.11	-15.21	-14.67	-6.24	0.65	-3.29	-3.84	0.27	55.49	
Area change/ total area (%)*	-0.09	-0.50	-0.69	-0.66	-0.28	0.03	-0.15	-0.17	0.01	2.50	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.4 Land use change matrix in Thap Lan National Park, between 2003 and 2006.

LULC in 2003	LULC in 2006 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	1226.1622	22.7566	0.3509	0.0005	0.1126	0.0356	0.0576	0.2002	0.0010	0.0293	1249.7066
MDF	23.9832	423.6469	6.5694	0.5477	6.5755	3.0411	1.1010	3.4116	0.2267	4.0048	473.1080
DDF	1.2250	11.6129	131.5040	0.2371	11.9781	2.7171	0.9282	2.0654	0.4431	4.8900	167.6010
PF	0.0006	0.5294	0.3728	22.5814	0.8010	1.2148	0.8576	0.8196	0.1181	1.2338	28.5291
FC	0.1205	4.9433	1.6771	1.4375	63.0139	5.0067	3.2843	0.5069	0.3987	2.4253	82.8143
PO	0.0265	1.4061	1.1454	5.7014	5.9903	46.6530	4.4776	1.2635	0.4326	0.9909	68.0873
GL	0.1076	1.2192	0.7358	0.2558	2.8156	3.3093	15.1707	0.1903	0.0467	0.5666	24.4176
WB	0.1077	1.8480	0.5666	0.6343	0.5604	0.7456	0.0539	22.6989	0.0730	0.5859	27.8743
UB	0.0035	0.1028	0.0538	0.0642	0.1012	0.1464	0.0133	0.0692	12.4401	0.1540	13.1484
OL	0.3992	8.2813	18.7413	9.3215	16.5867	13.8564	1.5823	2.3543	0.8222	12.2406	84.1859
Total	1252.1360	476.3466	161.7172	40.7813	108.5353	76.7260	27.5266	33.5800	15.0021	27.1212	2219.4724
Area/ total area (%)	56.42	21.46	7.29	1.84	4.89	3.46	1.24	1.51	0.68	1.22	
Area change (km^2)*	2.43	3.24	-5.88	12.25	25.72	8.64	3.11	5.71	1.85	-57.06	
Area change/ total area (%)*	0.11	0.15	-0.27	0.55	1.16	0.39	0.14	0.26	0.08	-2.57	

* -, decrease; +, increase. DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.5 Land use change matrix in Thap Lan National Park, between 1987 and 2006.

LULC in 1987	LULC in 2006 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	1235.1629	15.4558	0.0357	-	0.0567	0.0179	0.0359	0.2120	0.0011	0.0195	1250.9977
MDF	16.0001	451.1572	3.2794	0.1247	7.6033	2.4942	0.7405	12.8001	1.3002	5.0842	500.5840
DDF	0.8179	8.2075	157.0756	0.0508	15.2693	2.3771	0.6215	6.0661	0.3877	6.2716	197.1452
PF	0.0012	0.1358	0.3739	39.6495	1.6607	1.8950	0.4685	2.7059	0.2589	2.3952	49.5446
FC	0.0613	0.2143	0.1483	0.1827	79.4477	3.9794	4.9663	1.5807	0.9031	3.5320	95.0157
PO	0.0267	0.3135	0.2789	0.1541	4.0270	64.7781	7.5723	1.1949	0.8065	0.5305	79.6825
GL	0.0534	0.6641	0.4331	0.1437	0.0939	0.2514	13.0765	0.0406	0.0105	0.0245	14.7918
WB	0.0123	0.1765	0.0735	0.4544	0.2995	0.6852	0.0149	8.6429	0.3186	0.4551	11.1329
UB	-	0.0060	0.0089	0.0040	0.0117	0.0201	0.0007	0.0228	10.8875	0.1511	11.1127
OL	0.0001	0.0158	0.0099	0.0172	0.0655	0.2276	0.0297	0.3139	0.1279	8.6577	9.4653
Total	1252.1360	476.3466	161.7172	40.7813	108.5353	76.7260	27.5266	33.5800	15.0021	27.1212	2219.4724
Area/total area (%)	56.42	21.46	7.29	1.84	4.89	3.46	1.24	1.51	0.68	1.22	
Area change (km^2)*	1.14	-24.24	-35.43	-8.76	13.52	-2.96	12.73	22.45	3.89	17.66	
Area change/ total area (%)*	0.05	-1.09	-1.60	-0.39	0.61	-0.13	0.57	1.01	0.18	0.80	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.6 Predicted model of 10 land use types in Thap Lan National Park.

Land use type	Regression model	P value	R^2
Dry Evergreen Forest	y = 0.008x + 1234.61	0.935	0.004
Mixed Deciduous Forest	y = -1.413x + 3307.332	0.034*	0.933
Dry Dipterocarp Forest	y = -1.884x + 3941.71	0.009*	0.983
Paddy Field	y = -0.758x + 1555.319	0.278	0.521
Field Crop	y = 0.257x - 420.475	0.804	0.039
Perennial and Orchard	y = -0.297x + 666.676	0.595	0.164
Grassland	y = 0.609x - 1193.139	0.160	0.706
Water Body	y = 1.081x - 2133.505	0.116	0.782
Urban and Built-Up	y = 0.179x - 343.711	0.060	0.883
Other Land	y = 2.219x - 4397.017	0.426	0.329

Regression models were analyzed by linear regression (SPSS), where x = year (Christian Era) and y = area, * represent the significant level at $p < 0.05$.

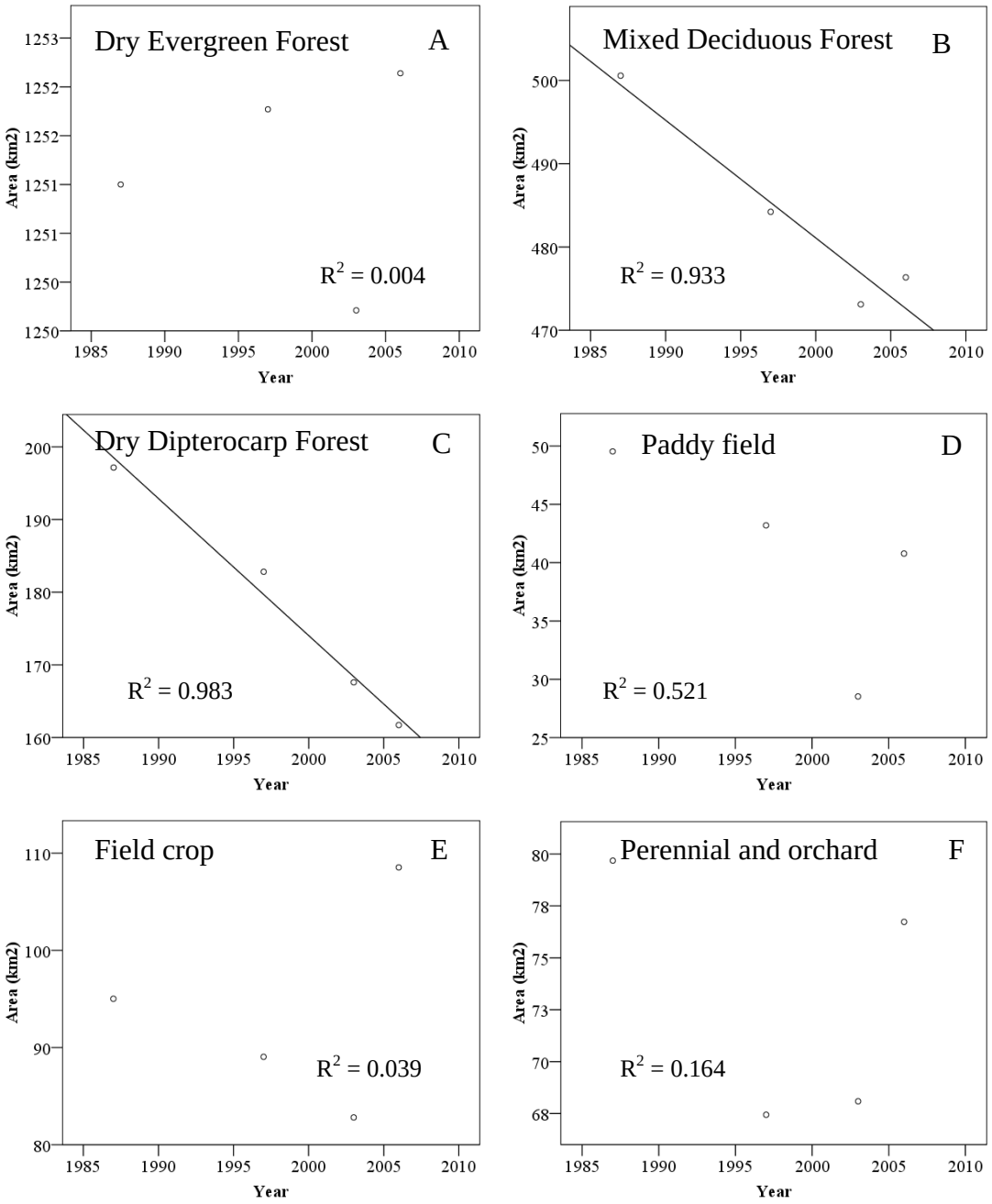

Figure 4.5 The fitted regression lines and data points of the 6 land use types. Dry Evergreen Forest (A), Mixed Deciduous Forest (B), Dry Dipterocarp Forest (C), paddy field (D), field crop (E), and perennial and orchard (F).

4.1.2 Land Use Change of Mixed Deciduous Forest

The Mixed Deciduous Forest (MDF**)** was the second dominant land use in Thap Lan National Park which was found mostly in the middle and the Western region (Wang Nam Khiaw district) (Figures 4.1-4.4). It contributed for 473.11-500.58 km^2 or 21.32-22.55% of total area during 1987-2006 (Table 4.1). The area of MDF was about 0.38-0.40 times less than the DEF. During 1987-1997, the MDF in the North-Eastern of Thap Lan National Park was decreased (-16.36 km^2 or -0.74% of total area) (Table 4.2) and mostly replaced with the Lam Plai Mat dam in Soeng Sang district (Figures 4.1 and 4.2). In addition, the decrease of MDF during 1997-2003 was related with the encroachment for the agricultural area; the area of 11.11 km^2 or 0.50% of total area loss was observed (Table 4.3) in Wang Nam Khiaw (the Western part), Na Dee (the South-Western part), and Soeng Sang district (the North-Eastern part) (Figures 4.2 and 4.3). However, during 2003-2006, before and after the declaration of DPKY-FCWH in 2005, the MDF area slightly increased, accounting for 3.24 km^2 or 0.15% of total area (Table 4.4). The overall change of MDF during 1987-2006 revealed that the MDF areas tend to decrease, accounting for 24.24 km^2 or 1.09% of total area loss which causing by the change of MDF to water body, field crop, other lands, and perennial and orchard (Table 4.5). The declining of MDF area could be fitting with the equation of $y = -1.413x + 3307.332$, $R^2 = 0.933$ ($p < 0.05$) (Table 4.6 and Figure 4.5B). Therefore, if there is continuous deforesting, the MDF will be accounted for 453.07 km^2 in 2020. It is noted that the decreasing rate of 1.413 km^2/yr is observed.

4.1.3 Land Use Change of Dry Dipterocarp Forest

Dry Dipterocarp Forest (DDF) was the third dominant land use of Thap Lan National Park, mostly found in Khon Buri district, accounting for 161.60-197.15 km^2 or 7.29-8.88% of total area (Table 4.1 and Figures 4.1-4.4). DDF area, the most decreased land use in Thap Lan National Park, gradually decreased from 197.15 km^2 in 1987 to 161.72 km^2 in 2006. The decreasing area of 14.34, 15.21, and 5.88 km^2 were observed in 1987-1997, 1997-2003, and 2003-2006 (Tables 4.2-4.4) in the North-Western (Khon Buri district), North-Eastern (Soeng Sang district) as well as the West and South-Western regions (Wang Nam Khiaw and Na Dee district). The overall change of DDF during 1987-2006 was a loss of 35.43 km^2 or 1.60% of total area which were from the conversion of DDF into field crop, water body, other lands as well as MDF (Table 4.5). These changes were significantly fitted the predicted equation of $y = -1.884x + 3941.71$, $R^2 = 0.983$ ($p < 0.01$) (Table 4.6 and Figure 4.5C). A decreasing rate of 1.884 km^2/yr was observed. The continuous deforestation will result in 136.03 km^2 of DDF in year 2020. Since, the MDF and DDF are located near human communities, then deforestation and trespassing will occur for the seeking of the agricultural land and tourist attractions.

4.1.4 Land Use Change of Paddy Filed

Paddy field (PF) accounted for 28.53-49.54 km^2 or 1.28-2.23% of total area (Table 4.1). It was found mostly in the North-Eastern (Soeng Sang district) and North-Western region (Khon Buri district) and some in the South-Western (Na Dee district) (Figures 4.1-4.4). An uncertain change of PF was observed (Figure 4.5). The decrease of 6.35 and 15.21 km^2 or 0.65 and 0.69% of total area was detected in

1987-1997 and 1997-2003 periods, respectively (Tables 4.2 and 4.3), whereas an increase of 12.25 km^2 or 0.55% of total area was observed in 2003-2006 (Table 4.4). The overall change of PF in the years 1987-2006 revealed that it decreased 8.76 km^2 from the conversion to water body, other lands, as well as perennial and orchard, and field crop (Table 4.5). Therefore, the less fitted regression equation ($p > 0.05$) for predicting the PF area was obtained (Table 4.6 and Figure 4.5D).

The decrease of PF area in 1987-2003 corresponded with the study of Noochdumrong and Noochdumrong (2005) which studied the land use in four selected villages located inside Thap Lan National Park, Na Dee district, Prachin Buri and Wang Num Khiaw, Nakhon Ratchaisma by field observation. They found the similar results with this study, the PF area was high (less than 0.16 km^2) during 1985-1993, decreased in year 1994 and then constant until year 2004. The high value of land during this period led to the change of land ownership, from the paddy field to vegetable and cut flower lands as well as tourist resorts. Moreover, the uncertainty and farming career discontinuity might result in the decreasing of PF area. In addition, the Landsat data were taken in December of each year which was during harvesting periods, this might be the reason for the mistake of interpreting the PF area.

4.1.5 Land Use Change of Field Crop

The forth dominant land use in Thap Lan National Park is field crop (FC). It covered 82.81-108.54 km^2 or 3.73-4.89% of total area (Table 4.1), mostly in the North-Eastern (Soeng Sang district) and North-Western regions (Khon Buri district) (Figures 4.1-4.4). The uncertain land use change of FC area was observed (Figure 4.5). Decreased FC area could be continuously observed during 1987-1997

and 1997-2003 which were -5.97 and -6.24 km^2 or -0.27 and -0.28%, respectively (Tables 4.2 and 4.3), whereas it tended to increase during 2003-2006 which was 25.72 km^2or 1.16% of total area (Table 4.4). The overall changing of FC, during 1987-2006 revealed that FC area tended to increase with the area of 13.52 km^2 or 0.61% of total area which obtained from the destruction of MDF and DDF including the conversion of FC to PF (Table 4.5). The change of FC was less matched with the regression equation ($p > 0.05$) (Table 4.6 and Figure 4.5E).

4.1.6 Land Use Change of Perennial and Orchard

During 1987-2006, the perennial and orchard (PO) area accounted for 67.44-79.68 km^2 or 3.04-3.59% of total area (Table 4.1). They were found throughout the four regions near villages, Western, South-Western, North-Western, and North-Eastern regions of Thap Lan National Park (Figures 4.1-4.4). As similar to the PF and FC, the PO was changing unstably. The PO area decreased during 1987-1997 which was -12.24 km^2 or -0.55% of total area, while it was increased in 1997-2003 and 2003-2006 with the area of 0.65 and 8.64 km^2 or 0.03 and 0.39%, respectively (Tables 4.2-4.4). In 2006, the PO area was 76.73 km^2, it decreased 2.96 km^2 as compared with year 1987 (Table 4.5). Although, MDF, DDF, and FC area were changed into the PO but the PO was further changed into the grassland and water body in year 2006. Because of the unstable change of PO then it could not be predicted by the regression model (Table 4.6 and Figure 4.5F).

4.1.7 Land Use Change of Grassland

Grassland was found in the South-Eastern region (Na Dee district) of Thap Lan National Park accounting for 14.79-27.71 km^2 or 0.67-1.25% of total area (Table 4.1). During 1987-1997, grassland was increased from 14.79 km^2 to 27.71 km^2. This was a 12.92 km^2 or 0.58% increase of total area (Table 4.2), and then grassland area remained quite stable in the last decade (1997-2006) (Tables 4.3 and 4.4). During the study period, an increased grassland area of 12.73 km^2 or 0.57% of total area was observed (Table 4.5). Most of the increased grasslands were gained from the PO and FC and some of them were from MDF, DDF and PF. This change did less fitted with the linear regression equation ($p > 0.05$) (Table 4.6 and Figure 4.6A).

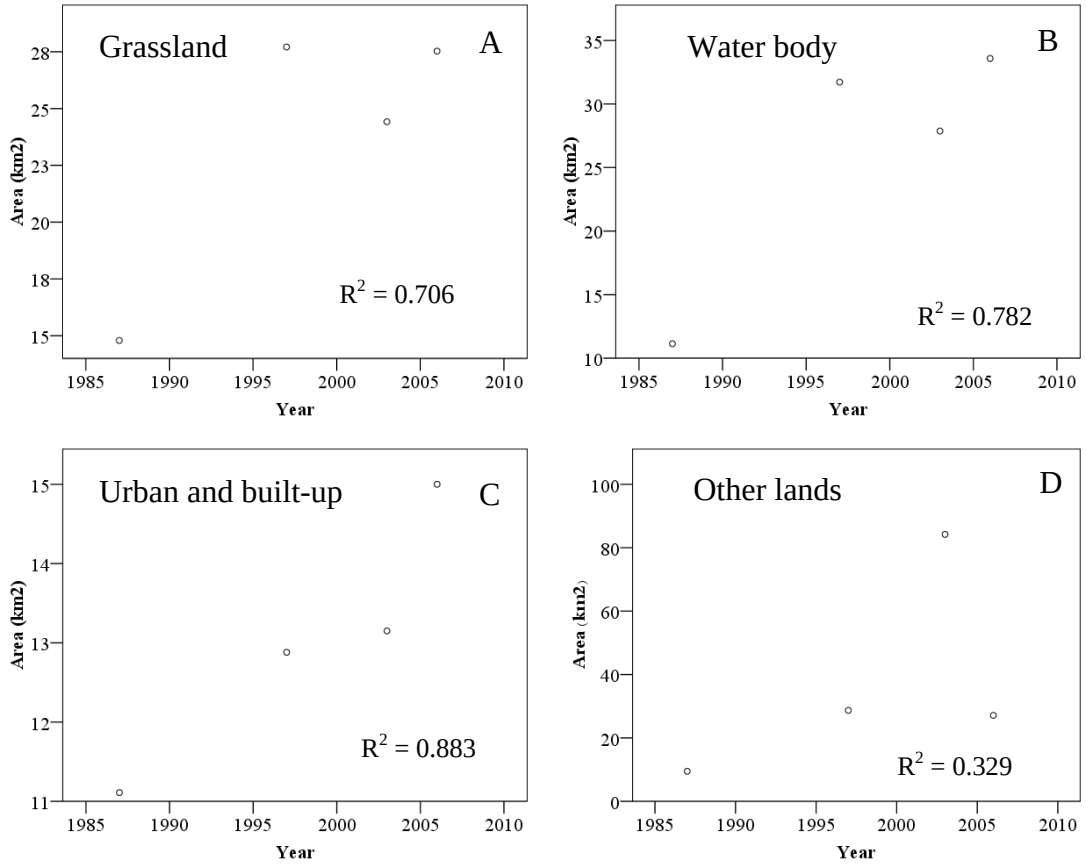

Figure 4.6 The fitted regression line and data points of the 4 land use types. Grassland (A), water body (B), urban and built-up (C), and other lands (D).

4.1.8 Land Use Change of Water Body

Water body was scarce, only 11.13 km^2 or 0.50% of total area (Table 4.1 and Figure 4.1), in Thap Lan National Park in 1987, which consisted of natural waterfalls and reservoirs. The number and site of water bodies obviously increased in 1997 since the construction of Lam Plai Mat dam in the North-Eastern part (Soeng Sang district) inside the National Park (Figure 4.2). Increased area of 20.58 km^2 or 0.93% of total area was observed during 1987-1997 (Table 4.2). After that, in the last decade of this study, water body showed slight change with fluctuating results (Tables 4.3-4.4) which might relate to the amount of rainfall in each year. By the conversion of MDF, DDF, and PF into water body, the increased water body area of 22.45 km^2 or 1.01% of total area was observed during 1987-2006 (Table 4.5). The increase was mostly due to the construction of reservoir dam to retain the water for several purposes such as agriculture, fishery and tourism. Changes in water body cannot be predicted by linear regression as shown in Table 4.6 and Figure 4.6B.

4.1.9 Land Use Change of Urban and Built-up

In 1987, urban and built-up (UB) covered the area of 11.11 km^2 or 0.50% of total area (Table 4.1) which is located in the four regions, North-Western, Western, South-Western, and North-Eastern region of Thap Lan National Park (Figure 4.1). In this period, there was the stepwise increase of UB which were 1.76, 0.27, and 1.85 km^2or 0.08, 0.01, and 0.08% of total area change in 1987-1997, 1997-2003, and 2003-2006, respectively (Tables 4.2-4.4). The increase of UB was found in the West (Wang Nam Khiaw district) and North-West (Khon Buri district), it increased to 15.00 km^2 or 0.68% of total area in year 2006. During two decades, the UB increased by 3.89 km^2

or 0.18% of total area (Table 4.5), mostly from the change of MDF into UB (1.29 km^2 or 33.27% of total change). Although, the increment of UB was not significantly fitted the regression equation ($p = 0.06$), it could be predicted as the equation of $y = 0.179x – 343.711$ (Table 4.6 and Figure 4.6C). It could be noted that the rate of UB increase was 0.20 km^2/yr.

4.1.10 Land Use Change of Other Lands

The other lands (OL) composed of old clearings, uncultivated land, barren/ bare land was the least observed in 1987, found only 9.47 km^2 or 0.43% of total area (Table 4.1). The OL showed obviously high in 1997 and 2003 which were 28.69 and 84.19 km^2 or 1.29 and 3.79% of total area distributing in Khon Buri, Wang Nam Khiaw, Soeng Sang as well as Na Dee district. Increased OL could be significantly observed during 1987-2003 (19.23 and 55.49 km^2 in 1987-1997 and 1997-2003) (Tables 4.2 and 4.3), and it sharply decreased (-57.06 km^2) during 2003-2006 (Table 4.4). Nevertheless, OL area tended to increase during the period of 1987-2006 which was 17.66 km^2 or 0.80% of total area (Table 4.5). Increased OL was mainly obtained from the changing of DDF and MDF which were 6.26 and 5.07 km^2 or 35.46 and 28.70% of total change, respectively.

4.2 Land Use and Land Cover Change of 5 km Buffer around Thap Lan National Park between 1987 and 2006

Land use and land cover change of 5 km buffer around Thap Lan National Park were also analyzed by the data obtained from Landsat-5 TM imagery in 1987, 1997, 2003, and 2006. The change of 10 important land use types was described as followed:

4.2.1 Land Use Change of Dry Evergreen Forest of 5 km Buffer

Dry Evergreen Forest (DEF) of 5 km buffer around Thap Lan National Park were found mostly in the Southern, South-Eastern, and Western regions which are the areas of Pang Sida National Park, Dong Yai wildlife sanctuary, and Khao Yai National Park, respectively (Figures 4.1-4.4). DEF was also the most dominant land use in the buffer zone with the area of 510.89-511.50 km^2 or 31.78-31.88% of total area in 1987-2006 (Table 4.7). The change of DEF in the buffer zone was similar to the result inside Thap Lan National Park which showed some fluctuating results. A decrease of 0.61 km^2 was detected in 1987-1997 (Table 4.8), while an increase of 0.08 and 0.47 km^2 was found in 1997-2003 and 2003-2006 (Table 4.9 and 4.10), respectively. The overall change of -0.06 km^2 was observed during 1987-2006 (Table 4.11) due to the conversion among DEF, MDF, and DDF. The change of DEF was less fitting with the predicted model ($p > 0.05$) (Table 4.12 and Figure 4.7A).

Table 4.7 Land use of 5 km buffer around Thap Lan National Park in 1987, 1997, 2003, and 2006.

Land use types	Area (km^2)			
	1987	**1997**	**2003**	**2006**
Dry Evergreen Forest	511.50	510.89	510.97	511.44
Mixed Deciduous Forest	330.88	318.91	301.85	302.21
Dry Dipterocarp Forest	198.97	184.18	167.80	159.64
Paddy Field	169.31	155.84	116.84	143.39
Field Crop	194.87	190.41	187.63	208.10
Perennial and Orchard	90.32	83.48	102.01	92.08
Grassland	6.49	18.79	12.49	18.14
Water Body	36.98	49.49	50.38	59.25
Urban and Built-Up	46.73	49.99	53.70	59.10
Other Lands	18.63	42.71	101.02	51.34
Total	**1604.68**	**1604.68**	**1604.68**	**1604.68**

Table 4.8 Land use change matrix of 5 km buffer around Thap Lan National Park, between 1987 and 1997.

LULC in 1987	LULC in 1997 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	502.5064	8.2271	0.5508	0.0056	0.1056	0.0465	0.0063	0.0178	0.0028	0.0301	511.4990
MDF	7.5870	295.5531	7.9543	1.8222	6.4121	2.4329	0.4779	3.3861	0.9266	4.3291	330.8814
DDF	0.6765	7.2850	171.7416	0.7450	4.2646	1.7459	0.2360	8.2490	0.2978	3.7241	198.9656
PF	0.0020	2.0142	0.7418	146.9655	4.1740	4.3827	0.6643	3.5868	1.5259	5.2518	169.3089
FC	0.0777	1.8308	0.9277	1.7214	168.6544	5.1084	7.7681	1.2165	1.0545	6.5133	194.8728
PO	0.0311	2.4523	1.6073	1.4509	5.1469	67.2716	4.5759	1.8060	0.9723	5.0101	90.3244
GL	0.0065	0.3026	0.1084	0.2616	0.2940	0.3308	4.8976	0.0290	0.0220	0.2424	6.4948
WB	0.0031	0.5987	0.2456	1.7453	0.7136	1.4257	0.0323	30.7068	0.2664	1.2421	36.9796
UB	0.0002	0.4581	0.1413	0.8510	0.4330	0.3788	0.0415	0.1465	43.6060	0.6721	46.7283
OL	0.0010	0.1841	0.1619	0.2674	0.2114	0.3539	0.0882	0.3456	1.3179	15.6968	18.6282
Total	510.8914	318.9060	184.1807	155.8359	190.4097	83.4772	18.7880	49.4901	49.9922	42.7119	1604.6831
Area/ total area (%)	31.83	19.87	11.48	9.71	11.86	5.20	1.17	3.08	3.12	2.66	
Area change (km^2)*	-0.61	-11.98	-14.78	-13.47	-4.46	-6.85	12.29	12.51	3.26	24.08	
Area change/total area (%)*	-0.04	-0.75	-0.92	-0.84	-0.28	-0.43	0.77	0.78	0.20	1.50	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.9 Land use change matrix of 5 km buffer around Thap Lan National Park, between 1997 and 2003.

LULC in 1997	LULC in 2003 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	498.3748	11.0525	1.0833	0.0031	0.1875	0.0684	0.0138	0.0511	0.0132	0.0439	510.8914
MDF	11.5288	264.4147	9.4178	1.8357	11.1366	3.2609	0.6992	2.4679	2.1880	11.9563	318.9060
DDF	0.7962	9.5471	146.3230	0.7064	2.6007	1.7429	0.3980	4.2197	0.3976	17.4491	184.1807
PF	0.0058	1.8867	0.7615	101.6861	7.4640	22.3574	0.2837	4.1107	2.2882	14.9916	155.8359
FC	0.1372	5.3646	3.5033	1.8535	145.2355	8.6491	4.3358	1.1642	2.4335	17.7330	190.4097
PO	0.0512	2.6534	1.8145	2.9882	6.8289	52.7128	2.1180	1.3234	0.9416	12.0452	83.4772
GL	0.0188	0.7543	0.3254	1.1945	6.8234	4.1280	3.9574	0.0943	0.1497	1.3422	18.7880
WB	0.0273	2.0071	1.7062	2.6212	1.1462	3.4446	0.1308	34.9108	0.3897	3.1063	49.4901
UB	0.0042	0.7018	0.2353	1.0518	1.0616	0.9522	0.0705	0.2314	42.6136	3.0700	49.9922
OL	0.0306	3.4675	2.6260	2.8967	5.1408	4.6976	0.4859	1.8083	2.2807	19.2779	42.7119
Total	510.9749	301.8496	167.7962	116.8372	187.6251	102.0139	12.4931	50.3818	53.6957	101.0155	1604.6831
Area/ total area (%)	31.84	18.81	10.46	7.28	11.69	6.36	0.78	3.14	3.35	6.29	
Area change (km^2)*	0.08	-17.06	-16.38	-39.00	-2.78	18.54	-6.29	0.89	3.70	58.30	
Area change/ total area (%)*	0.01	-1.06	-1.02	-2.43	-0.17	1.16	-0.39	0.06	0.23	3.63	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.10 Land use change matrix of 5 km buffer around Thap Lan National Park, between 2003 and 2006.

LULC in 2003	LULC in 2006 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	498.7688	11.5220	0.3346	0.0058	0.1873	0.0548	0.0184	0.0314	0.0159	0.0358	510.9749
MDF	11.0838	257.6317	6.1003	1.2104	10.9676	3.1904	0.7527	2.4823	0.7538	7.6765	301.8496
DDF	1.2020	10.0502	133.9254	0.3901	12.7519	2.2072	0.3188	2.2418	2.0610	2.6480	167.7962
PF	0.0031	1.0726	0.6960	97.6118	2.0258	3.4613	1.2049	4.1683	1.0930	5.5004	116.8372
FC	0.1893	8.3950	1.6247	6.5040	147.4285	7.3004	6.5043	1.2100	1.0343	7.4345	187.6251
PO	0.0664	1.7581	0.9288	21.2293	9.0927	57.5378	3.9905	3.5026	0.9089	2.9989	102.0139
GL	0.0144	0.5320	0.2434	0.2207	4.4154	2.4127	3.9613	0.1445	0.0582	0.4906	12.4931
WB	0.0502	1.4959	1.0558	2.1768	0.8007	1.3480	0.0658	41.6684	0.2227	1.4974	50.3818
UB	0.0143	0.3507	0.1308	0.6465	0.4632	0.3717	0.0291	0.2152	50.6719	0.8023	53.6957
OL	0.0455	9.4001	14.5953	13.3957	19.9692	14.1910	1.2917	3.5883	2.2786	22.2601	101.0155
Total	511.4378	302.2082	159.6350	143.3910	208.1024	92.0753	18.1376	59.2529	59.0984	51.3446	1604.6831
Area/ total area (%)	31.87	18.83	9.95	8.93	12.97	5.74	1.13	3.69	3.68	3.20	
Area change (km^2)*	0.46	0.36	-8.16	26.55	20.48	-9.94	5.64	8.87	5.40	-49.67	
Area change/ total area (%)*	0.03	0.02	-0.51	1.65	1.28	-0.62	0.35	0.55	0.34	-3.09	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.11 Land use change matrix of 5 km buffer around Thap Lan National Park, between 1987 and 2006.

LULC in 1987	LULC in 2006 (km^2)										
	DEF	**MDF**	**DDF**	**PF**	**FC**	**PO**	**GL**	**WB**	**UB**	**OL**	**Total**
DEF	503.0159	8.2012	0.0340	0.0056	0.1194	0.0460	0.0063	0.0224	0.0132	0.0350	511.4990
MDF	7.5723	284.9657	3.4924	0.3541	13.0428	2.6423	0.4582	4.9079	2.8242	10.6215	330.8814
DDF	0.7302	7.2769	154.7430	0.0667	15.4405	1.9241	0.2323	12.0294	2.1740	4.3484	198.9656
PF	0.0020	0.3087	0.6701	140.1002	4.1046	4.5982	0.5935	7.0025	2.5503	9.3788	169.3089
FC	0.0776	0.3234	0.1817	0.5457	169.2512	5.1122	7.3179	1.7043	3.3617	6.9971	194.8728
PO	0.0302	0.2641	0.1996	0.3723	4.9740	75.5182	4.3434	1.9600	1.4039	1.2587	90.3244
GL	0.0064	0.2973	0.1045	0.2592	0.2908	0.3352	5.1193	0.0316	0.0275	0.0229	6.4948
WB	0.0031	0.5145	0.1795	1.5298	0.6922	1.3958	0.0319	31.1746	0.4107	1.0474	36.9796
UB	0.0002	0.0349	0.0146	0.1007	0.0949	0.0622	0.0047	0.0616	45.6720	0.6825	46.7283
OL	-	0.0214	0.0155	0.0564	0.0919	0.4410	0.0302	0.3587	0.6609	16.9523	18.6282
Total	511.4378	302.2082	159.6350	143.3910	208.1024	92.0753	18.1376	59.2529	59.0984	51.3446	1604.6831
Area/ total area (%)	31.87	18.83	9.95	8.93	12.97	5.74	1.13	3.69	3.68	3.20	
Area change (km^2)*	-0.06	-28.67	-39.33	-25.92	13.23	1.75	11.64	22.27	12.37	32.72	
Area change/ total area (%)*	0.00	-1.79	-2.45	-1.62	0.82	0.11	0.73	1.39	0.77	2.04	

* -, decrease.DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; PF, Paddy Field; FC, Field Crop; PO, Perennial and Orchard; GL, Grassland; WB, Water Body; UB, Urban and Built-Up; OL, Other land.

Table 4.12 Predicted model of 10 land use types in 5 km buffer around Thap Lan National Park.

Land use types	Regression model	P value	R^2
Dry Evergreen Forest	y = -0.011x + 532.249	0.719	0.079
Mixed Deciduous Forest	y = -1.638x + 3585.781	0.025*	0.951
Dry Dipterocarp Forest	y = -2.061x + 4296.247	0.013*	0.975
Paddy Field	y = -2.056x + 4254.4011	0.229	0.595
Field Crop	y = 0.350x - 503.708	0.677	0.104
Perennial and Orchard	y = 0.369x - 644.915	0.596	0.163
Grassland	y = 0.491x - 966.540	0.283	0.514
Water Body	y = 1.047x - 2042.666	0.042*	0.917
Urban and Built-Up	y = 0.593x - 1131.873	0.064	0.876
Other Lands	y = 2.917x - 5775.444	0.294	0.499

Regression models were analyzed by linear regression (SPSS), where x = year (Christian Era) and y = area, * represent the significant level at $p < 0.05$.

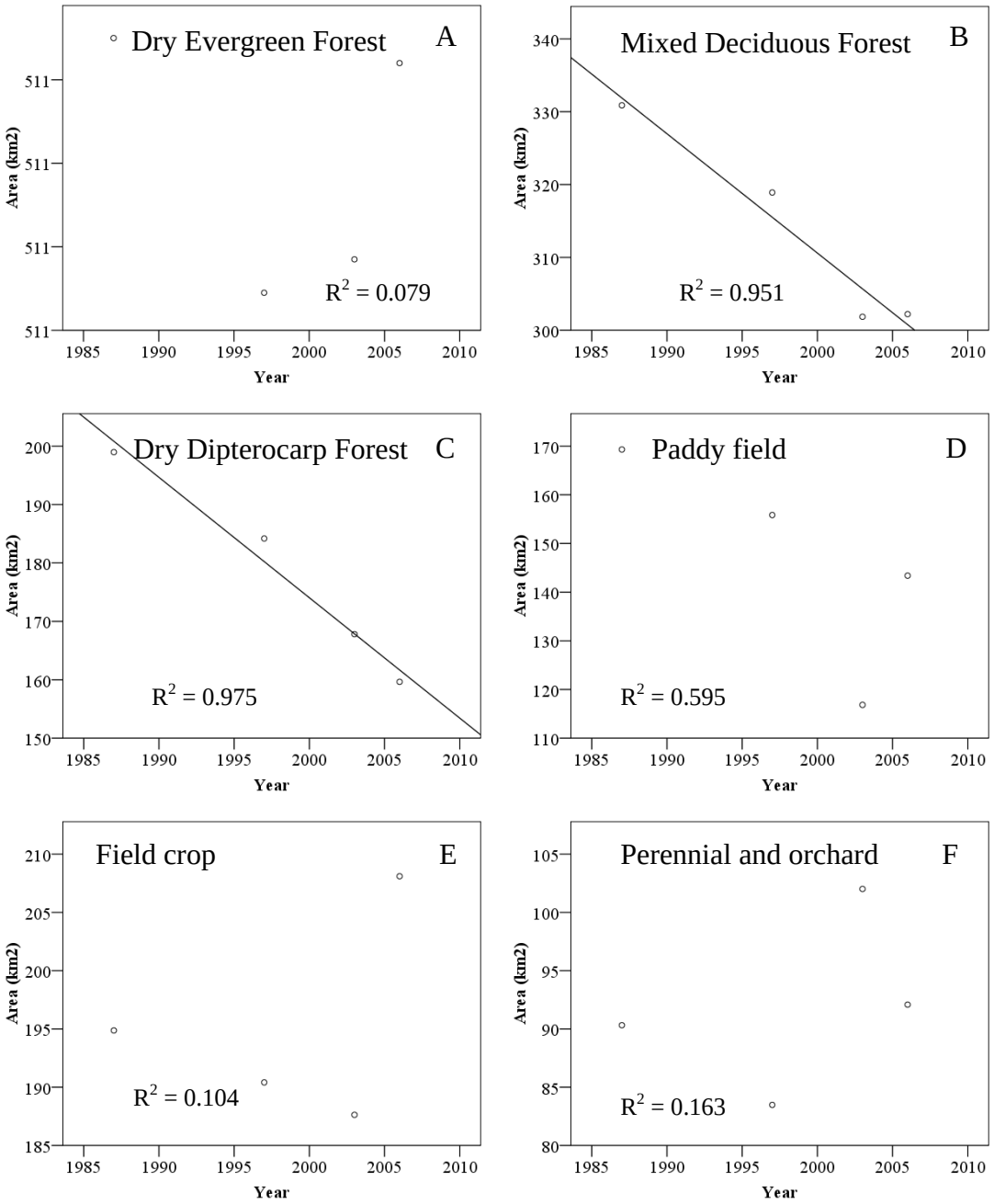

Figure 4.7 The fitted regression line and data points of 6 land use types of 5 km buffer around Thap Lan National Park. Dry Evergreen Forest (A), Mixed Deciduous Forest (B), Dry Dipterocarp Forest (C), paddy field (D), field crop (E), and perennial and orchard (F).

4.2.2 Land Use Change of Mixed Deciduous Forest of 5 km Buffer

Mixed Deciduous Forest (MDF) was the second dominant land use of the buffer zone distributed in the Southern, South-Eastern, and Western regions around Thap Lan National Park (Figures 4.1-4.4). MDF areas, located near the villages, decreased in the years 1987-1997 and 1997-2003 which were -11.97 and -17.06 km^2 or 0.74 and 1.06% of total area (Tables 4.8 and 4.9). The MDF slightly increased (0.36 km^2 or 0.02% of total area) in 2003-2006 (Table 4.10). However, as comparison of the change between 1987 and 2006, the overall decrease of 28.67 km^2 or 1.79% of total area was obtained (Table 4.10). Although, some of DDF changed into MDF (3.73 km^2), but the MDF further changed to field crop (12.72 km^2 or 44.37% of total change) and other lands (10.60 km^2 or 36.97% of total change). The change of MDF was well relating with the equation of $y = -1.638x + 3585.781$ ($p < 0.05$) (Table 4.12 and Figure 4.7B). MDF will be 277.02 km^2 in year 2020. The rate of MDF loss 1.638 km^2/yr in the buffer zone was higher than that observed in Thap Lan National Park.

4.2.3 Land Use Change of Dry Dipterocarp Forest of 5 km Buffer

The third dominant land use of 5 km buffer zone is Dry Dipterocarp Forest (DDF) accounting for 159.64-198.97 km^2 or 9.95-12.40% of total area (Table 4.7). DDF is distributed in the North and North-West beyond Thap Lan National Park (Figures 4.1-4.4). During 1987-1997 and 1997-2003, DDF areas of 14.79 and 16.38 km^2 were lost (Tables 4.8 and 4.9) related to the construction of Munbon dam in the North-Western region and Lam Sae dam in the Northern region, Khon Buri district (Figure 4.2). Moreover, during 2003-2006, DDF around the dams continuously decreased by 8.16 km^2 or 0.51% of total area (Table 4.10). The cause of change in

2003-2006 might be the encroachment of forest area for agricultural and economic purposes. Overall change of DDF during 1987-2006 revealed that the decrease of DDF was 39.33 km^2 or 2.45% of total area caused by deforestation into field crop (15.26km^2 or 38.80% of total change) and water body (11.85 km^2 or 30.13% of total change). The change of DDF was well predicted by the equation of $y = -2.061x + 4296.247$ ($p < 0.05$) (Table 4.12 and Figure 4.7C). As the result, the ongoing deforestation contributes to the DDF area of 133.03 km^2 will be observed in year 2020. The declining rate of 2.061 km^2/yr was observed which is higher than that inside Thap Lan National Park.

4.2.4 Land Use Change of Paddy Field of 5 km Buffer

Paddy field (PF) covered 116.84-169.31 km^2 or 7.28-10.55% of total area (Table 4.7). PF area was about 3.42-4.10 fold higher than that in Thap Lan National Park (Tables 4.1 and 4.7). The change of PF in the buffer zone had a similar pattern as that inside Thap Lan National Park. In 1987-2003, PF area tended to decrease (-13.47 km^2 during 1987-1997 and -39.00 km^2 during 1997-2003), but it increased in 2003-2006 (26.55 km^2 or 1.65% of total area) (Tables 4.8-4.10 and Figure 4.8). Overall, PF area decreased from 169.31 km^2 in 1987 to 143.39 km^2 in 2006, a decreasing area of 25.92 km^2 or 1.62% of total area was observed (Table 4.11). The PF changed to other lands, water body, perennial and orchard, and field crop with the area of 9.32, 5.47, 4.22, and 3.56 km^2, respectively.

4.2.5 Land Use Change of Field Crop of 5 km Buffer

Field crop (FC) was found between 187.63 to 208.10 km^2 or 11.69 to 12.97% of total area during study period (Table 4.7). It was 2.30 fold higher than that observed inside Thap Lan National Park (Table 4.1). The change of FC in the buffer zone showed a similar tends as observed in Thap Lan National Park. Slightly decreased FC area was observed during 1987-1997 and 1997-2003 which were -4.46 and -2.78 km^2 or -0.28 and -0.17%, respectively (Tables 4.8 and 4.9), whereas it tended to increase during 2003-2006 which was 20.48 km^2 or 1.28% of total area (Table 4.10). The overall change of FC in 1987-2006 periods revealed the 13.23 km^2 or 0.82% increasing area (Table 4.11) which was the similar amount as observed in Thap Lan. The increase of FC was detected from the high amount of decrease of DDF and MDF areas which were 15.26 and 12.72 km^2, respectively, and some of them changed to grassland.

Observed FC changes in this study showed the similar trend as Noochdumrong and Noochdumrong (2006). They reported that land use for cassava cultivation of the four villages near Thap Lan National Park border decreased during 1994-2000 and tended to increase during 2001-2004. Moreover, corn field showed unchanged during 1975-2000 and obviously increased in 2001-2004. The price of each crop and their market demands might be considered for the land use changes. From 1996-2005, cassava had the lowest price, it was not over 1.5 baht/kg. Meanwhile, the price of orchard products (rambutan, durian and mangosteen) was decreasing (the average of 17.13 baht/kg), but rubber tree price was increasing (the average of 29.71 baht/kg) (Office of Agricultural Economics quoted in Rodcha, Narkwiboonwong and Sawatruang, 2008).

4.2.6 Land Use Change of Perennial and Orchard of 5 km Buffer

Perennial and orchard (PO) covered 83.48-102.01 km^2 or 5.20-6.36% of total area (Table 4.7). The change of PO in the buffer zone exhibited some difference as compared with inside of Thap Lan National Park. PO decreased (-6.85 km^2) in 1987-1997 and tended to increase (18.54 km^2) in 1997-2003. Then, it turned out to decrease again from 2003 to 2006 (-9.94 km^2) (Tables 4.8-4.10). By the conversion among paddy filed, field crop, grassland and other lands, an increase of 1.75 km^2 or 0.11% of total area of the PO was obtained.

4.2.7 Land Use Change of Grassland of 5 km Buffer

Grassland was the land use least found in the buffer zone; it covered only 6.49 km^2 or 0.40% of total area (Table 4.7). As similar to the inside Thap Lan National Park, grassland of the buffer zone was clearly increased to 18.79 km^2 in 1997 and then tended to constant until year 2006. Therefore, during 1987-2006, the increase of 11.64 km^2 or 0.73% was detected (Table 4.11) which was obtained from the change of field crop (7.03 km^2) and perennial and orchard (4.01 km^2) to grassland.

4.2.8 Land Use Change of Water Body of 5 km Buffer

Water body (WB) of the buffer zone was 36.98 km^2 or 0.50% of total area in 1987 (Table 4.1 and Figure 4.1). Water body was gradually increased 12.5, 0.89, and 8.87 km^2 during 1987-1997, 1997-2003, and 2003-2006, respectively (Tables 4.8-4.10 and Figure 4.8). The forestland was converted into Munbon dam (some part) in the North-Western part (Khon Buri district) and Lum Sae dam in the Northern part (Khon Buri district), leading to the high WB area observed in 1997

(Figure 4.2). Furthermore, the minor change of WB was observed in the other reservoirs that attribute to an annual rainfall and irrigation. The increasing area of 22.27 km^2 or 1.39% of total WB area was observed during 1987-2006 (Table 4.11); these finding was the same magnitude as inside Thap Lan National Park (Table 4.5). Increased WB was mainly obtained from DDF, MDF, and PF which were 11.85, 5.47, and 4.39 km^2 or 53.21, 24.56, and 19.71%, respectively. Changing in water body could be predicted by the linear regression of $y = 1.047x - 2042.666$, $R^2 = 0.917$ ($p < 0.05$) shown in Table 4.12 and Figure 4.8 B.

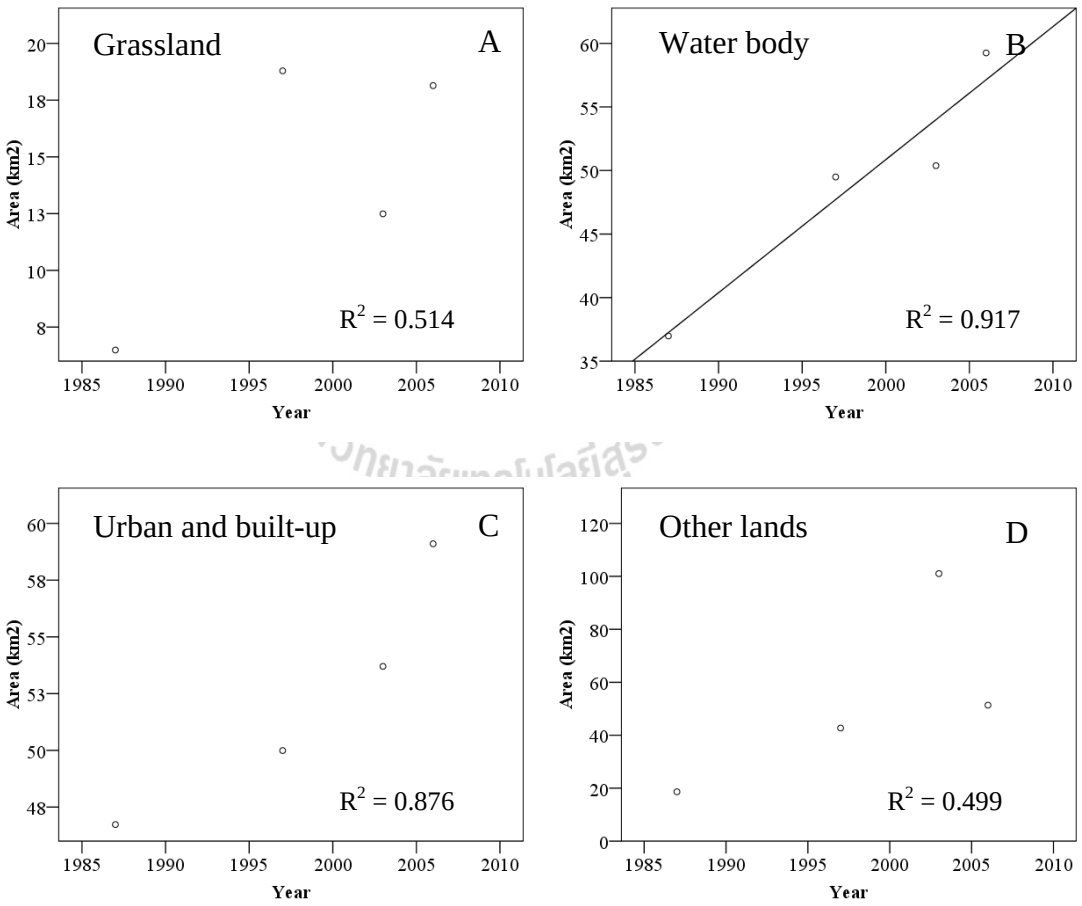

Figure 4.8 The fitted regression line and data points of 4 land use types of 5 km buffer around Thap Lan National Park. Grassland (A), water body (B), urban and built-up (C), and other lands (D).

4.2.9 Land Use Change of Urban and Built-up of 5 km Buffer

Urban and built-up (UB) covered the area of 46.73 km^2 or 2.91% of total area in year 1987 (Table 4.7) distributed in the four regions, North-Western (Khon Buri district), Western (Wang Num Khiaw district), South-Western (Na Dee district), and North-Eastern (Soeng Sang district) regions of Thap Lan National Park (Figure 4.1). In this period, UB gradually increased which were 3.26, 3.70, and 5.40 km^2 or 0.20, 0.23, and 0.34% of total area change in 1987-1997, 1997-2003, and 2003-2006, respectively (Tables 4.8-4.10). It should be noted that during the two decades, the UB increased 12.37 km^2 or 0.77% of total area (Table 4.11). Some of the forest area (MDF and DDF) and agricultural area (PF, FC, and PO) were changed to UB with the area of 2.79, 2.19, 2.45, 3.27, and 1.34 km^2, respectively. The rate of UB increasing was 0.65 km^2/yr that was more than the rate observed in Thap Lan National Park. The increment of UB was rather fitted the regression equation but not significantly ($p < 0.05$) (Table 4.12 and Figure 4.8 C). Supported data by Geo-Asia Company, quoted in Wongtawan (2006) showed that there were 259 villages in the 5 km buffer zone and inside Thap Lan National Park. The high amount of villages and population living near Thap Lan National Park put more pressure on natural forest for livelihood as well as the land for cultivation.

4.2.10 Land Use Change of Other Lands of 5 km Buffer

In 1987, other lands (OL) were 18.63 km^2 or 1.16% of total area (Table 4.7). Change of OL in the buffer zone had the similar trend as in Thap Lan National Park. OL area increased 24.08 and 58.30 km^2 or 1.50 and 3.63% of total area during 1987-1997 and 1997-2003, respectively (Tables 4.8 and 4.9), but it obviously

decreased -49.67 km^2 or -3.09% of total area during 2003-2006 (Table 4.10). The uncertain change of OL corresponded inversely with the agriculture lands such as paddy field and field crop indicating the conversion of the other lands and agricultural land. Overall change of OL over this study period was an increase of 32.72 km^2 or 2.04% of total area (Table 4.11) which were from forestland, MDF (10.60 km^2) and DDF (4.33 km^2) as well as agricultural areas, PF (9.32 km^2) and FC (6.90 km^2).

4.3 The Changes of Forest, Agriculture and Other Lands, Water Body, and Urban between 1987 and 2006

4.3.1 The Changes in Thap Lan National Park

The land use in Thap Lan National Park could be grouped into 4 main types: the forestland (DEF, MDF, and DDF), agricultural and other lands (paddy field, field crop, perennial and orchard, grassland, and other lands), water body, and urban and build-up. Land use mapping of the four categories are shown in Figures 4.9-4.12. The forestland of Thap Lan National Park decreased (58.53km^2 or 3.0% of forestland loss when compared with 1987) by encroaching and destruction of the DDF and MDF (Table 4.13 and Figure 4.17).

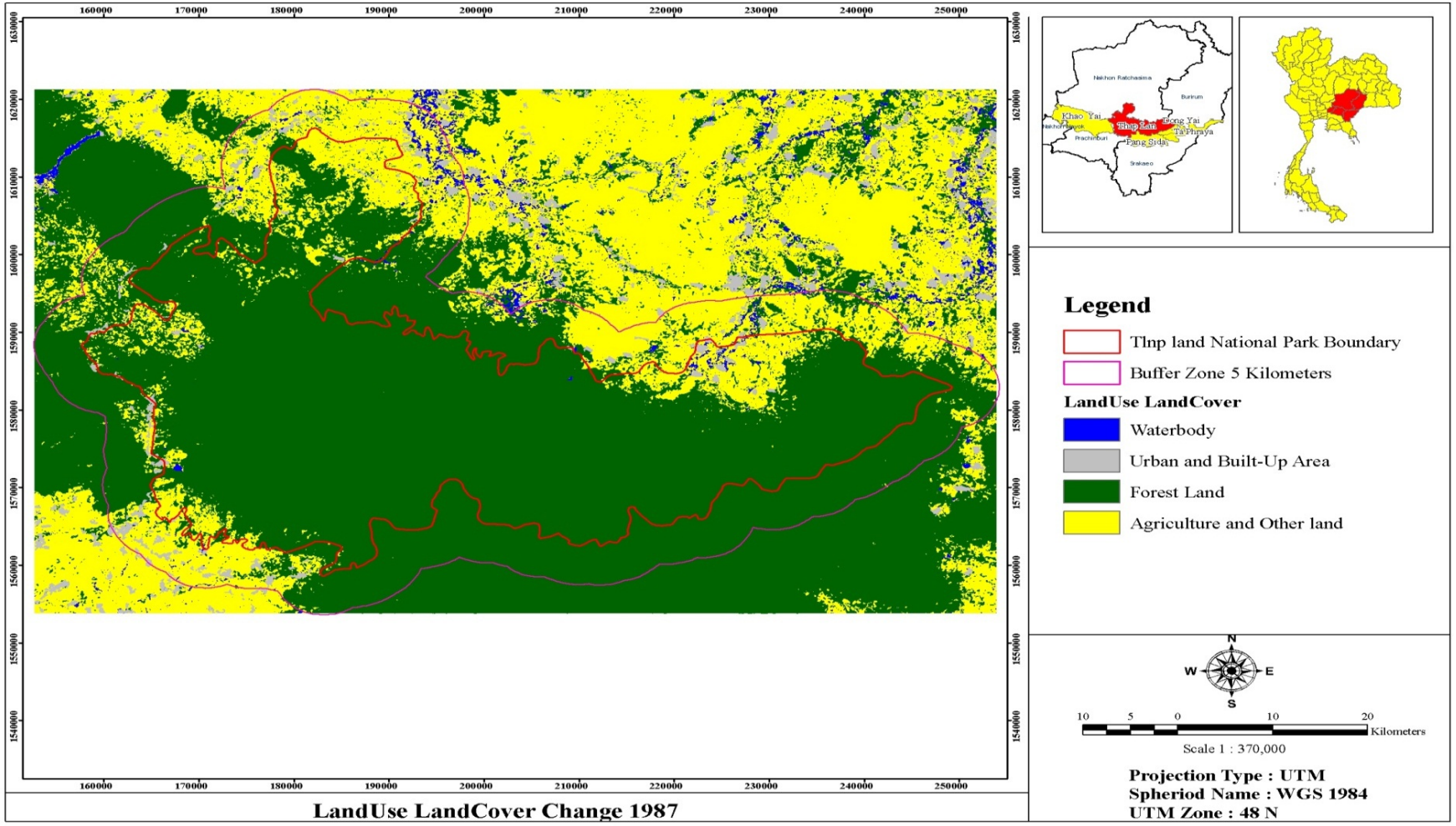

Figure 4.9 Land use and cover change of Thap Lan National Park and its buffer zone in 1987.

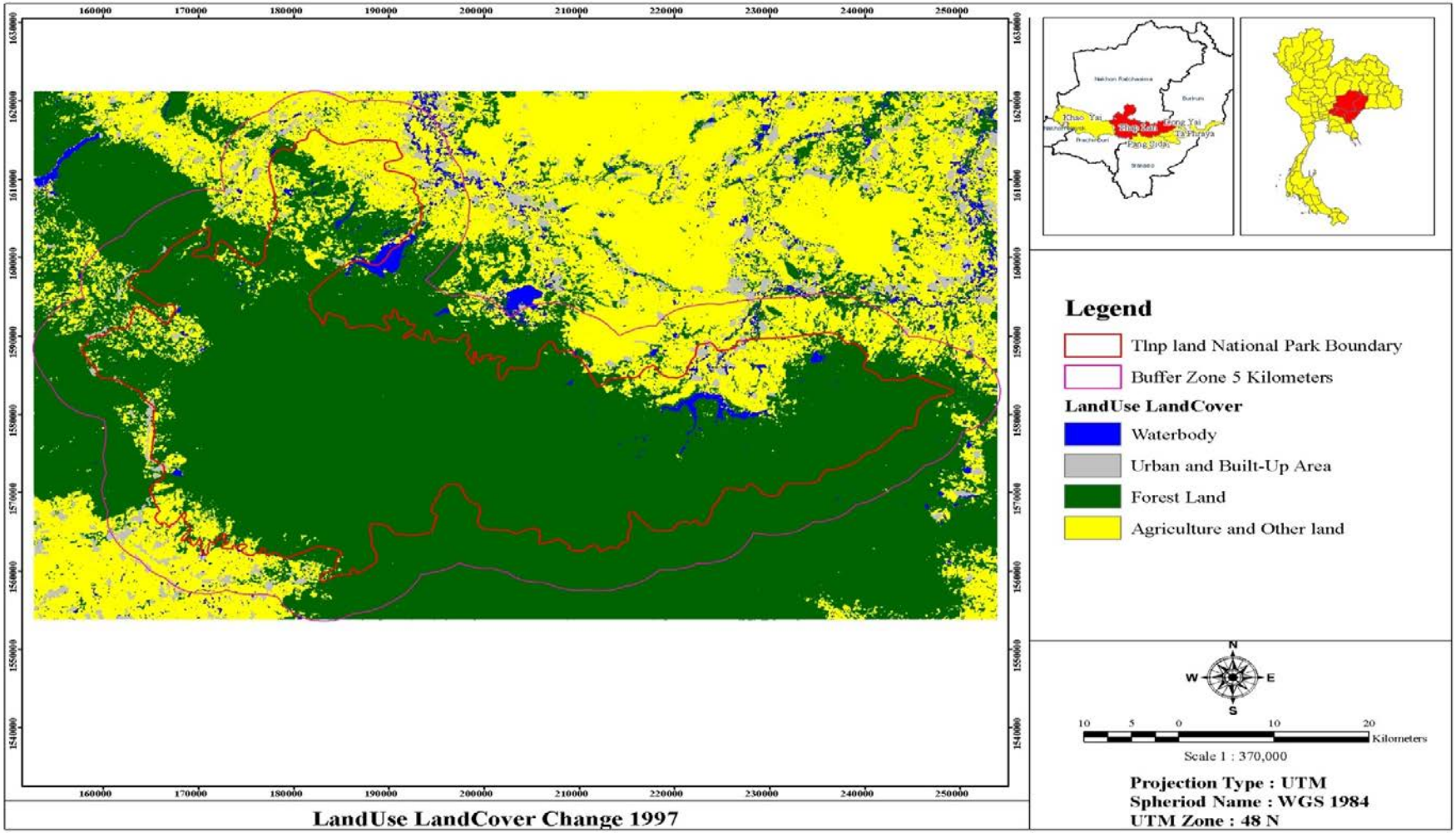

Figure 4.10 Land use and cover change of Thap Lan National Park and its buffer zone in 1997.

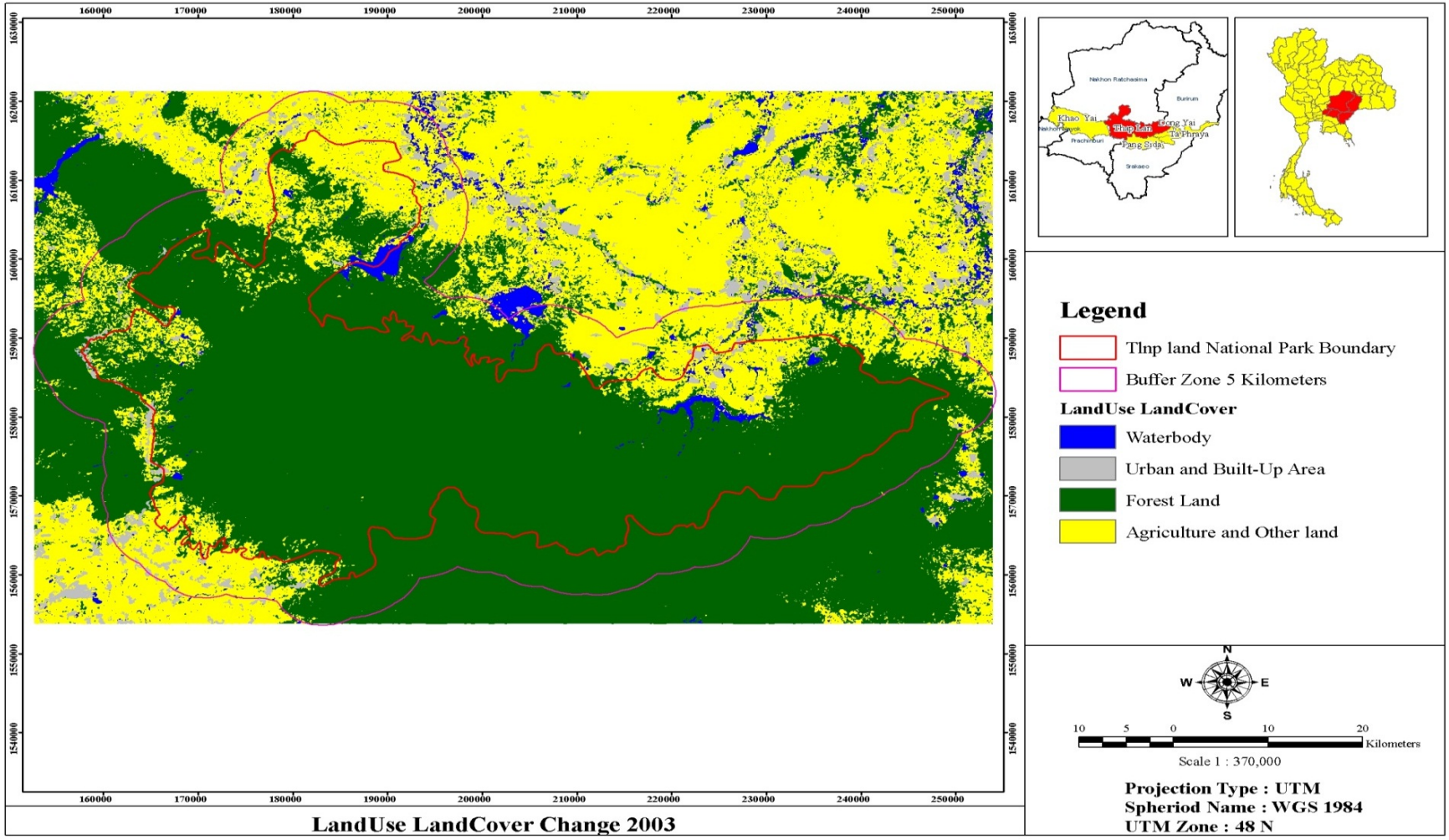

Figure 4.11 Land use and cover change of Thap Lan National Park and its buffer zone in 2003.

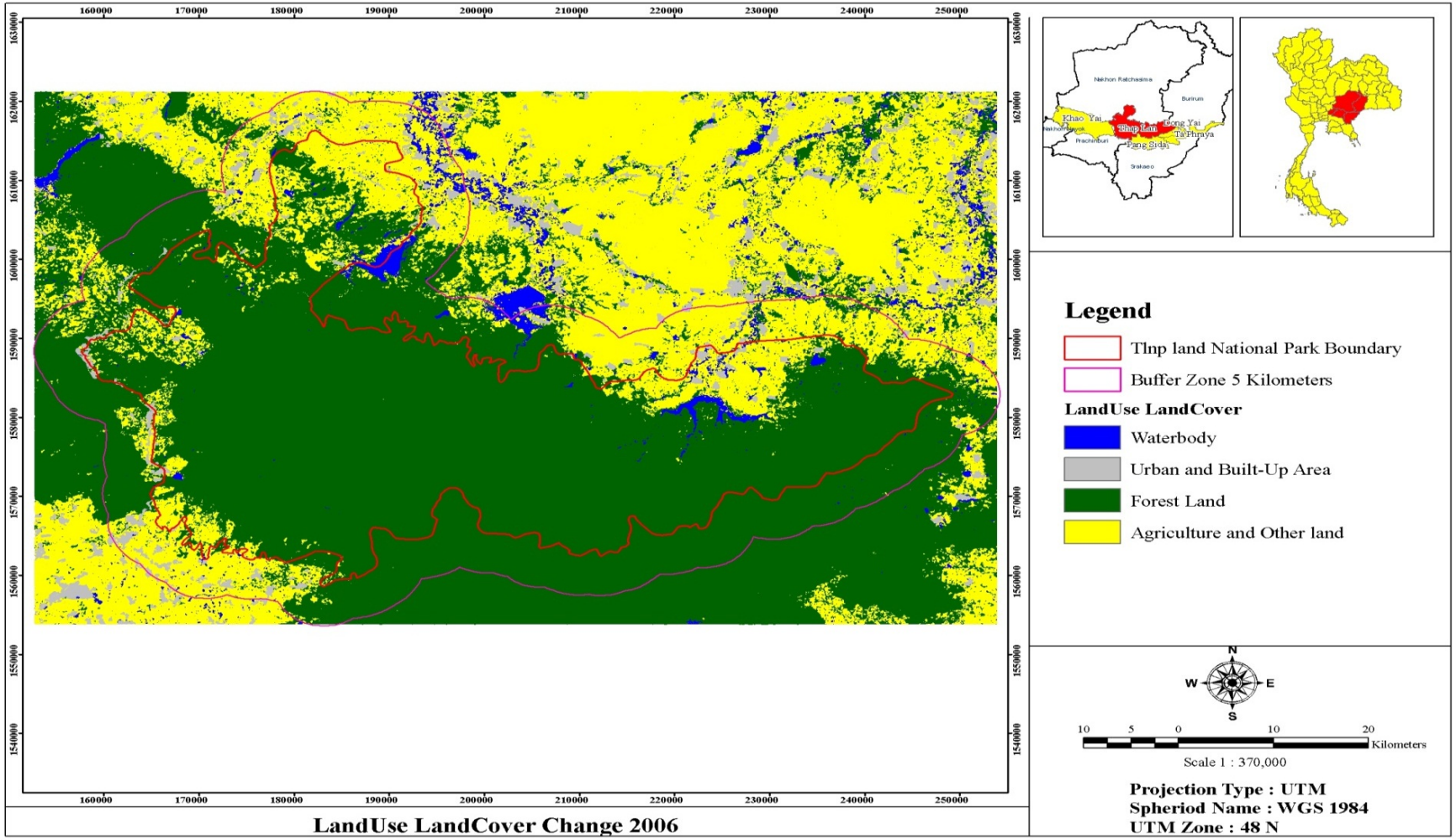

Figure 4.12 Land use and cover change of Thap Lan National Park and its buffer zone in 2006.

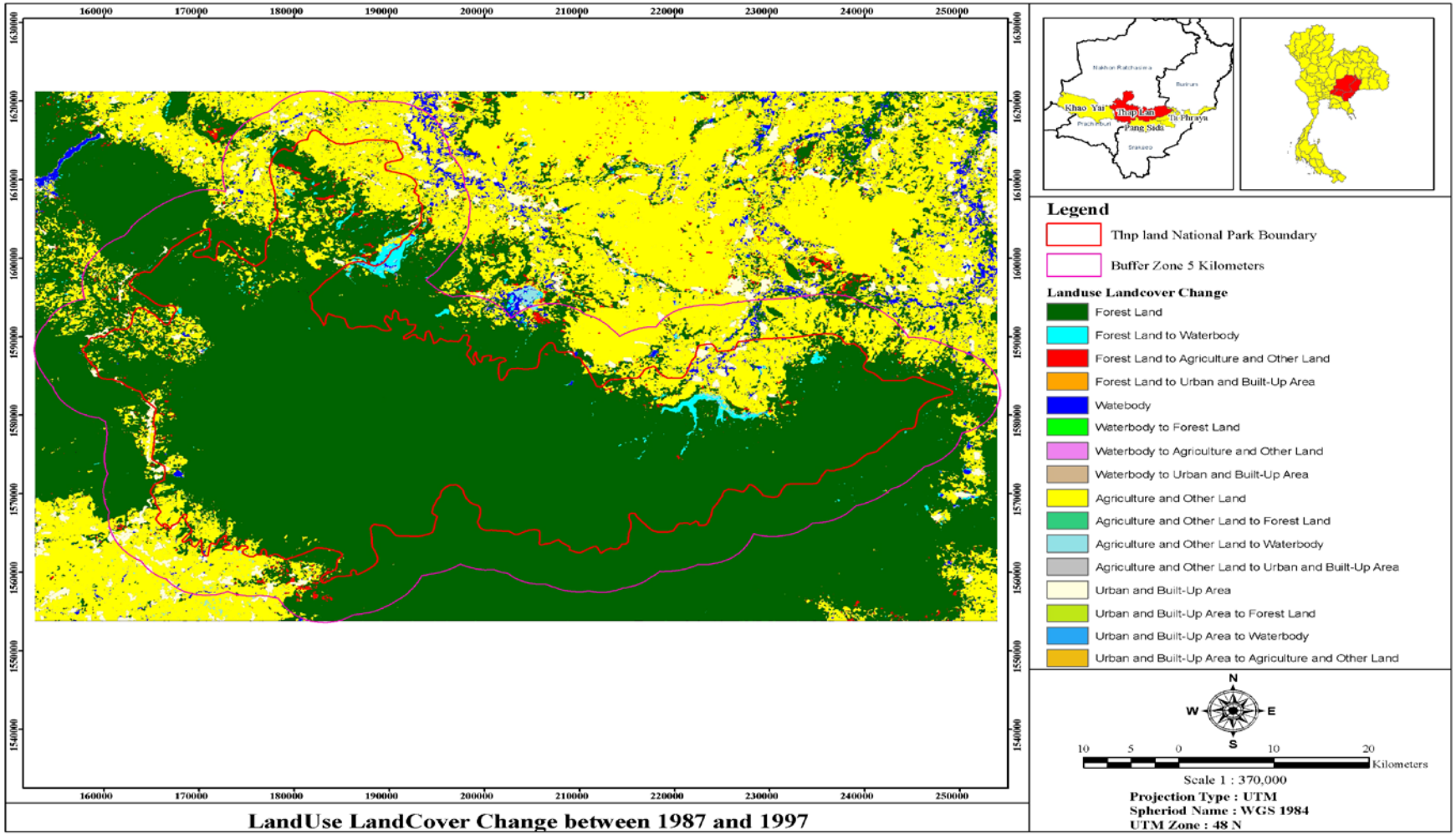

Figure 4.13 Comparison of land use and cover change of Thap Lan National Park and its buffer zone between 1987 and 1997.

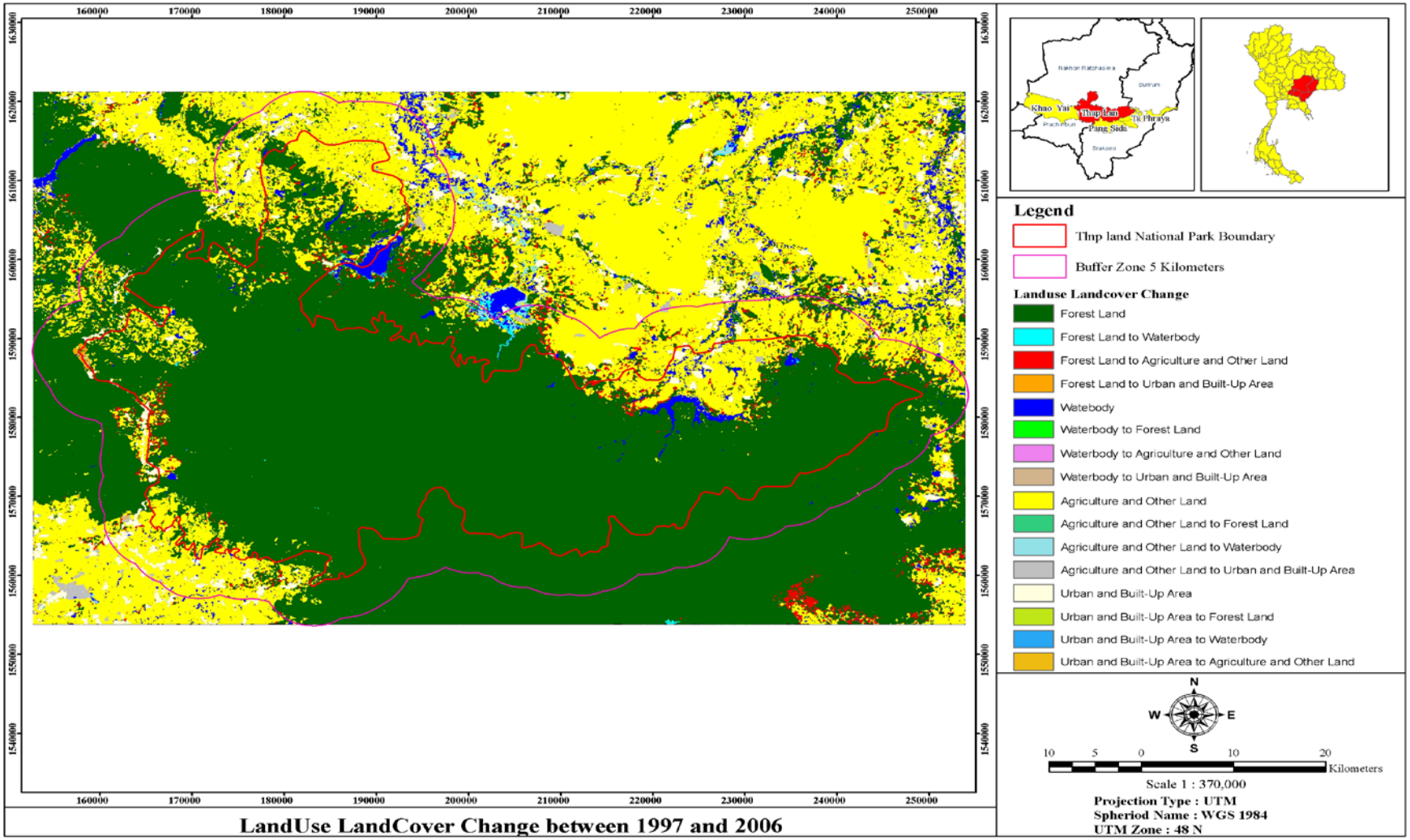

Figure 4.14 Comparison of land use and cover change of Thap Lan National Park and its buffer zone between 1997 and 2006.

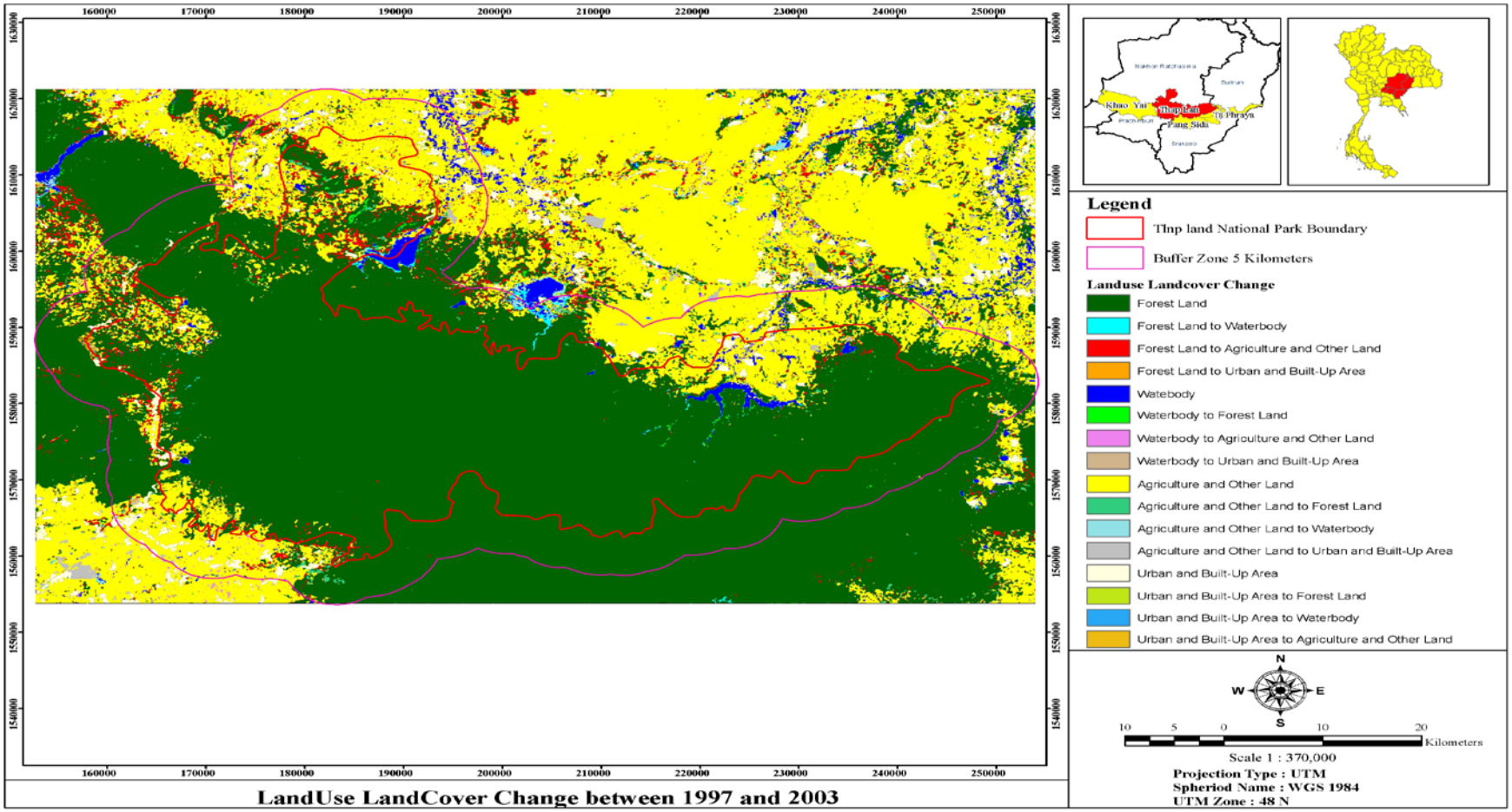

Figure 4.15 Comparison of land use and cover change of Thap Lan National Park and its buffer zone between 1997 and 2003.

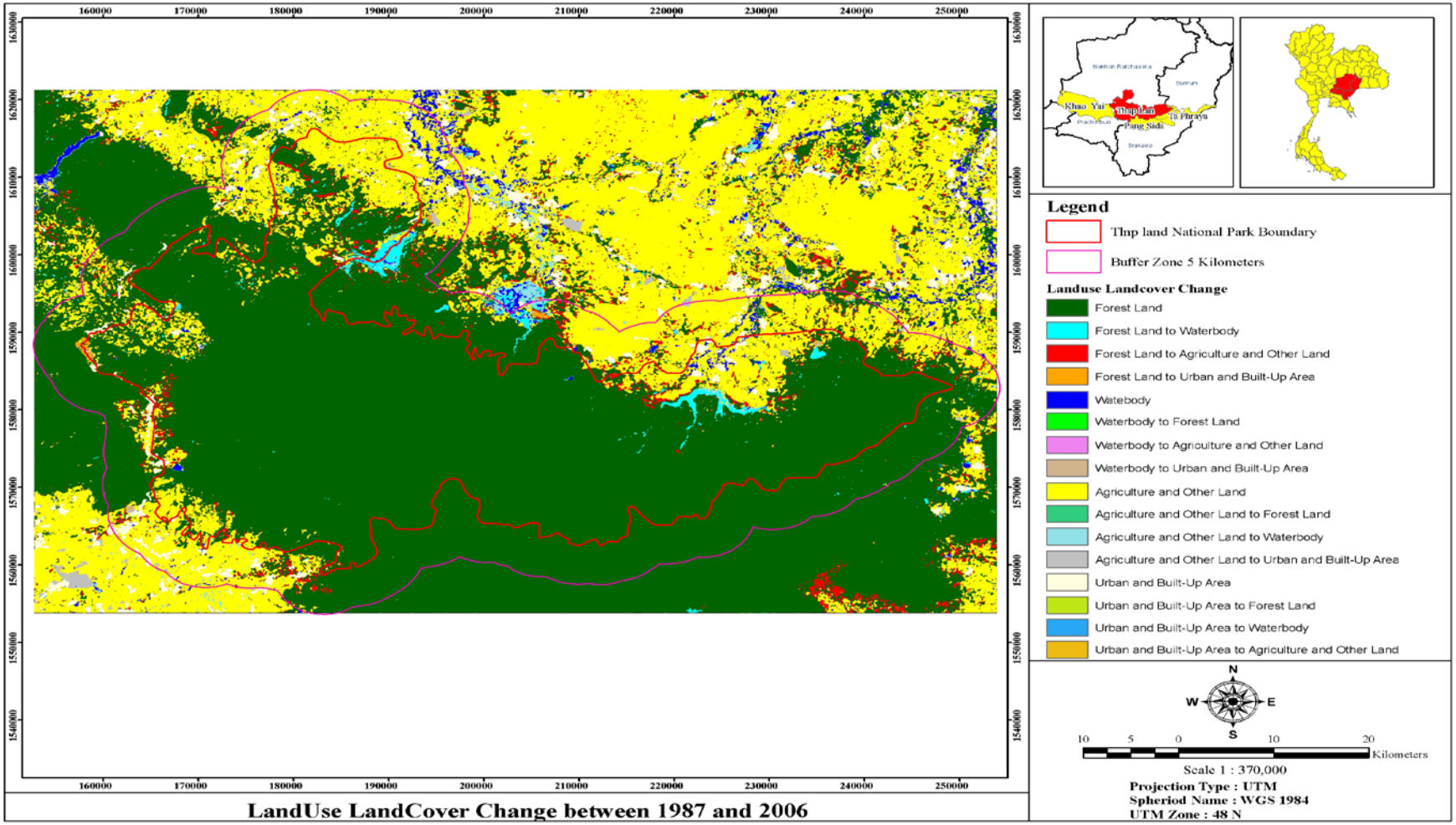

Figure 4.16 Comparison of land use and cover change of Thap Lan National Park and its buffer zone between 1987 and 2006.

Table 4.13 The forestland, agricultural and other lands, water body, and urban and built-up of Thap Lan National Park in 1987, 1997, 2003, and 2006.

Land use types	Area (km^2)			
	1987	**1997**	**2003**	**2006**
Forestland	1,948.73	1,918.79	1,890.42	1,890.20
Agricultural and other lands	248.50	256.09	288.03	280.69
Water body	11.13	31.72	27.87	33.58
Urban and Built-Up	11.11	12.88	13.15	15.00
Total	**2,219.47**	**2,219.47**	**2,219.47**	**2,219.47**

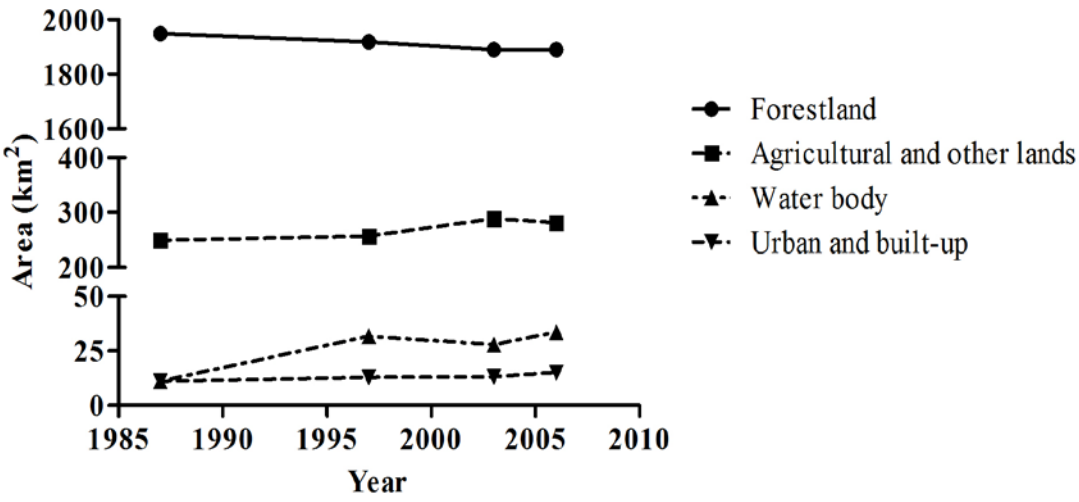

Figure 4.17 Comparison of the forestland, agricultural and other lands, water body, and urban and built-up of Thap Lan National Park between 1987 and 2006.

The area of forestland could be predicted by the regression equation of $y = -3.321x + 8549.129$, $R^2 = 0.974$ ($p < 0.05$) (Figure 4.18 A). The forestland will be 1,840.71

km^2 in 2020. A rate of decrease at -3.321 km^2/yr was observed. During 1987-1997, the decrease of forestland, especially the DDF and MDF, was 29.94 km^2or 1.35% of total area. These decreases of forestland corresponded to the construction of Lam Plai Mat dam in the North-Eastern part (during 1992-1996) and some part of Munbon dam in the North-Western part (Figure 4.13).

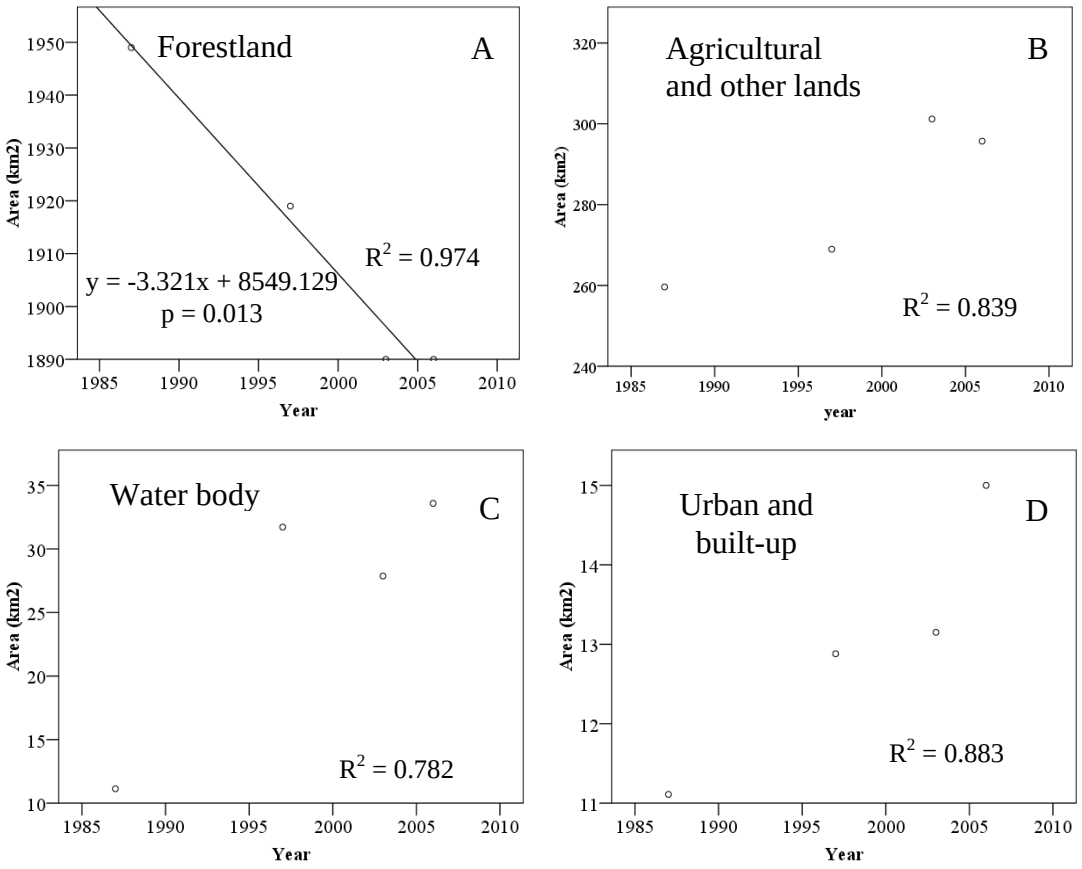

Figure 4.18 The fitted regression line and data points of the 4 main land uses of Thap Lan National Park. Forestland (A), Agricultural and other lands (B), Water body (C), and Urban and built-up (D).

During 1997-2006, the destruction of forest causing by encroachment, agricultural expansion and tourist attraction were going on (Figure 4.14). In contrast, the

agricultural and other lands increased significantly, most of which expanded into the encroached forest area which were 7.59 and 31.94 km^2or 0.34 and 1.44% of total area in 1987-1997 and 1997-2003 (Figure 4.15), respectively. Because of an increasing population and the demand of agricultural area, during 1997-2006, forestland has been converted to agriculture and other lands at about 21.83 km^2 (Table 4.13 and Figure 4.16). Furthermore, according to the good view and scenery of Thap Lan National Park, urban and built-up gradually increased which might be resorts for tourist attractions.

4.3.2 The Changes in the 5 km Buffer Zone

The forestland of 5 km buffer around Thap Lan National Park gradually decreased by destruction of the DDF and MDF (Table 4.14 and Figure 4.19). Changing of forestland well fitted the regression equation of $y = -3.693x + 8381.316$, $R^2 = 0.975$ ($p < 0.05$) (Figure 4.20A) indicating that the forestland will be 921.46 km^2 in 2020. The rate of decrease was -3.693 km^2/yr, higher than that observed in Thap Lan National Park. During 1987-1997, there was a decrease of forestland while the water body increased (12.51 km^2) (Figure 4.13). This could be from the construction of Munbon dam and Lum Sae dam in the North-Western and Northern part (Khon Buri district) beyond the Thap Lan National Park. It was noted that between 1997 and 2006, forestland area has been converted to field crop, perennial and orchard, grassland as well as other lands at about 30.94 km^2 or 1.93% of total area (Table 4.14 and Figures 4.14-4.16). The increment of agricultural and others land was not well predicted by the regression model (Figure 4.20B).

Table 4.14 The forestland, agricultural and other lands, water body, and urban and built-up of 5 km buffer around Thap Lan National Park in 1987, 1997, 2003, and 2006.

Land use type	Area (km^2)			
	1987	**1997**	**2003**	**2006**
Forestland	1,041.35	1,013.98	980.62	973.28
Agricultural and other lands	479.63	491.22	519.98	513.05
Water body	36.98	49.49	50.38	59.25
Urban and Built-Up	46.73	49.99	53.70	59.10
Total	**1,604.68**	**1,604.68**	**1,604.68**	**1,604.68**

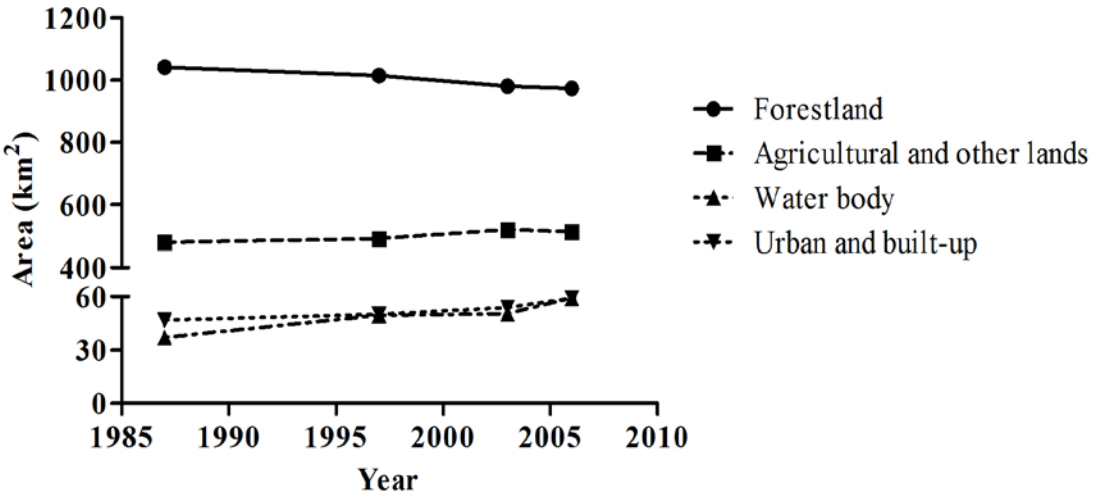

Figure 4.19 Comparison of the forestland, agricultural and other lands, water body, and urban and built-up of 5 km buffer around Thap Lan National Park between 1987 and 2006.

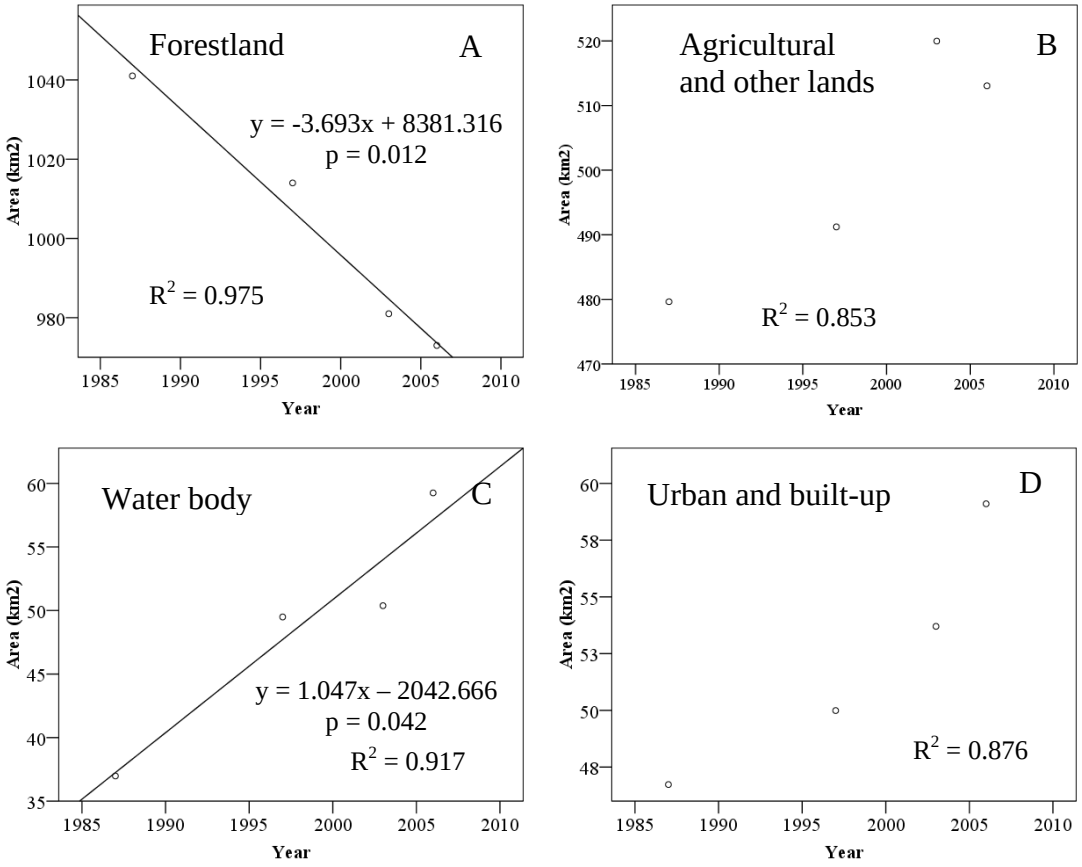

Figure 4.20 The fitted regression line and data points of the 4 main land uses of 5 km buffer around Thap Lan National Park. Forestland (A), Agricultural and other land (B), Water body (C), and Urban and built-up (D).

According to the study of Noochdumrong and Noochdumrong (2005) during 2000-2004, they found that the forest area decreased rapidly at 3,474.88 ha or 34.75 km^2 during 2000-2004, or an average of 8.69 km^2/yr. Moreover, they revealed that the other lands (including agricultural area) increased to 35.07 km^2. The main crops were cassava, corn, vegetable and cut flower. These findings showed different results from the present study which showed a rate of decrease of forestland at 4.73 km^2/yr, while the agricultural and others land were decreased at 32.22 km^2 during 1997-2003.

Moreover, Wongtawan (2006) studied the land use change of Dong Payayen-Khao Yai Forest complex which is composed of Khao Yai, Thap Lan, Pang Sida and Tha Phraya National Parks, along with Dong Yai Wildlife Sanctuary. The land use change of the forestland tended to decrease, except for Pang Sida National Park. The highest decrease was found in Thap Lan National Park, followed by Khao Yai, Tha Phraya National Parks, and Dong Yai Wildlife Sanctuary which were 34.75, 5.26, 5.64, and 4.54 km^2, respectively. In contrast, Pang Sida National Park showed an increase of forestland of 2.00 km^2 during 2000-2004. It could be said that Thap Lan National Park was the most vulnerable of forest trespassing and deforestation.

There are many reasons for the change of land use and land cover. As mentioned by Fujita (2006) that, aside from slash and burn, civil war, and agricultural expansion are expected to be the causes of land use change in Laos. However, a reason for this expansion is the increasing population and economic expectation of the farmers changing their future view from subsistence to economy perspective. Moreover, the causes of the changes in land use in Thap Lan National Park and 5 km buffer could be described as followings;

1) Most of the population in the area lacked the sense of the forest resource conservation and protection and did not participate in preventing forest fires. The main cause of changing in land use between 1987 and 2006 was the agricultural invaded by people. The government policy, forest conservation knowledge and campaign are needed for resolving this problem.

2) People took possession of the land between 1975 and 2004 by invading the forest in Thap Lan National Park and sale. In 1975, people lost the land-owner right by the government confiscation for restoration and plantation of the forest.

The projects of the forest villages, the dams and the reservoirs for agriculture were continuously begun.

Satellite images (Landsat TM) by remote sensing technique have been versatile use for analysis of land use and land cover change. Remote sensing for land evaluation have several advantages and easy to combine with other geographic coverage in the GIS. However, the misinterpretation may occur. Atmospheric water vapor, sun and shadow can interfere with the image and must be accounted for.

4.4 Forest Structure of Three Forest Types in Thap Lan National Park

Seventeen plots of 40x40 m^2 in Thap Lan National Park were analyzed for plant community structure and diversity. Seven plots in Dry Evergreen Forest (DEF), seven plots in Mixed Deciduous Forest (MDF), and three plots in Dry Dipterocarp Forest (DDF) were determined.

The total of 141 plant species were observed in the studied plots. Each forest type has a variable of plant species, but they share some of common species (Table 4.15). Only four plant species, commonly found in three forest types, were *Parinari anamense* Hance, *Elaeis griffithii* (Wight) A. Gray, *Fagraea fragrans* Roxb., and *Irvingia malayana* Oliv. Ex A. W.Benn. (Table 4.15). DEF had the same 23 species (16.31%) with MDF and 3 species (2.13%) with DDF. While only 2 species (1.42%) in MDF were the same as in the DDF. Therefore, three forest types have different plant composition.

Table 4.15 Tree species and basal area (m^2/ha) in three forest types.

No	Scientific name	DEF	MDF	DDF
1	*Ficus curtipes* Corner	3.3548	0	0
2	*Garcinia cowa* Roxb.	2.8799	0.8982	0
3	*Lagerstroemia floribunda* Jack	2.4101	1.4127	0
4	*Hydnocarpus anthelminthicus* Pierre ex Laness	2.0653	0	0
5	*Parinari anamense* Hance	1.4633	0.0253	0.0298
6	*Ceriscoides turgida* (Roxt) Tirveng	1.1659	0.0431	0
7	*Bouea oppositifolia* (Roxb.) Meisn.	0.9090	0	0
8	*Vitex pinnata* L.	0.8469	0	0
9	*Excoecaria oppositifolia* Griff.	0.8329	0	0
10	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	0.7080	0	0
11	*Ficus rumphii* Blume	0.7077	0	0
12	*Pentace burmanica* Kurz	0.6691	0.1481	0
13	*Syzygium cumini* (L.) Skeels	0.6067	0.0432	0
14	*Carallia brachiata* (Lour.) Merr.	0.5563	0.4877	0
15	*Shorea henryana* Pierre	0.5294	2.6437	0
16	*Paranephelium xestophyllum* Miq.	0.5182	0	0
17	*Hopea ferrea* Laness.	0.4493	0	0
18	*Aphanamixis polystachya* (Wall.) R.Parker	0.4280	0	0.0354
19	*Nyssa javanica* (Blume) Wangerin	0.4108	0	0
20	*Nephelium hypoleucum* Kurz	0.3735	0	0
21	*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne	0.3185	0	0
22	*Horsfieldia macrocoma* Warb. Var. *canarioides*	0.3103	0	0
23	*Hibiscus tiliaceus* L.	0.2859	0	0
24	*Acrocarpus fraxinifolius* Wight ex Arn.	0.2780	0	0
25	*Microcos paniculata* L.	0.2603	0.1656	0
26	*Cinnamomum glaucescens* (Nees) Drury	0.2494	0	0
27	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	0.2487	0.1512	0
28	*Sapindus rarak DC.*	0.2440	0	0
29	*Memecylon scutellatum* Naudin	0.2269	0.3304	0
30	*Aglaia rufinervis* (Blume) Bentv.	0.2250	0	0
31	*Pterocymbium acerifolium* (L.) Willd.	0.2154	0.8200	0
32	*Cleidion spiciflorum* (Burm.f.) Merr.	0.2056	0	0
33	*Croton cascarilloides* Raeusch.	0.1971	0	0
34	*Senecio garrettiana* (Craib) H.S. Irwin &Barneby	0.1969	0	0.1809
35	*Terminalia triptera* Stapt	0.1884	0	0
36	*Artocarpus lacucha* Roxb.	0.1851	0.4952	0

Table 4.15 (Continued).

	Scientific name	DEF	MDF	DDF
37	*Rhus javanica* L.	0.1791	0	0
38	*Elaeis griffithii* (Wight) A.Gray	0.1790	0.2469	0.1276
39	*Dipterocarpus turbinatus* C.F. Gaertn.	0.1754	1.2366	0
40	*Dipterocarpus alatus* Roxb. Ex G.Don	0.1556	0	0
41	*Pterocymbium tinctorium* (Blanco) Merr.	0.1413	0	0
42	*Knema globularia* (Lam.) Warb.	0.1269	0	0
43	*Dipterocarpus obtusifolius* Teijsm. ex Miq.	0.1242	0	0
44	*Litsea glutinosa* (Lour.) C.B.Rob.	0.1235	0.0593	0
45	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	0.0972	0.0195	0
46	*Neolitsea siamensis* Kosterm	0.0945	0	0
47	*Fagraea fragrans* Roxb.	0.0886	0.0385	0.0287
48	*Stereospermum neuranthum* Kurz	0.0834	0.3800	0
49	*Dracaena conferta* Ridl.	0.0786	0	0
50	*Polyalthia lateriflora* (Blume) King	0.0770	0	0
51	*Aquilaria crassna* Pierre ex Lecomte	0.0721	0	0
52	*Syzygium claviflorum* (Roxb.) A.M.Cowan & Cowan	0.0710	0	0
53	*Urobotrya siamensis* Hiepko	0.0686	0	0
54	*Knema globularia* (Lam.) Warb.	0.0545	0	0
55	*Dalbergia oliveri* Gamble	0.0535	0	0.1142
56	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	0.0526	0	0
57	*Dialium cochinchinense* Pierre	0.0497	0.0326	0
58	*Microcos tomentosa* Sm.	0.0463	0	0
59	*Drypetes roxburghii* (Wall.) Hurusawa	0.0456	0	0
60	*Irvingia malayana* Oliv. ex A.W.Benn.	0.0401	0.0077	0.1491
61	*Suregada multiflorum* (A.Juss.) Baill.	0.0398	0.2136	0
62	*Diospyros rubra* Lecomte	0.0389	0	0
63	*Garcinia nigrolineata* Planch. Ex T.Anderson	0.0382	0	0
64	*Adenanthera pavonina* L.	0.0357	0	0
65	*Hopea odorata* Roxb.	0.0347	0	0
66	*Diospyros gracillis* Fletcher	0.0306	0.3631	0
67	Dracontomelon dao (Blanco) Merr. & Rolfe	0.0260	0	0
68	unknow	0.0250	0	0
69	*Zamia limonella* (Dennst.) Alston	0.0250	0.0121	0
70	*Shorea farinosa* C.E.C.Fisch.	0.0209	0	0
71	*Melaleuca alternifolia* Cheel	0.0191	0	0
72	*Parkia speciosa* Hassk.	0.0183	0.3854	0
73	*Pentace* sp.	0.0183	0.2368	0
74	*Meliantha suavis* Pierre	0.0154	0	0

Table 4.15 (Continued).

No	Scientific name	DEF	MDF	DDF
75	*Dracaena loureiri* Gagnep	0.0147	0	0
76	*Cratoxylum maingayi* Dyer	0.0115	0.0788	0
77	*Cinnamomum porrectum* (Roxb.) Kosterm.	0.0109	0	0
78	*Mammea siamensis* (T. Anderson) Kosterm.	0.0087	0	0
79	*Casearia* sp.	0.0082	0	0
80	*Baccaurea ramiflora* Lour.	0.0077	0	0
81	*Broussonetia papyrifera* (L.) Vent.	0.0072	0	0
82	*Pterocarpus macrocarpus* Kurz	0	2.3029	0.9205
83	*Sandoricum koetjape* (Burm.f.) Merr.	0	1.3005	0
84	*Shorea roxburghii* G.Don	0	1.1357	0
85	*Ficus hirta* Vahl	0	0.9550	0
86	*Corypha lecomtei* Becc.	0	0.7413	0
87	*Sterculia guttata* Roxb.	0	0.6980	0
88	*Wrightia arborea* (Dennst.) Mabb.	0	0.4075	0
89	*Phyllocarpus septentrionalis* Donn.Sm.	0	0.3859	0
90	*Peltophorum dasyrachis* (Miq.) Kurz.	0	0.3190	0
92	*Vatica harmandiana* Pierre	0	0.2322	0
93	*Ficus hispida* L.f.	0	0.2281	0
94	*Haldina cordifolia* (Roxb.) Ridsdale	0	0.2116	0.0287
95	*Microcos tomentosa* Sm.	0	0.1778	0
96	*Nephelium hypoleucum* Kurz	0	0.1411	0
97	*Lagerstroemia speciosa*	0	0.1328	0
98	*Ardisia murtonii* Fletcher	0	0.1152	0
99	*Ixora cibdela* Craib	0	0.1063	0
100	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.	0	0.0943	0
101	*Bambusa* sp.	0	0.0870	0
102	*Erythrina subumbrans* (Hassk.) Merr.	0	0.0772	0
103	*Radermachera hainanensis* Merr.	0	0.0726	0
104	*Dalbergia cochinchinensis* Pierre	0	0.0675	0
105	*Croton roxburghii* N.T. Balakr.	0	0.0414	0
106	*Holarrhena pubescens* Wall. ex A.DC.	0	0.0364	0
107	*Hymenodictyon orixense* (Roxb.) Mabb.	0	0.0277	0
108	*Syzygium thorelii* (Gagnep.) Merr. & L.M.Perry	0	0.0272	0
109	*Amesiodendron chinense* (Merr.)	0	0.0271	0
110	*Paranephelium xestophyllum* Miq.	0	0.0241	0
111	*Colona auriculata* (Desv.) Craib	0	0.0218	0
112	*Anthocephalus chinensis* (Lam.) A.Rich ex Walp	0	0.0127	0
113	*Senna garrettiana* (Craib) Irwin & Barneby	0	0.0127	0

Table 4.15 (Continued).

No	Scientific name	DEF	MDF	DDF
114	*Zamia limonella* (Dennst.) Alston	0	0.0121	0
115	*Butea monosperma* (Lam.) Taub.	0	0.0104	0
116	*Baccaurea parviflora* (MÜll.Arg.) MÜll.Arg.	0	0.0098	0
117	*Streblus ilicifolius* (Vidal) Corner	0	0.0077	0
118	*Vitex quinata* (Lour.) F.N.Williams	0	0.0072	0
119	*Shorea obtusa* Wall. ex Blume	0	0	2.1709
120	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	0	0	0.4825
121	*Shorea siamensis* Miq.	0	0	0.3566
122	*Helicteres elongata* Wall. ex Bojer	0	0	0.1442
123	*Buchanania lanzan* Spreng.	0	0	0.1354
124	*Erythrophleum succirubrum* Gagnep.	0	0	0.1347
125	*Sindora siamensis* Teijsm. & Miq. var. siamensis	0	0	0.1175
126	*Quercus austro-cochinensis* Hickel & A.Camus	0	0	0.0559
127	*Morinda coreia* Ham.	0	0	0.0520
128	*Schleichera oleosa* (Lour.) Oken	0	0	0.0493
129	*Garcinia speciosa* Wall.	0	0	0.0484
130	*Sauropus androgynus* (L.) Merr.	0	0	0.0379
131	*Stephania pierrei* Diels	0	0	0.0322
132	*Micromelum minutum* (G.Forst.) Wight & Arn.	0	0	0.0302
133	*Castatanopsis wallichii* King ex Hook.f.	0	0	0.0296
134	*Cratoxylum sumatranum* (Jack)Blume subsp. Neriifolium Gogel.	0	0	0.0215
135	*Mangifera indica* L.	0	0	0.0214
136	*Phyllanthus emblica* L.	0	0	0.0207
137	*Bombax anceps Pierre var.* anceps	0	0	0.0176
138	*Diospyros areolata* King & Gamble	0	0	0.0161
139	*Bhesa robusta* (Roxb.) Ding Hou	0	0	0.0153
140	*Beta alnoides* Buch.-Ham. Ex G.Don	0	0	0.0129
141	*Vitex glabrata* R.Br.	0	0	0.0029
	Total basal area (m^2)	28.4536	21.2428	5.6206
	Total number of species	81	63	32

DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest.

4.4.1 Dry Evergreen Forest

Dry Evergreen Forest (DEF) was found throughout Thap Lan National Park at the range of 66.10-596.72 m above sea level. The amounts of 81 plant species in 38 families were observed in these study areas (Table 4.16) with 51 species (36.17%) found only in DEF. Plant density of DEF was 380.36 stem/ha. *Ficus curtipes* Corner, *Garcinia Cowa* Roxb., *Ceriscoides turgida* (Roxt) Tirveng, *Hydnocarpus anthelminthicus* Pierre ex Laness, *Lagerstroemia floribunda* Jack, and *Pentace burmanica* Kurz were dominant species found in this forest with important value index (IVI) of 13.63, 13.23, 12.00, 11.54, 11.34, and 10.21, respectively. The most observed species was *Ceriscoides turgida* with the density of 21.43 trees/ha. A large number of species belong to Euphorbiaceae and Dipterocarpaceae (Table 4.17).

Table 4.16 Plant species and their importance value index (IVI) of Dry Evergreen Forest (DEF) in Thap Lan National Park.

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
1	*Ficus curtipes* Corner	MORACEAE	3	2.68	3.3548	0.70	1.13	11.79	13.63
2	*Garcinia cowa* Roxb.	GUTTIFERAE	6	5.36	2.8799	1.41	1.70	10.12	13.23
3	*Ceriscoides turgida* (Roxt) Tirveng	RUBIACEAE	24	21.43	1.1659	5.63	2.26	4.10	12.00
4	*Hydnocarpus anthelminthicus* Pierre ex Laness	FLACOURTIACEAE	11	9.82	2.0652	2.58	1.70	7.26	11.54
5	*Lagerstroemia floribunda* Jack	LYTHRACEAE	5	4.46	2.4101	1.17	1.70	8.47	11.34
6	*Pentace burmanica* Kurz	TILIACEAE	19	16.96	0.6691	4.46	3.39	2.35	10.21
7	*Paranephelium xestophyllum* Miq.	SAPINDACEAE	16	14.29	0.5182	3.76	2.26	1.82	7.84
8	*Bouea oppositifolia* (Roxb.) Meisn.	ANACARDIACEAE	8	7.14	0.9090	1.88	2.26	3.20	7.34
9	*Nephelium hypoleucum* Kurz	SAPINDACEAE	17	15.18	0.3735	3.99	1.70	1.31	7.00
10	*Parinari anamense* Hance	CHRYSOBALANACEAE	3	2.68	1.4633	0.70	1.13	5.14	6.98
11	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	MYRTACEAE	7	6.25	0.7080	1.64	2.83	2.49	6.96
12	*Croton cascarilloides* Raeusch.	EUPHORBIACEAE	17	15.18	0.1971	3.99	2.26	0.69	6.95
13	*Vitex pinnata* L.	LABIATAE	11	9.82	0.8469	2.58	1.13	2.98	6.69
14	*Aglaia rufinervis* (Blume) Bentv.	MYLIACEAE	15	13.39	0.2250	3.52	2.26	0.79	6.58
15	*Cleidion spiciflorum* (Burm.f.) Merr.	EUPHORBIACEAE	9	8.04	0.2056	2.11	2.83	0.72	5.66
16	*Sapindus rarak DC.*	SAPINDACEAE	13	11.61	0.2440	3.05	1.70	0.86	5.61
17	*Excoecaria oppositifolia* Griff.	EUPHORBIACEAE	6	5.36	0.8329	1.41	1.13	2.93	5.47
18	*Horsfieldia macrocoma* Warb. Var. *canarioides*	MYRISTICACEAE	11	9.82	0.3103	2.58	1.70	1.09	5.37
19	*Terminalia triptera* Stapt	COMBRETACEAE	8	7.14	0.1884	1.88	2.83	0.66	5.37
20	*Syzygium cumini* (L.) Skeels	MYRTACEAE	6	5.36	0.6067	1.41	1.70	2.13	5.24
21	*Litsea glutinosa* (Lour.) C.B.Rob.	LAURACEAE	8	7.14	0.1235	1.88	2.83	0.43	5.14
22	*Carallia brachiata* (Lour.) Merr.	RHIZOPHORACEAE	8	7.14	0.5563	1.88	1.13	1.96	4.97

Table 4.16 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
23	*Pterocymbium acerifolium* (L.) Willd.	STERCULIACEAE	8	7.14	0.2154	1.88	2.26	0.76	4.90
24	*Memecylon scutellatum* Naudin	MEMECYLACEAE	15	13.39	0.2269	3.52	0.57	0.80	4.88
25	*Acrocarpus fraxinifolius* Wight ex Arn.	CAESALPINIOIDEAE	6	5.36	0.2780	1.41	2.26	0.98	4.65
26	*Hopea ferrea* Laness.	DIPTEROCARPACEAE	7	6.25	0.4493	1.64	1.13	1.58	4.35
27	*Hibiscus tiliaceus* L.	MALVACEAE	7	6.25	0.2859	1.64	1.70	1.00	4.35
28	*Senecio garrettiana* (Craib) H.S. Irwin & Barneby	LEGUMINOSAE-CAESALPINIOIDEAE	8	7.14	0.1969	1.88	1.70	0.69	4.27
29	*Stereospermum neuranthum* Kurz	BIGNONIACEAE	6	5.36	0.0834	1.41	2.26	0.29	3.96
30	*Knema globularia* (Lam.) Warb.	MYRISTICACEAE	5	4.46	0.1269	1.17	2.26	0.45	3.88
31	*Nyssa javanica* (Blume) Wangerin	CORNACEAE	3	2.68	0.4108	0.70	1.70	1.44	3.85
32	*Microcos paniculata* L.	TILIACEAE	5	4.46	0.2603	1.17	1.70	0.91	3.79
33	*Ficus rumphii* Blume	MORACEAE	3	2.68	0.7077	0.70	0.57	2.49	3.76
34	*Shorea henryana* Pierre	DIPTEROCARPACEAE	3	2.68	0.5294	0.70	1.13	1.86	3.70
35	*Aphanamixis polystachya* (Wall.) R.Parker	MELIACEAE	4	3.57	0.4280	0.94	1.13	1.50	3.57
36	*Neolitsea siamensis* Kosterm	LAURACEAE	4	3.57	0.0945	0.94	2.26	0.33	3.53
37	*Artocarpus lacucha* Roxb.	MORACEAE	5	4.46	0.1851	1.17	1.70	0.65	3.52
38	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	EUPHORBIACEAE	6	5.36	0.0972	1.41	1.70	0.34	3.45
39	*Dipterocarpus alatus* Roxb. Ex G.Don	DIPTEROCARPACEAE	5	4.46	0.1556	1.17	1.70	0.55	3.42
40	*Dipterocarpus turbinatus* C.F. Gaertn.	DIPTEROCARPACEAE	7	6.25	0.1754	1.64	1.13	0.62	3.39
41	*Fagraea fragrans* Roxb.	GENTIANACEAE	5	4.46	0.0886	1.17	1.70	0.31	3.18
42	*Dracaena conferta* Ridl.	DRACAENACEAE	7	6.25	0.0786	1.64	1.13	0.28	3.05
43	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	ANACARDIACEAE	6	5.36	0.2487	1.41	0.57	0.87	2.85
44	*Pterocymbium tinctorium* (Blanco) Merr.	STERCULIACEAE	4	3.57	0.1413	0.94	1.13	0.50	2.57

Table 4.16 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
45	*Drypetes roxburghii* (Wall.) Hurusawa	EUPHORBIACEAE	5	4.46	0.0456	1.17	1.13	0.16	2.47
46	*Urobotrya siamensis* Hiepko	OPILIACEAE	4	3.57	0.0686	0.94	1.13	0.24	2.31
47	*Rhus javanica* L.	ANACARDIACEAE	4	3.57	0.1791	0.94	0.57	0.63	2.13
48	*Polyalthia lateriflora* (Blume) King	ANNONACEAE	3	2.68	0.0770	0.70	1.13	0.27	2.11
49	*Syzygium claviflorum* (Roxb.) A.M.Cowan & Cowan	MYRTACEAE	3	2.68	0.0710	0.70	1.13	0.25	2.09
50	*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne	LEGUMINOSAE-CAESALPINIOIDEAE	1	0.89	0.3185	0.23	0.57	1.12	1.92
51	*Elaeis griffithii* (Wight) A.Gray	ELAEOCARPACEAE	3	2.68	0.1790	0.70	0.57	0.63	1.90
52	*Suregada multiflorum* (A.Juss.) Baill.	EUPHORBIACEAE	2	1.79	0.0398	0.47	1.13	0.14	1.74
53	*Cinnamomum glaucescens* (Nees) Drury	LAURACEAE	1	0.89	0.2494	0.23	0.57	0.88	1.68
54	*Aquilaria crassna* Pierre ex Lecomte	THYMELAEACEAE	3	2.68	0.0721	0.70	0.57	0.25	1.52
55	*Dipterocarpus obtusifolius* Teijsm. ex Miq.	DIPTEROCARPACEAE	2	1.79	0.1242	0.47	0.57	0.44	1.47
56	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	LAURACEAE	3	2.68	0.0526	0.70	0.57	0.18	1.45
57	*Microcos tomentosa* Sm.	TILIACEAE	3	2.68	0.0463	0.70	0.57	0.16	1.43
58	*Knema globularia* (Lam.) Warb.	MYRISTICACEAE	2	1.79	0.0545	0.47	0.57	0.19	1.23
59	*Garcinia nigrolineata* Planch. Ex T.Anderson	GUTTIFERAE	2	1.79	0.0382	0.47	0.57	0.13	1.17
60	*Hopea odorata* Roxb.	DIPTEROCARPACEAE	2	1.79	0.0347	0.47	0.57	0.12	1.16
61	Dracontomelon dao (Blanco) Merr. & Rolfe	ANACARDIACEAE	2	1.79	0.0260	0.47	0.57	0.09	1.13
62	*Shorea farinosa* C.E.C.Fisch.	DIPTEROCARPACEAE	2	1.79	0.0209	0.47	0.57	0.07	1.11
63	*Dalbergia oliveri* Gamble	LEGUMINOSAE-PAPILIONOIDEAE	1	0.89	0.0535	0.23	0.57	0.19	0.99

Table 4.16 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
64	*Dialium cochinchinense* Pierre	LEGUMINOSAE-CAESALPINIOIDEAE	1	0.89	0.0497	0.23	0.57	0.17	0.98
65	*Irvingia malayana* Oliv. ex A.W.Benn.	SIMAROUBACEAE	1	0.89	0.0401	0.23	0.57	0.14	0.94
66	*Diospyros rubra* Lecomte	EBENACEAE	1	0.89	0.0389	0.23	0.57	0.14	0.94
67	*Adenanthera pavonina* L.	LEGUMINOSAE - MIMOSOIDEAE	1	0.89	0.0357	0.23	0.57	0.13	0.93
68	*Diospyros gracillis* Fletcher	EBENACEAE	1	0.89	0.0306	0.23	0.57	0.11	0.91
69	unknow		1	0.89	0.0250	0.23	0.57	0.09	0.89
70	*Zamia limonella* (Dennst.) Alston	ZAMIACEAE	1	0.89	0.0250	0.23	0.57	0.09	0.89
71	*Melaleuca alternifolia* Cheel	MYRTACEAE	1	0.89	0.0191	0.23	0.57	0.07	0.87
72	*Parkia speciosa* Hassk.	LEGUMINOSAE-MIMOSOIDEAE	1	0.89	0.0183	0.23	0.57	0.06	0.87
73	*Pentace* sp.	TILIACEAE	1	0.89	0.0183	0.23	0.57	0.06	0.87
74	*Melientha suavis* Pierre	OPILIACEAE	1	0.89	0.0154	0.23	0.57	0.05	0.85
75	*Dracaena loureiri* Gagnep	AGAVACEAE	1	0.89	0.0147	0.23	0.57	0.05	0.85
76	*Cratoxylum maingayi* Dyer	GUTTIFERAE	1	0.89	0.0115	0.23	0.57	0.04	0.84
77	*Cinnamomum porrectum* (Roxb.) Kosterm.	LAURACEAE	1	0.89	0.0109	0.23	0.57	0.04	0.84
78	*Mammea siamensis* (T. Anderson) Kosterm.	GUTTIFERAE	1	0.89	0.0087	0.23	0.57	0.03	0.83
79	*Casearia* sp.	FLACOURTIACEAE	1	0.89	0.0082	0.23	0.57	0.03	0.83
80	*Baccaurea ramiflora* Lour.	EUPHORBIACEAE	1	0.89	0.0077	0.23	0.57	0.03	0.83
81	*Broussonetia papyrifera* (L.) Vent.	MORACEAE	1	0.89	0.0072	0.23	0.57	0.03	0.83
			426	380.357	28.4535	100.00	100.00	100.00	300.00

D, density; BA, basal area; RD, relative density; RF, relative frequency; RDo, relative dominance; IVI, important value index.

Table 4.17 Importance value index (IVI) for the 10 important families of the Dry Evergreen Forest (DEF) in Thap Lan National Park.

No	Family	No. of species	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
1	EUPHORBIACEAE	7	46	41.07	1.4259	10.80	10.75	5.01	26.56
2	MORACEAE	4	12	10.71	4.2548	2.82	3.96	14.96	21.73
3	SAPINDACEAE	3	46	41.07	1.1356	10.80	5.66	3.99	20.45
4	DIPTEROCARPACEAE	7	28	25.00	1.4896	6.57	6.79	5.24	18.60
5	TILIACEAE	4	28	25.00	0.9940	6.57	6.22	3.49	16.29
6	GUTTIFERAE	4	10	8.93	2.9383	2.35	3.39	10.33	16.07
7	MYRTACEAE	4	17	15.18	1.4048	3.99	6.22	4.94	15.15
8	ANACARDIACEAE	4	20	17.86	1.3628	4.69	3.96	4.79	13.45
9	LAURACEAE	5	17	15.18	0.5309	3.99	6.79	1.87	12.65
10	FLACOURTIACEAE	2	12	10.71	2.0734	2.82	2.26	7.29	12.37
11	Remaining families	37	190	169.64	10.8435	44.60	44.70	38.12	127.42
	Total	81	426	380.36	28.4535	100.00	100.00	100.00	300.00

D, density; BA, basal area; RD, relative density; RF, relative frequency; RDo, relative dominance; IVI, important value index.

The Euphorbiaceae was the most dominant family found in DEF, followed by Moraceae and Sapindaceae with IVI value of 26.56, 21.73, and 20.45, respectively. DEF was a dense and translucent forest composed of four-layer canopy with 80% plant covered. The dominant trees have straight and large girth with wide spreading crowns. The forest profile is composed of trees with small, medium, and large sizes. The lower layer consists of trees with 5-12 m height such as *Ficus curtipes* Corner (the dominant specie), *Bouea oppositifolia* (Roxb.) Meisn, *Carallia brachiata* (Lour.) Merr., *Cleidion spiciflorum* (Burm.f.) Merr., *Hibiscus tiliaceus* L., and *Horsfieldia macrocoma* Warb. Var. *canarioides*. Whereas *Croton cascarilloides* Raeusch was found in the middle layer (Figure 4.21). The upper layer, 28-38 m height, was composed mainly of *Elaeis griffithii* (Wight) A. Gray.

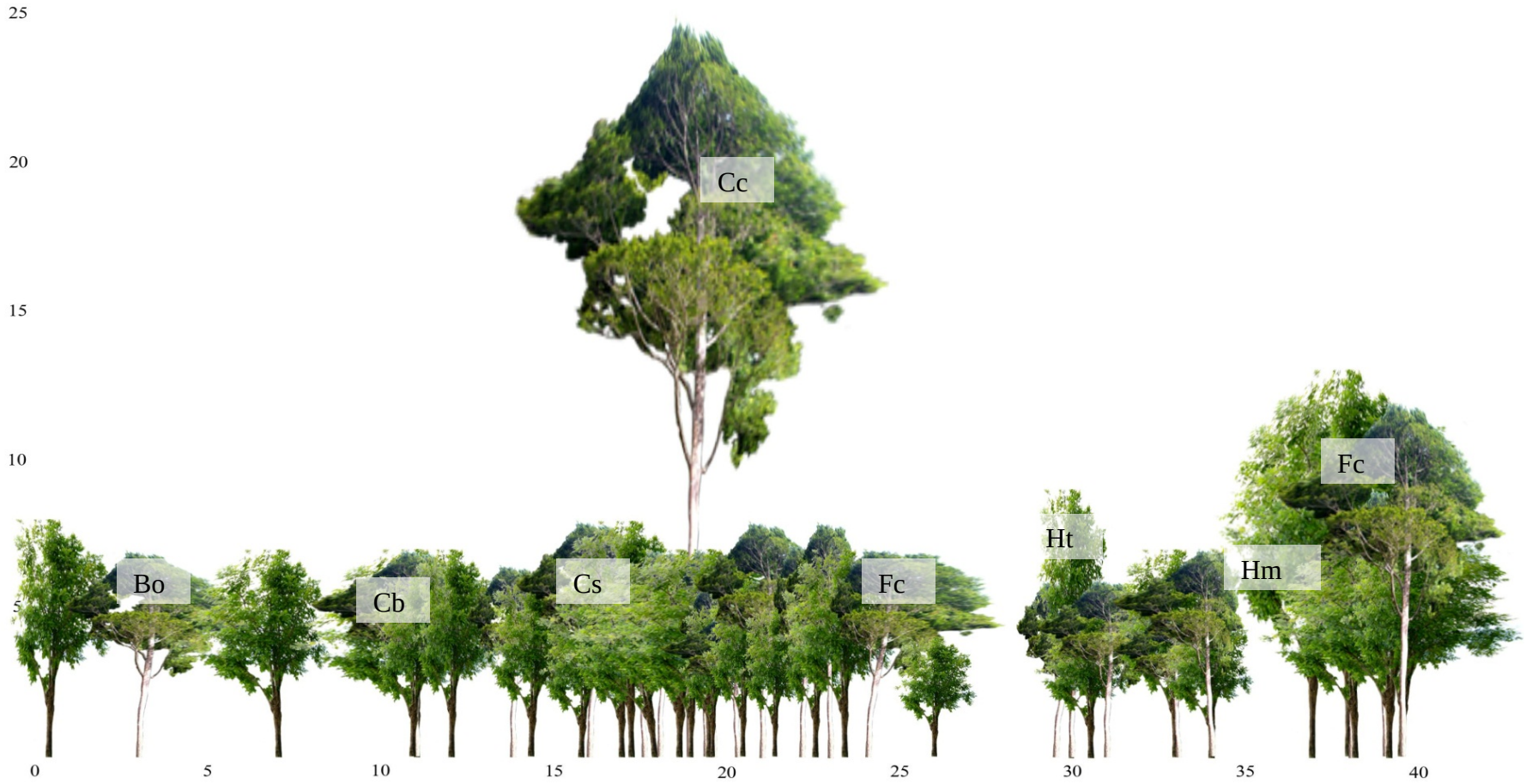

Figure 4.21 Profile diagram of Dry Evergreen Forest (DEF6). Bo, *Bouea oppositifolia* (Roxb.) Meisn; Cb, *Carallia brachiata* (Lour.)Merr.; Cs, *Cleidion spiciflorum* (Burm.f.) Merr.; Cc, *Croton cascarilloides* Raeusch.; Fc, *Ficus curtipes* Corner; Ht, *Hibiscus tiliaceus* L.; Hm, *Horsfieldia macrocoma* Warb. Var. *canarioides*.

4.4.2 Mixed Deciduous Forest

Mixed Deciduous Forest (MDF) was found in the middle of Thap Lan National Park at the range of 71.02-612.06 m above sea level. There were 63 plant species in 32 families (Table 4.18), with 32 species (22.70%) observed only in MDF. Plant density of MDF was 396.43 stem/ha. The most dominant species was *Pterocarpus macrocarpus* Kurz with the density of 53.57 stem/ha and IVI value of 26.42. *Shorea henryana* Pierre, *Pterocymbium acerifolium* (L.) Willd, *Ficus hirta* Vahl, *Lagerstroemia floribunda* Jack, and *Wrightia arborea* (Dennst.) Mabb. were also important species found in this forest with IVI values of 15.39, 12.09, 11.62, 10.82, and 10.37, respectively. Dipterocarpaceae and Leguminosae-Papilionoideae were dominant families found in MDF with IVI of 36.38 and 32.69, respectively (Table 4.19). The Mixed Deciduous Forest is seasonal forest with long dry season for 4-7 months. The forest was sparsely distributed trees with 30% canopy cover. *Dialium cochinchinense* Pierre was found in the upper layer, 11-13 m high, and *Pterocarpus macrocarpus* Kurz. (dominant species), *Microcos paniculata* L., and *Nephelium hypoleucum* Kurz were distributed throughout the lower layer, 4-10 m high (Figure 4.22).

Table 4.18 Plant species and their importance value index (IVI) of Mixed Deciduous Forest (MDF) in Thap Lan National Park.

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
1	*Pterocarpus macrocarpus* Kurz	LEGUMINOSAE-PAPILIONOIDEAE	60	53.57	2.3029	13.51	2.20	10.71	26.42
2	*Shorea henryana* Pierre	DIPTEROCARPACEAE	4	3.57	2.6437	0.90	2.20	12.29	15.39
3	*Pterocymbium acerifolium* (L.) Willd.	STERCULIACEAE	27	24.11	0.8200	6.08	2.20	3.81	12.09
4	*Ficus hirta* Vahl	MORACEAE	27	24.11	0.9550	6.08	1.10	4.44	11.62
5	*Lagerstroemia floribunda* Jack	LYTHRACEAE	14	12.50	1.4127	3.15	1.10	6.57	10.82
6	*Wrightia arborea* (Dennst.) Mabb.	APOCYNACEAE	23	20.54	0.4075	5.18	3.30	1.90	10.37
7	*Dipterocarpus turbinatus* C.F. Gaertn.	DIPTEROCARPACEAE	8	7.14	1.2366	1.80	2.20	5.75	9.75
8	*Sandoricum koetjape* (Burm.f.) Merr.	MELIACEAE	6	5.36	1.3005	1.35	2.20	6.05	9.60
9	*Sterculia guttata* Roxb.	STERCULIACEAE	11	9.82	0.6980	2.48	3.30	3.25	9.02
10	*Diospyros gracillis* Fletcher	EBENACEAE	16	14.29	0.3631	3.60	3.30	1.69	8.59
11	*Shorea roxburghii* G.Don	DIPTEROCARPACEAE	4	3.57	1.1357	0.90	2.20	5.28	8.38
12	*Garcinia cowa* Roxb.	GUTTIFERAE	13	11.61	0.8982	2.93	1.10	4.18	8.20
13	*Artocarpus lacucha* Roxb.	MORACEAE	21	18.75	0.4952	4.73	1.10	2.30	8.13
14	*Corypha lecomtei* Becc.	PALMAE	10	8.93	0.7413	2.25	1.10	3.45	6.80
15	*Stereospermum neuranthum* Kurz	BIGNONIACEAE	16	14.29	0.3800	3.60	1.10	1.77	6.47
16	*Pentace* sp.	TILIACEAE	16	14.29	0.2368	3.60	1.10	1.10	5.80
17	*Elaeis griffithii* (Wight) A.Gray	ELAEOCARPACEAE	4	3.57	0.2469	0.90	3.30	1.15	5.35
18	*Memecylon scutellatum* Naudin	MEMECYLACEAE	12	10.71	0.3304	2.70	1.10	1.54	5.34
19	*Carallia brachiata* (Lour.) Merr.	RHIZOPHORACEAE	2	1.79	0.4877	0.45	2.20	2.27	4.92
20	*Peltophorum dasyrachis* (Miq.) Kurz.	LEGUMINOSAE-CAESALPINIOIDEAE	5	4.46	0.3190	1.13	2.20	1.48	4.81
21	*Cratoxylum maingayi* Dyer	GUTTIFERAE	5	4.46	0.0788	1.13	3.30	0.37	4.79
22	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	ANACARDIACEAE	8	7.14	0.1512	1.80	2.20	0.70	4.70

Table 4.18 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
23	*Nephelium hypoleucum* Kurz	SAPINDACEAE	8	7.14	0.1411	1.80	2.20	0.66	4.66
24	*Phyllocarpus septentrionalis* Donn.Sm.	LEGUMINOSAE-CAESALPINIOIDEAE	7	6.25	0.3859	1.58	1.10	1.79	4.47
25	*Microcos paniculata* L.	TILIACEAE	9	8.04	0.1656	2.03	1.10	0.77	3.90
26	*Pentace burmanica* Kurz	TILIACEAE	4	3.57	0.1481	0.90	2.20	0.69	3.79
27	*Ficus hispida* L.f.	MORACEAE	7	6.25	0.2281	1.58	1.10	1.06	3.74
28	*Microcos tomentosa* Sm.	TILIACEAE	8	7.14	0.1778	1.80	1.10	0.83	3.73
29	*Meliosma pinnaia* Walp.	SABIACEAE	5	4.46	0.2779	1.13	1.10	1.29	3.52
30	*Bambusa* sp.	GRAMINEAE	4	3.57	0.0870	0.90	2.20	0.40	3.50
31	*Ceriscoides turgida* (Roxt) Tirveng	RUBIACEAE	4	3.57	0.0431	0.90	2.20	0.20	3.30
32	*Parkia speciosa* Hassk.	LEGUMINOSAE-MIMOSOIDEAE	1	0.89	0.3854	0.23	1.10	1.79	3.12
33	*Lagerstroemia speciosa*	LYTHRACEAE	6	5.36	0.1328	1.35	1.10	0.62	3.07
34	*Suregada multiflorum* (A.Juss.) Baill.	EUPHORBIACEAE	4	3.57	0.2136	0.90	1.10	0.99	2.99
35	*Haldina cordifolia* (Roxb.) Ridsdale	RUBIACEAE	4	3.57	0.2116	0.90	1.10	0.98	2.98
36	*Litsea glutinosa* (Lour.) C.B.Rob.	LAURACEAE	2	1.79	0.0593	0.45	2.20	0.28	2.92
37	*Vatica harmandiana* Pierre	DIPTEROCARPACEAE	3	2.68	0.2322	0.68	1.10	1.08	2.85
38	*Croton roxburghii* N.T. Balakr.	EUPHORBIACEAE	2	1.79	0.0414	0.45	2.20	0.19	2.84
39	*Radermachera hainanensis* Merr.	BIGNONIACEAE	6	5.36	0.0726	1.35	1.10	0.34	2.79
40	*Parinari anamense* Hance	CHRYSOBALANACEAE	2	1.79	0.0253	0.45	2.20	0.12	2.77
41	*Dalbergia cochinchinensis* Pierre	LEGUMINOSAE-PAPILIONOIDEAE	6	5.36	0.0675	1.35	1.10	0.31	2.76
42	*Colona auriculata* (Desv.) Craib	TILIACEAE	2	1.79	0.0218	0.45	2.20	0.10	2.75
43	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	EUPHORBIACEAE	2	1.79	0.0195	0.45	2.20	0.09	2.74

Table 4.18 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
44	*Ardisia murtonii* Fletcher	MYRSINACEAE	3	2.68	0.1152	0.68	1.10	0.54	2.31
45	*Ixora cibdela* Craib	RUBIACEAE	3	2.68	0.1063	0.68	1.10	0.49	2.27
46	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.	THEACEAE	3	2.68	0.0943	0.68	1.10	0.44	2.21
47	*Fagraea fragrans* Roxb.	GENTIANACEAE	4	3.57	0.0385	0.90	1.10	0.18	2.18
48	*Dialium cochinchinense* Pierre	LEGUMINOSAE-CAESALPINIOIDEAE	3	2.68	0.0326	0.68	1.10	0.15	1.93
49	*Erythrina subumbrans* (Hassk.) Merr.	LEGUMINOSAE-PAPILIONOIDEAE	2	1.79	0.0772	0.45	1.10	0.36	1.91
50	*Syzygium cumini* (L.) Skeels	MYRTACEAE	2	1.79	0.0432	0.45	1.10	0.20	1.75
51	*Holarrhena pubescens* Wall. ex A.DC.	APOCYNACEAE	2	1.79	0.0364	0.45	1.10	0.17	1.72
52	*Amesiodendron chinense* (Merr.)	SAPINDACEAE	2	1.79	0.0271	0.45	1.10	0.13	1.68
53	*Butea monosperma* (Lam.) Taub.	LEGUMINOSAE-PAPILIONOIDEAE	2	1.79	0.0104	0.45	1.10	0.05	1.60
54	*Hymenodictyon orixense* (Roxb.) Mabb.	RUBIACEAE	1	0.89	0.0277	0.23	1.10	0.13	1.45
55	*Syzygium thorelii* (Gagnep.) Merr. & L.M.Perry	MYRTACEAE	1	0.89	0.0272	0.23	1.10	0.13	1.45
56	*Paranephelium xestophyllum* Miq.	SAPINDACEAE	1	0.89	0.0241	0.23	1.10	0.11	1.44
57	*Anthocephalus chinensis* (Lam.) A.Rich ex Walp	RUBIACEAE	1	0.89	0.0127	0.23	1.10	0.06	1.38
58	*Senna garrettiana* (Craib) Irwin & Barneby	LEGUMINOSAE-CAESALPINIOIDEAE	1	0.89	0.0127	0.23	1.10	0.06	1.38
59	*Zamia limonella* (Dennst.) Alston	ZAMIACEAE	1	0.89	0.0121	0.23	1.10	0.06	1.38
60	*Baccaurea parviflora* (MÜll.Arg.) MÜll.Arg.	EUPHORBIACEAE	1	0.89	0.0098	0.23	1.10	0.05	1.37

Table 4.18 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
61	*Irvingia malayana* Oliv. ex A.W.Benn.	IRVINGIACEAE	1	0.89	0.0077	0.23	1.10	0.04	1.36
62	*Streblus ilicifolius* (Vidal) Corner	MORACEAE	1	0.89	0.0077	0.23	1.10	0.04	1.36
63	*Vitex quinata* (Lour.) F.N.Williams	LABIATAE	1	0.89	0.0072	0.23	1.10	0.03	1.36
	Total		444	396.429	21.5086	100.00	100.00	100.00	300.00

D, density; BA, basal area; RD, relative density; RF, relative frequency; RDo, relative dominance; IVI, important value index.

Table 4.19 Importance value index (IVI) for the 10 important families of the Mixed Deciduous Forest (MDF) in Thap Lan National Park.

No.	Family	No. of species	No of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
1	DIPTEROCARPACEAE	4	19	16.96	5.2483	4.28	7.69	24.41	36.38
2	LEGUMINOSAE-PAPILIONOIDEAE	4	70	62.50	2.4580	15.77	5.49	11.43	32.69
3	MORACEAE	4	56	50.00	1.6861	12.61	4.40	7.84	24.85
4	STERCULIACEAE	2	38	33.93	1.5180	8.56	5.49	7.06	21.11
5	TILIACEAE	5	39	34.82	0.7501	8.78	7.69	3.49	19.96
6	LYTHRACEAE	2	20	17.86	1.5454	4.50	2.20	7.19	13.89
7	GUTTIFERAE	2	18	16.07	0.9769	4.05	4.40	4.54	12.99
8	LEGUMINOSAE-CAESALPINIOIDEAE	4	16	14.29	0.7503	3.60	5.49	3.49	12.59
9	APOCYNACEAE	2	25	22.32	0.4440	5.63	4.40	2.06	12.09
10	RUBIACEAE	5	13	11.61	0.4014	2.93	6.59	1.87	11.39
11	Remaining families	29	130	116.07	5.73014	29.28	46.15	26.65	102.08
	Total	63	444	396.43	21.5086	100.00	100.00	100.02	300.02

D, density; BA, basal area; RD, relative density; RF, relative frequency; RDo, relative dominance; IVI, important value index.

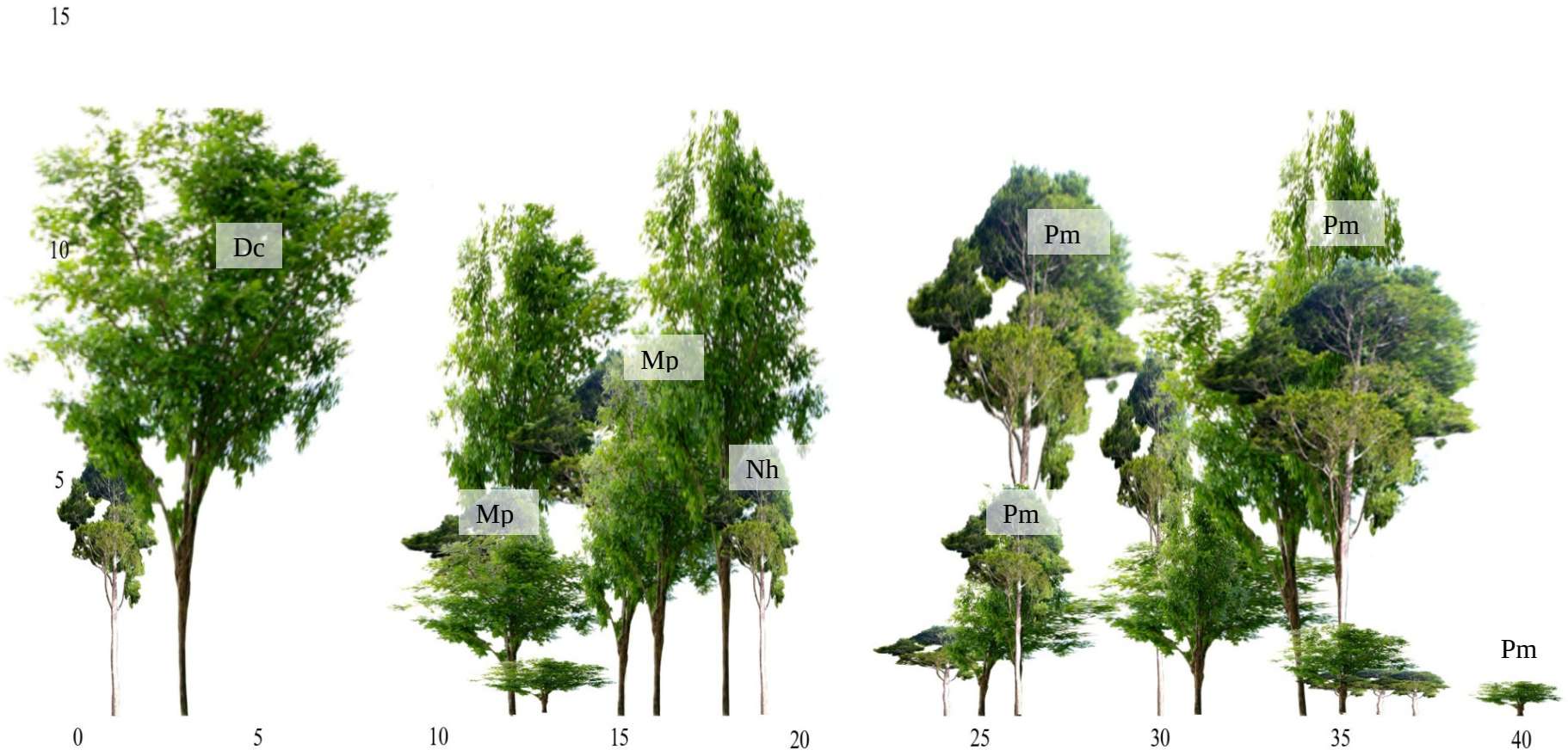

Figure 4.22 Profile diagram of the Mixed Deciduous Forest (MDF6). Dc, *Dialium cochinchinense* Pierre; Mp, *Microcos paniculata* L.; Nh, *Nephelium hypoleucum* Kurz; Pm, *Pterocarpus macrocarpus* Kurz.

4.4.3 Dry Dipterocarp Forest

Dry Dipterocarp Forest (DDF) in Thap Lan National Park was found in Khon Buri and Soeng Sang districts in Nakhon Ratchasima province at the range of 247.53-277.69 m above sea level. DDF was composed of a variety of 32 plant species in 23 families (Table 4.20) which possessed its own 23 species (16.31%). The density of DDF was 537.50 stem/ha. The most dominant species was *Shorea obtusa* Wall. Ex Blume, belong to the Dipterocarpaceae family, with the density of 247.92 stem/ha and IVI value of 91.00. The second dominant species were *Pterocarpus macrocarpus* Kurz and *Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* with IVI values of 28.83 and 22.05, respectively. Dipterocarpaceae, including *Shorea obtusa* Wall. Ex Blumeand *Shorea siamensis* Miq. were in majority and obviously found in DDF with IVI value of 106.16 (Table 4.21). DDF is deciduous forest which a dense and disperse trees with three-layer 50% canopy cover. The upper, middle and lower layers consist of 4-7, 8-10, and 11-15 m high canopies, respectively (Figure 4.23). The important species, *Shorea obtusa* Wall.ex Blume, *Xylia xylocarpa* (Roxb.) Taub.var. *kerrii* (Craib & Hutch.) I. C. Nielsen, and *Irvingia malayana* Oliv. ex A.W.Benn. were 11-15 m high, distributed throughout DDF. Whereas, *Castatanopsis wallichii* King ex Hook.f. was found only in DDF1 ranging from 6-15 m high.

Table 4.20 Plant species and their importance value index (IVI) of Dry Dipterocarp Forest (DDF) in Thap Lan National Park.

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
1	*Shorea obtusa* Wall. ex Blume	DIPTEROCARPACEAE	119	247.92	2.1709	46.12	6.25	38.62	91.00
2	*Pterocarpus macrocarpus* Kurz	LEGUMINOSAE-PAPILIONOIDEAE	16	33.33	0.9205	6.20	6.25	16.38	28.83
3	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	LEGUMINOSAE-MIMOSOIDEAE	24	50.00	0.4825	9.30	4.17	8.58	22.05
4	*Shorea siamensis* Miq.	DIPTEROCARPACEAE	12	25.00	0.3566	4.65	4.17	6.35	15.16
5	*Buchanania lanzan* Spreng.	ANACARDIACEAE	11	22.92	0.1354	4.26	6.25	2.41	12.92
6	*Irvingia malayana* Oliv. ex A.W.Benn.	IRVINGIACEAE	6	12.50	0.1491	2.33	6.25	2.65	11.23
7	*Senecio garrettiana* (Craib) H.S. Irwin & Barneby	LEGUMINOSAE-CAESALPINIOIDEAE	7	14.58	0.1809	2.71	4.17	3.22	10.10
8	*Elaeis griffithii* (Wight) A.Gray	ELAEOCARPACEAE	4	8.33	0.1276	1.55	6.25	2.27	10.07
9	*Helicteres elongata* Wall. ex Bojer	STERCULIACEAE	9	18.75	0.1442	3.49	2.08	2.57	8.14
10	*Dalbergia oliveri* Gamble	LEGUMINOSAE-PAPILIONOIDEAE	4	8.33	0.1142	1.55	4.17	2.03	7.75
11	*Erythrophleum succirubrum* Gagnep.	LEGUMINOSAE-CAESALPINIOIDEAE	8	16.67	0.1347	3.10	2.08	2.40	7.58
12	*Sindora siamensis* Teijsm. & Miq. var. siamensis	LEGUMINOSAE-CAESALPINIOIDEAE	2	4.17	0.1175	0.78	4.17	2.09	7.03
13	*Morinda coreia* Ham.	RUBIACEAE	3	6.25	0.0520	1.16	4.17	0.93	6.26
14	*Quercus austro-cochinensis* Hickel & A.Camus	FAGACEAE	5	10.42	0.0559	1.94	2.08	0.99	5.02
15	*Schleichera oleosa* (Lour.) Oken	SAPINDACEAE	4	8.33	0.0493	1.55	2.08	0.88	4.51
16	*Castatanopsis wallichii King ex Hook.f.*	FAGACEAE	3	6.25	0.0296	1.16	2.08	0.53	3.77
17	*Aphanamixis polystachya* (Wall.) R.Parker	MELIACEAE	2	4.17	0.0354	0.78	2.08	0.63	3.49

Table 4.20 (Continued).

No	Scientific name	Family	No. of tree	D (tree/ha)	BA (m2)	RD	RF	RDo	IVI
18	*Micromelum minutum* (G.Forst.) Wight & Arn.	RUTACEAE	2	4.17	0.0302	0.78	2.08	0.54	3.40
19	*Parinari anamense* Hance	CHRYSOBALANACEAE	2	4.17	0.0298	0.78	2.08	0.53	3.39
20	*Garcinia speciosa* Wall.	GUTTIFERAE	1	2.08	0.0484	0.39	2.08	0.86	3.33
21	*Mangifera indica* L.	ANACARDIACEAE	2	4.17	0.0214	0.78	2.08	0.38	3.24
22	*Sauropus androgynus* (L.) Merr.	EUPHORBIACEAE	1	2.08	0.0379	0.39	2.08	0.67	3.15
23	*Bhesa robusta* (Roxb.) Ding Hou	CELASTRACEAE	2	4.17	0.0153	0.78	2.08	0.27	3.13
24	*Stephania pierrei* Diels	MENISPERMACEAE	1	2.08	0.0322	0.39	2.08	0.57	3.04
25	*Haldina cordifolia* (Roxb.) Ridsdale	RUBIACEAE	1	2.08	0.0287	0.39	2.08	0.51	2.98
26	*Fagraea fragrans* Roxb.	GENTIANACEAE	1	2.08	0.0287	0.39	2.08	0.51	2.98
27	*Cratoxylum sumatranum* (Jack) Blume subsp. Neriifolium Gogel.	GUTTIFERAE	1	2.08	0.0215	0.39	2.08	0.38	2.85
28	*Phyllanthus emblica* L.	EUPHORBIACEAE	1	2.08	0.0207	0.39	2.08	0.37	2.84
29	*Bombax anceps* Pierre var. anceps	BOMBACACEAE	1	2.08	0.0176	0.39	2.08	0.31	2.78
30	*Diospyros areolata* King & Gamble	EBENACEAE	1	2.08	0.0161	0.39	2.08	0.29	2.76
31	*Beta alnoides* Buch.-Ham. Ex G.Don	BETULACEAE	1	2.08	0.0129	0.39	2.08	0.23	2.70
32	*Vitex glabrata* R.Br.	LABIATAE	1	2.08	0.0029	0.39	2.08	0.05	2.52
			258	537.5	5.62063	100.00	100.00	100.00	300.00

D, density; BA, basal area; RD, relative density; RF, relative frequency; RDo, relative dominance; IVI, important value index.

Table 4.21 Importance value index (IVI) for the 10 important families of the Dry Dipterocarp Forest (DDF) in Thap Lan National Park.

No.	Family	No. of species	No. of tree	D (tree/ha)	BA (m^2)	RD	RF	RDo	IVI
1	DIPTEROCARPACEAE	2	131	272.92	2.5275	50.78	10.42	44.97	106.16
2	LEGUMINOSAE-PAPILIONOIDEAE	2	20	41.67	1.0347	7.75	10.42	18.41	36.58
3	LEGUMINOSAE-CAESALPINIOIDEAE	3	17	35.42	0.4331	6.59	10.42	7.71	24.71
4	LEGUMINOSAE-MIMOSOIDEAE	1	24	50.00	0.4825	9.30	4.17	8.58	22.05
5	ANACARDIACEAE	2	13	27.08	0.1568	5.04	8.33	2.79	16.16
6	IRVINGIACEAE	1	6	12.50	0.1491	2.33	6.25	2.65	11.23
7	ELAEOCARPACEAE	1	4	8.33	0.1276	1.55	6.25	2.27	10.07
8	RUBIACEAE	2	4	8.33	0.0807	1.55	6.25	1.44	9.24
9	FAGACEAE	2	8	16.67	0.0854	3.10	4.17	1.52	8.79
10	STERCULIACEAE	1	9	18.75	0.1442	3.49	2.08	2.57	8.14
11	Remaining families	15	22	45.83	0.3991	8.53	31.25	7.10	46.88
	Total	32	258	537.50	5.6206	100.00	100.00	100.00	300.00

D, density; BA, basal area; RD, relative density; RF, relative frequency; RDo, relative dominance; IVI, important value index.

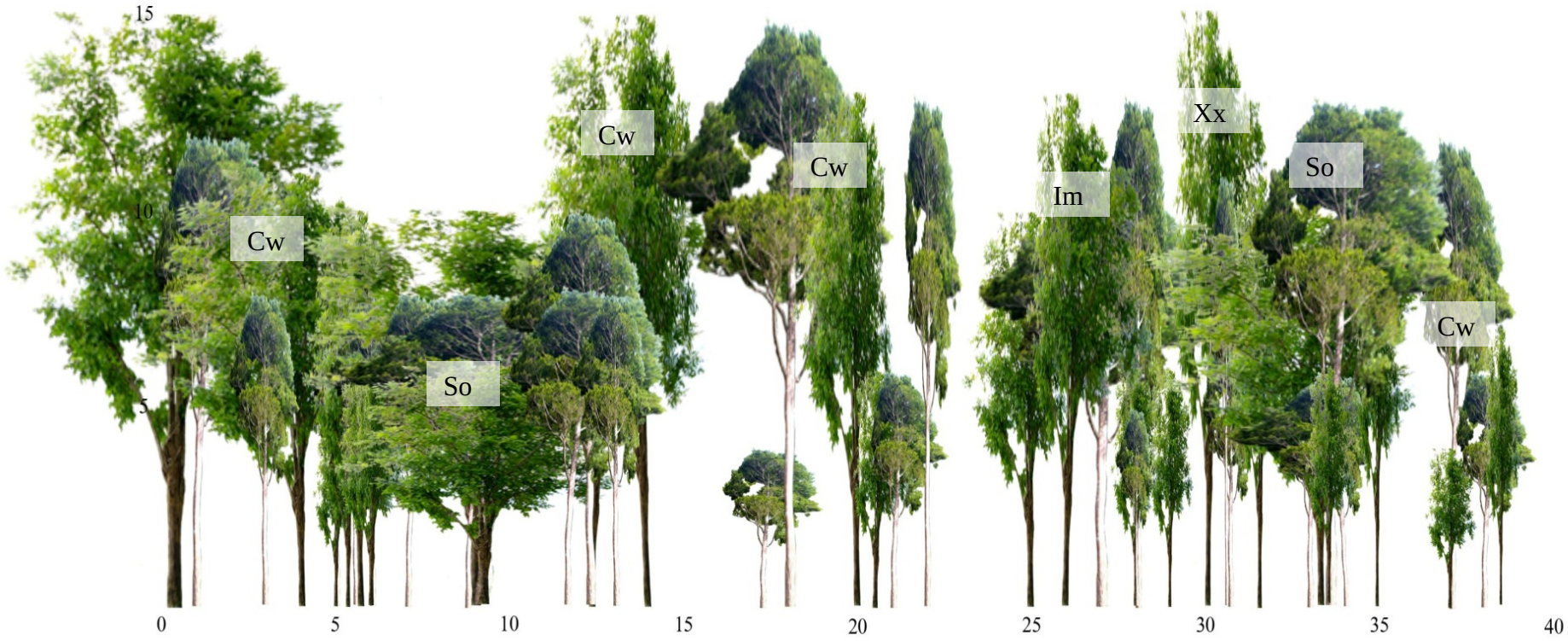

Figure 4.23 Profile diagram of the Dry Dipterocarb Forest (DDF1). Cw, *Castatanopsis wallichii* King ex Hook.f.; So, *Shorea obtusa* Wall. ex Blume; Im, *Irvingia malayana* Oliv. ex A.W.Benn., Xx, *Xylia xylocpa* (Roxb.) Taub.var. *kerrii* (Craib & Hutch.) I.C.Nielsen; Qh, *Quercus austro-cochinensis* Hickel & A.Camus.

In this study, DDF, dominant family was Dipterocarpaceae as observed in Sakaerat Environmental Research Station (SERS), Pak Tong Chai, Nakhon Ratchasima (Lamotte *et al*., 1998). However, there were some variations in DEF. The dominant family was Euphorbiaceae in the present study, but it was Dipterocarpaceae in the SERS (Lamotte *et al*., 1998). The differences in region, climate and geography might result in the difference forest community and structure.

4.5 Carbon Storage of the Three Natural Forests in Thap Lan National Park and Its 5 km Buffer Zone

4.5.1 Carbon Storage in Three Forests

The arbitrarily placed plots of 40x40 m^2, 7 plots in Dry Evergreen Forest (DEF) and Mixed Deciduous Forest (MDF), and 3 plots in Dry Dipterocarp Forest (DDF) were determined. The above and belowground biomass was estimated by using allometric equations. The carbon storage of each part of trees was estimated by multiplying the total biomass with 0.47 carbon fraction.

The aboveground biomass (stem, branch, and leaf) of three forest types was not significantly different, while the belowground (root) biomass of DEF was slightly higher than those of MDF and DDF ($p < 0.05$) (Table 4.22). Although the total biomass showed no significant difference among the three forest types, it can be said that the total biomass of DEF was slightly higher than MDF and DDF which were 242.32, 137.46, and 59.40 t/ha, respectively. As a result, DEF was the excellent source for carbon storage, followed by MDF and DDF which were 113.89, 64.61, and 27.91 tC/ha, respectively (Table 4.22 and Figure 4.24). The ratio of aboveground and belowground carbon storage in the DEF, MDF and DDF were 9:1, 11:1, and 7:1,

respectively (Figure 4.24), indicating that 90% of total carbon sequestration in each forest were obtained in the aboveground of tree. However, DEF1 (Heo Nok Kok, Prachin Buri), DEF7 (Mun Sam Ngam, Nakhon Ratchasima) and especially MDF5 (Huai Hin Dat, Nakhon-Ratchasima) had very low carbon storage in DEF and MDF resulting in non-significant difference among three forest types.

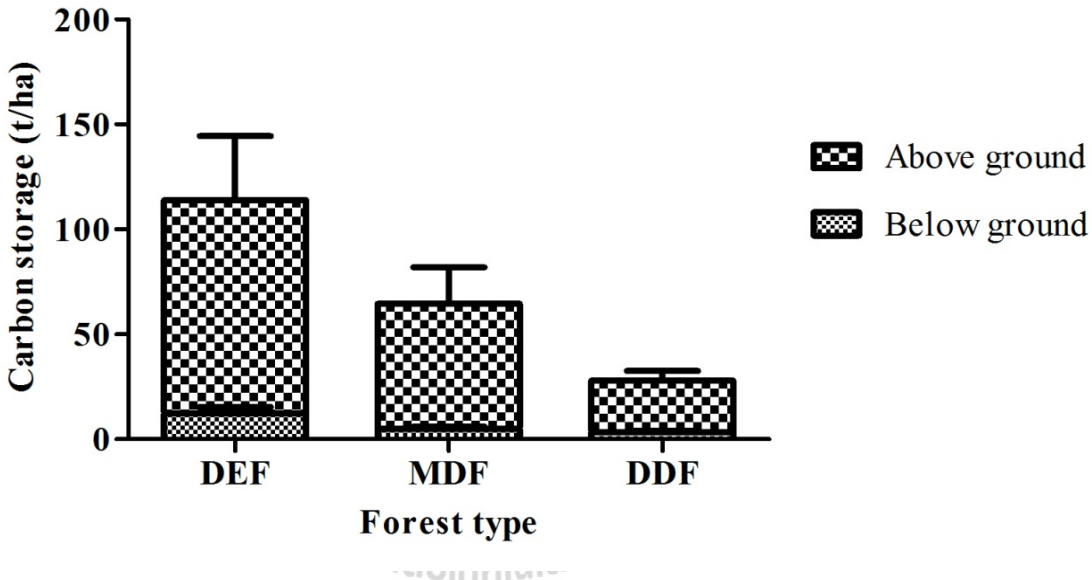

Figure 4.24 Aboveground and belowground carbon storage in three forest types of Thap Lan National Park. DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest.

Table 4.22 Biomass and carbon sequestration in three types of forest in Thap Lan National Park.

Forest type	Biomass (t/ha)			Aboveground	Belowground	Total Biomass	Carbon storage
	Stem	Branch	Leaf	(t/ha)	(Root) (t/ha)	(t/ha)	(tC/ha)
DEF1	46.38	13.11	1.17	60.66	9.54	130.86	61.50
DEF2	383.7	137.18	5.52	526.4	59.87	1112.67	522.95
DEF3	136.62	48	2.25	186.87	22.39	396.13	186.18
DEF4	267.63	102.01	2.88	372.52	36.59	781.63	367.37
DEF5	122.95	40.24	2.59	165.78	22.88	354.44	166.59
DEF6	105.34	32.97	2.62	140.93	21.25	303.11	142.46
DEF7	45.82	14.16	1.17	61.15	9.41	131.71	61.90
Mean ± SE	158.35 ± 46.92	55.38 ± 17.69	2.60 ± 0.55b	216.33 ± 65.16	25.99 ± 6.64a	242.32 ± 71.65	113.89 ± 33.68
MDF1	193.77	54.98	54.92	303.67	18.68	322.34	151.5
MDF2	110.63	29.41	29.32	169.36	11.94	181.29	85.21
MDF3	36.71	7.86	8.81	53.38	5.79	59.18	27.81
MDF4	92.83	19.93	40.01	152.77	14.44	167.22	78.59
MDF5	6.59	1.18	1.25	9.02	1.37	10.38	4.88
MDF6	89.79	18.56	23.49	131.84	14.58	146.41	68.81
MDF7	47.53	10.42	10.4	68.35	7.05	75.4	35.44
Mean ± SE	82.55 ± 23.10	20.33 ± 6.74	24.03 ± 7.19a	126.91 ± 37.03	10.55 ± 2.28ab	137.46 ± 38.79	64.60 ± 18.23
DDF1	46.02	9.8	0.15	55.97	7.14	63.12	29.66
DDF2	27.64	5.25	0.46	33.35	5.21	38.56	18.12
DDF3	55.35	10.94	0.47	66.76	9.75	76.52	35.96
Mean ± SE	43.00 ± 8.14	8.66 ± 1.74	0.36 ± 0.10b	52.03 ± 9.98	7.37 ± 1.32b	59.40 ± 11.11	27.91 ± 5.22
F-test	ns	ns	**	ns	*	ns	ns

Means in the columns followed by different letters are significantly different at P <0.05, *; 0.01, **; and ns, not significant. DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest.

Nuanurai (2005) also found the same result that, in Kaeng Krachan National Park, carbon stock in DEF was higher than in MDF and DDF which were 103.85, 34.26, and 29.31 tC/ha, respectively. Furthermore, aboveground and belowground carbon storage of DEF was also higher than MDF which were 152.15 and 71.51 tC/ha in Sakaerat DEF, and 86.17 and 40.50 tC/ha in Maeklong MDF, respectively (Diloksumpun *et al*., 2005). The carbon storage in MDF was about 57% of DEF, which is probably due to the difference in plant structures and plant communities.

4.5.2 Estimated Carbon Storage of the Three Forest Types in Thap Lan National Park and 5 km Buffer Zone

The capacity of carbon storage in each forest was combined with remote sensing based forest area of Thap Lan National Park and its 5 km buffer zone to obtain an estimation of forest carbon pool during 1987-2006 (Tables 4.23 and 4.24). In Thap Lan National Park, DEF, the most dominant land use, was the largest source for carbon sequestration, followed by MDF and DDF which were 14.25, 3.23, and 0.55 million tC in 1987, respectively (Table 4.23). As summarized, in 1987, the estimated carbon sequestration was 18.03 million tC. According to the continuously declining forest area in Thap Lan National Park during 1987-2006, especially the MDF and DDF, the estimated carbon sequestration of MDF and DDF decreased with time (Figures 4.25B and 4.25C -●-). The estimated total carbon sequestration decreased from 18.03 million tC in 1987 to 17.79 million tC in 2006. The estimated carbon loss of 0.24 million tC or 1.33% of total carbon in year 1987, was observed during two decades. The change of estimated carbon sequestration could be fitted by the

regression model of $y = -0.0144x + 46.573$, $R^2 = 0.920$ ($p < 0.05$) (Figure 4.26A). If there is continuous destruction of the forest, especially the DDF, the total carbon sequestration of Thap Lan National Park will be reduced to 17.48 million tC in year 2020.

Table 4.23 The forest area and the estimated carbon sequestration of three forest types in Thap Lan National Park during 1987-2006.

Year	Forest area (ha)			Carbon storage (tC/ha)			Carbon storage in Thap Lan (million tC)				Carbon change (million tC)
	DEF	MDF	DDF	DEF	MDF	DDF	DEF	MDF	DDF	Total	(from year 1987)
1987	125,100	50,058	19,715	113.89	64.61	27.91	14.25	3.23	0.55	18.03	
1997	125,177	48,422	18,281	113.89	64.61	27.91	14.26	3.13	0.51	17.90	-0.13
2003	124,871	47,311	16,760	113.89	64.61	27.91	14.22	3.06	0.47	17.75	-0.28
2006	125,214	47,635	16,172	113.89	64.61	27.91	14.26	3.08	0.45	17.79	-0.24

DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest.

Table 4.24 The forest area and the estimated carbon sequestration of three forest types of 5 km buffer around Thap Lan National Park during 1987-2006

Year	Forest area (ha)			Carbon storage (tC/ha)			Carbon storage of buffer around Thap Lan (million tC)				Carbon change (million tC)
	DEF	MDF	DDF	DEF	MDF	DDF	DEF	MDF	DDF	Total	(from year 1987)
1987	51,150	33,088	19,897	113.89	64.61	27.91	5.83	2.14	0.56	8.52	
1997	51,089	31,891	18,418	113.89	64.61	27.91	5.82	2.06	0.51	8.39	-0.13
2003	51,097	30,185	16,780	113.89	64.61	27.91	5.82	1.95	0.47	8.24	-0.28
2006	51,144	30,221	15,964	113.89	64.61	27.91	5.82	1.95	0.45	8.22	-0.30

DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest.

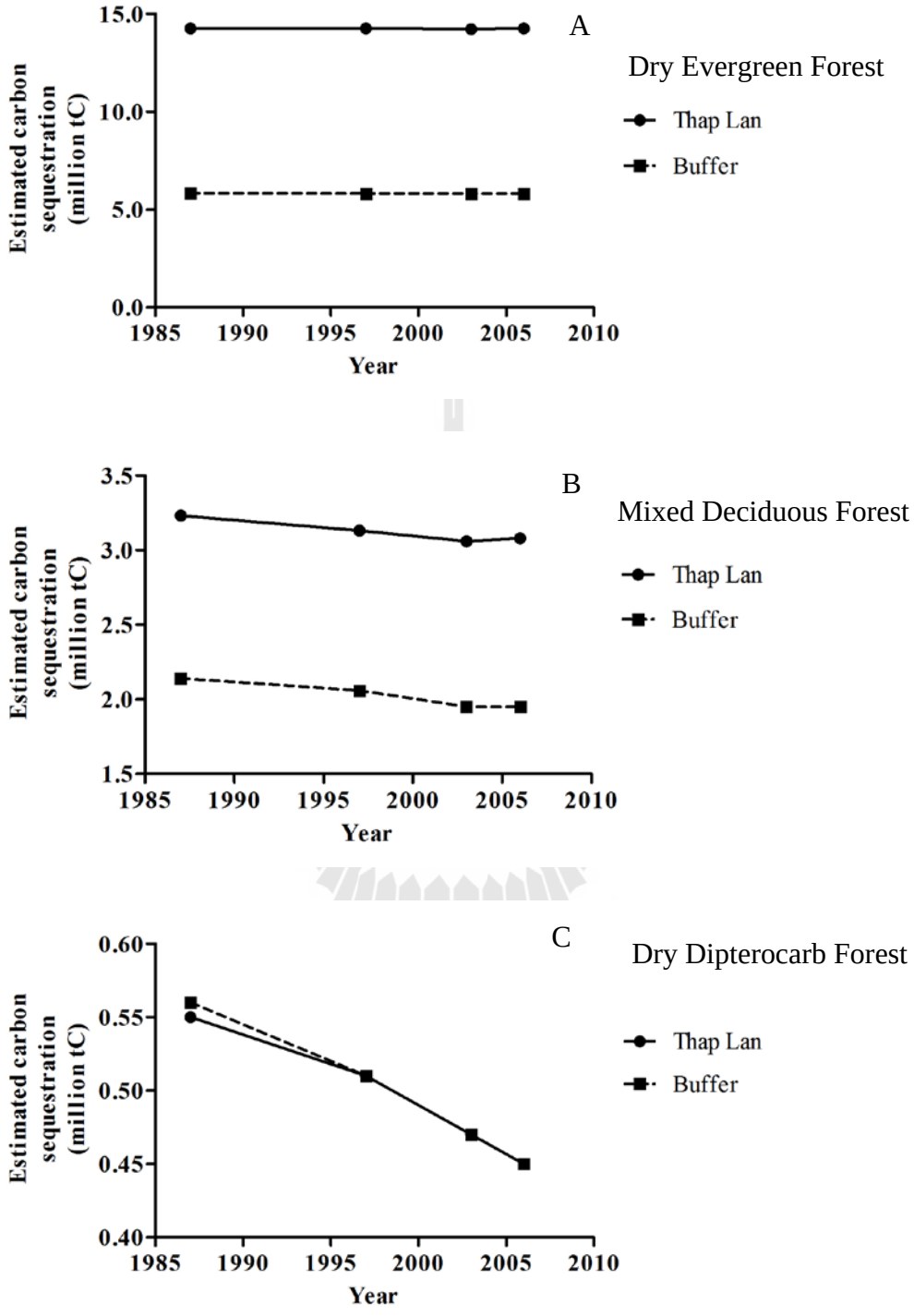

Figure 4.25 The estimated carbon storage of three forest types of Thap Lan National Park and its 5 km buffer zone during 1987-2006.

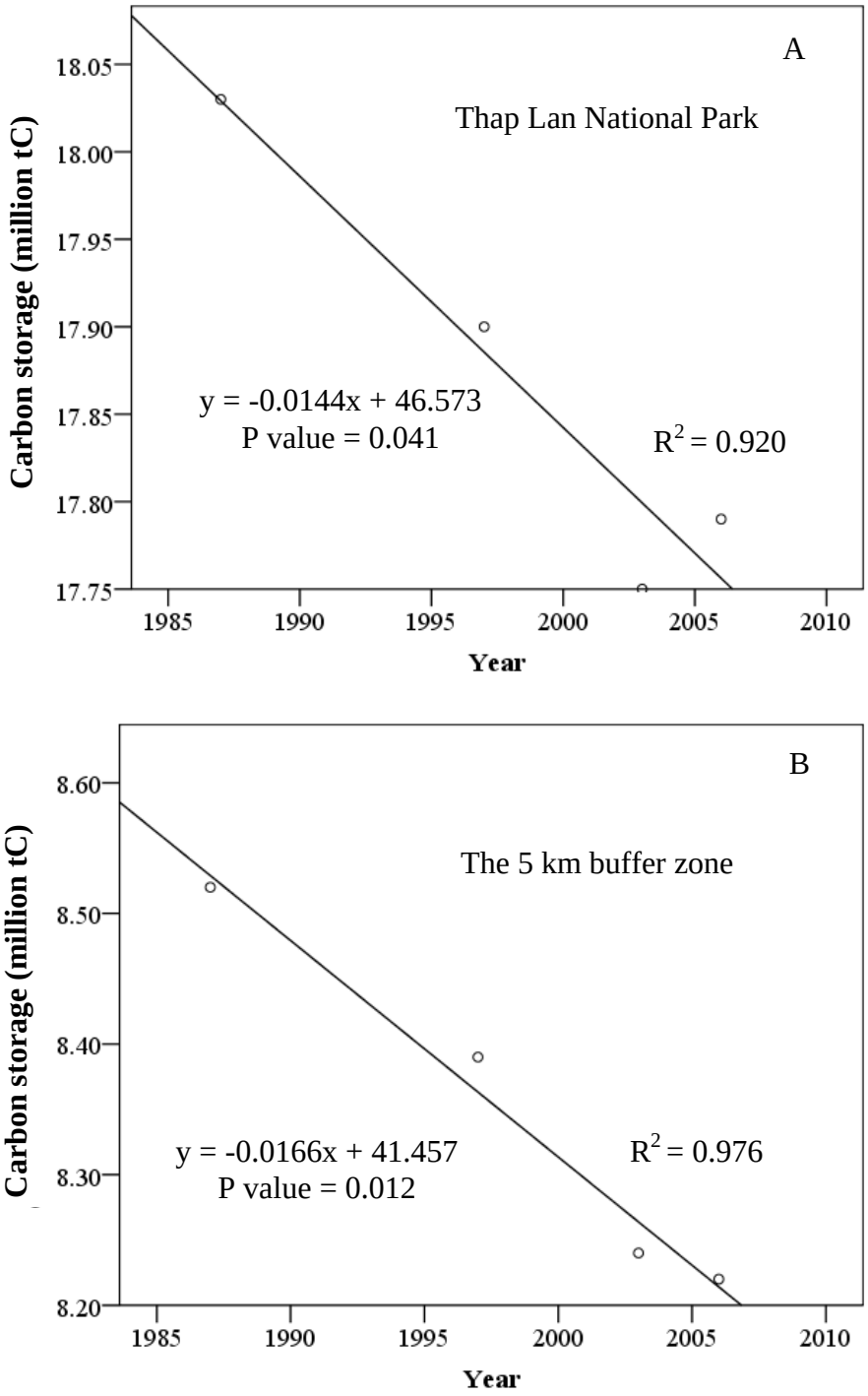

Figure 4.26 Regression equations of the estimated total carbon sequestration of Thap Lan National Park and its 5 km buffer zone. x = year (Christian Era), y = area.

For the 5 km buffer zone, the estimated carbon in 1987 (Table 4.24) was 2 folds less than in Thap Lan National Park, attributed to the lower of observed DEF area in buffer zone (511.50 km^2) than the Thap Lan (1,251.00 km^2). In year 1987, DEF also had more carbon storage than MDF and DEF with the capacity of 5.83, 2.14, and 0.56 million tC, respectively. The estimated total carbon storage in the buffer zone was also declining, mainly from MDF and DDF (Figures 4.25B and 4.25C -■-). The estimated total carbon storage in the buffer zone in 1987 was 8.52 million tC, whereas in 2006 it was reduced to 8.22 million tC. The carbon loss of 0.30 million tC or 3.52% of total carbon storage was observed during the study period. These changing could be fitted by the regression model of $y = -0.0166x + 41.457$, $R^2 = 0.976$ (Figure 4.26B). As carbon storage of the buffer zone is decreasing, the carbon storage would be 7.92 million tC in 2020.

Contributing to the carbon cycle, vegetation and forest are important carbon sinks of an atmospheric CO_2. Recent research revealed that the forests of Southeast Asia could store the carbon for 26% of the total carbon stock in the world and the total biomass carbon ranging 12-175 mgC/ha was observed in Thailand (Saatchi *et al.*, 2011). In Thailand, total carbon storage in forest biomass decreased from 908 to 877 million tC during 1990-2005 and slightly increased to 880 million tC during 2005-2010 (FAO, 2011). The forest biomass carbon changes were parallel with the present study, decreasing in 1987-2003 and slightly increasing in 2003-2006.

4.6 Soil Carbon and Other Properties

Soil organic carbon (SOC) plays an important role in global C cycle, as it is a large carbon storage pool. The observations of 3 levels of soil depth were carried out under the 3 forest types. Although SOC showed no significant difference among 3 forest types, SOC in DDF soils were lower than those in DEF and MDF (Table 4.25 and Figure 4.27). Amount of SOC was significantly higher ($p < 0.05$) in top 10 cm than those in others soil depths in all three forest types. The organic carbon in top 10 cm was 2.77-3.90%, whereas it showed 1.40-2.00% and 0.93-1.40% in 10-20 and 20-30 soil depth, respectively. There was no interaction between forest types and soil depth.

The soil moisture content was significantly different among three forest types ($p < 0.05$), but not different among soil depths ($p > 0.05$). The soil moisture content in DEF was higher than those in MDF and DDF which were 11.29-13.99, 7.69-8.94, and 3.78-5.92%, respectively. The important elements for plant growth such as phosphorus were similar in all three forests. Whereas, soil potassium was significantly higher at 0-10 cm depth in DEF and MDF than DDF ($p < 0.05$), which were 78.29, 73.71, and 43.00 ppm, respectively. Available phosphorus and potassium were highly accumulated in the top 10 cm depth and significantly decreased with soil horizon ($p < 0.05$). Soil phosphorus was 6.71-10.33, 3.86-6.33, and 3.29-5.33 $\times 10^{-4}$ppm in 0-10, 10-20, and 20-30 cm soil depth, respectively. Calcium content, exchangeable calcium, was significantly high in DDF and MDF ($p < 0.05$) with an average of 462.11 and 388.90 ppm, respectively. It was noted that calcium was varied in all of the observed soil depths. Soil pH of MDF was significantly higher than those of DEF and DDF which were 5.02-5.39, 4.31-4.39, and 4.31-4.33, respectively.

Table 4.25 Soil carbon and soil properties of three types of forest in Thap Lan National Park.

Forest type	Soil Depth (cm)	Organic Carbon (%)	Moisture (%)	P (× 10^{-4} ppm)	K (ppm)	Ca (ppm)	pH
DEF	0 - 10	$3.90 \pm 0.57^{a,a}$	$13.99 \pm 1.42^{a,a}$	$7.14 \pm 1.14^{a,a}$	$78.29 \pm 12.33^{ab,a}$	$104.00 \pm 30.39^{b,a}$	$4.31 \pm 0.23^{b,a}$
	10 - 20	$2.00 \pm 0.20^{a,b}$	$11.91 \pm 1.62^{a,a}$	$3.86 \pm 0.99^{a,ab}$	$40.00 \pm 6.43^{ab,b}$	$57.14 \pm 18.76^{b,a}$	$4.31 \pm 0.20^{b,a}$
	20 - 30	$1.40 \pm 0.13^{a,b}$	$11.29 \pm 1.74^{a,a}$	$3.29 \pm 0.68^{a,b}$	$32.00 \pm 6.42^{ab,b}$	$73.00 \pm 10.39^{b,a}$	$4.39 \pm 0.11^{b,a}$
MDF	0 - 10	$3.10 \pm 0.28^{ab,a}$	$8.05 \pm 2.00^{b,a}$	$6.71 \pm 1.91^{a,a}$	$73.71 \pm 17.58^{a,a}$	$378.00 \pm 158.07^{a,a}$	$5.39 \pm 0.39^{a,a}$
	10 - 20	$1.90 \pm 0.21^{ab,b}$	$7.69 \pm 1.49^{b,a}$	$4.71 \pm 1.48^{a,ab}$	$54.71 \pm 16.29^{a,b}$	$446.57 \pm 142.10^{a,a}$	$5.02 \pm 0.41^{a,a}$
	20 - 30	$1.39 \pm 0.26^{ab,b}$	$8.94 \pm 1.17^{b,a}$	$4.43 \pm 1.60^{a,b}$	$46.86 \pm 15.24^{a,b}$	$342.14 \pm 106.06^{a,a}$	$5.04 \pm 0.32^{a,a}$
DDF	0 - 10	$2.77 \pm 0.78^{b,a}$	$3.78 \pm 2.13^{c,a}$	$10.33 \pm 4.91^{a,a}$	$43.00 \pm 19.00^{b,a}$	$436.00 \pm 237.10^{a,a}$	$4.31 \pm 0.32^{b,a}$
	10 - 20	$1.48 \pm 0.37^{b,b}$	$4.94 \pm 1.78^{c,a}$	$6.33 \pm 3.38^{a,ab}$	$22.67 \pm 5.90^{b,b}$	$535.00 \pm 210.73^{a,a}$	$4.32 \pm 0.16^{b,a}$
	20 - 30	$0.93 \pm 0.61^{b,b}$	$5.92 \pm 1.51^{c,a}$	$5.33 \pm 2.96^{a,b}$	$17.33 \pm 3.71^{b,b}$	$415.33 \pm 181.24^{a,a}$	$4.33 \pm 0.18^{b,a}$
P- value	Forest	0.122	0.000	0.307	0.078	0.001	0.002
	Depth	0.000	0.933	0.047	0.026	0.796	0.905
	Forest × Depth	0.736	0.716	0.967	0.917	0.966	0.938

Means± SEM in the columns followed by different letters are significantly different at $P < 0.05$; first letter indicated the forest, second letter indicated the depth. DEF, Dry Evergreen Forest; MDF, Mixed Deciduous Forest; DDF, Dry Dipterocarp Forest; P, phosphorus; K, potassium; Ca, calcium.

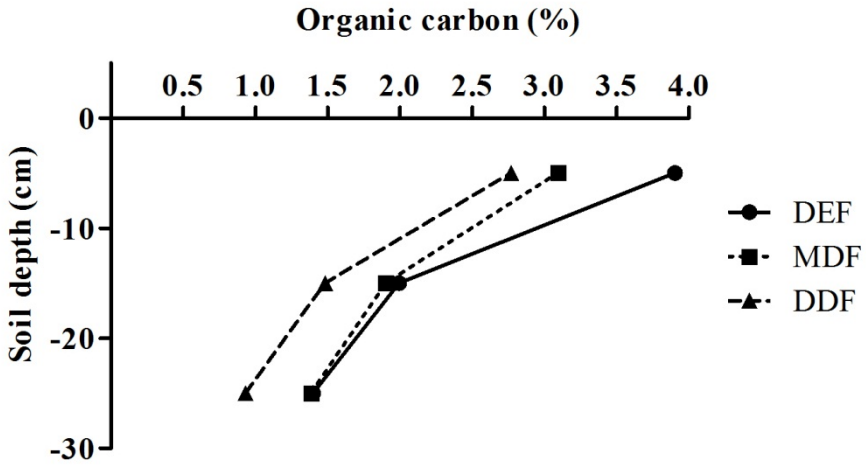

Figure 4.27 Soil organic carbon (%) of Dry Evergreen Forest (DEF), Mixed Deciduous Forest (MDF), and Dry Dipterocarp Forest (DDF) under various soil depths at Thap Lan National Park.

pH value of DEF and DDF was quite acidic in the top 10 cm layer and seemed to increase with soil horizon, whereas pH value of MDF showed the opposite tend.

The SOC content varies depending on the physiography or location of the study. The organic matter was positively significantly correlated with altitude (Banerjee, Gupta, Jha, and Das, 1998). An increase of 8.75% organic matter in soils of Andhra Pradesh was observed as the altitude increased from 180 to 1800 m. As compare to this study, DEF, MDF, and DDF are located in various altitudes between elevations of 66.10-596.72 m, 71.02-61.06 m, and 247.53-277.69 m height above sea level. The soil in DEF and MDF were richer in organic matter than DDF and seemed to be more appropriate for stand and poling trees and also weedy plants.

SOC and soil organic matter (SOM) was high accumulated in the 0-15 cm soil depth and decreased with increasing soil depth (Pumijumnong, 2007). Tangsinmankong (2004) reported that the SOC in teak plantation, Uthai Thani

province was the richest in top 15 cm soil depth (0.87-1.95%) and decreased with soil horizon at each teak age. Similarly, phosphorus and potassium was highly accumulated in 0-15 cm layer at 5.52-16.71 $\times$ 10^{-4}ppm and 105.9-364.0 ppm, respectively at each teak age and seemed to decrease with soil depth to the 50-100 cm layer. In contrast, Moncharoen and Vearasilp (2001) demonstrated the accumulation of SOC in the 0-25 cm soil depth at around 10.27, 6.99, and 3.66 kg/m^2 and increased nearly two times in 0-100 cm depth at around 20.82, 14.17, and 6.56 kg/m^2 in Thailand DEF, MDF, and DDF, respectively. The litter and residue accumulation on the soil surface are decomposed by soil microbial activities and some of the OC is sequestrated into the soil surface (Takahashi, Limtong, Sukawong, and Hirai, 2002).

The SOC accumulation varied with different land use, showing higher accumulations in native forest than reforestation and agriculture land. The study of Lichaikun *et al*. (2006) in Sakaerat Environmental Research Station revealed that the carbon content was highest in the DEF soil ranging from 15-30 mgC/g soil, followed by soil under reforest site (10-15 mgC/g soil) and cornfield (<10 mgC/g soil), respectively.

CHAPTER V

CONCLUSION

Land use and land cover change (LUCC) is one of the key impact factors for the climate and ecological system change. The reduction of forestland with the increment of inappropriate agricultural and settlement areas affect the carbon cycle and cause the net carbon dioxide (CO_2) release into the atmosphere. Therefore, the main objectives of this study are to assess land use change in Thap Lan National Park during 1987-2006 by the remote sensing technique and to estimate the carbon sequestration in forest as biomass and in soil.

5.1 Land Use Change of Thap Lan National Park between 1987 and 2006

The dominant land use of Thap Lan National Park during 1987-2006 was the forestland (85.17-87.80%) which are Dry Evergreen Forest (DEF), Mixed Deciduous Forest (MDF), and Dry Dipterocarp Forest (DDF) covering the area of 1,224.71-1,252.14, 473.11-500.58, and 161.72-197.15 km^2, respectively. The forestland was declining from the total of 1,948.73 km^2 in 1987 to 1,890.20 km^2 in 2006, the rate of decrease of 3.08 km^2/yr was observed which mainly reflects the decline of MDF and DDF. The most decreasing land use was the DDF, followed by MDF which were -35.43 and -24.24 km^2 or -1.60 and -1.09% of total area, respectively. In contrast, the agricultural and other lands (paddy field, field crop, perennial and orchard, grassland,

and other lands), accounting for 11.20-12.98%, tended to increase with time from 248.50 km^2 in 1987 to 280.69 km^2 in 2006 and seem to encroach into DDF and MDF. During the study period, field crop, grassland, and other lands increased with the area of 13.52, 12.73, and 17.66 km^2, whereas the paddy field and perennial and orchard decreased with the area of -8.76 and -2.96 km^2, respectively. During 1987-1997, water body, covered for 0.50% of total area in 1987, was sharply increased (20.58 km^2 or 0.95% of total area) attributed by the construction of Lam Plai Mat dam. Urban and building area, covering for 0.50-0.68% of total area, was gradually increasing from 11.11 km^2 in 1987 to 15.00 km^2 in 2006.

During 1987-2006, there were two land use types, MDF and DDF, those changes were well fitted by the regression equations as follows:

MDF area (y) = $-1.413x + 3307.332$, $R^2 = 0.933$

DDF area (y) = $-1.884x + 3941.710$, $R^2 = 0.983$

where x = year (Christain Era), y = area (km^2)

5.2 Land Use Change of the 5 km Buffer Zone around Thap Lan National Park between 1987 and 2006

The changes of the 5 km buffer zone showed a similar trend as inside the Thap Lan National Park, but higher percentages of change were observed in the buffer zone. The forestland in the buffer zone, accounting for 60.65-64.89% of total area, was decreasing from the total of 1,041.35 km^2 in 1987 to 973.28 km^2 in 2006, the rate of decrease of 3.58 km^2/yr was observed (higher than the inside Thap Lan National Park). The most decreasing land use was DDF, followed by MDF which were -39.33 and -28.67 km^2 or -2.45 and -1.79% of total area, respectively. The agricultural and

other lands were increased from the total of 479.63 km^2 in 1987 to 513.05 km^2 in 2006, which was due to the deforestation of DDF and MDF. The overall changes of agricultural and other lands revealed that field crop, perennial and orchard, grassland, and other lands increased by the area of 13.23, 1.75, 11.64, and 32.72 km^2, whereas paddy field decreased by the area of -25.92 km^2. Water bodies were also sharply increased during 1987-1997, by the construction of Munbon and Lum Sae dams. The urban and built-up gradually increased from 46.73 km^2 in 1987 to 59.10 km^2 in 2006. The increment of urban and built-up was 0.65 km^2/yr.

During 1987-2006, there were three land use types, MDF, DDF as well as the water body, those changes were well fitted by the regression equations as follows:

MDF area (y) = -1.638x + 3585.781, R^2 = 0.951

DDF area (y) = -2.061x + 4296.247, R^2 = 0.975

WB area (y) = 1.047x – 2042.666, R^2 = 0.917

where x = year (Christain Era), y = area (km^2)

5.3 Forest Structure

The three major forest types in Thap Lan National Park, Dry Evergreen Forest, Mixed Deciduous Forest and Dry Dipterocarp Forest, consist of various plant species and different dominant species. *Ficus curtipes* Corner and *Garcinia cowa* Roxb. were the dominant species in dry evergreen forest with important value index (IVI) of 13.63 and 13.23, respectively. Whereas, *Pterocarpus macrocarpus* Kurz and *Shorea obtusa* Wall. Ex Blume, belonging to the Leguminosae-Mimosoideae and Dipterocarpaceae, were the dominant species in the deciduous forests (Mixed Deciduous and Dry Dipterocarp Forest) with IVI value of 26.42 and 91.00, respectively.

5.4 The Assessment of Carbon Forest Sequestration of Thap Lan National Park

Dry Evergreen Forest was the most important source of carbon sequestration or carbon storage, followed by the Mixed Deciduous and Dry Dipterocarp Forest with the capacities of 113.89, 64.61, and 27.91 tC/ha, respectively. During 1987-2006, the estimated total forest carbon sequestration in Thap Lan National Park and its 5 km buffer zone was reduced with the decreased total forest area (remote sensing based). The estimated total carbon sequestration in Thap Lan National Park was 18.03 million tC in 1987, while it reduced to 17.79 million tC was observed in 2006. The average carbon loss of 12,631.58 tC/yr was observed during this period. In the 5 km buffer zone, the estimated total carbon sequestration was reduced from 8.52 million tC in 1987 to 8.22 million tC in 2006, the average of 15,789.47 tC/yr carbon loss was observed.

The total carbon sequestration pool of Thap Lan National Park and its 5 km buffer zone can be predicted by the following equations:

Total carbon sequestration (Thap Lan) (y) = $-0.0144x + 46.573$, $R^2 = 0.9200$

Total carbon sequestration (Buffer zone) (y) = $-0.0166x + 41.457$, $R^2 = 0.9764$

where x = year (Christian Era), y = carbon sequestration (million tC)

5.5 Soil Carbon and Other Properties

The soil organic carbon was significantly higher in the top 10 cm depth and decreased with soil depth ($p < 0.05$) in all three forest type. There was no significant difference of the soil carbon in the three forest type, but soil carbon in DEF showed the highest value, followed by MDF and DDF which were 3.90, 3.10, and 2.77% carbon in the 0-10 cm layer, respectively. The available phosphorus and potassium were also significantly accumulated in the top 10 cm soil depth ($p < 0.05$), but no significantly different among three forest types. Soil calcium was significantly higher in MDF and DDF than DEF ($p < 0.05$). Soil pH of MDF in top 10 cm depth was 5.39 which was higher than the DEF and DDF (4.31 and 4.31), respectively.

5.6 Recommendations

1) To improve the accuracy of land use change assessment, more satellite images should be used in the analysis, correlated with more field survey. Also the comparison among different years, pixel by pixel, should be used to reduce anomalies in changes of each image.

2) More forest sampling plots should be placed randomly around the study area especially in Dry Dipterocarp Forest to increase the accuracy of forest structure and carbon storage evaluation.

3) Soil nitrogen analysis should be added to evaluate soil fertility among forest types along with soil structure and texture.

4) Carbon storage of other land use types should be added in the assessment to get close to realistic situation.

5) The change of soil carbon should be measured per area to easily calculate the loss of soil carbon from deforestation.

6) Since natural forest can capture carbon in the form of plant biomass and soil organic carbon better than those of other land use. Forest protection and reforestation are essential in Thap Lan National Park and buffer zone. However, it will not possible without the participation of local people.

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APPENDIX

FOREST BIOMASS COLLECTION AND CALCULATION

A.1 Dry evergreen forest (Plot1)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1007	101	แดงดง(หน้าบุด)	*Aglaia rufinervis* (Blume) Bentv.	31	4.93	9.87	5	15.01	3.77	0.88	4.56
1007	102	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	84	13.37	26.73	22	365.90	112.43	8.99	74.78
1007	104	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	85	13.53	27.05	18	310.97	94.58	7.98	64.85
1007	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	45	7.16	14.32	8	45.86	12.36	1.98	12.13
1007	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	39	6.21	12.41	10	43.27	11.62	1.90	11.53
1007	103	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	46	7.32	14.64	18	100.60	28.49	3.51	24.13
1007	104	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	38	6.05	12.09	6	25.80	6.71	1.30	7.33
1007	104	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	34	5.41	10.82	5	17.79	4.52	0.99	5.29
1007	101	ยางเหียง	*Dipterocarpus obtusifolius* Teijsm. ex Miq.	41	6.52	13.05	18	81.42	22.76	3.01	20.05
1007	102	ยางเหียง	*Dipterocarpus obtusifolius* Teijsm. ex Miq.	118	18.78	37.56	30	908.75	95.06	17.43	165.90
1007	102	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	32	5.09	10.18	18	51.63	14.02	2.16	13.45
1007	102	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	76	12.09	24.19	28	379.95	117.03	9.24	77.29

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1007	104	ตะเคียนหิน	*Hopea ferrea* Laness.	38	6.05	12.09	13	52.51	14.27	2.19	13.65
1007	101	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	32	5.09	10.18	12	35.57	9.43	1.65	9.71
1007	101	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	34	5.41	10.82	12	39.76	10.62	1.79	10.70
1007	102	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	68	10.82	21.64	28	309.70	94.17	7.96	64.62
1007	103	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	43	6.84	13.69	23	111.33	31.73	3.78	26.37
1007	104	กะเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	38	6.05	12.09	18	70.81	19.62	2.72	17.74
1007	103	เลือดม้า	*Knema globularia* (Lam.) Warb.	40	6.37	12.73	10	15.83	12.21	1.97	12.00
1007	101	ผักหวานป่า	*Meliantha suavis* Pierre	44	7.00	14.00	8	44.00	11.83	1.92	11.69
1007	103	ตาทิบทอง (ตาทิบหิน)	*Neolitsea siamensis* Kosterm	83	13.21	26.42	28	446.74	139.02	10.39	89.07
1007	102	คางคก	*Nyssa javanica* (Blume) Wangerin	78	12.41	24.82	20	292.53	88.63	7.64	61.47
1007	101	ลำใยป่า	*Paranephelium xestophyllum* Miq.	36	5.73	11.46	10	37.35	9.94	1.71	10.13
1007	101	ลำใยป่า	*Paranephelium xestophyllum* Miq.	68	10.82	21.64	22	248.14	74.40	6.77	53.21
1007	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	110	17.50	35.01	20	550.27	173.50	12.10	106.91
1007	101	กระดูก	*Suregada multiflorum* (A.Juss.) Baill.	32	5.09	10.18	12	35.57	9.43	1.65	9.71
1007	103	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	113	17.98	35.96	31	864.91	280.60	16.81	158.87
1007	104	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	113	17.98	35.96	31	864.91	280.60	16.81	158.87
Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1007	101	หว้าแดง(หว้าหิน)	*Syzygium claviflorum* (Roxb.) A.M.Cowan & Cowan	61	9.71	19.41	20	186.18	54.82	5.50	41.38
1007	104	หว้า	*Syzygium cumini* (L.) Skeels	64	10.18	20.37	15	156.11	45.46	4.83	35.46
1007	104	หว้า	*Syzygium cumini* (L.) Skeels	78	12.41	24.82	18	265.53	79.96	7.12	56.47
1007	104	หว้า	*Syzygium cumini* (L.) Skeels	77	12.25	24.51	19	272.52	82.20	7.25	57.77
1007	104	แสนประสาน	*Terminalia triptera* Stapt	62	9.87	19.73	18	174.13	51.06	5.23	39.02
					Biomass (kg/rai)			7,421.37	2,096.84	187.15	1,526.10
					Biomass (t/ha)			46.38	13.10	1.17	9.54
					C storage (kg/rai)			3488.04	985.52	87.96	717.27
					C storage (kg/ha)			21800.26	463.19	41.34	337.12
					C storage (t/ha)			21.80	0.46	0.04	0.34

A.2 Dry evergreen forest (Plot2)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1007	102	มะหาด	*Artocarpus lacucha* Roxb.	32	5.09	10.18	12	35.57	9.43	1.65	9.71
1007	102	มะหาด	*Artocarpus lacucha* Roxb.	62	9.87	19.73	20	191.83	56.59	5.62	42.47
1007	101	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	30	4.77	9.55	5	14.13	3.54	0.84	4.32
1007	101	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	195	31.03	62.06	33	2,497.19	866.22	36.38	402.16
1007	104	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	176	28.01	56.02	35	2,183.25	750.93	32.99	357.51
1007	104	ปอกระสา	*Broussonetia papyrifera* (L.) Vent.	30	4.77	9.55	9	24.25	6.28	1.25	6.94
1007	101	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	123	19.57	39.15	31	1,010.79	331.17	18.83	182.11
1007	102	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	40	6.37	12.73	17	73.83	20.51	2.80	18.40
1007	102	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	122	19.41	38.83	30	966.18	315.65	18.22	175.05
1007	103	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	113	17.98	35.96	31.5	877.72	285.02	16.99	160.93
1007	104	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	67	10.66	21.32	31	330.93	101.05	8.35	68.48
1007	104	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata* (Lour.) Merr.	82	13.05	26.10	31	479.74	149.96	10.95	94.80
1007	101	กะเพราต้น	*Cinnamomum glaucescens* (Nees) Drury	177	28.17	56.33	18	1,197.36	396.51	21.30	211.24
1007	102	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	56	8.91	17.82	12	99.49	28.16	3.48	23.90
Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

1007	104	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	62	9.87	19.73	8	82.64	23.12	3.04	20.31
1007	104	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	40	6.37	12.73	10	45.34	12.21	1.97	12.00
1007	101	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	33	5.25	10.50	8	25.93	6.74	1.31	7.36
1007	101	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	56	8.91	17.82	15	122.14	35.02	4.04	28.60
1007	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	35	5.57	11.14	8	28.89	7.56	1.42	8.09
1007	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	31	4.93	9.87	11	30.98	8.14	1.49	8.60
1007	103	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	38	6.05	12.09	8	33.61	8.88	1.58	9.24
1007	103	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	42	6.68	13.37	9	45.01	12.12	1.96	11.93
1007	104	น้ำออย (น้ำข้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	62	9.87	19.73	15	147.26	42.73	4.63	33.69
1007	103	ประคำไก่	*Drypetes roxburghii* (Wall.) Hurusawa	36	5.73	11.46	9	33.91	8.97	1.59	9.31
1007	103	ประคำไก่	*Drypetes roxburghii* (Wall.) Hurusawa	31	4.93	9.87	9	25.76	6.69	1.30	7.32
1007	103	กันเกา	*Fagraea fragrans* Roxb.	34	5.41	10.82	12	39.76	10.62	1.79	10.70
1007	103	มะเดื่อหิน (ไทรหิน)	*Ficus curtipes* Corner	38	6.05	12.09	12	48.78	13.20	2.07	12.80
1007	104	มะเดื่อหิน (ไทรหิน)	*Ficus curtipes* Corner	444	70.66	141.31	45	15,067.63	5,854.44	134.61	1,941.62
1007	101	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum Müll. Aeg.*	88	14.00	28.01	21	381.88	117.66	9.27	77.63
1007	103	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	32	5.09	10.18	8	24.51	6.35	1.26	7.00

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

1007	103	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	30	4.77	9.55	8	21.76	5.60	1.15	6.31
1007	101	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	80	12.73	25.46	23	348.47	106.75	8.67	71.65
1007	102	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	65	10.34	20.69	25	256.86	77.18	6.95	54.85
1007	102	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	49	7.80	15.60	23	141.53	40.96	4.50	32.54
1007	102	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	41	6.52	13.05	20	89.70	25.22	3.23	21.82
1007	102	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	55	8.75	17.50	20	153.92	44.78	4.78	35.02
1007	103	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	87	13.84	27.69	23	406.55	125.76	9.70	82.01
1007	103	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	95	15.12	30.24	41	812.94	262.71	16.07	150.48
1007	104	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	34	5.41	10.82	11	36.71	9.76	1.69	9.98
1007	104	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	63	10.03	20.05	13	132.97	38.33	4.30	30.81
1007	104	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	58	9.23	18.46	10	89.75	25.24	3.23	21.84
1007	101	กระเปาช้าง	*Hydnocarpus anthelminthicus* Pierre ex Laness	426	67.79	135.58	40	12,531.43	4,812.71	117.70	1,652.15
1007	102	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	45	7.16	14.32	14	76.69	21.35	2.88	19.03
1007	102	คอนส้ม	*Microcos paniculata* L.	43	6.84	13.69	15	75.16	20.90	2.84	18.69
1007	102	ลำไยป่า	*Paranephelium xestophyllum* Miq.	86	13.69	27.37	17	301.47	91.51	7.81	63.11
1007	102	ลำไยป่า	*Paranephelium xestophyllum* Miq.	75	11.94	23.87	19	259.65	78.08	7.00	55.37

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1007	103	ลำไยป่า	*Paranephelium xestophyllum* Miq.	53	8.43	16.87	10	76.05	21.16	2.86	18.89
1007	103	ลำไยป่า	*Paranephelium xestophyllum* Miq.	35	5.57	11.14	12	41.94	11.24	1.86	11.21
1007	104	ลำไยป่า	*Paranephelium xestophyllum* Miq.	87	13.84	27.69	22	390.28	120.41	9.42	79.13
1007	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	48	7.64	15.28	12	74.94	20.84	2.83	18.65
1007	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	45	7.16	14.32	15	81.71	22.84	3.02	20.11
1007	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	43	6.84	13.69	16	79.75	22.26	2.96	19.69
1007	102	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	98	15.60	31.19	29	626.14	199.03	13.29	119.71
1007	104	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	48	7.64	15.28	15	92.00	25.91	3.29	22.31
1007	104	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	46	7.32	14.64	11	63.98	17.61	2.53	16.23
1007	103	กระดังงาป่า	*Polyalthia lateriflora* (Blume) King	30	4.77	9.55	6	16.71	4.23	0.95	5.01
1007	102	ปอหูช้าง	*Pterocymbium acerifolium* (L.) Willd.	58	9.23	18.46	21	177.48	52.10	5.31	39.68
1007	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	49	7.80	15.60	20	124.47	35.73	4.10	29.08
1007	104	ปออีเก้ง	*Pterocymbium tinctorium* (Blanco) Merr.	67	10.66	21.32	14	159.39	46.48	4.91	36.11
1007	104	ปออีเก้ง	*Pterocymbium tinctorium* (Blanco) Merr.	71	11.30	22.60	17	211.96	62.92	6.04	46.35
1007	104	ปออีเก้ง	*Pterocymbium tinctorium* (Blanco) Merr.	84	13.37	26.73	17	288.71	87.40	7.56	60.76
1007	101	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	31	4.93	9.87	7	20.45	5.24	1.10	5.98

1007	101	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	75	11.94	23.87	12	170.21	49.84	5.15	38.25
1007	102	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	39	6.21	12.41	13	55.07	15.02	2.26	14.24
1007	104	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	38	6.05	12.09	10	41.26	11.05	1.83	11.05
1007	104	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	61	9.71	19.41	11	107.48	30.57	3.68	25.57
1007	104	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	70	11.14	22.28	10	126.81	36.44	4.16	29.56
1007	101	แรงคำ	*Shorea farinosa* C.E.C.Fisch.	40	6.37	12.73	13	57.70	15.78	2.34	14.83
1007	102	แรงคำ	*Shorea farinosa* C.E.C.Fisch.	32	5.09	10.18	12	35.57	9.43	1.65	9.71
1007	102	เชื่อม (เคี่ยมคะนอง)	*Shorea henryana* Pierre	227	36.12	72.25	50	4,837.06	1,749.36	58.86	717.65
1007	102	ปอแคชาย	*Stereospermum neuranthum* Kurz	36	5.73	11.46	14	50.89	13.81	2.14	13.28
1007	102	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	180	28.64	57.29	45	2,866.46	1,003.00	40.22	453.80
1007	104	หว้า	*Syzygium cumini* (L.) Skeels	221	35.17	70.34	48	4,435.13	1,595.24	55.26	665.14
1007	104	แสนคำ	*Terminalia triptera* Stapt	49	7.80	15.60	12	77.84	21.69	2.91	19.28
1007	101	ตีนนก	*Vitex pinnata* L.	172	27.37	54.74	25	1,536.25	516.80	25.54	262.78
1007	101	ตีนนก	*Vitex pinnata* L.	39	6.21	12.41	14	58.96	16.14	2.38	15.11
1007	101	ตีนนก	*Vitex pinnata* L.	52	8.27	16.55	15	106.58	30.30	3.66	25.38
1007	102	ตีนนก	*Vitex pinnata* L.	162	25.78	51.56	33	1,776.05	602.96	28.38	298.38

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

1007	103	ตีนนก	*Vitex pinnata* L.	99	15.75	31.51	25	556.59	175.62	12.20	107.98
1007	104	ตีนนก	*Vitex pinnata* L.	42	6.68	13.37	7	35.73	9.48	1.65	9.74
1007	104	ตีนนก	*Vitex pinnata* L.	32	5.09	10.18	11	32.84	8.67	1.55	9.05
					Biomass (kg/rai)			61,392.30	21,948.88	883.35	9,579.60
					Biomass (t/ha)			383.70	137.18	5.52	59.87
					C storage (kg/rai)			28854.38	10315.98	415.17	4502.41
					C storage (kg/ha)			180339.87	64474.85	2594.83	28140.09
					C storage (t/ha)			180.34	64.47	2.59	28.14

A.3 Dry evergreen forest (Plot3)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1008	103	สะเดาช้าง	*Acrocarpus fraxinifolius* Wight ex Arn.	47	7.48	14.96	9	55.35	15.10	2.27	14.30
1008	104	สะเดาช้าง	*Acrocarpus fraxinifolius* Wight ex Arn.	38	6.05	12.09	10	41.26	11.05	1.83	11.05
1008	101	มะกล่ำ	*Adenanthera pavonina* L.	67	10.66	21.32	10	117.00	33.45	3.92	27.54
1008	102	แดงดง(หน้าบุด)	*Aglaia rufinervis* (Blume) Bentv.	80	12.73	25.46	12	191.65	56.53	5.61	42.44
1008	103	แดงดง(หน้าบุด)	*Aglaia rufinervis* (Blume) Bentv.	52	8.27	16.55	6	45.92	12.38	1.98	12.14
1008	103	แดงดง(หน้าบุด)	*Aglaia rufinervis* (Blume) Bentv.	24	3.82	7.64	7	12.77	3.18	0.78	3.96
1008	104	แดงดง(หน้าบุด)	*Aglaia rufinervis* (Blume) Bentv.	51	8.12	16.23	10	70.85	19.63	2.72	17.75
1008	102	มะไฟป่า	*Baccaurea ramiflora* Lour.	31	4.93	9.87	7	20.45	5.24	1.10	5.98
1008	101	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	55	8.75	17.50	15	118.16	33.81	3.95	27.78
1008	103	หมากย่าสาม	*Casearia* sp.	32	5.09	10.18	7	21.68	5.57	1.15	6.29
1008	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	34	5.41	10.82	8	27.39	7.15	1.36	7.72
1008	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	144	22.92	45.83	15	693.03	221.71	14.31	130.85
1008	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	41	6.52	13.05	10	47.44	12.81	2.03	12.49
1008	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	84	13.37	26.73	11	193.52	57.12	5.65	42.80
1008	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	35	5.57	11.14	8	28.89	7.56	1.42	8.09
1008	103	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	37	5.89	11.78	8	32.00	8.43	1.53	8.85
Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1008	104	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	86	13.69	27.37	8	150.80	43.82	4.71	34.40
1008	104	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	45	7.16	14.32	8	45.86	12.36	1.98	12.13
1008	103	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	122	19.41	38.83	7	253.65	76.16	6.88	54.25
1008	103	พญารากดำ	*Diospyros rubra* Lecomte	92	14.64	29.28	9	190.21	56.09	5.58	42.16
1008	102	ยางนา	*Dipterocarpus alatus* Roxb. Ex G.Don	41	6.52	13.05	10	47.44	12.81	2.03	12.49
1008	101	พระเจ้าห้าพระองค์	Dracontomelon dao (Blanco) Merr. & Rolfe	31	4.93	9.87	5	15.01	3.77	0.88	4.56
1008	103	พระเจ้าห้าพระองค์	Dracontomelon dao (Blanco) Merr. & Rolfe	48	7.64	15.28	6	39.64	10.59	1.78	10.67
1008	101	โพปราสาท (โพขี้นก)	*Ficus rumphii* Blume	160	25.46	50.92	25	1,345.03	448.69	23.18	233.89
1008	102	โพปราสาท (โพขี้นก)	*Ficus rumphii* Blume	206	32.78	65.56	18	1,582.47	533.35	26.10	269.69
1008	104	โพปราสาท (โพขี้นก)	*Ficus rumphii* Blume	144	22.92	45.83	12	564.53	178.28	12.32	109.33
1008	102	ชะม่วง(ส้มวาง)	*Garcinia nigrolineata* Planch. Ex T.Anderson	50	7.96	15.91	12	80.78	22.57	2.99	19.91
1008	102	ชะม่วง(ส้มวาง)	*Garcinia nigrolineata* Planch. Ex T.Anderson	48	7.64	15.28	12	74.94	20.84	2.83	18.65
1008	102	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum Müll. Aeg.*	22	3.50	7.00	8	12.31	3.05	0.76	3.83
1008	104	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum Müll. Aeg.*	30	4.77	9.55	9	24.25	6.28	1.25	6.94
1008	101	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	44	7.00	14.00	8	44.00	11.83	1.92	11.69
Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1008	101	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	44	7.00	14.00	8	44.00	11.83	1.92	11.69
1008	101	เลือดม้า	*Knema globularia* (Lam.) Warb.	44	7.00	14.00	10	54.02	14.71	2.23	14.00
1008	102	กำลังเลือดม้า	*Knema globularia* (Lam.) Warb.	60	9.55	19.10	9	86.70	24.33	3.15	21.19
1008	102	กำลังเลือดม้า	*Knema globularia* (Lam.) Warb.	57	9.07	18.14	9	78.90	22.01	2.94	19.51
1008	101	ตะแบก	*Lagerstroemia floribunda* Jack	421	67.00	133.99	40	12,262.43	4,702.95	115.86	1,621.04
1008	102	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	35	5.57	11.14	5	18.76	4.78	1.03	5.54
1008	102	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	42	6.68	13.37	5	26.23	6.82	1.32	7.43
1008	102	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	33	5.25	10.50	5	16.84	4.26	0.96	5.04
1008	104	คอนสัม	*Microcos paniculata* L.	72	11.46	22.92	10	133.55	38.51	4.31	30.93
1008	103	พลับพลา	*Microcos tomentosa* Sm.	59	9.39	18.78	9	84.07	23.54	3.08	20.62
1008	103	พลับพลา	*Microcos tomentosa* Sm.	31	4.93	9.87	9	25.76	6.69	1.30	7.32
1008	104	พลับพลา	*Microcos tomentosa* Sm.	37	5.89	11.78	6	24.57	6.37	1.26	7.02
1008	101	ตาทิบทอง (ตาทิบหิน)	*Neolitsea siamensis* Kosterm	39	6.21	12.41	15	62.81	17.27	2.49	15.97
1008	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	94	14.96	29.92	15	316.44	96.35	8.09	65.85
1008	102	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	99	15.75	31.51	11	261.74	78.74	7.04	55.76
1008	102	สีเสียดแดง	*Pentace burmanica* Kurz	75	11.94	23.87	13	183.20	53.89	5.43	40.80
Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1008	104	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	78	12.41	24.82	12	182.93	53.81	5.43	40.74
1008	102	ปอหูช้าง	*Pterocymbium acerifolium* (L.) Willd.	87	13.84	27.69	12	223.59	66.60	6.28	48.57
1008	103	ปอหูช้าง	*Pterocymbium acerifolium* (L.) Willd.	57	9.07	18.14	13	110.63	31.52	3.76	26.23
1008	101	แสมสาร	*Senna garrettiana* (Craib) H.S. Irwin & Barneby	61	9.71	19.41	9	89.38	25.13	3.22	21.76
1008	102	แสมดง (แสมสาร)	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	52	8.27	16.55	12	86.82	24.36	3.15	21.21
1008	103	ปอแคชาย	*Stereospermum neuranthum* Kurz	34	5.41	10.82	6	21.03	5.40	1.12	6.13
1008	103	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	142	22.60	45.19	25	1,080.10	355.36	19.76	193.00
1008	102	แสนคำ	*Terminalia triptera* Stapt	44	7.00	14.00	8	44.00	11.83	1.92	11.69
1008	103	แสนคำ	*Terminalia triptera* Stapt	34	5.41	10.82	8	27.39	7.15	1.36	7.72
1008	104	แสนคำ	*Terminalia triptera* Stapt	38	6.05	12.09	10	41.26	11.05	1.83	11.05
1008	103	กำจัด	*Zamia limonella* (Dennst.) Alston	56	8.91	17.82	10	84.14	23.57	3.08	20.64
					Biomass (kg/rai)			21,859.57	7,680.01	360.19	3,583.07
					Biomass (t/ha)			136.62	48.00	2.25	22.39
					C storage (kg/rai)			10274.00	3609.60	169.29	1684.04
					C storage (kg/ha)			64212.48	22560.03	1058.045	10525.28
					C storage (t/ha)			64.21	22.56	1.06	10.52

A.4 Dry evergreen forest (Plot4)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1009	101	สะเดาช้าง	*Acrocarpus fraxinifolius* Wight ex Arn.	33	5.25	10.50	12	37.64	10.02	1.72	10.20
1009	102	กฤษณา	*Aquilaria crassna* Pierre ex Lecomte	57	9.07	18.14	1.5	15.20	3.82	0.89	4.61
1009	104	กฤษณา	*Aquilaria crassna* Pierre ex Lecomte	60	9.55	19.10	10	95.52	26.97	3.38	23.06
1009	104	กฤษณา	*Aquilaria crassna* Pierre ex Lecomte	47	7.48	14.96	6	38.13	10.16	1.73	10.32
1009	104	มะหาด	*Artocarpus lacucha* Roxb.	55	8.75	17.50	6	50.91	13.81	2.14	13.29
1009	103	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	79	12.57	25.14	15	229.89	68.60	6.41	49.77
1009	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	47	7.48	14.96	10	60.98	16.73	2.44	15.56
1009	102	อบเชย	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	45	7.16	14.32	6	35.20	9.33	1.63	9.62
1009	103	อบเชย	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	56	8.91	17.82	10	84.14	23.57	3.08	20.64
1009	103	อบเชย	*Cinnamomum bejolghota* (Buch.-Ham.) Sweet	38	6.05	12.09	10	41.26	11.05	1.83	11.05
1009	103	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	37	5.89	11.78	8	32.00	8.43	1.53	8.85
1009	101	ยางนา	*Dipterocarpus alatus* Roxb. Ex G.Don	43	6.84	13.69	10	51.78	14.06	2.16	13.49
1009	101	ยางนา	*Dipterocarpus alatus* Roxb. Ex G.Don	43	6.84	13.69	10	51.78	14.06	2.16	13.49
1009	101	ยางนา	*Dipterocarpus alatus* Roxb. Ex G.Don	43	6.84	13.69	8	42.18	11.31	1.86	11.27
1009	102	มะเดื่อหิน (ไทรหิน)	*Ficus curtipes* Corner	472	75.11	150.22	40	15,130.43	5,880.39	135.01	1,948.71
Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1009	102	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	65	10.34	20.69	11	120.79	34.61	4.01	28.32
1009	104	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	583	92.78	185.55	35	19,731.05	7,797.97	163.80	2,458.92
1009	104	ส้มโมง	*Irvingia malayana* Oliv. ex A.W.Benn.	71	11.30	22.60	11	142.07	41.13	4.51	32.65
1009	102	ตะแบกนา	*Lagerstroemia floribunda* Jack	284	45.19	90.39	30	4,565.90	1,645.29	56.44	682.29
1009	104	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	40	6.37	12.73	11	49.49	13.40	2.09	12.96
1009	101	คอนส้ม	*Microcos paniculata* L.	133	21.16	42.33	9	374.49	115.24	9.14	76.31
1009	101	คอนส้ม	*Microcos paniculata* L.	47	7.48	14.96	8	49.67	13.46	2.10	13.00
1009	101	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	33	5.25	10.50	7	22.94	5.92	1.20	6.61
1009	103	คางคก	*Nyssa javanica* (Blume) Wangerin	122	19.41	38.83	20	665.62	212.40	13.89	126.30
1009	102	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	54	8.59	17.19	7	56.71	15.49	2.31	14.60
1009	103	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	30	4.77	9.55	7	19.25	4.91	1.05	5.67
1009	104	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	108	17.19	34.37	12	332.70	101.62	8.39	68.80
1009	101	เสียดบ้าน	*Pentace* sp.	48	7.64	15.28	12	74.94	20.84	2.83	18.65
1009	101	ปอหูช้าง	*Pterocymbium acerifolium* (L.) Willd.	79	12.57	25.14	19	285.67	86.42	7.51	60.20
1009	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	40	6.37	12.73	9	41.15	11.02	1.83	11.03
1009	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	40	6.37	12.73	8	36.93	9.82	1.69	10.03
Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1009	104	ปออีเก้ง	*Pterocymbium tinctorium* (Blanco) Merr.	34	5.41	10.82	12	39.76	10.62	1.79	10.70
1009	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	46	7.32	14.64	10	58.61	16.04	2.37	15.03
1009	104	แสนคำ	*Terminalia triptera* Stapt	63	10.03	20.05	11	114.05	32.56	3.85	26.93
1009	104	แสนคำ	*Terminalia triptera* Stapt	49	7.80	15.60	6	41.17	11.02	1.83	11.03
					Biomass (kg/rai)			42,820.01	16,322.08	460.63	5,853.98
					Biomass (t/ha)			267.63	102.01	2.88	36.59
					C storage (kg/rai)			20125.40	7671.38	216.50	2751.37
					C storage (kg/ha)			125783.77	47946.11	1353.10	17196.06
					C storage (t/ha)			125.78	47.95	1.35	17.20

A.5 Dry evergreen forest (Plot5)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Hei ght (m)	stem	branch	leaf	root
1010	103	สะเดาช้าง	*Acrocarpus fraxinifolius* Wight ex Arn.	48	7.64	15.28	8	51.63	14.02	2.16	13.45
1010	104	สะเดาช้าง	*Acrocarpus fraxinifolius* Wight ex Arn.	36	5.73	11.46	8	30.43	7.99	1.47	8.47
1010	101	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	45	7.16	14.32	8	45.86	12.36	1.98	12.13
1010	101	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	34	5.41	10.82	7	24.23	6.27	1.25	6.93
1010	104	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	31	4.93	9.87	7	20.45	5.24	1.10	5.98
1010	101	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	47	7.48	14.96	12	72.10	20.00	2.75	18.02
1010	101	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	169	26.89	53.79	18	1,099.78	362.25	20.02	196.08
1010	101	มะหาด	*Artocarpus lacucha* Roxb.	100	15.91	31.83	15	354.55	108.73	8.78	72.74
1010	101	มะหาด	*Artocarpus lacucha* Roxb.	82	13.05	26.10	12	200.54	59.33	5.80	44.16
1010	102	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	179	28.49	56.97	15	1,033.77	339.18	19.14	185.73
1010	103	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	44	7.00	14.00	9	49.03	13.27	2.08	12.86
1010	103	มะปริง	*Bouea oppositifolia* (Roxb.) Meisn.	32	5.09	10.18	10	30.08	7.90	1.46	8.38
1010	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	150	23.87	47.74	14	701.13	224.47	14.43	132.19
1010	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	68	10.82	21.64	13	153.01	44.50	4.76	34.84
1010	103	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	19	3.02	6.05	4	4.97	1.16	0.39	1.73
Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

1010	103	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	52	8.27	16.55	6	45.92	12.38	1.98	12.14
1010	104	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	31	4.93	9.87	10	28.38	7.42	1.40	7.96
1010	103	เทพทาโธ(จวา)	*Cinnamomum porrectum* (Roxb.) Kosterm.	37	5.89	11.78	5	20.78	5.33	1.11	6.06
1010	101	ตีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	51	8.12	16.23	4	30.53	8.02	1.47	8.49
1010	104	ตีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	51	8.12	16.23	6	44.31	11.92	1.93	11.77
1010	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	33	5.25	10.50	4	13.71	3.43	0.82	4.21
1010	104	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	38	6.05	12.09	5	21.82	5.61	1.15	6.33
1010	103	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	54	8.59	17.19	11	85.91	24.09	3.13	21.01
1010	104	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	54	8.59	17.19	12	93.06	26.23	3.32	22.54
1010	102	กำลังหนุมาน	*Dracaena conferta* Ridl.	43	6.84	13.69	4	22.31	5.75	1.17	6.45
1010	103	กำลังหนุมาน	*Dracaena conferta* Ridl.	39	6.21	12.41	4	18.64	4.75	1.03	5.51
1010	103	กำลังหนุมาน	*Dracaena conferta* Ridl.	44	7.00	14.00	3	17.86	4.54	1.00	5.31
1010	103	กำลังหนุมาน	*Dracaena conferta* Ridl.	17	2.71	5.41	2.5	2.63	0.59	0.25	0.99
1010	103	กำลังหนุมาน	*Dracaena conferta* Ridl.	41	6.52	13.05	8	38.64	10.30	1.75	10.44
1010	103	ตังตาบอด	*Excoecaria oppositifolia* Griff.	182	28.96	57.92	18	1,260.26	418.69	22.11	220.93
1010	101	กันเกา	*Fagraea fragrans* Roxb.	32	5.09	10.18	8	24.51	6.35	1.26	7.00
1010	101	ปอโพธิ์ศรี	*Hibiscus tiliaceus* L.	120	19.10	38.19	13	434.61	135.01	10.19	86.95

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root

1010	103	ตะคียนหิน	*Hopea ferrea* Laness.	42	6.68	13.37	8	40.39	10.80	1.81	10.85
1010	103	ตะคียนหิน	*Hopea ferrea* Laness.	97	15.44	30.87	13	293.94	89.08	7.66	61.73
1010	103	ตะคียนหิน	*Hopea ferrea* Laness.	69	10.98	21.96	11	134.80	38.89	4.34	31.18
1010	103	ตะคียนหิน	*Hopea ferrea* Laness.	109	17.35	34.69	15	415.40	128.67	9.86	83.57
1010	103	ตะคียนหิน	*Hopea ferrea* Laness.	140	22.28	44.56	16	698.27	223.50	14.39	131.71
1010	104	ตะคียนหิน	*Hopea ferrea* Laness.	87	13.84	27.69	13	240.66	72.02	6.62	51.81
1010	104	เลือดม้า	*Knema globularia* (Lam.) Warb.	31	4.93	9.87	8	23.12	5.97	1.20	6.65
1010	104	เลือดม้า	*Knema globularia* (Lam.) Warb.	71	11.30	22.60	12	153.90	44.77	4.78	35.02
1010	104	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	73	11.62	23.23	12	161.96	47.27	4.97	36.62
1010	104	ตาทิบทอง (ตาทิบหิน)	*Neolitsea siamensis* Kosterm	34	5.41	10.82	10	33.63	8.89	1.58	9.24
1010	101	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	30	4.77	9.55	10	26.72	6.96	1.34	7.55
1010	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	46	7.32	14.64	12	69.31	19.17	2.68	17.41
1010	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	36	5.73	11.46	12	44.17	11.88	1.93	11.73
1010	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	39	6.21	12.41	10	43.27	11.62	1.90	11.53
1010	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	30	4.77	9.55	5	14.13	3.54	0.84	4.32
1010	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	51	8.12	16.23	11	77.34	21.54	2.90	19.17

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1010	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	52	8.27	16.55	12	86.82	24.36	3.15	21.21

1010	102	คางคก	*Nyssa javanica* (Blume) Wangerin	175	27.85	55.70	16	1,052.31	345.65	19.39	188.65
1010	101	ลำไยป่า	*Paranephelium xestophyllum* Miq.	82	13.05	26.10	15	246.19	73.78	6.74	52.85
1010	101	ลำไยป่า	*Paranephelium xestophyllum* Miq.	50	7.96	15.91	8	55.65	15.19	2.28	14.37
1010	101	ลำไยป่า	*Paranephelium xestophyllum* Miq.	48	7.64	15.28	8	51.63	14.02	2.16	13.45
1010	103	ลำไยป่า	*Paranephelium xestophyllum* Miq.	73	11.62	23.23	10	136.97	39.56	4.40	31.62
1010	103	ลำไยป่า	*Paranephelium xestophyllum* Miq.	79	12.57	25.14	12	187.27	55.16	5.52	41.59
1010	101	กะพอก (มะพอก)	*Parinari anamense* Hance	118	18.78	37.56	15	480.62	150.25	10.96	94.96
1010	103	กะพอก (มะพอก)	*Parinari anamense* Hance	410	65.25	130.49	20	6,177.26	2,268.80	70.33	889.11
1010	102	สะตอป่า	*Parkia speciosa* Hassk.	48	7.64	15.28	12	74.94	20.84	2.83	18.65
1010	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	42	6.68	13.37	10	49.59	13.43	2.10	12.99
1010	101	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	41	6.52	13.05	10	47.44	12.81	2.03	12.49
1010	102	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	61	9.71	19.41	12	116.43	33.28	3.90	27.43
1010	103	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	59	9.39	18.78	12	109.51	31.18	3.73	25.99
1010	104	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	34	5.41	10.82	8	27.39	7.15	1.36	7.72
1010	101	แสมดง (แสมสาร)	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	87	13.84	27.69	14	257.62	77.43	6.96	54.99

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1010	103	แสมดง (แสมสาร)	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	31	4.93	9.87	5	15.01	3.77	0.88	4.56

1010	104	แสมดง (แสมสาร)	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	78	12.41	24.82	12	182.93	53.81	5.43	40.74
1010	102	ปอแคชาย	*Stereospermum neuranthum* Kurz	40	6.37	12.73	12	53.61	14.59	2.22	13.90
1010	102	ปอแคชาย	*Stereospermum neuranthum* Kurz	55	8.75	17.50	12	96.25	27.19	3.40	23.21
1010	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	43	6.84	13.69	8	42.18	11.31	1.86	11.27
1010	102	กระดูก	*Suregada multiflorum* (A.Juss.) Baill.	63	10.03	20.05	12	123.54	35.45	4.08	28.89
1010	101	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	49	7.80	15.60	12	77.84	21.69	2.91	19.28
1010	102	หว้าแดง(หว้าหิน)	*Syzygium claviflorum* (Roxb.) A.M.Cowan & Cowan	51	8.12	16.23	12	83.78	23.46	3.07	20.56
1010	102	หว้าแดง(หว้าหิน)	*Syzygium claviflorum* (Roxb.) A.M.Cowan & Cowan	51	8.12	16.23	12	83.78	23.46	3.07	20.56
1010	103	เสม	*Urobotrya siamensis* Hiepko	58	9.23	18.46	11	97.97	27.70	3.44	23.58
1010	101	ตีนนก	*Vitex pinnata* L.	65	10.34	20.69	15	160.63	46.86	4.94	36.36
1010	101	ตีนนก	*Vitex pinnata* L.	163	25.94	51.88	15	870.33	282.47	16.89	159.74
1010	101	ตีนนก	*Vitex pinnata* L.	43	6.84	13.69	10	51.78	14.06	2.16	13.49
1010	103	ตีนนก	*Vitex pinnata* L.	33	5.25	10.50	9	28.90	7.56	1.42	8.09

Biomass (kg/rai)	19672.60	6437.88	415.10	3660.17
Biomass (t/ha)	122.95	40.24	2.59	22.88
C storage (kg/rai)	9246.12	3025.80	195.09	1720.28
C storage (kg/ha)	57788.27	18911.27	1219.34	10751.74
C storage (t/ha)	57.79	18.91	1.22	10.75

A.6 Dry evergreen forest (Plot6)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1011	102	สะเดาช้าง	*Acrocarpus fraxinifolius* Wight ex Arn.	163	25.94	51.88	20	1,133.71	374.14	20.47	201.37
1011	102	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	54	8.59	17.19	14	107.22	30.49	3.68	25.52
1011	103	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	34	5.41	10.82	10	33.63	8.89	1.58	9.24
1011	103	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	54	8.59	17.19	7	56.71	15.49	2.31	14.60
1011	103	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	40	6.37	12.73	10	45.34	12.21	1.97	12.00
1011	104	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	30	4.77	9.55	8	21.76	5.60	1.15	6.31
1011	104	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	32	5.09	10.18	5	15.91	4.01	0.92	4.80
1011	104	แดงดง(หน้าบุต)	*Aglaia rufinervis* (Blume) Bentv.	41	6.52	13.05	6	29.67	7.78	1.44	8.28
1011	102	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	78	12.41	24.82	15	224.57	66.91	6.30	48.76
1011	103	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	130	20.69	41.37	25	918.31	299.05	17.56	167.43
1011	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	220	35.01	70.02	15	1,510.27	507.51	25.23	258.88
Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1011	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	30	4.77	9.55	8	21.76	5.60	1.15	6.31
1011	101	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	58	9.23	18.46	11	97.97	27.70	3.44	23.58
1011	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	50	7.96	15.91	10	68.32	18.88	2.65	17.19

1011	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	57	9.07	18.14	14	118.42	33.89	3.95	27.84
1011	103	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	83	13.21	26.42	12	205.06	60.75	5.90	45.03
1011	103	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	30	4.77	9.55	8	21.76	5.60	1.15	6.31
1011	104	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	55	8.75	17.50	15	118.16	33.81	3.95	27.78
1011	104	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	42	6.68	13.37	10	49.59	13.43	2.10	12.99
1011	104	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	79	12.57	25.14	8	129.01	37.12	4.21	30.01
1011	104	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	57	9.07	18.14	8	70.81	19.62	2.72	17.74
1011	104	ดีหมี	*Cleidion spiciflorum* (Burm.f.) Merr.	44	7.00	14.00	5	28.57	7.47	1.40	8.01
1011	101	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	31	4.93	9.87	9	25.76	6.69	1.30	7.32
1011	101	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	39	6.21	12.41	10	43.27	11.62	1.90	11.53
1011	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	30	4.77	9.55	8	21.76	5.60	1.15	6.31
1011	102	เปล้าน้ำเงิน	*Croton cascarilloides* Raeusch.	31	4.93	9.87	8	23.12	5.97	1.20	6.65
1011	103	ยางนา	*Dipterocarpus alatus* Roxb. Ex G.Don	111	17.66	35.33	20	559.50	176.59	12.24	108.48
1011	101	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	76	12.09	24.19	13	187.72	55.30	5.53	41.68

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1011	101	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	66	10.50	21.01	12	134.57	38.82	4.34	31.14
1011	101	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	56	8.91	17.82	7	60.63	16.63	2.43	15.49
1011	101	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	45	7.16	14.32	10	56.29	15.37	2.30	14.51

1011	101	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	30	4.77	9.55	10	26.72	6.96	1.34	7.55
1011	102	กำลังหนุมาน	*Dracaena conferta* Ridl.	34	5.41	10.82	5	17.79	4.52	0.99	5.29
1011	102	กำลังหนุมาน	*Dracaena conferta* Ridl.	38	6.05	12.09	8	33.61	8.88	1.58	9.24
1011	101	ตังตาบอด	*Excoecaria oppositifolia* Griff.	211	33.58	67.15	25	2,236.61	770.45	33.57	365.16
1011	101	ตังตาบอด	*Excoecaria oppositifolia* Griff.	37	5.89	11.78	6	24.57	6.37	1.26	7.02
1011	101	ตังตาบอด	*Excoecaria oppositifolia* Griff.	30	4.77	9.55	10	26.72	6.96	1.34	7.55
1011	101	ตังตาบอด	*Excoecaria oppositifolia* Griff.	77	12.25	24.51	13	192.28	56.73	5.63	42.56
1011	102	ตังตาบอด	*Excoecaria oppositifolia* Griff.	137	21.80	43.60	20	823.74	266.42	16.23	152.23
1011	101	กันเกา	*Fagraea fragrans* Roxb.	51	8.12	16.23	8	57.72	15.78	2.34	14.83
1011	102	กันเกา	*Fagraea fragrans* Roxb.	32	5.09	10.18	8	24.51	6.35	1.26	7.00
1011	102	กันเกา	*Fagraea fragrans* Roxb.	73	11.62	23.23	12	161.96	47.27	4.97	36.62
1011	102	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	34	5.41	10.82	10	33.63	8.89	1.58	9.24
1011	102	ตะเคียน	*Hopea odorata* Roxb.	56	8.91	17.82	12	99.49	28.16	3.48	23.90

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1011	102	ตะเคียน	*Hopea odorata* Roxb.	35	5.57	11.14	8	28.89	7.56	1.42	8.09
1011	104	กรวยป่า	*Horsfieldia macrocoma* Warb. Var. *canarioides*	47	7.48	14.96	8	49.67	13.46	2.10	13.00
1011	101	กระเบาควิด	*Hydnocarpus anthelminthicus* Pierre ex Laness.	42	6.68	13.37	10	49.59	13.43	2.10	12.99

1011	102	กระเบาควิด	*Hydnocarpus anthelminthicus* Pierre ex Laness.	44	7.00	14.00	13	68.74	19.01	2.66	17.29
1011	102	กระเบาควิด	*Hydnocarpus anthelminthicus* Pierre ex Laness.	240	38.19	76.38	20	2,308.49	796.80	34.35	375.42
1011	102	กระเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	83	13.21	26.42	12	205.06	60.75	5.90	45.03
1011	103	กระเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	37	5.89	11.78	11	42.88	11.51	1.89	11.43
1011	104	กระเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	57	9.07	18.14	10	86.93	24.39	3.16	21.23
1011	104	กระเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	32	5.09	10.18	6	18.81	4.79	1.04	5.56
1011	104	กระเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	31	4.93	9.87	6	17.75	4.50	0.99	5.28
1011	104	กระเบา	*Hydnocarpus anthelminthicus* Pierre ex Laness.	41	6.52	13.05	5	25.09	6.51	1.28	7.15
1011	101	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	90	14.32	28.64	13	256.13	76.95	6.93	54.71
1011	104	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	75	11.94	23.87	15	208.95	61.98	5.98	45.78
1011	102	เลือดม้า	*Knema globularia* (Lam.) Warb.	80	12.73	25.46	16	249.64	74.88	6.80	53.50
1011	102	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	39	6.21	12.41	10	43.27	11.62	1.90	11.53
1011	103	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	31	4.93	9.87	12	33.55	8.87	1.58	9.22
1011	104	เสม็ดขาว	*Melaleuca alternifolia* Cheel	49	7.80	15.60	10	65.83	18.15	2.58	16.64

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1011	101	คอนส้ม	*Microcos paniculata* L.	123	19.57	39.15	14	486.84	152.32	11.06	96.03
1011	102	คอนส้ม	*Microcos paniculata* L.	31	4.93	9.87	10	28.38	7.42	1.40	7.96
1011	101	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	73	11.62	23.23	9	124.33	35.69	4.10	29.05

1011	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	33	5.25	10.50	10	31.83	8.38	1.52	8.81
1011	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	33	5.25	10.50	11	34.75	9.20	1.62	9.51
1011	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	104	16.55	33.10	12	310.40	94.40	7.97	64.75
1011	103	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	95	15.12	30.24	16	342.37	104.76	8.56	70.55
1011	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	34	5.41	10.82	10	33.63	8.89	1.58	9.24
1011	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	35	5.57	11.14	8	28.89	7.56	1.42	8.09
1011	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	45	7.16	14.32	6	35.20	9.33	1.63	9.62
1011	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	45	7.16	14.32	9	51.10	13.87	2.14	13.33
1011	102	ลำไยป่า	*Paranephelium xestophyllum* Miq.	63	10.03	20.05	12	123.54	35.45	4.08	28.89
1011	103	ลำไยป่า	*Paranephelium xestophyllum* Miq.	49	7.80	15.60	12	77.84	21.69	2.91	19.28
1011	104	ลำไยป่า	*Paranephelium xestophyllum* Miq.	84	13.37	26.73	11	193.52	57.12	5.65	42.80
1011	104	ลำไยป่า	*Paranephelium xestophyllum* Miq.	38	6.05	12.09	10	41.26	11.05	1.83	11.05
1011	102	กะพอก (มะพอก)	*Parinari anamense* Hance	42	6.68	13.37	11	54.13	14.74	2.24	14.02
1011	102	สีเสียดแดง	*Pentace burmanica* Kurz	33	5.25	10.50	10	31.83	8.38	1.52	8.81

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1011	101	กระดังงาป่า	*Polyalthia lateriflora* (Blume) King	37	5.89	11.78	11	42.88	11.51	1.89	11.43
1011	103	กระดังงาป่า	*Polyalthia lateriflora* (Blume) King	86	13.69	27.37	15	268.71	80.98	7.18	57.06
1011	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	32	5.09	10.18	12	35.57	9.43	1.65	9.71

1011	101	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	36	5.73	11.46	11	40.77	10.91	1.82	10.94
1011	103	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	54	8.59	17.19	8	64.11	17.65	2.53	16.26
1011	103	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	33	5.25	10.50	10	31.83	8.38	1.52	8.81
1011	103	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	31	4.93	9.87	10	28.38	7.42	1.40	7.96
1011	104	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	31	4.93	9.87	10	28.38	7.42	1.40	7.96
1011	104	ประคำดีควาย (มะคำดีควาย)	*Sapindus rarak DC.*	64	10.18	20.37	5	56.88	15.54	2.32	14.64
1011	102	แสมสาร	*Senna garrettiana* (Craib) H.S. Irwin & Barneby	32	5.09	10.18	10	30.08	7.90	1.46	8.38
1011	104	แสมสาร	*Senecio garrettiana* (Craib) H.S. Irwin & Barneby	38	6.05	12.09	6	25.80	6.71	1.30	7.33
1011	104	แสมสาร	*Senecio garrettiana* (Craib) H.S. Irwin & Barneby	35	5.57	11.14	6	22.18	5.71	1.17	6.42
1011	101	เชื่อม (เคี่ยมคะนอง)	*Shorea henryana* Pierre	85	13.53	27.05	15	263.00	79.15	7.07	56.00
1011	103	เชื่อม (เคี่ยมคะนอง)	*Shorea henryana* Pierre	88	14.00	28.01	20	365.14	112.19	8.97	74.64
1011	101	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	86	13.69	27.37	10	185.12	54.49	5.47	41.17

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1011	103	เสม็ดแดง	*Syzygium cinnereum* (Kurz) P. Chantaranothai. & J. Parn.	32	5.09	10.18	11	32.84	8.67	1.55	9.05
1011	102	หว้า	*Syzygium cumini* (L.) Skeels	75	11.94	23.87	15	208.95	61.98	5.98	45.78
1011	102	หว้า	*Syzygium cumini* (L.) Skeels	75	11.94	23.87	16	221.72	66.01	6.24	48.22
1011	104	แสนคำ	*Terminalia triptera* Stapt	112	17.82	35.65	7	216.75	64.44	6.14	47.27

1011	103	เสม	*Urobotrya siamensis* Hiepko	32	5.09	10.18	12	35.57	9.43	1.65	9.71
1011	104	เสม	*Urobotrya siamensis* Hiepko	47	7.48	14.96	10	60.98	16.73	2.44	15.56
1011	104	เสม	*Urobotrya siamensis* Hiepko	45	7.16	14.32	6	35.20	9.33	1.63	9.62
					Biomass (kg/rai)			16854.75	5275.55	419.37	3399.46
					Biomass (t/ha)			105.34	32.97	2.62	21.25
					C storage (kg/rai)			7921.73	2479.51	197.10	1597.75
					C storage (kg/ha)			49510.84	15496.93	1231.89	9985.92
					C storage (t/ha)			49.51	15.50	1.23	9.99

A.7 Dry evergreen forest (Plot7)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1012	104	แต้วเปรี้ว	*Cratoxylum maingayi* Dyer	38	6.05	12.09	11	45.03	12.12	1.96	11.93
1012	101	ชิงชัง	*Dalbergia oliveri* Gamble	82	13.05	26.10	10	169.61	49.65	5.14	38.13
1012	101	นางดำ (เขลง หมากเค็ง)	*Dialium cochinchinense* Pierre	79	12.57	25.14	12	187.27	55.16	5.52	41.59

1012	102	ปะคำไก่	*Drypetes roxburghii* (Wall.) Hurusawa	28	4.46	8.91	3	7.78	1.88	0.54	2.56
1012	102	ปะคำไก่	*Drypetes roxburghii* (Wall.) Hurusawa	33	5.25	10.50	4	13.71	3.43	0.82	4.21
1012	103	ปะคำไก่	*Drypetes roxburghii* (Wall.) Hurusawa	40	6.37	12.73	8	36.93	9.82	1.69	10.03
1012	101	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	70	11.14	22.28	12	149.94	43.55	4.69	34.23
1012	102	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	105	16.71	33.42	14	363.99	111.81	8.95	74.44
1012	104	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	81	12.89	25.78	14	225.91	67.34	6.33	49.02
1012	103	ตะแบกนา	*Lagerstroemia floribunda* Jack	76	12.09	24.19	15	214.10	63.60	6.08	46.76
1012	103	ตะแบกนา	*Lagerstroemia floribunda* Jack	132	21.01	42.01	19	733.91	235.64	14.92	137.58
1012	104	ตะแบกนา	*Lagerstroemia floribunda* Jack	147	23.39	46.79	18	851.09	275.84	16.62	156.65
1012	101	สาระภี	*Mammea siamensis* (T. Anderson) Kosterm.	33	5.25	10.50	4	13.71	3.43	0.82	4.21
1012	101	เมือดแอ	*Memecylon scutellatum* Naudin	58	9.23	18.46	9	81.47	22.77	3.01	20.06
1012	101	เมือดแอ	*Memecylon scutellatum* Naudin	52	8.27	16.55	7	52.91	14.39	2.20	13.74

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1012	101	เมือดแอ	*Memecylon scutellatum* Naudin	41	6.52	13.05	10	47.44	12.81	2.03	12.49
1012	101	เมือดแอ	*Memecylon scutellatum* Naudin	34	5.41	10.82	12	39.76	10.62	1.79	10.70
1012	102	เมือดแอ	*Memecylon scutellatum* Naudin	43	6.84	13.69	8	42.18	11.31	1.86	11.27
1012	102	เมือดแอ	*Memecylon scutellatum* Naudin	38	6.05	12.09	10	41.26	11.05	1.83	11.05
1012	103	เมือดแอ	*Memecylon scutellatum* Naudin	40	6.37	12.73	12	53.61	14.59	2.22	13.90

1012	103	เมือดแอ	*Memecylon scutellatum* Naudin	50	7.96	15.91	5	36.13	9.59	1.67	9.84
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	45	7.16	14.32	7	40.56	10.85	1.81	10.89
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	33	5.25	10.50	7	22.94	5.92	1.20	6.61
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	50	7.96	15.91	7	49.23	13.33	2.09	12.90
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	40	6.37	12.73	10	45.34	12.21	1.97	12.00
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	51	8.12	16.23	9	64.32	17.71	2.54	16.31
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	33	5.25	10.50	10	31.83	8.38	1.52	8.81
1012	104	เมือดแอ	*Memecylon scutellatum* Naudin	36	5.73	11.46	7	26.91	7.01	1.34	7.60
1012	102	ตาทิบทอง (ตาทิบหิน)	*Neolitsea siamensis* Kosterm	48	7.64	15.28	11	69.19	19.14	2.67	17.38
1012	102	นนทรี	*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne	200	31.83	63.65	20	1,651.17	557.99	26.92	279.92
1012	102	มะเหลี่ยม	*Rhus javanica* L.	88	14.00	28.01	19	348.33	106.70	8.67	71.62
1012	104	มะเหลี่ยม	*Rhus javanica* L.	80	12.73	25.46	11	176.92	51.93	5.30	39.57

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1012	104	มะเหลี่ยม	*Rhus javanica* L.	79	12.57	25.14	16	243.94	73.06	6.69	52.43
1012	104	มะเหลี่ยม	*Rhus javanica* L.	46	7.32	14.64	10	58.61	16.04	2.37	15.03
1012	102	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	76	12.09	24.19	13	187.72	55.30	5.53	41.68
1012	102	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	38	6.05	12.09	6	25.80	6.71	1.30	7.33
1012	103	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	69	10.98	21.96	14	168.25	49.23	5.11	37.86

1012	103	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	60	9.55	19.10	16	147.12	42.68	4.63	33.67
1012	103	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	97	15.44	30.87	15	335.25	102.45	8.43	69.26
1012	103	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	79	12.57	25.14	15	229.89	68.60	6.41	49.77
							Biomass (kg/rai)	7331.05	2265.63	187.18	1505.05
							Biomass (t/ha)	45.82	14.16	1.17	9.41
							C storage (kg/rai)	3445.59	1064.85	87.98	707.38
							C storage (kg/ha)	21534.95	6655.30	549.85	4421.09
							C storage (t/ha)	21.53	6.66	0.55	4.42

A.8 Mixed Deciduous forest (Plot1)

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1002	101	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata (Lour.) Merr.*	175	27.85	55.70	40	2228.96	593.89	592.93	234.01
1002	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	41	6.52	13.05	6	25.36	4.30	4.42	5.67

1002	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	32	5.09	10.18	6	15.97	2.58	3.36	3.86
1002	101	ปอพาน (ปอพราน)	*Colona auriculata* (Desv.) Craib	37	5.89	11.78	12	39.97	7.09	6.81	8.28
1002	101	เปล้าใบเลื่อย (เปล้าใหญ่)	*Croton roxburghii* N.T. Balakr.	51	8.12	16.23	8	49.83	9.04	8.62	9.94
1002	103	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	127	20.21	40.42	30	937.31	228.77	227.83	113.92
1002	103	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	243	38.67	77.34	48	4873.77	1405.60	1404.63	448.32
1002	104	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	31	4.93	9.87	7	17.38	2.83	3.47	4.14
1002	101	ยางแดง	*Dipterocarpus turbinatus* C.F.Gaertn.	39	6.21	12.41	8	30.21	5.21	5.16	6.56
1002	103	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	35	5.57	11.14	6	18.88	3.10	3.61	4.44
1002	103	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	61	9.71	19.41	12	101.57	19.80	19.10	17.97
1002	102	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	63	10.03	20.05	10	91.00	17.54	16.87	16.40
1002	104	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	73	11.62	23.23	10	119.78	23.74	23.00	20.61
1002	101	กระท้อน	*Sandoricum koetjape (Burm.f.) Merr.*	210	33.42	66.84	22	1793.30	467.41	466.45	195.32
1002	103	กระท้อน	*Sandoricum koetjape* (Burm.f.) Merr.	51	8.12	16.23	12	72.73	13.70	13.11	13.62

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1002	104	กระท้อนป่า	*Sandoricum koetjape* (Burm.f.) Merr.	187	29.76	59.52	50	3106.02	855.85	854.88	308.31
1002	101	เชื่อมคะนอง (เคี่ยมคะนอง เคียนทราย)	*Shorea henryana Pierre*	200	31.83	63.65	45	3191.34	881.77	880.80	315.33
1002	102	เชื่อมคะนอง (เคี่ยมคะนอง เคียนทราย)	*Shorea henryana Pierre*	355	56.49	112.99	50	10267.19	3193.02	3192.05	832.70

1002	102	พะยอม	*Shorea roxburghii G.Don*	165	26.26	52.51	45	2229.17	593.95	592.99	234.03
1002	102	พะยอม	*Shorea roxburghii G.Don*	210	33.42	66.84	22	1793.30	467.41	466.45	195.32
					Biomass (kg/rai)			31003.05	8796.59	8786.55	2988.78
					Biomass (t/ha)			193.77	54.98	54.92	18.68
					C storage (kg/rai)			14571.43	4134.40	4129.68	1404.73
					C storage (kg/ha)			91071.45	25840.00	25810.49	8779.54
					C storage (t/ha)			91.07	25.84	25.81	8.78

A.9 Mixed Deciduous forest (Plot2)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1001	101	ละมั่ง (บงมัง เฉียงพร้านางแอ)	*Carallia brachiata (Lour.) Merr.*	175	27.85	55.70	8	496.87	113.73	112.81	67.23
1001	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	41	6.52	13.05	8	33.17	5.77	5.64	7.09

1001	102	กระเบียน	*Ceriscoides turgida* (Roxt) Tirveng	32	5.09	10.18	12	30.49	5.26	5.20	6.61
1001	101	ปอพาน (ปอพราน)	*Colona auriculata* (Desv.) Craib	37	5.89	11.78	22	70.35	13.21	12.63	13.24
1001	101	เปล้าใบเลื่อย (เปล้าใหญ่)	*Croton roxburghii* N.T. Balakr.	51	8.12	16.23	45	249.49	53.26	52.40	37.92
1001	103	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	127	20.21	40.42	40	1225.75	307.41	306.46	142.37
1001	103	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	243	38.67	77.34	45	4589.07	1315.45	1314.48	426.45
1001	104	ยางแดง	*Dipterocarpus turbinatus* C.F. Gaertn.	31	4.93	9.87	22	50.58	9.19	8.76	10.07
1001	101	ยางแดง	*Dipterocarpus turbinatus* C.F.Gaertn.	39	6.21	12.41	50	166.89	34.20	33.40	27.15
1001	103	มันปู	*Glochidion littorale* Blume, *Glochidion wallichianum* Müll. Aeg.	35	5.57	11.14	10	30.40	5.24	5.19	6.60
1001	103	หมีเหม็น	*Litsea glutinosa* (Lour.) C.B.Rob.	61	9.71	19.41	6	53.21	9.71	9.27	10.50
1001	102	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	63	10.03	20.05	6	56.51	10.38	9.90	11.04
1001	104	สีเสียดแดง (สีเสียดเปลือก)	*Pentace burmanica* Kurz	73	11.62	23.23	12	141.98	28.63	27.85	23.74
1001	101	กระท้อน	*Sandoricum koetjape (Burm.f.) Merr.*	210	33.42	66.84	30	2394.82	642.74	641.77	248.40

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1001	103	กระท้อน	*Sandoricum koetjape* (Burm.f.) Merr.	51	8.12	16.23	48	264.97	56.91	56.04	39.87
1001	104	กระท้อน	*Sandoricum koetjape* (Burm.f.) Merr.	187	29.76	59.52	12	820.71	197.64	196.70	102.01
1001	101	เชื่อมคะนอง (เคี่ยมคะนอง เคียนทราย)	*Shorea henryana Pierre*	200	31.83	63.65	6	487.41	111.34	110.43	66.16
1001	102	เชื่อมคะนอง (เคี่ยมคะนอง เคียนทราย)	*Shorea henryana Pierre*	355	56.49	112.99	10	2288.72	611.45	610.49	239.21

1001	102	พะยอม	*Shorea roxburghii G.Don*	165	26.26	52.51	7	393.09	87.87	86.96	55.33
1001	102	พะยอม	*Shorea roxburghii G.Don*	210	33.42	66.84	50	3856.28	1086.10	1085.14	369.04
					Biomass (kg/rai)			17700.75	4705.49	4691.51	1910.03
					Biomass (t/ha)			110.63	29.41	29.32	11.94
					C storage (kg/rai)			8319.35	2211.58	2205.01	897.72
					C storage (kg/ha)			51995.96	13822.38	13781.31	5610.73
					C storage (t/ha)			52.00	13.82	13.78	5.61

A.10 Mixed Deciduous forest (Plot3)

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1017	101	กะฮาด	*Amesiodendron chinense* (Merr.)	50	7.96	15.91	10	59.13	10.91	10.41	11.46
1017	101	กะฮาด	*Amesiodendron chinense* (Merr.)	30	4.77	9.55	0.7	1.91	0.25	13.94	0.66

1017	101	ลาน	*Corypha lecomtei* Becc.	90	14.32	28.64	4	75.31	14.24	13.64	14.02
1017	101	ลาน	*Corypha lecomtei* Becc.	102	16.23	32.46	0.5	13.68	2.18	3.25	3.40
1017	101	ลาน	*Corypha lecomtei* Becc.	90	14.32	28.64	6	109.92	21.60	20.88	19.19
1017	101	ลาน	*Corypha lecomtei* Becc.	100	15.91	31.83	2	48.02	8.68	8.28	9.64
1017	101	ลาน	*Corypha lecomtei* Becc.	100	15.91	31.83	4.5	102.30	19.95	19.25	18.08
1017	101	ลาน	*Corypha lecomtei* Becc.	120	19.10	38.19	5	158.58	32.33	31.54	26.02
1017	101	ลาน	*Corypha lecomtei* Becc.	80	12.73	25.46	2	31.67	5.49	5.40	6.82
1017	101	ลาน	*Corypha lecomtei* Becc.	40	6.37	12.73	0.6	2.83	0.38	9.31	0.92
1017	101	ลาน	*Corypha lecomtei* Becc.	150	23.87	47.74	2.5	125.97	25.09	24.34	21.49
1017	102	ลาน	*Corypha lecomtei* Becc.	40	6.37	12.73	1	4.55	0.65	5.82	1.36
1017	101	น้ำจ้อย (มะเกลือกา)	*Diospyros gracilis* Fletcher	50	7.96	15.91	1	6.91	1.03	4.10	1.92
1017	101	น้ำจ้อย (มะเกลือกา)	*Diospyros gracilis* Fletcher	40	6.37	12.73	0.5	2.39	0.32	11.08	0.80
1017	102	น้ำจ้อย (มะเกลือกา)	*Diospyros gracilis* Fletcher	130	20.69	41.37	2.2	85.62	16.40	15.75	15.59

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1017	102	น้ำจ้อย (มะเกลือกา)	*Diospyros gracilis* Fletcher	40	6.37	12.73	0.8	3.70	0.52	7.11	1.15
1017	102	น้ำจ้อย (มะเกลือกา)	*Diospyros gracilis* Fletcher	80	12.73	25.46	0.8	13.48	2.14	3.24	3.35
1017	103	น้ำจ้อย (มะเกลือกา)	*Diospyros gracilis* Fletcher	40	6.37	12.73	0.7	3.27	0.45	8.05	1.03
1017	104	ตอใส (ต่อใส้)	*Elaeis griffithii* (Wight) A.Gray	86	13.69	27.37	12	192.74	40.08	39.25	30.60

1017	101	มะเดื่อปล้อง	*Ficus hispida* L.f.	31	4.93	9.87	8	19.69	3.25	3.70	4.60
1017	102	มะเดื่อปล้อง	*Ficus hispida* L.f.	33	5.25	10.50	5	14.27	2.28	3.27	3.52
1017	103	มะเดื่อปล้อง	*Ficus hispida* L.f.	48	7.64	15.28	8	44.50	7.98	7.63	9.05
1017	103	มะเดื่อปล้อง	*Ficus hispida* L.f.	80	12.73	25.46	1	16.59	2.69	3.40	3.99
1017	103	มะเดื่อปล้อง	*Ficus hispida* L.f.	90	14.32	28.64	0.8	16.79	2.73	3.42	4.03
1017	103	มะเดื่อปล้อง	*Ficus hispida* L.f.	70	11.14	22.28	0.9	11.72	1.84	3.25	2.99
1017	103	มะเดื่อปล้อง	*Ficus hispida* L.f.	70	11.14	22.28	0.7	9.28	1.42	3.46	2.46
1017	102	เขว้า	*Haldina cordifolia* (Roxb.) Ridsdale	66	10.50	21.01	5.5	56.83	10.44	9.96	11.09
1017	102	เขว้า	*Haldina cordifolia* (Roxb.) Ridsdale	30	4.77	9.55	50	102.30	19.95	19.25	18.08
1017	102	เขว้า	*Haldina cordifolia* (Roxb.) Ridsdale	150	23.87	47.74	2	102.30	19.95	19.25	18.08
1017	102	เขว้า	*Haldina cordifolia* (Roxb.) Ridsdale	30	4.77	9.55	0.7	1.91	0.25	13.94	0.66
1017	104	สัมกบ	*Hymenodictyon orixense* (Roxb.) Mabb.	59	9.39	18.78	11	88.00	16.91	16.25	15.95
1017	102	อะราง	*Peltophorum dasyrachis* (Miq.) Kurz.	56	8.91	17.82	12	86.59	16.61	15.96	15.74

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1017	104	อะราง	*Peltophorum dasyrachis* (Miq.) Kurz.	43	6.84	13.69	8.5	38.36	6.77	6.53	8.00
1017	104	อะราง	*Peltophorum dasyrachis* (Miq.) Kurz.	178	28.33	56.65	13	806.59	193.90	192.96	100.55
1017	103	ปะคู่ตั่ง	*Pterocarpus macrocarpus* Kurz	46	7.32	14.64	5	26.52	4.51	4.59	5.89
1017	103	ปะคู่ตั่ง	*Pterocarpus macrocarpus* Kurz	150	23.87	47.74	2	102.30	19.95	19.25	18.08

1017	103	ปะคู่ตั้ง	*Pterocarpus macrocarpus* Kurz	150	23.87	47.74	2	102.30	19.95	19.25	18.08
1017	103	ปะคู่ตั้ง	*Pterocarpus macrocarpus* Kurz	80	12.73	25.46	4.5	67.47	12.62	12.06	12.79
1017	103	ปะคู่ตั้ง	*Pterocarpus macrocarpus* Kurz	40	6.37	12.73	1	4.55	0.65	5.82	1.36
1017	103	ปะคู่ตั้ง	*Pterocarpus macrocarpus* Kurz	30	4.77	9.55	0.9	2.41	0.32	10.95	0.80
1017	103	ปะคู่ตั้ง	*Pterocarpus macrocarpus* Kurz	50	7.96	15.91	0.7	4.95	0.71	5.39	1.46
1017	104	ปะคู่ตั้ง(ป่า)	*Pterocarpus macrocarpus* Kurz	39	6.21	12.41	13	47.51	8.58	8.19	9.56
1017	104	ปะคู่ตั้ง(ป่า)	*Pterocarpus macrocarpus* Kurz	108	17.19	34.37	10	248.68	53.07	52.21	37.82
1017	104	ปะคู่ตั้ง(ป่า)	*Pterocarpus macrocarpus* Kurz	40	6.37	12.73	2	8.69	1.32	3.57	2.33
1017	104	ปะคู่ตั้ง(ปลูก)	*Pterocarpus macrocarpus* Kurz	78	12.41	24.82	11	148.13	30.00	29.21	24.59
1017	104	ปะคู่ตั้ง(ปลูก)	*Pterocarpus macrocarpus* Kurz	180	28.64	57.29	4	274.36	59.13	58.26	41.04
1017	104	ปะคู่ตั้ง(ปลูก)	*Pterocarpus macrocarpus* Kurz	32	5.09	10.18	6	15.97	2.58	3.36	3.86
1017	104	ประคู่	*Pterocarpus macrocarpus* Kurz	33	5.25	10.50	6	16.92	2.75	3.43	4.05
1017	104	ประคู่	*Pterocarpus macrocarpus* Kurz	120	19.10	38.19	1.3	45.15	8.11	7.75	9.16

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1017	104	ประคู่	*Pterocarpus macrocarpus* Kurz	39	6.21	12.41	6	23.10	3.88	4.11	5.25
1017	104	ประคู่	*Pterocarpus macrocarpus* Kurz	40	6.37	12.73	0.8	3.70	0.52	7.11	1.15
1017	104	ประคู่	*Pterocarpus macrocarpus* Kurz	31	4.93	9.87	4	10.32	1.60	3.33	2.69
1017	101	ปอหูช้าง	*Pterocymbium acerifolium* (L.) Willd.	35	5.57	11.14	7	21.80	3.64	3.95	5.00

1017	102	ปอหูช้าง	*Pterocymbium acerifolium* (L.) Willd.	120	19.10	38.19	4	128.79	25.71	24.95	21.89
1017	102	ปอแดง	*Sterculia guttata* Roxb.	50	7.96	15.91	9	53.60	9.79	9.34	10.57
1017	102	ปอแดง	*Sterculia guttata* Roxb.	100	15.91	31.83	4.5	102.30	19.95	19.25	18.08
1017	102	ปอแดง	*Sterculia guttata* Roxb.	70	11.14	22.28	0.9	11.72	1.84	3.25	2.99
1017	102	ปอแดง	*Sterculia guttata* Roxb.	130	20.69	41.37	2.5	96.46	18.70	18.02	17.22
1017	102	ปอแดง	*Sterculia guttata* Roxb.	40	6.37	12.73	0.6	2.83	0.38	9.31	0.92
1017	102	ปอแดง	*Sterculia guttata* Roxb.	150	23.87	47.74	3	149.32	30.26	29.47	24.75
1017	102	ปอแดง	*Sterculia guttata* Roxb.	30	4.77	9.55	0.5	1.40	0.18	19.27	0.51
1017	102	ปอแดง	*Sterculia guttata* Roxb.	100	15.91	31.83	5.5	123.36	24.52	23.77	21.12
1017	104	ปอแดง	*Sterculia guttata* Roxb.	53	8.43	16.87	8	53.54	9.78	9.33	10.55
1017	102	สักขี	*Vatica harmandiana* Pierre	227	36.12	72.25	14	1,360.33	344.78	343.82	155.25
1017	102	สักขี	*Vatica harmandiana* Pierre	50	7.96	15.91	1	6.91	1.03	4.10	1.92
1017	102	สักขี	*Vatica harmandiana* Pierre	30	4.77	9.55	50	102.30	19.95	19.25	18.08

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1017	102	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	30	4.77	9.55	0.5	1.40	0.18	19.27	0.51
1017	102	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	70	11.14	22.28	1.2	15.33	2.47	3.32	3.73
1017	102	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	40	6.37	12.73	0.5	2.39	0.32	11.08	0.80
1017	104	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	38	6.05	12.09	8	28.78	4.94	4.94	6.30

Biomass (kg/rai)	5873.32	1258.31	1410.41	926.45
Biomass (t/ha)	36.71	7.86	8.82	5.79
C storage (kg/rai)	2760.46	591.41	662.89	435.43
C storage (kg/ha)	17252.89	3696.30	4143.07	2721.46
C storage (t/ha)	17.25	3.70	4.14	2.72

A.11 Mixed Deciduous forest (Plot4)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1016	101	ตีนเป็ด	*Ardisia murtonii* Fletcher	54	8.59	17.19	10	68.26	12.78	12.22	12.92
1016	101	ตีนเป็ด	*Ardisia murtonii* Fletcher	76	12.09	24.19	15	188.46	39.10	38.28	30.04

1016	102	ตีนเป็ด	*Ardisia murtonii* Fletcher	76	12.09	24.19	18	223.39	47.16	46.31	34.60
1016	101	มะหาด	*Artocarpus lacucha* Roxb.	76	12.09	24.19	13	164.92	33.76	32.95	26.88
1016	102	มะหาด	*Artocarpus lacucha* Roxb.	70	11.14	22.28	13	141.46	28.51	27.74	23.67
1016	102	มะหาด	*Artocarpus lacucha* Roxb.	30	4.77	9.55	0.5	1.40	0.18	19.27	0.51
1016	102	มะหาด	*Artocarpus lacucha* Roxb.	35	5.57	11.14	10	30.40	5.24	5.19	6.60
1016	103	มะหาด	*Artocarpus lacucha* Roxb.	52	8.27	16.55	13	81.26	15.48	14.85	14.93
1016	103	มะหาด	*Artocarpus lacucha* Roxb.	32	5.09	10.18	7	18.44	3.02	3.57	4.35
1016	103	มะหาด	*Artocarpus lacucha* Roxb.	2	0.24	0.48	1	0.01	0.00	2,807.09	0.01
1016	103	มะหาด	*Artocarpus lacucha* Roxb.	40	6.37	12.73	0.8	3.70	0.52	7.11	1.15
1016	103	มะหาด	*Artocarpus lacucha* Roxb.	40	6.37	12.73	0.5	2.39	0.32	11.08	0.80
1016	103	มะหาด	*Artocarpus lacucha* Roxb.	132	21.01	42.01	15	527.74	121.53	120.61	70.68
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	32	5.09	10.18	10	25.72	4.36	4.48	5.74
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	100	15.91	31.83	1.2	29.82	5.13	5.10	6.49

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	60	9.55	19.10	1	9.70	1.49	3.40	2.55
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	30	4.77	9.55	0.7	1.91	0.25	13.94	0.66
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	82	13.05	26.10	13	190.03	39.46	38.63	30.24
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	42	6.68	13.37	12	50.63	9.20	8.78	10.08

1016	104	มะหาด	*Artocarpus lacucha* Roxb.	52	8.27	16.55	12	75.41	14.26	13.66	14.03
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	50	7.96	15.91	15	86.31	16.55	15.90	15.70
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	46	7.32	14.64	13	64.65	12.04	11.50	12.35
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	67	10.66	21.32	13	130.37	26.06	25.30	22.11
1016	104	มะหาด	*Artocarpus lacucha* Roxb.	40	6.37	12.73	0.7	3.27	0.45	8.05	1.03
1016	104	มะไฟป่า	*Baccaurea parviflora* (MÜll.Arg.) MÜll.Arg.	35	5.57	11.14	10	30.40	5.24	5.19	6.60
1016	101	จาน (ทองกวาว)	*Butea monosperma* (Lam.) Taub.	30	4.77	9.55	0.8	2.16	0.29	12.26	0.73
1016	101	จาน (ทองกวาว)	*Butea monosperma* (Lam.) Taub.	20	3.18	6.37	0.3	0.41	0.05	67.91	0.18
1016	101	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	50	7.96	15.91	0.7	4.95	0.71	5.39	1.46
1016	101	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	40	6.37	12.73	1	4.55	0.65	5.82	1.36
1016	102	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	30	4.77	9.55	0.5	1.40	0.18	19.27	0.51
1016	102	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	30	4.77	9.55	0.3	0.87	0.10	31.44	0.34

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	102	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	58	9.23	18.46	12	92.45	17.85	17.18	16.62
1016	102	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	31	4.93	9.87	9	21.97	3.67	3.97	5.04
1016	102	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	34	5.41	10.82	8	23.39	3.93	4.15	5.30
1016	104	น้ำออย (น้ำจ้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	38	6.05	12.09	9	32.13	5.57	5.47	6.90

1016	104	น้ำออย (น้ำข้อย มะเกลือกา)	*Diospyros gracillis* Fletcher	34	5.41	10.82	12	34.14	5.96	5.80	7.26
1016	101	ทองหลาง	*Erythrina subumbrans* (Hassk.) Merr.	90	14.32	28.64	15	258.33	55.34	54.47	39.04
1016	101	ทองหลาง	*Erythrina subumbrans* (Hassk.) Merr.	40	6.37	12.73	1	4.55	0.65	5.82	1.36
1016	101	มะเดื่อหอม	*Ficus hirta* Vahl	68	10.82	21.64	12	124.38	24.74	23.99	21.27
1016	101	มะเดื่อหอม	*Ficus hirta* Vahl	36	5.73	11.46	6	19.90	3.29	3.72	4.64
1016	101	มะเดื่อหอม	*Ficus hirta* Vahl	30	4.77	9.55	0.6	1.65	0.21	16.17	0.59
1016	102	มะเดื่อหอม	*Ficus hirta* Vahl	119	18.94	37.87	10	298.00	64.77	63.89	43.96
1016	102	มะเดื่อหอม	*Ficus hirta* Vahl	31	4.93	9.87	6	15.06	2.42	3.30	3.68
1016	102	มะเดื่อหอม	*Ficus hirta* Vahl	161	25.62	51.24	12	620.76	145.32	144.39	80.89
1016	102	มะเดื่อหอม	*Ficus hirta* Vahl	92	14.64	29.28	11	201.54	42.10	41.27	31.76
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	196	31.19	62.38	13	965.35	236.32	235.38	116.74
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	60	9.55	19.10	12	98.48	19.14	18.44	17.52

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	44	7.00	14.00	10	46.59	8.39	8.02	9.40
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	30	4.77	9.55	0.3	0.87	0.10	31.44	0.34
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	40	6.37	12.73	0.3	1.48	0.19	18.11	0.54
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	76	12.09	24.19	13	164.92	33.76	32.95	26.88
1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	50	7.96	15.91	0.7	4.95	0.71	5.39	1.46

1016	103	มะเดื่อหอม	*Ficus hirta* Vahl	30	4.77	9.55	0.4	1.13	0.14	23.87	0.43
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	90	14.32	28.64	8	143.74	29.02	28.24	23.98
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	44	7.00	14.00	8	37.84	6.67	6.44	7.91
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	50	7.96	15.91	10	59.13	10.91	10.41	11.46
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	64	10.18	20.37	11	102.42	19.98	19.28	18.10
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	57	9.07	18.14	11	82.52	15.75	15.11	15.12
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	128	20.37	40.74	10	341.41	75.23	74.34	49.22
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	68	10.82	21.64	13	134.02	26.86	26.10	22.63
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	82	13.05	26.10	12	176.36	36.35	35.53	28.43
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	90	14.32	28.64	12	209.80	44.01	43.17	32.84
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	117	18.62	37.24	15	421.41	94.86	93.95	58.63
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	60	9.55	19.10	9	75.31	14.24	13.64	14.02

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	104	มะเดื่อหอม	*Ficus hirta* Vahl	47	7.48	14.96	9	47.76	8.62	8.23	9.60
1016	101	ตะแบกหิน	*Lagerstroemia speciosa*	79	12.57	25.14	13	177.27	36.55	35.74	28.55
1016	101	ตะแบกหิน	*Lagerstroemia speciosa*	36	5.73	11.46	7	22.98	3.85	4.10	5.23
1016	102	ตะแบกหิน	*Lagerstroemia speciosa*	77	12.25	24.51	10	132.31	26.49	25.72	22.39
1016	103	ตะแบกหิน	*Lagerstroemia speciosa*	20	3.18	6.37	7	7.68	1.15	3.82	2.10

1016	103	ตะแบกหิน	*Lagerstroemia speciosa*	43	6.84	13.69	8	36.25	6.37	6.16	7.63
1016	104	ตะแบกหิน	*Lagerstroemia speciosa*	31	4.93	9.87	9	21.97	3.67	3.97	5.04
1016	101	มะยมหิน	*Meliosma pinnaia* Walp.	37	5.89	11.78	11	36.86	6.48	6.27	7.74
1016	101	มะยมหิน	*Meliosma pinnaia* Walp.	57	9.07	18.14	16	117.04	23.14	22.41	20.22
1016	102	มะยมหิน	*Meliosma pinnaia* Walp.	61	9.71	19.41	13	109.44	21.49	20.77	19.12
1016	104	มะยมหิน	*Meliosma pinnaia* Walp.	156	24.82	49.65	14	675.77	159.57	158.63	86.80
1016	104	มะยมหิน	*Meliosma pinnaia* Walp.	120	19.10	38.19	2	67.47	12.62	12.06	12.79
1016	101	พลับพลา	*Microcos tomentosa* Sm.	35	5.57	11.14	10	30.40	5.24	5.19	6.60
1016	101	พลับพลา	*Microcos tomentosa* Sm.	30	4.77	9.55	16	35.35	6.19	6.01	7.48
1016	102	พลับพลา	*Microcos tomentosa* Sm.	73	11.62	23.23	15	174.82	36.00	35.19	28.22
1016	103	พลับพลา	*Microcos tomentosa* Sm.	32	5.09	10.18	11	28.11	4.81	4.83	6.18
1016	103	พลับพลา	*Microcos tomentosa* Sm.	78	12.41	24.82	15	197.82	41.25	40.41	31.27

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	104	พลับพลา	*Microcos tomentosa* Sm.	57	9.07	18.14	13	96.43	18.70	18.01	17.21
1016	104	พลับพลา	*Microcos tomentosa* Sm.	45	7.16	14.32	11	53.10	9.69	9.24	10.48
1016	104	พลับพลา	*Microcos tomentosa* Sm.	50	7.96	15.91	9	53.60	9.79	9.34	10.57
1016	103	ลำไยป่า	*Paranephelium xestophyllum* Miq.	55	8.75	17.50	8	57.37	10.55	10.07	11.18
1016	101	กะพอก (มะพอก)	*Parinari anamense* Hance	34	5.41	10.82	10	28.80	4.94	4.94	6.31

1016	102	สะตอป่า	*Parkia speciosa* Hassk.	220	35.01	70.02	20	1,789.51	466.32	465.36	194.98
1016	101	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	55	8.75	17.50	16	109.49	21.50	20.79	19.13
1016	101	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	62	9.87	19.73	10	88.32	16.97	16.32	16.00
1016	101	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	46	7.32	14.64	9	45.88	8.25	7.89	9.28
1016	102	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	30	4.77	9.55	0.4	1.13	0.14	23.87	0.43
1016	102	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	50	7.96	15.91	0.5	3.62	0.50	7.27	1.12
1016	102	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	91	14.48	28.96	15	263.71	56.61	55.74	39.71
1016	102	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	30	4.77	9.55	0.4	1.13	0.14	23.87	0.43
1016	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	39	6.21	12.41	11	40.66	7.22	6.94	8.40
1016	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	46	7.32	14.64	12	60.00	11.09	10.58	11.60
1016	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	56	8.91	17.82	13	93.30	18.03	17.35	16.75
1016	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	48	7.64	15.28	8	44.50	7.98	7.63	9.05

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	103	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	98	15.60	31.19	15	302.81	65.92	65.04	44.55
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	36	5.73	11.46	9	29.04	4.99	4.98	6.35
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	44	7.00	14.00	8	37.84	6.67	6.44	7.91
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	70	11.14	22.28	13	141.46	28.51	27.74	23.67
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	43	6.84	13.69	11	48.78	8.83	8.43	9.77

1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	85	13.53	27.05	13	203.20	42.49	41.65	31.98
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	81	12.89	25.78	17	238.52	50.69	49.83	36.53
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	63	10.03	20.05	17	149.26	30.25	29.46	24.75
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	36	5.73	11.46	11	35.02	6.13	5.95	7.42
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	34	5.41	10.82	9	26.11	4.43	4.53	5.81
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	42	6.68	13.37	7	30.63	5.29	5.23	6.64
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	94	14.96	29.92	14	262.70	56.37	55.50	39.59
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	71	11.30	22.60	9	103.09	20.12	19.42	18.19
1016	104	ปออ้อยช้าง	*Pterocymbium acerifolium* (L.) Willd.	36	5.73	11.46	0.5	1.96	0.26	13.56	0.68
1016	101	ปีบทอง	*Radermachera hainanensis* Merr.	60	9.55	19.10	13	106.12	20.77	20.06	18.64
1016	101	ปีบทอง	*Radermachera hainanensis* Merr.	30	4.77	9.55	0.6	1.65	0.21	16.17	0.59
1016	101	ปีบทอง	*Radermachera hainanensis* Merr.	37	5.89	11.78	7	24.18	4.08	4.26	5.45

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	101	ปีบทอง	*Radermachera hainanensis* Merr.	30	4.77	9.55	0.8	2.16	0.29	12.26	0.73
1016	101	ปีบทอง	*Radermachera hainanensis* Merr.	30	4.77	9.55	0.8	2.16	0.29	12.26	0.73
1016	102	ปีบทอง	*Radermachera hainanensis* Merr.	38	6.05	12.09	9	32.13	5.57	5.47	6.90
1016	104	ปอแดง	*Sterculia guttata* Roxb.	82	13.05	26.10	15	217.16	45.71	44.86	33.79
1016	101	ปอแคชาย	*Stereospermum neuranthum* Kurz	37	5.89	11.78	8	27.39	4.67	4.72	6.05

1016	101	ปอแคชาย	*Stereospermum neuranthum* Kurz	51	8.12	16.23	12	72.73	13.70	13.11	13.62
1016	101	ปอแคชาย	*Stereospermum neuranthum* Kurz	44	7.00	14.00	7	33.41	5.82	5.68	7.13
1016	101	ปอแคชาย	*Stereospermum neuranthum* Kurz	30	4.77	9.55	0.6	1.65	0.21	16.17	0.59
1016	102	ปอแคชาย	*Stereospermum neuranthum* Kurz	36	5.73	11.46	8	26.02	4.42	4.52	5.80
1016	102	ปอแคชาย	*Stereospermum neuranthum* Kurz	48	7.64	15.28	12	64.95	12.10	11.56	12.39
1016	103	ปอแคชาย	*Stereospermum neuranthum* Kurz	59	9.39	18.78	15	117.52	23.25	22.51	20.29
1016	103	ปอแคชาย	*Stereospermum neuranthum* Kurz	70	11.14	22.28	15	161.66	33.03	32.23	26.44
1016	103	ปอแคชาย	*Stereospermum neuranthum* Kurz	37	5.89	11.78	8	27.39	4.67	4.72	6.05
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	59	9.39	18.78	15	117.52	23.25	22.51	20.29
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	49	7.80	15.60	10	56.95	10.47	9.98	11.11
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	54	8.59	17.19	11	74.61	14.09	13.49	13.91
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	53	8.43	16.87	13	84.20	16.10	15.46	15.38

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	70	11.14	22.28	1.2	15.33	2.47	3.32	3.73
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	100	15.91	31.83	1.3	32.13	5.57	5.47	6.91
1016	104	ปอแคชาย	*Stereospermum neuranthum* Kurz	50	7.96	15.91	1	6.91	1.03	4.10	1.92
1016	101	กระดูก	*Suregada multiflorum* (A.Juss.) Baill.	44	7.00	14.00	5	24.41	4.12	4.29	5.50
1016	101	กระดูก	*Suregada multiflorum* (A.Juss.) Baill.	82	13.05	26.10	12	176.36	36.35	35.53	28.43

1016	102	กระดูก	*Suregada multiflorum* (A.Juss.) Baill.	50	7.96	15.91	0.7	4.95	0.71	5.39	1.46
1016	102	กระดูก	*Suregada multiflorum* (A.Juss.) Baill.	30	4.77	9.55	0.4	1.13	0.14	23.87	0.43

Biomass (kg/rai)	14853.42	3188.51	6402.10	2310.87
Biomass (t/ha)	92.83	19.93	40.01	14.44
C storage (kg/rai)	6981.11	1498.60	3008.99	1086.11
C storage (kg/ha)	43631.91	9366.25	18806.17	6788.19
C storage (t/ha)	43.63	9.37	18.81	6.79

A.12 Mixed Deciduous forest (Plot5)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1015	104	กระทุ่มใหญ่	*Anthocephalus chinensis* (Lam.) A.Rich ex Walp	40	6.37	12.73	7.5	29.82	5.13	5.10	6.49
1015	102	แค้วเปรี้ยว	*Cratoxylum maingayi* Dyer	44	7.00	14.00	9	42.23	7.53	7.22	8.67
1015	104	แค้วเปรี้ยว	*Cratoxylum maingayi* Dyer	33	5.25	10.50	2.2	6.64	0.98	4.23	1.86
1015	101	น้ำออย (น้ำจ้อย มะเกลือ	*Diospyros gracillis* Fletcher	70	11.14	22.28	3	36.04	6.32	6.13	7.60

		กา)									
1015	101	กันเกา	*Fagraea fragrans* Roxb.	45	7.16	14.32	6	30.17	5.20	5.15	6.55
1015	102	กันเกา	*Fagraea fragrans* Roxb.	86	13.69	27.37	2.5	44.63	8.00	7.66	9.07
1015	102	กันเกา	*Fagraea fragrans* Roxb.	42	6.68	13.37	1.2	5.91	0.86	4.62	1.69
1015	102	กันเกา	*Fagraea fragrans* Roxb.	46	7.32	14.64	3	16.47	2.67	3.40	3.96
1015	104	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	31	4.93	9.87	8.5	20.83	3.46	3.83	4.82
1015	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	44	7.00	14.00	5.5	26.68	4.54	4.62	5.92
1015	101	เสียดหนาม	*Pentace* sp.	34	5.41	10.82	7	20.65	3.43	3.81	4.78
1015	101	เสียดหนาม	*Pentace* sp.	48	7.64	15.28	7	39.29	6.96	6.69	8.16
1015	101	เสียดหนาม	*Pentace* sp.	29	4.61	9.23	8	17.39	2.83	3.47	4.15
1015	102	เสียดหนาม	*Pentace* sp.	34	5.41	10.82	3.2	9.95	1.53	3.37	2.61
1015	102	เสียดหนาม	*Pentace* sp.	31	4.93	9.87	7	17.38	2.83	3.47	4.14

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1015	102	เสียดหนาม	*Pentace* sp.	33	5.25	10.50	4	11.59	1.81	3.25	2.96
1015	102	เสียดหนาม	*Pentace* sp.	67	10.66	21.32	7.5	78.05	14.81	14.20	14.44
1015	103	เสียดหนาม	*Pentace* sp.	53	8.43	16.87	7.5	50.41	9.15	8.73	10.04
1015	103	เสียดหนาม	*Pentace* sp.	44	7.00	14.00	5.5	26.68	4.54	4.62	5.92
1015	103	เสียดหนาม	*Pentace* sp.	50	7.96	15.91	8	48.02	8.68	8.28	9.64

1015	103	เสียดหนาม	*Pentace* sp.	49	7.80	15.60	5	29.83	5.14	5.10	6.49
1015	103	เสียดหนาม	*Pentace* sp.	47	7.48	14.96	7	37.78	6.66	6.43	7.90
1015	104	เสียดหนาม	*Pentace* sp.	38	6.05	12.09	8	28.78	4.94	4.94	6.30
1015	104	เสียดหนาม	*Pentace* sp.	35	5.57	11.14	5	15.93	2.57	3.36	3.85
1015	104	เสียดหนาม	*Pentace* sp.	40	6.37	12.73	2.7	11.50	1.80	3.26	2.94
1015	104	เสียดหนาม	*Pentace* sp.	38	6.05	12.09	4.5	16.83	2.73	3.42	4.03
1015	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	37	5.89	11.78	9	30.57	5.28	5.22	6.62
1015	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	37	5.89	11.78	9	30.57	5.28	5.22	6.62
1015	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	41	6.52	13.05	6	25.36	4.30	4.42	5.67
1015	102	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	79	12.57	25.14	7.5	106.13	20.78	20.07	18.64
1015	103	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	106	16.87	33.74	4.5	114.05	22.49	21.76	19.79

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1015	104	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	36	5.73	11.46	9	29.04	4.99	4.98	6.35
							Biomass (kg/rai)	1055.21	188.24	200.00	218.70
							Biomass (t/ha)	6.60	1.18	1.25	1.37
							C storage (kg/rai)	495.95	88.47	94.00	102.79
							C storage (kg/ha)	3099.68	552.95	587.51	642.42

C storage (t/ha)	3.10	0.55	0.59	0.64

A.13 Mixed Deciduous Forest (Plot6)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1014	103	แต้ว	*Cratoxylum maingayi* Dyer	30	4.77	9.55	8	18.52	3.04	3.58	4.37
1014	103	แต้วเปรี้ยว	*Cratoxylum maingayi* Dyer	65	10.34	20.69	8	78.34	14.87	14.26	14.48
1014	101	นางดำ (เขลง หมากเค็ง)	*Dialium cochinchinense* Pierre	67	10.66	21.32	7.5	78.05	14.81	14.20	14.44

1014	102	นางดำ (เขลง หมากเค็ง)	*Dialium cochinchinense* Pierre	59	9.39	18.78	7	57.73	10.63	10.14	11.24
1014	102	นางดำ (เขลง หมากเค็ง)	*Dialium cochinchinense* Pierre	25	3.98	7.96	5.5	9.29	1.42	3.46	2.46
1014	103	ตอใส (ต่อใส้)	*Elaeis griffithii* (Wight) A.Gray	32	5.09	10.18	8	20.89	3.47	3.83	4.83
1014	103	โมกใหญ่	*Holarrhena pubescens* Wall. ex A.DC.	76	12.09	24.19	6.5	86.40	16.57	15.92	15.71
1014	103	โมกใหญ่	*Holarrhena pubescens* Wall. ex A.DC.	38	6.05	12.09	6	22.01	3.67	3.97	5.04
1014	101	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	136	21.64	43.28	8	310.46	67.76	66.87	45.48
1014	101	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	69	10.98	21.96	10	107.83	21.14	20.43	18.89
1014	102	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	31	4.93	9.87	8	19.69	3.25	3.70	4.60
1014	102	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	54	8.59	17.19	6	42.39	7.56	7.25	8.69
1014	102	คอนส้ม (ลาย)	*Microcos paniculata* L.	99	15.75	31.51	7.5	161.68	33.03	32.23	26.44
1014	102	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	55	8.75	17.50	7	50.65	9.20	8.78	10.08
1014	102	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	82	13.05	26.10	9	134.86	27.05	26.28	22.74

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1014	103	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	51	8.12	16.23	8	49.83	9.04	8.62	9.94
1014	104	คอนส้ม (ลาย คอม)	*Microcos paniculata* L.	86	13.69	27.37	7	116.59	23.04	22.31	20.15
1014	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	85	13.53	27.05	12	188.58	39.13	38.31	30.05
1014	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	60	9.55	19.10	12.5	102.30	19.95	19.25	18.08
1014	102	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	42	6.68	13.37	8	34.69	6.06	5.90	7.36

1014	103	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	55	8.75	17.50	9	64.03	11.91	11.37	12.25
1014	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	48	7.64	15.28	7	39.29	6.96	6.69	8.16
1014	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	44	7.00	14.00	8	37.84	6.67	6.44	7.91
1014	104	คอแรน(แงว)	*Nephelium hypoleucum* Kurz	64	10.18	20.37	7	67.19	12.56	12.00	12.75
1014	101	กะพอก (มะพอก)	*Parinari anamense* Hance	45	7.16	14.32	7	34.84	6.09	5.92	7.39
1014	103	อะราง	*Peltophorum dasyrachis* (Miq.) Kurz.	50	7.96	15.91	8.5	50.82	9.23	8.81	10.11
1014	103	อะราง	*Peltophorum dasyrachis* (Miq.) Kurz.	30	4.77	9.55	6	14.16	2.26	3.26	3.50
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	71	11.30	22.60	13	145.26	29.36	28.57	24.19
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	117	18.62	37.24	13	368.77	81.90	81.00	52.47
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	1	0.12	0.25	14	0.03	0.00	829.65	0.02
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	56	8.91	17.82	11	79.84	15.19	14.56	14.71
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	86	13.69	27.37	11	177.72	36.66	35.84	28.61

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	115	18.30	36.60	13	357.09	79.05	78.15	51.09
1014	101	ประดู่แดง	*Phyllocarpus septentrionalis* Donn.Sm.	90	14.32	28.64	10.5	185.23	38.37	37.54	29.61
1014	101	ประดู่	*Pterocarpus macrocarpus* Kurz	90	14.32	28.64	16	274.36	59.13	58.26	41.04
1014	101	ประดู่	*Pterocarpus macrocarpus* Kurz	133	21.16	42.33	13	468.36	106.56	105.65	64.00
1014	101	ประดู่	*Pterocarpus macrocarpus* Kurz	99	15.75	31.51	12	250.62	53.52	52.66	38.07

1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	66	10.50	21.01	12	117.64	23.27	22.54	20.30
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	85	13.53	27.05	13	203.20	42.49	41.65	31.98
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	49	7.80	15.60	10	56.95	10.47	9.98	11.11
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	49	7.80	15.60	8	46.25	8.32	7.95	9.35
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	71	11.30	22.60	12	134.81	27.04	26.27	22.74
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	96	15.28	30.55	11	218.19	45.95	45.10	33.93
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	30	4.77	9.55	7	16.35	2.65	3.39	3.94
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	32	5.09	10.18	7	18.44	3.02	3.57	4.35
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	75	11.94	23.87	12	149.32	30.26	29.47	24.75
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	94	14.96	29.92	10.5	200.88	41.95	41.12	31.67
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	53	8.43	16.87	9	59.75	11.04	10.53	11.56
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	58	9.23	18.46	9	70.69	13.28	12.70	13.30

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	80	12.73	25.46	9	128.79	25.71	24.95	21.89
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	72	11.46	22.92	8	94.80	18.35	17.67	16.97
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	55	8.75	17.50	6	43.87	7.85	7.52	8.94
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	100	15.91	31.83	10	215.43	45.31	44.46	33.57
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	79	12.57	25.14	10	138.79	27.92	27.15	23.29

1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	61	9.71	19.41	6.5	57.34	10.55	10.06	11.17
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	53	8.43	16.87	9	59.75	11.04	10.53	11.56
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	96	15.28	30.55	10	199.64	41.67	40.83	31.51
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	81	12.89	25.78	12	172.37	35.44	34.63	27.89
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	122	19.41	38.83	8.5	268.26	57.69	56.82	40.28
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	108	17.19	34.37	7.5	190.16	39.49	38.67	30.26
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	94	14.96	29.92	13	245.16	52.24	51.38	37.38
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	82	13.05	26.10	13	190.03	39.46	38.63	30.24
1014	102	ประดู่	*Pterocarpus macrocarpus* Kurz	67	10.66	21.32	12	120.99	24.00	23.26	20.78
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	40	6.37	12.73	6	24.22	4.08	4.26	5.46
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	110	17.50	35.01	11	281.26	60.77	59.90	41.90
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	76	12.09	24.19	11	141.12	28.44	27.66	23.62

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	30	4.77	9.55	8	18.52	3.04	3.58	4.37
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	111	17.66	35.33	8	212.55	44.64	43.80	33.20
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	94	14.96	29.92	10	191.95	39.90	39.07	30.50
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	67	10.66	21.32	11	111.56	21.95	21.23	19.43
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	61	9.71	19.41	11	93.65	18.10	17.43	16.80

1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	40	6.37	12.73	11	42.63	7.61	7.29	8.73
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	141	22.44	44.88	13	522.27	120.15	119.22	70.07
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	70	11.14	22.28	9	100.39	19.54	18.85	17.80
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	106	16.87	33.74	12	284.68	61.59	60.71	42.32
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	108	17.19	34.37	11	271.80	58.53	57.65	40.72
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	57	9.07	18.14	10.5	79.02	15.01	14.39	14.59
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	105	16.71	33.42	10	235.95	50.09	49.23	36.21
1014	103	ประดู่	*Pterocarpus macrocarpus* Kurz	91	14.48	28.96	8	146.73	29.68	28.90	24.40
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	48	7.64	15.28	7	39.29	6.96	6.69	8.16
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	135	21.48	42.97	10.5	394.61	88.24	87.33	55.51
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	116	18.46	36.92	10	284.14	61.46	60.58	42.25
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	113	17.98	35.96	11	295.74	64.23	63.35	43.68

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	85	13.53	27.05	10	159.10	32.45	31.65	26.09
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	94	14.96	29.92	11	209.79	44.01	43.16	32.84
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	67	10.66	21.32	7	73.19	13.80	13.21	13.69
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	134	21.32	42.65	11	406.43	91.15	90.25	56.89
1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	75	11.94	23.87	7	90.33	17.40	16.73	16.30

1014	104	ประดู่	*Pterocarpus macrocarpus* Kurz	67	10.66	21.32	8.5	87.72	16.84	16.19	15.91
1014	103	ขี้เหล็กสาร (แสมสาร)	*Senna garrettiana* (Craib) Irwin & Barneby	40	6.37	12.73	4.5	18.52	3.04	3.58	4.37
1014	102	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	23	3.66	7.32	12	16.47	2.67	3.40	3.96
1014	102	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	91	14.48	28.96	12.5	222.48	46.94	46.10	34.48
1014	102	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	75	11.94	23.87	6.5	84.29	16.12	15.48	15.39
1014	104	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	70	11.14	22.28	7.5	84.70	16.21	15.56	15.45
1014	103	หว้า	*Syzygium cumini* (L.) Skeels	48	7.64	15.28	7	39.29	6.96	6.69	8.16
1014	103	หว้า	*Syzygium cumini* (L.) Skeels	79	12.57	25.14	8	112.72	22.20	21.48	19.60
1014	103	หว้าน้ำ	*Syzygium thorelii* (Gagnep.) Merr. & L.M.Perry	82	13.05	26.10	9	134.86	27.05	26.28	22.74
1014	102	ไก่เตื่อน	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.	91	14.48	28.96	7	129.55	25.88	25.12	22.00
1014	103	ไก่เตื่อน	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.	94	14.96	29.92	8	155.89	31.73	30.93	25.66
1014	104	ไก่เตื่อน	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.	122	19.41	38.83	8	253.52	54.21	53.34	38.43

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	43	6.84	13.69	13	57.01	10.48	10.00	11.12
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	37	5.89	11.78	10	33.72	5.88	5.73	7.19
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	50	7.96	15.91	13	75.52	14.29	13.68	14.05
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	48	7.64	15.28	13	69.99	13.14	12.56	13.19
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	47	7.48	14.96	7	37.78	6.66	6.43	7.90

1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	16	2.55	5.09	6	4.38	0.62	6.03	1.32
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	30	4.77	9.55	8	18.52	3.04	3.58	4.37
1014	101	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	33	5.25	10.50	4	11.59	1.81	3.25	2.96
1014	102	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	34	5.41	10.82	4.3	13.11	2.08	3.24	3.28
1014	102	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	98	15.60	31.19	7	148.76	30.14	29.35	24.68
1014	103	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	25	3.98	7.96	2.5	4.46	0.63	5.94	1.34
1014	103	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	78	12.41	24.82	6	84.17	16.10	15.45	15.37
1014	104	โมกมัน	*Wrightia arborea* (Dennst.) Mabb.	41	6.52	13.05	8	33.17	5.77	5.64	7.09
					Biomass (kg/rai)			14367.17	2969.91	3757.68	2331.21
					Biomass (t/ha)			89.79	18.56	23.49	14.57
					C storage (kg/rai)			6752.57	1395.86	1766.11	1095.67

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
					C storage (kg/ha)			42203.56	8724.10	11038.18	6847.94
					C storage (t/ha)			42.20	8.72	11.04	6.85

A.14 Mixed Deciduous Forest (Plot7)

Main plot	**Minor plot**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**

code	code										
1013	103	แต้วเปรี้ยว	*Cratoxylum maingayi* Dyer	62	9.87	19.73	12	104.69	20.47	19.76	18.43
1013	102	พะยูง	*Dalbergia cochinchinensis* Pierre	41	6.52	13.05	7	29.28	5.03	5.01	6.39
1013	102	พะยูง	*Dalbergia cochinchinensis* Pierre	49	7.80	15.60	8	46.25	8.32	7.95	9.35
1013	102	พะยูง	*Dalbergia cochinchinensis* Pierre	38	6.05	12.09	7	25.41	4.31	4.43	5.68
1013	103	พะยูง	*Dalbergia cochinchinensis* Pierre	32	5.09	10.18	6	15.97	2.58	3.36	3.86
1013	103	พะยูง	*Dalbergia cochinchinensis* Pierre	32	5.09	10.18	7	18.44	3.02	3.57	4.35
1013	103	พะยูง	*Dalbergia cochinchinensis* Pierre	30	4.77	9.55	1	2.66	0.36	9.90	0.87
1013	102	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	85	13.53	27.05	10	159.10	32.45	31.65	26.09
1013	102	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	138	21.96	43.92	20	749.81	178.92	177.98	94.63
1013	104	เข็มดอกข้าวสาร	*Ixora cibdela* Craib	38	6.05	12.09	6	22.01	3.67	3.97	5.04
1013	104	เข็มดอกข้าวสาร	*Ixora cibdela* Craib	104	16.55	33.10	18	401.00	89.81	88.91	56.26
Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1013	104	เข็มดอกข้าวสาร	*Ixora cibdela* Craib	33	5.25	10.50	6	16.92	2.75	3.43	4.05
1013	101	ตะแบกนา	*Lagerstroemia floribunda* Jack	226	35.96	71.93	1	115.13	22.73	21.99	19.94
1013	101	ตะแบกนา	*Lagerstroemia floribunda* Jack	95	15.12	30.24	20	373.68	83.10	82.20	53.05
1013	101	ตะแบกนา	*Lagerstroemia floribunda* Jack	71	11.30	22.60	18	196.76	41.01	40.17	31.13
1013	101	ตะแบกนา	*Lagerstroemia floribunda* Jack	94	14.96	29.92	20	366.37	81.31	80.41	52.19

1013	101	ตะแบกนา	*Lagerstroemia floribunda* Jack	75	11.94	23.87	16	195.27	40.66	39.83	30.94
1013	102	ตะแบกนา	*Lagerstroemia floribunda* Jack	102	16.23	32.46	11	244.31	52.04	51.18	37.27
1013	102	ตะแบกนา	*Lagerstroemia floribunda* Jack	92	14.64	29.28	6	114.52	22.59	21.86	19.86
1013	103	ตะแบกนา	*Lagerstroemia floribunda* Jack	120	19.10	38.19	20	577.74	134.27	133.35	76.20
1013	103	ตะแบกนา	*Lagerstroemia floribunda* Jack	123	19.57	39.15	20	604.98	141.26	140.33	79.17
1013	103	ตะแบกนา	*Lagerstroemia floribunda* Jack	90	14.32	28.64	20	337.83	74.36	73.47	48.79
1013	104	ตะแบกนา	*Lagerstroemia floribunda* Jack	126	20.05	40.10	20	632.79	148.43	147.50	82.19
1013	104	ตะแบกนา	*Lagerstroemia floribunda* Jack	103	16.39	32.78	20	434.50	98.11	97.20	60.14
1013	104	ตะแบกนา	*Lagerstroemia floribunda* Jack	34	5.41	10.82	6	17.89	2.92	3.51	4.24
1013	104	ตะแบกนา	*Lagerstroemia floribunda* Jack	117	18.62	37.24	20	551.10	127.47	126.54	73.27
1013	101	เมือดแอ	*Memecylon scutellatum* Naudin	45	7.16	14.32	8	39.45	6.99	6.72	8.19
1013	101	เมือดแอ	*Memecylon scutellatum* Naudin	126	20.05	40.10	6	205.88	43.10	42.26	32.33

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1013	101	เมือดแอ	*Memecylon scutellatum* Naudin	30	4.77	9.55	5	11.95	1.88	3.24	3.04
1013	101	เมือดแอ	*Memecylon scutellatum* Naudin	62	9.87	19.73	4	37.58	6.62	6.39	7.87
1013	102	เมือดแอ	*Memecylon scutellatum* Naudin	60	9.55	19.10	8	67.47	12.62	12.06	12.79
1013	102	เมือดแอ	*Memecylon scutellatum* Naudin	40	6.37	12.73	6	24.22	4.08	4.26	5.46
1013	102	เมือดแอ	*Memecylon scutellatum* Naudin	56	8.91	17.82	9	66.21	12.36	11.81	12.59

1013	103	เมือดแอ	*Memecylon scutellatum* Naudin	54	8.59	17.19	7	48.94	8.86	8.46	9.80
1013	103	เมือดแอ	*Memecylon scutellatum* Naudin	51	8.12	16.23	6	38.10	6.73	6.48	7.96
1013	103	เมือดแอ	*Memecylon scutellatum* Naudin	40	6.37	12.73	10	39.00	6.90	6.64	8.11
1013	104	เมือดแอ	*Memecylon scutellatum* Naudin	30	4.77	9.55	5	11.95	1.88	3.24	3.04
1013	104	เมือดแอ	*Memecylon scutellatum* Naudin	50	7.96	15.91	7	42.40	7.56	7.25	8.70
1013	104	ปอแดง	*Sterculia guttata* Roxb.	94	14.96	29.92	19	349.26	77.14	76.24	50.16
1013	102	ข่อยหนาม	*Streblus ilicifolius* (Vidal) Corner	31	4.93	9.87	4	10.32	1.60	3.33	2.69
1013	101	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	52	8.27	16.55	8	51.67	9.40	8.97	10.25
1013	101	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	39	6.21	12.41	10	37.20	6.55	6.33	7.80
1013	101	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	42	6.68	13.37	8	34.69	6.06	5.90	7.36
1013	103	ก้านจ้อง (ก้านทอง)	*Swintonia schwenckii* (Teijsm. & Binn.) Teijsm. & Binn.	70	11.14	22.28	8	89.95	17.32	16.65	16.25
Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1013	103	อีแปะ	*Vitex quinata* (Lour.) F.N.Williams	30	4.77	9.55	6	14.16	2.26	3.26	3.50
1013	101	กำจัด	*Zamia limonella* (Dennst.) Alston	39	6.21	12.41	8	30.21	5.21	5.16	6.56
					Biomass (kg/rai)			7605.04	1667.08	1664.17	1127.81
					Biomass (t/ha)			47.53	10.42	10.40	7.05
					C storage (kg/rai)			3574.37	783.53	782.16	530.07

C storage (kg/ha)	22339.82	4897.06	4888.50	3312.94
C storage (t/ha)	22.34	4.90	4.89	3.31

A.15 Dry Dipterocarp Forest (Plot1)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1005	103	จิ๊วป่า	*Bombax anceps Pierre var.* anceps	47	7.48	14.96	8.6	45.77	8.23	0.52	9.27
1005	102	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	31	4.93	9.87	7	17.38	2.83	1.32	4.14
1005	102	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	47	7.48	14.96	8	42.79	7.64	0.55	8.76
1005	103	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	40	6.37	12.73	6	24.22	4.08	0.95	5.46

1005	104	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	87	13.84	27.69	12	196.94	41.05	0.14	31.16
1005	104	ตอใส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	48	7.64	15.28	10	54.80	10.03	0.44	10.76
1005	103	กระทุ้มแดง	*Haldina cordifolia* (Roxb.) Ridsdale	60	9.55	19.10	10	83.08	15.87	0.30	15.21
1005	101	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	58	9.23	18.46	8	63.34	11.77	0.38	12.14
1005	101	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	52	8.27	16.55	8	51.67	9.40	0.46	10.25
1005	102	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1005	102	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1005	103	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	48	7.64	15.28	7	39.29	6.96	0.60	8.16
1005	103	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	50	7.96	15.91	10	59.13	10.91	0.41	11.46
1005	104	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	36	5.73	11.46	8	26.02	4.42	0.89	5.80
1005	104	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	54	8.59	17.19	9	61.87	11.47	0.39	11.90

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1005	104	ปอขี้อ้น	*Helicteres elongata* Wall. ex Bojer	35	5.57	11.14	7	21.80	3.64	1.06	5.00
1005	103	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	53	8.43	16.87	9	59.75	11.04	0.40	11.56
1005	104	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	47	7.48	14.96	11	57.58	10.60	0.42	11.21
1005	104	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	92	14.64	29.28	15	269.14	57.90	0.11	40.39
1005	101	ยอป่า (ยอเถื่อน)	*Morinda coreia* Ham.	50	7.96	15.91	8	48.02	8.68	0.49	9.64
1005	104	ยอป่า (ยอเถื่อน)	*Morinda coreia* Ham.	56	8.91	17.82	8	59.33	10.95	0.40	11.50

1005	101	ประดู่	*Pterocarpus macrocarpus* Kurz	62	9.87	19.73	12	104.69	20.47	0.24	18.43
1005	101	ประดู่	*Pterocarpus macrocarpus* Kurz	53	8.43	16.87	10	65.92	12.30	0.37	12.55
1005	101	ประดู่	*Pterocarpus macrocarpus* Kurz	154	24.51	49.01	15	703.55	166.80	0.06	89.76
1005	101	ประดู่	*Pterocarpus macrocarpus* Kurz	94	14.96	29.92	15	280.16	60.51	0.11	41.76
1005	102	ประดู่	*Pterocarpus macrocarpus* Kurz	76	12.09	24.19	15	188.46	39.10	0.14	30.04
1005	102	ประดู่	*Pterocarpus macrocarpus* Kurz	67	10.66	21.32	15	148.98	30.19	0.18	24.71
1005	103	ประดู่	*Pterocarpus macrocarpus* Kurz	71	11.30	22.60	15	166.00	34.00	0.16	27.03
1005	103	ประดู่	*Pterocarpus macrocarpus* Kurz	130	20.69	41.37	17	576.43	133.94	0.06	76.06
1005	103	ประดู่	*Pterocarpus macrocarpus* Kurz	82	13.05	26.10	15	217.16	45.71	0.13	33.79
1005	104	ประดู่	*Pterocarpus macrocarpus* Kurz	91	14.48	28.96	12	214.17	45.02	0.13	33.41
1005	104	ประดู่	*Pterocarpus macrocarpus* Kurz	71	11.30	22.60	5	59.58	11.00	0.40	11.54

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1005	101	ผักหวาน	*Sauropus androgynus* (L.) Merr.	69	10.98	21.96	4	45.88	8.25	0.52	9.28
1005	101	แสมสาร	*Senecio garrettiana* (Craib) H.S. Irwin & Barneby	43	6.84	13.69	9	40.46	7.18	0.58	8.36
1005	101	เต็ง	*Shorea obtusa* Wall. ex Blume	109	17.35	34.69	18	437.70	98.91	0.08	60.50
1005	103	เต็ง	*Shorea obtusa* Wall. ex Blume	109	17.35	34.69	15	369.26	82.02	0.09	52.53
1005	103	เต็ง	*Shorea obtusa* Wall. ex Blume	89	14.16	28.33	15	253.01	54.09	0.11	38.37
1005	103	เต็ง	*Shorea obtusa* Wall. ex Blume	102	16.23	32.46	17	366.66	81.38	0.09	52.22

1005	103	เต็ง	*Shorea obtusa* Wall. ex Blume	64	10.18	20.37	15	136.78	27.47	0.19	23.01
1005	103	เต็ง	*Shorea obtusa* Wall. ex Blume	87	13.84	27.69	17	272.53	58.70	0.11	40.81
1005	103	เต็ง	*Shorea obtusa* Wall. ex Blume	34	5.41	10.82	7	20.65	3.43	1.11	4.78
1005	104	เต็ง	*Shorea obtusa* Wall. ex Blume	47	7.48	14.96	8	42.79	7.64	0.55	8.76
1005	104	เต็ง	*Shorea obtusa* Wall. ex Blume	62	9.87	19.73	12	104.69	20.47	0.24	18.43
1005	104	เต็ง	*Shorea obtusa* Wall. ex Blume	82	13.05	26.10	15	217.16	45.71	0.13	33.79
1005	103	รัง	*shorea siamensis* Miq.	80	12.73	25.46	12	168.42	34.55	0.16	27.36
1005	103	รัง	*shorea siamensis* Miq.	119	18.94	37.87	18	515.57	118.45	0.07	69.32
1005	104	รัง	*shorea siamensis* Miq.	89	14.16	28.33	15	253.01	54.09	0.11	38.37
1005	101	มะค่าแต้	*Sindora siamensis* Teijsm. & Miq. var. siamensis	71	11.30	22.60	6	70.63	13.27	0.34	13.29

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1005	102	ไข่เน่า	*Vitex glabrata* R.Br.	19	3.02	6.05	4	4.14	0.58	5.46	1.26
							Biomass (kg/rai)	7363.41	1568.76	24.60	1142.03
							Biomass (t/ha)	46.02	9.80	0.15	7.14
							C storage (kg/rai)	3460.80	737.32	11.56	536.76
							C storage (kg/ha)	21630.02	4608.24	72.28	3354.72
							C storage (t/ha)	21.63	4.61	0.07	3.35

A.16 Dry Dipterocarp Forest (Plot2)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
1004	102	กำลังเสือโคร่ง	*Beta alnoides* Buch.-Ham. Ex G.Don	55	8.75	17.50	9	64.03	11.91	0.38	12.25
1004	102	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	66	10.50	21.01	10	99.25	19.30	0.25	17.63
1004	102	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	35	5.57	11.14	6	18.88	3.10	1.22	4.44
1004	102	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	31	4.93	9.87	6	15.06	2.42	1.52	3.68
1004	102	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	31	4.93	9.87	6	15.06	2.42	1.52	3.68
1004	102	ชิงชัน	*Dalbergia oliveri Gamble*	32	5.09	10.18	8	20.89	3.47	1.10	4.83
Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1004	102	ชิงชัน	*Dalbergia oliveri Gamble*	78	12.41	24.82	15	197.82	41.25	0.14	31.27
1004	102	ตอไส (ต่อไส้)	*Elaeis griffithii* (Wight) A.Gray	48	7.64	15.28	8	44.50	7.98	0.53	9.05
1004	101	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	44	7.00	14.00	8	37.84	6.67	0.62	7.91
1004	102	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	39	6.21	12.41	8	30.21	5.21	0.77	6.56
1004	102	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	48	7.64	15.28	12	64.95	12.10	0.37	12.39
1004	102	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	41	6.52	13.05	8	33.17	5.77	0.70	7.09
1004	103	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	36	5.73	11.46	8	26.02	4.42	0.89	5.80

1004	103	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	84	13.37	26.73	10	155.62	31.67	0.17	25.62
1004	103	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	54	8.59	17.19	7	48.94	8.86	0.48	9.80
1004	104	พันชาด (ชาด)	*Erythrophleum succirubrum* Gagnep.	41	6.52	13.05	8	33.17	5.77	0.70	7.09
1004	101	กระบก 53 46	*Irvingia malayana* Oliv. ex A.W.Benn.	38	6.05	12.09	8	28.78	4.94	0.81	6.30
1004	101	มะม่วง	*Mangifera indica* L.	33	5.25	10.50	7	19.53	3.22	1.18	4.57
1004	104	มะม่วง	*Mangifera indica* L.	40	6.37	12.73	7	27.96	4.78	0.83	6.15
1004	101	หวงไทร (หัสคุณ)	*Micromelum minutum* (G.Forst.) Wight & Arn.	42	6.68	13.37	8	34.69	6.06	0.67	7.36
1004	101	หวงไทร (หัสคุณ)	*Micromelum minutum* (G.Forst.) Wight & Arn.	45	7.16	14.32	6	30.17	5.20	0.77	6.55
1004	102	ยอป่า (ยอเถื่อน)	*Morinda coreia* Ham.	30	4.77	9.55	6	14.16	2.26	1.61	3.50
1004	102	มะขามป้อม	*Phyllanthus emblica* L.	51	8.12	16.23	7	44.00	7.88	0.54	8.97

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1004	102	ประดู่	*Pterocarpus macrocarpus* Kurz	92	14.64	29.28	15	269.14	57.90	0.11	40.39
1004	103	ตะค้อ	*Schleichera oleosa* (Lour.) Oken	30	4.77	9.55	6	14.16	2.26	1.61	3.50
1004	103	ตะคร้อ	*Schleichera oleosa* (Lour.) Oken	41	6.52	13.05	8	33.17	5.77	0.70	7.09
1004	104	ตะคร้อ	*Schleichera oleosa* (Lour.) Oken	44	7.00	14.00	5	24.41	4.12	0.95	5.50
1004	104	ตะคร้อ	*Schleichera oleosa* (Lour.) Oken	41	6.52	13.05	5	21.40	3.56	1.08	4.93
1004	102	แสมสาร	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	85	13.53	27.05	6	98.80	19.20	0.25	17.56
1004	102	แสมสาร	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	35	5.57	11.14	6	18.88	3.10	1.22	4.44

1004	102	แสมสาร	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	40	6.37	12.73	6	24.22	4.08	0.95	5.46
1004	103	แสมสาร	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	33	5.25	10.50	6	16.92	2.75	1.35	4.05
1004	104	แสมสาร	*Senecio garrettiana* (Craib) H.S. Irwin & Barneby	49	7.80	15.60	12	67.50	12.62	0.36	12.80
1004	101	แสมดง (แสมสาร)	*Senna garrettiana* (Craib) H.S.Irwin & Barneby	121	19.26	38.51	12	364.39	80.83	0.09	51.95
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	38	6.05	12.09	10	35.44	6.21	0.66	7.49
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	32	5.09	10.18	7	18.44	3.02	1.24	4.35
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	7	17.38	2.83	1.32	4.14
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	37	5.89	11.78	12	39.97	7.09	0.59	8.28
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	28	4.46	8.91	9	18.17	2.98	1.26	4.30
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	45	7.16	14.32	8	39.45	6.99	0.60	8.19

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1004	101	เต็ง	*Shorea obtusa* Wall. ex Blume	33	5.25	10.50	6	16.92	2.75	1.35	4.05
1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	4	10.32	1.60	2.21	2.69
1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	10	44.63	8.00	0.53	9.07
1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	8	36.25	6.37	0.65	7.63
1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	34	5.41	10.82	8	23.39	3.93	0.99	5.30
1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	39	6.21	12.41	6	23.10	3.88	1.00	5.25
1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	30	4.77	9.55	6	14.16	2.26	1.61	3.50

1004	102	เต็ง	*Shorea obtusa* Wall. ex Blume	39	6.21	12.41	8	30.21	5.21	0.77	6.56
1004	103	เต็ง	*Shorea obtusa* Wall. ex Blume	51	8.12	16.23	8	49.83	9.04	0.48	9.94
1004	103	เต็ง	*Shorea obtusa* Wall. ex Blume	35	5.57	11.14	5	15.93	2.57	1.44	3.85
1004	103	เต็ง	*Shorea obtusa* Wall. ex Blume	30	4.77	9.55	4	9.70	1.49	2.34	2.55
1004	103	เต็ง	*Shorea obtusa* Wall. ex Blume	45	7.16	14.32	10	48.58	8.79	0.49	9.74
1004	103	เต็ง	*Shorea obtusa* Wall. ex Blume	32	5.09	10.18	6	15.97	2.58	1.43	3.86
1004	104	เต็ง	*Shorea obtusa* Wall. ex Blume	30	4.77	9.55	5	11.95	1.88	1.91	3.04
1004	104	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	5	12.70	2.01	1.80	3.19
1004	104	เต็ง	*Shorea obtusa* Wall. ex Blume	44	7.00	14.00	11	50.92	9.25	0.47	10.12
1004	104	เต็ง	*Shorea obtusa* Wall. ex Blume	45	7.16	14.32	27	122.68	24.37	0.21	21.02

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1004	104	เต็ง	*Shorea obtusa* Wall. ex Blume	39	6.21	12.41	8	30.21	5.21	0.77	6.56
1004	101	รัง	*shorea siamensis* Miq.	58	9.23	18.46	12	92.45	17.85	0.27	16.62
1004	102	รัง	*shorea siamensis* Miq.	37	5.89	11.78	10	33.72	5.88	0.69	7.19
1004	102	รัง	*shorea siamensis* Miq.	52	8.27	16.55	12	75.41	14.26	0.32	14.03
1004	102	รัง	*shorea siamensis* Miq.	35	5.57	11.14	8	24.69	4.17	0.94	5.55
1004	102	รัง	*shorea siamensis* Miq.	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1004	102	รัง	*shorea siamensis* Miq.	43	6.84	13.69	10	44.63	8.00	0.53	9.07

1004	102	รัง	*shorea siamensis* Miq.	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1004	103	รัง	*shorea siamensis* Miq.	40	6.37	12.73	9	35.35	6.19	0.66	7.48
1004	103	รัง	*shorea siamensis* Miq.	49	7.80	15.60	10	56.95	10.47	0.42	11.11
1004	103	บัวบก	*Stephania pierrei* Diels	87	13.84	27.69	10	166.15	34.04	0.16	27.05
1004	101	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	34	5.41	10.82	7	20.65	3.43	1.11	4.78
1004	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	71	11.30	22.60	8	92.36	17.83	0.27	16.61
1004	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	40	6.37	12.73	8	31.67	5.49	0.74	6.82
1004	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	27	4.30	8.59	8	15.22	2.45	1.50	3.71
1004	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	82	13.05	26.10	10	148.78	30.14	0.18	24.68
1004	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	38	6.05	12.09	8	28.78	4.94	0.81	6.30

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1004	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	55	8.75	17.50	8	57.37	10.55	0.42	11.18
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	67	10.66	21.32	11	111.56	21.95	0.23	19.43
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	41	6.52	13.05	9	37.02	6.51	0.63	7.77
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	30	4.77	9.55	8	18.52	3.04	1.24	4.37
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	41	6.52	13.05	6	25.36	4.30	0.91	5.67

1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	32	5.09	10.18	7	18.44	3.02	1.24	4.35
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	61	9.71	19.41	11	93.65	18.10	0.27	16.80
1004	103	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	45	7.16	14.32	8	39.45	6.99	0.60	8.19
1004	104	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	71	11.30	22.60	9	103.09	20.12	0.24	18.19
1004	104	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	48	7.64	15.28	9	49.67	9.00	0.48	9.92
1004	104	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	60	9.55	19.10	11	90.81	17.50	0.27	16.37
1004	104	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	47	7.48	14.96	8	42.79	7.64	0.55	8.76
					Biomass (kg/rai)			4422.63	839.19	73.19	834.34
					Biomass (t/ha)			27.64	5.24	0.46	5.21

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root
					C storage (kg/rai)			2078.63	394.42	34.40	392.14
					C storage (kg/ha)			12991.47	2465.12	214.99	2450.86
					C storage (t/ha)			12.99	2.47	0.21	2.45

A.17 Dry Dipterocarp Forest (Plot3)

Main plot code	Minor plot code	Thai name	Scientific name	Perimeter (cm)	Radius (cm)	Diameter (cm)	Height (m)	stem	branch	leaf	root

1003	103	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	43	6.84	13.69	9	40.46	7.18	0.58	8.36
1003	103	ตาเสือ	*Aphanamixis polystachya* (Wall.) R.Parker	51	8.12	16.23	8	49.83	9.04	0.48	9.94
1003	101	กระบกคาย (กระโดงแดง)	*Bhesa robusta* (Roxb.) Ding Hou	20	3.18	6.37	5	5.61	0.82	4.04	1.62
1003	104	กระบกคาย (กระโดงแดง)	*Bhesa robusta* (Roxb.) Ding Hou	39	6.21	12.41	8	30.21	5.21	0.77	6.56
1003	101	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	34	5.41	10.82	8	23.39	3.93	0.99	5.30
1003	103	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	30	4.77	9.55	5	11.95	1.88	1.91	3.04
1003	103	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	39	6.21	12.41	10	37.20	6.55	0.63	7.80
1003	104	มะม่วงหัวแมลงวัน	*Buchanania lanzan* Spreng.	34	5.41	10.82	6	17.89	2.92	1.28	4.24
1003	101	ก่อบ้าน	*Castatanopsis wallichii* King ex Hook.f.	40	6.37	12.73	12	46.23	8.32	0.51	9.34
1003	102	ก่อบ้าน	*Castatanopsis wallichii* King ex Hook.f.	33	5.25	10.50	11	29.77	5.13	0.78	6.48

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	102	ก่อบ้าน	*Castatanopsis wallichii* King ex Hook.f.	32	5.09	10.18	10	25.72	4.36	0.90	5.74
1003	104	ติ้วหม่น (ติ้วดำ)	*Cratoxylum sumatranum* (Jack) Blume subsp. Neriifolium Gogel.	52	8.27	16.55	6	39.51	7.00	0.59	8.20
1003	102	ชิงชัน	*Dalbergia oliveri Gamble*	74	11.78	23.55	11	134.28	26.92	0.19	22.66
1003	103	ชิงชัน	*Dalbergia oliveri Gamble*	42	6.68	13.37	8	34.69	6.06	0.67	7.36
1003	103	ลูกพลับนา	*Diospyros areolata* King & Gamble	58	9.23	18.46	6	48.43	8.76	0.49	9.71
1003	102	ตอใส (ต่อใส้)	*Elaeis griffithii* (Wight) A.Gray	62	9.87	19.73	8	71.73	13.50	0.34	13.46
1003	102	มันปลา	*Fagraea fragrans* Roxb.	60	9.55	19.10	10	83.08	15.87	0.30	15.21

1003	103	ส้มโมง	*Garcinia speciosa* Wall.	78	12.41	24.82	12	160.65	32.80	0.17	26.31
1003	102	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	34	5.41	10.82	8	23.39	3.93	0.99	5.30
1003	102	กระบก	*Irvingia malayana* Oliv. ex A.W.Benn.	72	11.46	22.92	10	116.74	23.08	0.22	20.17
1003	103	กะพอก (มะพอก)	*Parinari anamense* Hance	31	4.93	9.87	7	17.38	2.83	1.32	4.14
1003	104	กะพอก 41 (มะพอก)	*Parinari anamense* Hance	74	11.78	23.55	9	111.36	21.91	0.23	19.40
1003	101	ประดู่	*Pterocarpus macrocarpus* Kurz	61	9.71	19.41	13	109.44	21.49	0.23	19.12
1003	102	ประดู่	*Pterocarpus macrocarpus* Kurz	103	16.39	32.78	13	290.75	63.03	0.10	43.07
1003	103	ประดู่	*Pterocarpus macrocarpus* Kurz	46	7.32	14.64	8	41.11	7.31	0.57	8.47
1003	103	ประดู่	*Pterocarpus macrocarpus* Kurz	93	14.80	29.60	15	274.63	59.20	0.11	41.07

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	101	ก่อ	*Quercus austro-cochinensis* Hickel & A.Camus	34	5.41	10.82	11	31.48	5.45	0.74	6.79
1003	101	ก่อ	*Quercus austro-cochinensis* Hickel & A.Camus	31	4.93	9.87	10	24.24	4.09	0.95	5.46
1003	101	ก่อ	*Quercus austro-cochinensis* Hickel & A.Camus	67	10.66	21.32	10	102.07	19.90	0.25	18.04
1003	102	ก่อ	*Quercus austro-cochinensis* Hickel & A.Camus	37	5.89	11.78	15	49.22	8.92	0.48	9.84
1003	102	ก่อ	*Quercus austro-cochinensis* Hickel & A.Camus	32	5.09	10.18	10	25.72	4.36	0.90	5.74
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	56	8.91	17.82	102	637.16	149.56	0.06	82.66
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	50	7.96	15.91	12	70.09	13.16	0.35	13.20
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	81	12.89	25.78	15	212.24	44.57	0.13	33.16

1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	8	19.69	3.25	1.17	4.60
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	34	5.41	10.82	8	23.39	3.93	0.99	5.30
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	57	9.07	18.14	15	110.20	21.66	0.23	19.23
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	54	8.59	17.19	15	99.63	19.38	0.25	17.69
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	34	5.41	10.82	10	28.80	4.94	0.81	6.31
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	37	5.89	11.78	10	33.72	5.88	0.69	7.19
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	10	44.63	8.00	0.53	9.07
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	58	9.23	18.46	15	113.83	22.44	0.22	19.76
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	34	5.41	10.82	10	28.80	4.94	0.81	6.31

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	48	7.64	15.28	13	69.99	13.14	0.35	13.19
1003	101	เต็ง	*Shorea obtusa* Wall. ex Blume	41	6.52	13.05	12	48.41	8.75	0.49	9.71
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	38	6.05	12.09	14	48.51	8.77	0.49	9.72
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	32	5.09	10.18	10	25.72	4.36	0.90	5.74
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	41	6.52	13.05	13	52.16	9.50	0.46	10.33
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	35	5.57	11.14	12	36.04	6.32	0.65	7.60
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	60	9.55	19.10	15	121.27	24.06	0.21	20.82
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	35	5.57	11.14	11	33.23	5.78	0.70	7.10

1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	42	6.68	13.37	15	62.35	11.57	0.39	11.98
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	13	57.01	10.48	0.42	11.12
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	36	5.73	11.46	13	40.92	7.28	0.57	8.44
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	41	6.52	13.05	13	52.16	9.50	0.46	10.33
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	15	65.14	12.14	0.37	12.42
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	38	6.05	12.09	12	42.01	7.49	0.56	8.63
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	46	7.32	14.64	13	64.65	12.04	0.37	12.35
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	41	6.52	13.05	15	59.61	11.01	0.40	11.54
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	41	6.52	13.05	13	52.16	9.50	0.46	10.33

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	46	7.32	14.64	15	73.88	13.94	0.33	13.79
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	40	6.37	12.73	15	56.92	10.46	0.42	11.11
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	39	6.21	12.41	13	47.51	8.58	0.50	9.56
1003	102	เต็ง	*Shorea obtusa* Wall. ex Blume	53	8.43	16.87	15	96.22	18.65	0.26	17.18
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	85	13.53	27.05	15	232.21	49.21	0.12	35.73
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	48	7.64	15.28	13	69.99	13.14	0.35	13.19
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	30	4.77	9.55	15	33.29	5.79	0.70	7.11
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	49	7.80	15.60	12	67.50	12.62	0.36	12.80

1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	15	65.14	12.14	0.37	12.42
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	49	7.80	15.60	15	83.12	15.87	0.30	15.21
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	30	4.77	9.55	6	14.16	2.26	1.61	3.50
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	7	17.38	2.83	1.32	4.14
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	12	52.90	9.65	0.45	10.45
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	36	5.73	11.46	6	19.90	3.29	1.16	4.64
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	41	6.52	13.05	11	44.63	8.00	0.53	9.07
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	56	8.91	17.82	10	73.05	13.77	0.33	13.67
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	66	10.50	21.01	11	108.47	21.28	0.23	18.98

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	33	5.25	10.50	6	16.92	2.75	1.35	4.05
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	33	5.25	10.50	8	22.12	3.70	1.04	5.06
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	10	24.24	4.09	0.95	5.46
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	43	6.84	13.69	10	44.63	8.00	0.53	9.07
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	36	5.73	11.46	10	32.04	5.56	0.73	6.89
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	59	9.39	18.78	12	95.44	18.49	0.26	17.07
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	35	5.57	11.14	8	24.69	4.17	0.94	5.55
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	48	7.64	15.28	10	54.80	10.03	0.44	10.76

1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	37	5.89	11.78	10	33.72	5.88	0.69	7.19
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	15	2.39	4.77	6	3.89	0.54	5.81	1.19
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	47	7.48	14.96	10	52.69	9.61	0.45	10.42
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	8	19.69	3.25	1.17	4.60
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	39	6.21	12.41	12	44.10	7.90	0.54	8.98
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	99	15.75	31.51	15	308.59	67.31	0.10	45.25
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	42	6.68	13.37	13	54.56	9.99	0.44	10.72
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	57	9.07	18.14	15	110.20	21.66	0.23	19.23
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	49	7.80	15.60	10	56.95	10.47	0.42	11.11

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	58	9.23	18.46	12	92.45	17.85	0.27	16.62
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	42	6.68	13.37	8	34.69	6.06	0.67	7.36
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	44	7.00	14.00	10	46.59	8.39	0.51	9.40
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	46	7.32	14.64	6	31.43	5.44	0.74	6.78
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	42	6.68	13.37	8	34.69	6.06	0.67	7.36
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	39	6.21	12.41	10	37.20	6.55	0.63	7.80
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	37	5.89	11.78	8	27.39	4.67	0.85	6.05
1003	103	เต็ง	*Shorea obtusa* Wall. ex Blume	91	14.48	28.96	13	230.77	48.87	0.12	35.54

1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	34	5.41	10.82	8	23.39	3.93	0.99	5.30
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	46	7.32	14.64	12	60.00	11.09	0.40	11.60
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	58	9.23	18.46	8	63.34	11.77	0.38	12.14
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	55	8.75	17.50	10	70.64	13.27	0.34	13.29
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	71	11.30	22.60	15	166.00	34.00	0.16	27.03
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	38	6.05	12.09	12	42.01	7.49	0.56	8.63
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	38	6.05	12.09	10	35.44	6.21	0.66	7.49
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	42	6.68	13.37	10	42.72	7.63	0.55	8.75
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	31	4.93	9.87	10	24.24	4.09	0.95	5.46

Main plot code	**Minor plot code**	**Thai name**	**Scientific name**	**Perimeter (cm)**	**Radius (cm)**	**Diameter (cm)**	**Height (m)**	**stem**	**branch**	**leaf**	**root**
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	40	6.37	12.73	12	46.23	8.32	0.51	9.34
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	32	5.09	10.18	10	25.72	4.36	0.90	5.74
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	77	12.25	24.51	12	156.83	31.94	0.17	25.78
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	46	7.32	14.64	12	60.00	11.09	0.40	11.60
1003	104	เต็ง	*Shorea obtusa* Wall. ex Blume	38	6.05	12.09	12	42.01	7.49	0.56	8.63
1003	102	มะค่าแต้	*Sindora siamensis* Teijsm. & Miq. var. siamensis	139	22.12	44.24	11	435.17	98.28	0.08	60.21
1003	101	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii (Craib & Hutch.) I.C.Nielsen*	56	8.91	17.82	10	73.05	13.77	0.33	13.67
1003	102	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii* (Craib & Hutch.) I.C.Nielsen	65	10.34	20.69	10	96.46	18.70	0.26	17.22

1003	104	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii (Craib & Hutch.) I.C.Nielsen*	38	6.05	12.09	8	28.78	4.94	0.81	6.30
1003	104	แดง	*Xylia xylocarpa* (Roxb.) Taub. var. *kerrii (Craib & Hutch.) I.C.Nielsen*	120	19.10	38.19	10	302.69	65.89	0.10	44.53
						Biomass (kg/rai)		8856.86	1751.99	75.10	1560.30
						Biomass (t/ha)		55.36	10.95	0.47	9.75
						C storage (kg/rai)		4162.72	823.43	35.30	733.34
						C storage (kg/ha)		26017.02	5146.46	220.62	4583.37
						C storage (t/ha)		26.02	5.15	0.22	4.58

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"**Assessment of Forest Carbon Sequestration in Thap Lan National Park, Thailand**" National Academic Conference : "The 2nd Thailand and World Climate : Changing Vision to Green Economy. August 18-19, 2011, IMPACT MUANG THONG THANI held by Thailand Greenhouse Gas Management Organization (Public Organization)

Grants and Fellowships

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