ความแปรผันของสังคมพืช ตามลักษณะภูมิประเทศและปัจจัยสิ่งแวดล้อม บริเวณเขาโซ่ ในเขตป่าสงวนแห่งชาติ ป่าเขาภูหลวง จังหวัดนครราชสีมา

นางสาวประดับ เรียนประยูร

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต

สาขาวิชาชีววิทยาสิ่งแวดล้อม

มหาวิทยาลัยเทคโนโลยีสุรนารี

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PLANT COMMUNITY VARIATIONS BASED ON TOPOGRAPHICAL GRADIENTS AND ENVIRONMENTAL FACTORS OF KHAO SO, PHU LUANG NATIONAL RESERVED FOREST, NAKHON RATCHASIMA PROVINCE

Miss Pradub Reanprayoon

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Environmental Biology

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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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การศึกษาลักษณะนิเวศวิทยาทางสังคมพืช ได้ดำเนินการในเขตป่าสงวนแห่งชาติป่าเขาภูหลวง เพื่อศึกษาถึงองค์ประกอบของชนิดพรรณไม้ ลักษณะทางนิเวศวิทยาบางประการของพรรณไม้ รวมถึงคุณลักษณะดินตามการเปลี่ยนแปลงทางภูมิประเทศและปัจจัยสิ่งแวดล้อม โดยวิธี Two Way Indicator Species Analysis (TWINSPAN) และ Canonical Correspondence Analysis (CCA)

จากการตรวจสอบชนิดพรรณไม้ พบว่าที่เขาโซ่มีพรรณไม้ทั้งสิ้น 188 ชนิด 130 สกุล 52 วงศ์ โดยจำนวนชนิดพรรณไม้ที่พบมากที่สุดคือ Euphorbiaceae และ *Hopea ferrea* เป็นชนิดพรรณที่มีมากที่สุดในพื้นที่ศึกษา การเปลี่ยนแปลงของจำนวนชนิด สกุล และวงศ์ ตามระดับความสูงมีแนวโน้มลดลงเมื่อความสูงเพิ่มขึ้น ผลการศึกษาการเปลี่ยนแปลงของสังคมพืชตามปัจจัยทางกายภาพพบว่า สังคมพืชมีแนวโน้มการกระจายตัวไปตามแนวระดับความสูงมากกว่าตามแนวทิศทางการรับแสงอย่างมีนัยสำคัญยิ่ง การศึกษาด้านความหลากหลายของชนิดพันธุ์สำหรับไม้ยืนต้น ไม้ขนาดเล็ก และลูกไม้ พบว่ามีค่า 2.34 2.48 และ 2.35 ตามลำดับ โดยพบว่าด้านทิศเหนือและใต้มีความหลากหลายสูงสำหรับไม้ยืนต้นและลูกไม้ ในขณะที่ไม้ยืนต้นขนาดเล็กด้านทิศเหนือและตะวันออกสูงกว่าด้านทิศใต้และตะวันตก ผลของการจำแนกสังคมพืชจากการจัดกลุ่มด้วย TWINSPAN สามารถจำแนกสังคมพืชในไม้ยืนต้น ไม้ขนาดเล็ก และลูกไม้ ออกตามแนวหมู่ไม้ได้เป็น 14 13 และ 12 กลุ่ม และตามแนวของชนิดพรรณได้เป็น 35 24 และ 22 กลุ่ม ตามลำดับ โดยมีเคี่ยมคะนอง และตะเคียนหินเป็นสังคมหลัก การวิเคราะห์สังคมพืชเชิงพื้นที่ด้วยวิธีทีเสนโพลีกอนโดย GIS แสดงให้เห็นว่าทิศตะวันตกมีความหลากหลายของสังคมพืชมากที่สุด และผลของการหาความสัมพันธ์ของสังคมพืชกับสิ่งแวดล้อมชี้ให้เห็นว่า ทุกๆ สังคมพืชมีความสัมพันธ์อย่างมากกับความชื้นในดิน และความสูงจากระดับน้ำทะเล นอกจากนั้นปัจจัยทางสิ่งแวดล้อมยังมีอิทธิพลต่อ

การเจริญเติบโตทางพื้นที่หน้าตัดและปริมาตรไม้ ได้แก่ ปริมาณของธาตุแคลเซียม โพแทสเซียม ฟอสฟอรัส ความสามารถในการแลกเปลี่ยนประจุของดิน ความชื้นในดิน และความเป็นกรด-ด่างของดิน ตัวอย่างเช่น สังคมตะเคียนหินสามารถเจริญเติบโตในพื้นที่ที่มีปริมาณโซเดียมสูง ส่วนสังคมเคี่ยมคะนองพบว่าเจริญเติบโตในพื้นที่ที่มีความชื้นสูง นอกจากนั้นปัจจัยทางกายภาพมีความสัมพันธ์ต่อคุณลักษณะของดินทั้งทางกายภาพและเคมี โดยเฉพาะอย่างยิ่งต่อความเป็นกรด-ด่างของดิน ความสามารถในการแลกเปลี่ยนประจุ ปริมาณของธาตุแคลเซียม แมกนีเซียม และโซเดียมที่เป็นประโยชน์ได้ของดิน ส่งผลให้เกิดความแตกต่างของโครงสร้างและองค์ประกอบของสังคมพืชอย่างเด่นชัดด้วย

สาขาวิชาชีววิทยา	ลายมือชื่อนักศึกษา ....
ปีการศึกษา 2547	ลายมือชื่ออาจารย์ที่ปรึกษา ....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม ....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม ....
	ลายมือชื่ออาจารย์ที่ปรึกษาร่วม ....

PRADUB REANPRAYOON : PLANT COMMUNITY VARIATIONS BASED ON TOPOGRAPHICAL GRADIENTS AND ENVIRONMENTAL FACTORS OF KHAO SO, PHU LUANG NATIONAL RESERVED FOREST, NAKHON RATCHASIMA PROVINCE. THESIS ADVISOR : ASST. PROF. HATSACHAI BOONJUNG, Ph.D. 247 PP.

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PLANT COMMUNITIES/SOIL PROPERTIES/TOPOGRAPHY/CCA/TWINSPAN

Plant community characteristics of Khao So, Phu Luang National Reserved Forest, were identified using two way indicator species analysis and canonical correspondence analysis including the identification of variations, relative patterns of plant communities to topographical and some environmental factors.

The results indicated that the vegetation (tree, sapling and seedling) of Khao So consisted of 188 species, 130 genera and 52 families. Euphorbiaceae had the highest species richness and abundance. *Hopea ferrea* was the most common species in the study area. The distribution tended to decrease in numbers of species, genera, families and individuals with increasing altitudes. Plant communities were more homogeneously distributed along altitudinal gradients than along aspects based on Sorensen's index measurement. The Shannon diversity index for tree, sapling and seedling communities were 2.34, 2.48 and 2.35 respectively. The northern and southern aspects were much higher in species diversity, especially trees and seedlings, than the eastern and western aspects. Whereas saplings in the northern and eastern aspects demonstrated greater species diversity than those of the southern and western aspects. Phytosociological analysis showed that plant communities could be classified into tree, sapling and seedling as 14, 13, 12 and 35, 24, 22 sub-communities for stand and species classifications. *Shorea henryana* and *H. ferrea* were dominated in community types. The interpolation result by Thiessen polygon (GIS) also showed that the western aspect was more diverse in plant community than other aspects.

The analysis the relationships between plant communities and environmental variables indicated that elevation and soil moisture content were closely correlated with the plant communities. The distributions of basal area and volume cover were positively correlated with exchangeable Ca, K, CEC, moisture content, available P, and pH. For instant, *H. ferrea* and *S. henryana* groups were found in the area of high in exchangeable Na and moisture content respectively. In addition, soil properties were significantly correlated with topographic factors, especially slope direction. These results also pointed out that topographic factors were involved in the transportation and accumulation of ions and change in pH, CEC, and exchangeable Ca, Mg, and K in the depositional areas of the footslope consequently effecting floristic compositions and structures along slope position.

School of Biology	Student's Signature ………………………
Academic Year 2004	Advisor's Signature ……………………
	Co-advisor's Signature ……………….....
	Co-advisor's Signature ……………….....
	Co-advisor's Signature ……………….....

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Pradub Reanprayoon

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CHAPTER I

INTRODUCTION

1.1 Introduction

Forest ecosystems, which are the major source of biodiversity and habitat of fauna and flora, benefit humans in many ways including commercial value, climate regulators and medicinal sources. Tropical forests are the most structurally complex plant communities on the earth (Givnish, 1998) and they consisted of approximately 175,200 number of vascular plant species (Asker, 2001). These communities are dependant on interactions between species and the physical forces of their environments such as climatic factors, edaphic factors, topographic and biotic factors (Hanson, and Churchill, 1964). In addition, the distribution pattern of tree diversity in many areas is mainly controlled by natural and human disturbances (Xiongween, 2001). The variation in plant diversity and abundance as well as composition is related to site attributes (Kadaval, 1999). Many studies have reported that plant species diversity increases with the number of distinct communities and the number of mountain peaks (Bell, 2000). Vivain (1997) found that complex environmental factors in mountainous area have more diverse plant assemblages than flat surface.

At present, the forest ecosystems are facing the degradation and decreasing of forest areas at an alarming rate. Conspicuously, several forests of Thailand are assigned as protected areas, i.e. national parks, wildlife sanctuary and non hunting areas covering approximately 74,594 km^2 (Jirawataki, 2000). Phu Luang National Reserved Forest, the national reserved forest area, which is both ecologically and economically important repositories of biodiversity, is one of important. It covers numerous mountains and consists of three forest types as dry evergreen forest, mixed deciduous, deciduous dipterocarp forest. Khao So is one of the highest mountain of Phu Luang National Reserved Forest. Dry dipterocarp and dry evergreen forests, which composed of spatial heterogeneity in environments, geology, slope, elevation and aspects, are the head-watershed forest of Lam Phra Phloeng Dam. These heterogeneous environments are expected to support a greater number of species. According to economic depression in Thailand, the government proposes numerous strategies to solve this problem. The tourist is one of the top priority planning. The exertion on tourism potential to natural sites is concentrated on national park, wildlife sanctuary and protected areas. Phu Luang National Reserved Forest is focused to be a natural area for potential eco-tourism. Thus its existing resource status and ecological characteristics are vastly required for planning management to maintain biodiversity coupling with ecotourism aspects. Phu Luang National Reserved Forest covers vastly areas therefore the study on plant communities is difficult and time consuming. As a result, these areas are divided in to several site and Khao So is one of them. Thus the ecological status and the relationship between plant characteristics and some environmental factors of Khao So are useful for forest plantation and also assist for planning and zoning area to support the eco-tourism and biodiversity conservation projects.

1.2 Research Objectives

The main objectives of this investigation are as following:

1. to identify plant community characteristics based upon topographic gradients; and

2. to identify the relative patterns between plant community characteristics and some environmental factors.

1.3 Scope and Limitations of the Study

The research focused on Khao So, which is one of Phu Luang National Reserved Forest. It is located at Nakhon Ratchasima province. It covers around 36 square kilometers or 21,921 rais (3,507 hectares). It is located at the latitude of $14^{\circ} 32^{\prime}$ to $14^{\circ} 38^{\prime}$ north and longitude $101^{\circ} 45^{\prime}$ to $101^{\circ} 52^{\prime}$ east. The altitude is between 400-800 meters above mean sea level.

1.4 Expected Results

This investigation on the relationship between plant community characteristics and some environmental factors as well as of ecological biodiversity status will provide useful database for biodiversity conservation and management both on academic and eco-tourism management of Khao So.

CHAPTER II

LITERATURE REVIEWS

2.1 The Concept of Plant Community Study

Ecosystem is defined as a range of scales from an individual which leaf up to the level of the whole biosphere. Habitat system linked to local ecosystems next to regional ecosystems and next to world biomes and biosphere finally. Vegetation formation is defined and classified the same as ecosystem. It stems from smaller and smaller units of vegetation, from individuals of a species to associations or communities up to vegetation type and to formation of world vegetation. The nature of vegetation varies in both space and time (Kent and Coker, 1996) because the building blocks of vegetation are individuals which cannot be taken together equally in population number at any area on the earth. Although within the local area where is more similar in environment, they can slightly show similar in plant community. Particularly in the tropical rain forest, there are more differences in species composition at all scales. This varies greatly from place to place mainly due to the variation in biogeography, habitat and disturbance (Whitmore, 1998; Richards, 1952). Early plant community study is likely to be abstract ideal. In nineteen century the classifying or grouping of plant community accepted on two main principle concepts of F.E. Clements and H.A. Gleason (Crawley, M.J., 1997).

First concept, Clements point out that plant communities are clearly recognizable and definable entities that repeated themselves with great regularity over a given region of the earth's surface. Clements's opinion is named as **the organismic concept**, in which the various species comprising the vegetation at a point on the earth's surface were likened as the organs and parts of the body of animal or human. Putting all the parts together made a kind of super-organism, which was thus the plant community could not function without all its sub-communities present (Clement, 1949; Kent and Coker, 1996; Hanson, Herbert and Churchill, 1964).

Second concept, Gleason (1917; 1926; 1939) believed that all plant species distributed as a continuum because it respond individually to variation in environmental factors and those factors vary continuously in both space and time. Gleason's view is therefore called an **individualistic concept**. Every species has a different in distribution, tolerance range and abundance over that range of environmental factors. Therefore the vegetative community of any particular landscape is the result of the joint occurrence of species, which have the overlapping of their amplitudes of tolerance, more similar in their amplitudes of tolerance, more likely to grow together in the same environmental complex. The combination of plant species found at any given point on the earth's surface was unique and never can be defined into communities clearly as Clements' view.

Today, most ecologists used both concepts for a plant community study. This is a new method of classification, known as phytosociology derived from Clements' view. The main objective of the classification is to group together a set of individuals (quadrats or vegetation samples) on the basis of their attributes (floristic composition). The end product of a classification provides a set of groups from the individuals where every individual within each group is more similar to the other individuals in that group than to any individuals in other group. The second concept or continuum concept or individual concept concentrates on both vegetation and environment. Ordination means ‘to set in order’, is the method used for individual analysis. It is the arrangement of vegetation samples in relation to each other in terms of their similarity of species composition and/or their associated environmental factors.

2.2 Plant Community Characteristics

Plant community means the collection of plant species growing together in a particular location that show a definite association or affinity with each other. They have mutual relation among themselves and to their environment (Kent and Coker, 1996). Hanson and Churchill (1964) classified the study on plant community into analytic and synthetic. The analytic groups included quantitative and qualitative characteristics. These characteristics are as follows:

2.2.1 Analytic characteristics of the community

1. Qualitative

   1.1 Kinds of species in the community (floristic composition)

   1.2 Stratification (of organisms, or their parts, above or below ground)

   1.3 Periodicity (phenology, aspection)

   1.4 Vitality (vigor)

   1.5 Life-form (vegetation-, habitat-, and growth-, form)

1.6 Sociability (gregariousness)

1.7 Association of species (interspecific association)

2. Quantitative

2.1 Population density (number of individuals, abundance)

2.2 Cover (area occupied)

2.3 Height of plants

2.4 Weight of plants

2.5 Volume occupied by plants

2.6 Frequency

2.2.2 Synthetic characteristics of the community

Synthetic characteristics are generalizations or abstractions that are derived from data on analytic qualities and integrated of many analytic characteristics. They are consisted of presence and constancy, fidelity, dominance, physiognomy and pattern.

Kutintara (1998) has defined the analytical characteristics and synthetical characteristics which based on quantitative and qualitative characteristics. The analytical characteristics are composed of quantitative characteristics such as present list, density, mean area, frequency, abundance, dominance, relative frequency, relative density, relative dominance and importance value and qualitative characteristics are identified as dispersion, stratification, periodicity, vitality, life form, pattern and associability format. The synthetic characteristics are identified as quantitative characteristics such as presence, constancy, coefficient of community, species diversity, classification and ordination, and qualitative characteristics including fidelity and classification format.

Krebs (1978) measured and studied plant community characteristics on species diversity, dominance, relative abundance, growth form and structure as following:

Species diversity is basically a measure of variety in ecological communities. Species diversity for a plant community is a function of the number of different species present, the number of individuals per species, and the total number of individuals of all species in that community. Usually it may be considered in two components as species richness and species evenness or equitability.

Growth form and structure show the type of community derived from major categories of growth forms such as trees, shrubs, herbs, grasses and mosses. Additionally, growth forms can categorize to broad-leaved and needle-leaved trees. These different growth forms can be also used to determine the stratification of the community.

Dominance, usually in the natural community not all species, is equally in the size, number and biomass. Species that are highly successful ecologically or more performance acts as dominant species in that community. Dominance is measured in percent of cover, basal area or biomass.

Relative abundance can be measured in the relative proportions of different species in the community

.

2.3 Factors Influencing Plant Community

Hanson and Churchill (1964) point out the relationships of species to the physical environment that every species has certain essential requirements, processes in ecological amplitude such as a characteristic potentiality for growth within a limited range of environmental conditions. Furthermore every plant species has a characteristic capacity for utilizing the available resources of the environment in which it occurs. For physical environment, it can be divided as following:

1. Climatic factors, which included light, heat or cold, precipitation, humidity, wind, gases, and evaporating power of air.

2. Soil factors, which included texture, structure, depth, and components such as water, gases, mineral constituents, acidity, alkalinity, and salinity. Whitemore (1998) found that most of the rain forest soil, are low in plant nutrients and physical factors play more important role than fertility in determining species ranges. Therefore soil physical factors probably determined which species were more abundant over that area.

3. Topographic factors, include the degree, extent, and direction of slope, relief, altitude, and ground water. In addition, human is included in topographic factors too (Hanson and Churchill, 1964).

Clement (1949) and Knight (1967) found that these factors relate to each others. For instance, topography affects on climate as increase in humidity and precipitation on higher altitude. Furthermore the temperature decreases by 1°F to every 300 foots or 1°C every 100 meters increase (Kutintara, 1998).

2.4 Plant Community Analysis Reviews

In a world ecological system, the patterns that we see typically were driven by a number of many interacting ecological processes. These processes always vary in space and time. The distribution and abundance are affected simultaneously by many biotic and abiotic factors. This multiplicity and interaction of these affecting factors makes it exceptionally difficult to analyze ecological systems. As a result, multivariate approach is required because it can handle many sets of variables and characteristics in every sampling entity.

Multivariate techniques commonly used in ecological research, were group mainly into four types as ordination analysis, cluster analysis, discriminant analysis and canonical correlation analysis.

The study of plant community variations based on topographic gradients and environmental factors carried on ordination and cluster analysis as in the following.

2.4.1 Ordination analysis

Ordination is the collective term for multivariable techniques that elucidate the variation in communities and detect relationships between communities along gradients of environmental factors. Kevin McGarigal, Sam Cushman and Susan Stafford (2000) described about these techniques that comprises a large family of techniques including canonical correspondence analysis where the main purpose is to organize sampling entities such as sites, individuals, species and so on along a meaningful continuum or gradient. These techniques are employed to quantify the interrelationships among a large number of interdependent variables and to explain those variables in terms of smaller set of underlying dimensions. Ordination method is a part of gradient analysis. It divided into direct and indirect gradient analysis. Direct gradient analysis arranged vegetation on known magnitudes of indices of environmental gradients while indirect analysis compared and arranged the vegetative samples in the term of their similarity in species composition and vegetative characteristics. The results would suggested that vegetation may or may not correlate with environmental gradients.

2.4.2 Cluster analysis

Cluster analysis is the most popular in plant community researchers in term of classification analysis (Garigal, Cushman and Stafford, 2000). It is a part of analytic procedures including Two-Way INdicator SPecies ANalysis (TWINSPAN). The main purpose is to develop meaningful aggregations or groups of entities based on a large number of interdependent variables. Anotherword the specific objective is to classify a sample of entities into a smaller number of usually mutually exclusive groups based on the multivariate similarities among entities (Whittaker, 1975).

2.5 Relevant Researches

2.5.1 Vegetation distribution along topographic gradients

At Khao So, Phu Luang National Reserved Forest, there are quite few researches on the study area. Similar studies were done in Nepal and Malaysia. The study on community ecology of tropical forest within the Makalu-Barun conservation area of eastern Nepal reports that tropical zone forest communities along the upper Arun, which is a one part of the Makalu-Barun conservation area, were found to be more diverse both species composition and community structure. These diversity associated with the physiographically complex and diverse of landscape. This field study was conducted in the Makalu-Barun conservation area. Ecological and botanical data were collected on 30 quadrats. TWINSPAN and CCA were used to exhibited community groups separated along topo-climatic and land use gradients (Zomer *et al*., 2001). Another study on altitudinal zonation of forest communities was done in Selangor, Peninsular Malaysia indicated higher altitude with higher tree density and lower maximum tree height. The number of family, genus and species per 500 m^2 were higher at higher altitudes, while individuals were lower at higher altitude. For diversity index, Nakashizuka *et al.* (1991) shown that altitudes was more affecting diversity index than equitability index. The diversity index (H') significantly decreased linearly with altitudes, while equitability (J) was almost uniform. The forest composition also demonstrated that it varied continuously with altitude, ordination via reciprocal averaging, and elevational trends in the Sorenson similarities of samples at adjacent altitude, supporting the individualistic hypothesis of plant community organization (Givnish and Vazquez, 1998; Pattanakiat, 2001).

2.5.2 Soil distribution along topographic gradients

Many studies concluded that vegetation distributions have been influenced by importance topographic factors such as slopes, aspects, elevations, climatic gradients; rainfall, temperature and humidity. Soil characteristics both physical and chemical properties also vary along topographic factors especially altitudes. For soil physical properties (Hunt, 1792) soil profile studied along the altitudinal gradients found that soil depth decreased with increase in altitude. Kitayama (1992) studied soil profile in mountain Kinabalu also found that soil depth decreased at higher altitudes whereas the formation of soil texture will increase with sand particle when increasing in altitude. For soil chemical properties soil pH value decreased with increasing in altitude (Kitayama and Muller, 1994; Kitayama, 1992; Marh *et al*., 1988; Pendry and Procter, 1996; Tsui, Chen and Hsieh, 2004). Organic matter in upper soil surface was highest especially in the hill evergreen forest where altitude is higher than other forest types of Kinabalu. This forest is also higher in exchangeable cation and available phosphorous comparing to the places where there are low organic matter in upper soil surface. The leaching process in exchangeable cation of calcium and magnesium increased with increase altitudes.

2.5.3 Relative patterns of vegetation

Relative patterns in plant community characteristics with some environmental factors are concentrated on dipterocarp and dry evergreen forests due to the altitude of study area is 400 meters above mean sea level composing of these two type of forest.

2.5.3.1 Dipterocarp forest

Bunyavejchewin (1987) found that plant community compositions on dipterocarp forest at Sakaerat, Nakhon Ratchasima, can be divided into two dominance-types with slightly different in basal area and density. The structure of two dominance types was similar by means of size-class analysis. The relationship between basal area and environment factors revealed the positive relationship between basal area per hectare with magnesium, available moisture capacity, available phosphorus and bulk density. On the other hand, silt+clay, soil pH and slope produced the negative relationships with stand basal area. Sahunalu Pongsak *et al.*

(1994) studied the relationships of soils and plant in dry dipterocarp forest at Sakaerat. They found that trees of this site composed of 46 species in total and varied among stands. Patterns of species abundance distribution were similar and less diverse in both positive and negative associations. Organic matter and calcium in the soil were important factors in discriminating between two stands significantly than other nutrients. The area that high in organic matter but low calcium storages groups showed high values of mean tree height, basal area, total aboveground biomass and stand density but lower species diversity whereas the area with low organic matter but high calcium storages groups showed the opposite trends with high species diversity

2.5.3.2 Dry evergreen forest

In the Sierra de Manantlan, the forest composition was closely related to altitudes. It made of a total of 470 species, 292 genera and 103 families of vascular plants and comprised of 97 tree species, 76 shrubs, 70 vines, 181 terrestrial herbs, 39 epiphytes, 3 succulent rosette shrubs and 1 saprophyte. Understorey herbs, shrubs and vines showed the greatest decline in species number with increasing altitude. The proportion of evergreen woody plants was greater at higher altitudes. The proportion of endozoochorous species increased with altitude, while the proportion of pterochorous and ectozoochorous species decreased. Total basal area of woody plants, diameter at breath height (DBH) > 2.5 centimeters, and basal area per tree both increased roughly fourfold between 1500 and 2500 meters in altitude (Givnish and Vazquez, 1998). Species diversity varied among aspects according to the research of Pattanakiat (2001) in Khao Chamao area, Chanthaburi Province, Thailand. Plant communities of Khao Chamao were consisted of 187 species within

49 families. The species richness also tended to be decreasing along the higher altitudes. The north and south aspects were much more diverse than east and west aspects. The higher in elevation caused more diverse in plant community. These variations were mainly caused from altitudinal gradients. As a result soil fertility, effective soil depth, available phosphorus, potassium, sodium, calcium, magnesium, and soil reaction (pH) decreased along the higher elevation, while organic matter, available nitrogen, and cation exchange capacity increased.

For structural characteristics on dry evergreen forest at Sakaerat environmental research station, Visarat Thiti (1983) divided trees into three categories as: tree at ≥ 4.5 DBH and ≥ 1.30 m. in height, tree at ≤ 4.5 DBH and ≥ 1.30 m. in height, and tree < 1.30 m. in height. This study also indicated that the maximum number of species, diversity, basal area and average tree height were found in the first category (tree ≥ 4.5 DBH) while the heighest density was found in the third category (tree < 1.30 m. in height). The vertical structure of the first category divided into three layers, over 24 m., 24-16 m. and below 16 m. in height respectively. Intrarayotha (1989) found that the plant community compositions on dry evergreen forest at Sakaerat, Nakhon Ratchasima could be classified into three sub-communities according to environmental relationships on ordination technique. Basal area and density of three sub-communities were 56.17 square meters per hectares and 476 trees per hectares, 65.65 square meters per hectares and 500 trees per hectares, 129.06 square meters per hectares and 726 tree per hectares.

CHAPTER III

STUDY SITE AND METHODS

3.1 Equipment and Chemicals

There are various instruments both in the fieldwork process (soil sampling and plant community inventory) and in laboratory process (soil analysis and data analysis).

3.1.1 Equipment for collecting soil and plant in fieldwork

1. Aerial photography, scale 1: 15,000 and 50,000 from Royal Thai Survey Department in 1999
2. Topographic map, scale 1: 50,000 from Royal Thai Survey Department in 1992
3. Global Positioning System, GPS 12 XL GARMIN
4. Altimeter, Casio PAT 40B-3V
5. Compass, Casio PAT 40B-3V
6. Diameter tape
7. Knife
8. Notebook
9. String
10. Soil auger
11. Soil core

12. Plastic bags

3.1.2 Equipment and chemicals for analyzing soil properties

3.1.2.1 Equipment for soil analysis were analytical balance, seive no. 10 (2-mm opening), stop watch, soil color handbook (Munsell soil color charts), electrical oven, muffle furnace, grinder, hot plate, digestion tools and crucible, nitrogen distillation apparatus (Kjeltec auto sampler system 1035 analyzer), pH meter, hydrometer, centrifuge, atomic absorption spectrophotometer (Spectro AA-250 plus, Varian), spectro-photometer (Spectronic genesys 5, Becthai), mechanical reciprocating shaker, dissicator, plastic centrifuge tube, whatman filter paper no.5, 4 and 1, cylinder, volumetric pipette, adjustable pipette, volumetric flask, funnel, erlenmyer flask, beaker and glass rod.

3.1.2.2 Chemicals used in soil analysis were of analytical grades as phosphoric acid, sulfuric acid, silver sulfate, potassium dicromate, barium diphenylamine sulfonate indicator, ferrous ammonium sulfate, ammonium acetate, ethyl alcohol, boric acid, sodium chloride, magnesium oxide, sodium acetate, sodium hydroxide, ammonium fluoride, hydrochloric acid, ammonium heptamolybdate, potassium antimony tartrate, ascorbic acid.

3.1.3 Software for data analysis

3.1.3.1 Software PC Arc /Info version 8.0, Remote Sensing Lab, Suranaree University of Technology.

3.1.3.2 Software Arcview version 3.3, Remote Sensing Lab, Suranaree University of Technology.

3.1.3.3 Software PC-ORD version 4.1 for Windows, MjM Software.

3.2 Methods

3.2.1 Method for determining the study plots

The field study used "Line transect sampling method" to determine sample plots (Krebs, 1999). Each sampling plot was 20x50 meters in size and divided into 10 subplots of 10x10 meters. Then every subplot was nested into 4x4 meters and 1x1 meters at the first right corner. Each plot was placed along four aspects, north, south, east and west and every 40 meters of altitude between 400 meters to 800 meters above mean sea level. The total number of sample plots was 41 sampling plots. The structural profile, it was drawn from the first to fifth subplots in dry evergreen forest and transitional zone.

3.2.2 Method for collecting plant data

In the fieldwork, the inventory study of plant community was derived from the line transect sampling method and every tree species divided into three categories as woody tree or canopy layer, sapling or understory layer, and seedling or ground layer. Each sampling quadrat 10x10 meters, all tree species with $\geq$ 4.5 DBH and > 1.30 meters in height were measured by diameter tape, recorded and identified. In the sampling quadrat 4x4 meters, all shrubs, small trees or saplings with $\leq$ 4.5 DBH and >1.30 meters in height were numbered, identified. In the sampling quadrat 1x1 meters, all vegetation on ground layer with < 1.30 meters in height were numbered and identified excluding climbers, lianas and herbaceous. These species lists were brought to the next step in vegetation analytical process.

3.2.3 Method for collecting environmental and topographical data

Soil samplings and aspects for plant community variations based on topographical gradients and environmental factors study were collected within the same site as vegetation samples. Composite soil samples from two levels of soil depth (0-5 and 20-25 cm) were collected and determine to physical properties as soil texture (percent sand, silt and clay), soil depth, and chemical properties as soil reaction (pH), organic matter (O.M.), Available phosphorus (P), Exchangeable cation of potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), Cation exchange capacity (CEC). For bulk density and moisture content, soil samples approximately 30 cm in depth were done by soil coring method. For relative humidity, rainfall, temperature and evaporation factors, the data were collected from nearby meteorological stations as Lam Phra Phloeng, Sakaerat, Chock Chai and Pak Chong stations.

3.2.4 Method for plant and soil characteristics analysis

3.2.4.1 Plant analysis

The species lists from fieldwork were carried into statistical analysis as similarity and dissimilarity in floristic composition, species richness and diversity, relative dominance, density and frequency to obtain species indices. Importance value index (IVI) of each species were used to analyze phytosociological and plant community classification by TWINSPAN. Then, these groups were of analyzed to find out the spatial patterns by interpolation analysis of Thiessen polygon technique in GIS's software. For the relationship between plant community and environmental factors was done by the ordination process of CCA At the end the study of vertical stratification was expressed by profile diagram for each forest types as dry-evergreen forest, and transitional zone.

3.2.4.2 Soil properties analysis

Each soil sample was analyzed as in the following.

1. Soil texture was determined by hydrometer method (Bouyoucos, 1936) on air-dried soil that has been passed through a 2 mm sieve which removing rocks and pebbles then obtained the percentage of clay, sand and silt from soil textural triangle diagram (Soil survey staff, 1975).

2. Soil reaction (pH) was made with a glass-electrode pH meter on a 1:1 ratio soil water suspension of air – dried samples which had been passed through a 2 mm soil sieve.

3. Soil organic matter (O.M.) was analyzed by rapid titration method (Walkly and Black, 1934).

4. Available phosphorus (P) was extracted according to Bray II procedure.

5. Exchangeable cation of potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) was determined by ammonium acetate extraction (Jachson, 1973).

6. Cation exchange capacity (CEC) was determined using ammonium saturation method.

7. Soil bulk density (Db) was determined according to a volume of soil coring basis by weighing the soil sample after dried for 48 hours at 105 $^{\circ}$C.

8. Soil moisture content was determined by oven dried basis.

9. Soil aspect and slope were analyzed to percentage of slope and aspect by creating the TIN theme technique in GIS before obtaining aspect and slope.

3.2.4.3 Vegetation and environmental relationship analysis and model establishment

CCA was calculated the relationship of soil properties, climatic factors, topographic factors and vegetation along various altitudes and aspects. In addition, Stepwise multiple regression analysis was employed to construct models of relationship between basal areas (BA), volume of tree (as dependent variables), and environmental factors (as independent variables).

3.3 Statistical Analysis

Most of statistical analysis of plant community characteristics based on analytical and synthetical characteristics which included qualitative and quantitative characteristics as following:

3.3.1 Analytical characteristics

Density = (Number of individuals of species/Total number of sampling area)

Frequency = (Number of sampling plots for each species/Total number of sampling plot)

Dominance = (Basal area of species/Total basal area of all species)

Relative density (R.Den.) = (Density of a species/Density of all species) x 100

Relative frequency = (Frequency of a species/Frequency of all species) x 100

(R.Fre.)

Relative dominance = (Dominance of species/Dominance of all species) x 100

(R.Do.)

Importance value for each species = relative density + relative dominance +

(IVI) relative frequency

For sapling and seedling of each species were calculated by relative density plus relative frequency.

3.3.2 Synthetical characteristics

3.3.2.1 The species diversity

Diversity within a community was identified by Shannon diversity index (H') as a following formula:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where H' = Shannon diversity index

s = the number of species

p_i = the proportion of individuals or abundance of the ith species expressed as a proportion of total cover

ln = log base_n

Kent and Coker (1996) found that the species diversity values on tropical forest usually lied between 1.5-3.5 values. Therefore species diversity of study area was classified as following:

Normal = >1.5 indices

Disturbed = < 1.5 indices

In addition, The IUCN Red List Categories and Criteria (version 2.3) was used to obtain threatened species of the study area. The World Conservation Union (IUCN, 1994) classified rare species or threatened species into three categories as in the following:

Critically endangered (CR) = Species which is facing an extremely high risk of extinction in the immediate future

Endangered (EN) = Species which is facing a high risk of extinction in the near future

Vulnerable (VU) = Species which is facing a high risk of extinction in the medium-term future

3.3.2.2 The equitability or evenness index

The evenness index was calculated by:

$$J = \frac{H'}{H'_{max}}$$

Where J = Equitability or evenness index

H' = Shannon diversity index

H'_{max} = $\ln s$

3.3.2.3 The Sørensen's coefficient index

Kent and Coker (1996) used assessment of similarity and dissimilarity between vegetation samples or quadrats along both aspects and altitudes as:

$$S_s = \frac{2a}{2a + b + c}$$

$$D_s = \frac{b + c}{2a + b + c}$$

Where S_s = Similarity coefficient

D_s = Dissimilarity coefficient

a = number of species common to both quadrats/samples

b = number of species in quadrats/sample 1

c = number of species in quadrats/sample 2

3.3.2.4 Classification and phytosociological analysis

TWINSPAN was used for grouping plant community by software PC-ORD version 4. This process used only the main matrix which composed of species and their important value index (IVI) were prepared for two way indicator species analysis. It classified each species based on pseudospecies that derived from their abundance classes. The performance values in ecology were used to make abundance classes along pseudospecies. Therefore six level of classes were classified according to the percentage of performance cover (Kent and Coker, 1996) as:

1 = percentage cover of species up to 2 percent,

2 = percentage cover of species 3-5 percent,

3 = percentage cover of species 6-10 percent,

4 = percentage cover of species 11-20 percent,

5 = percentage cover of species 21-50 percent,

6 = percentage cover of species over 50 percent.

On the phytosociological analysis, stand classification was analyzed by interpolation method based on Thiessen polygon technique in Arcview GIS version 3.3, to show spatial distribution of each sub-community.

3.3.2.5 Ordination analysis

CCA was used to analyze plant community ordination analysis. The data composed of two matrixes of the species data and the environment data.

Multiple regression analysis was used to calculate the relationship of soil properties, topographic factors and vegetation in both vertical and horizontal directions. The tree basal area cover serves as the horizontal and the volume represents the vertical direction. The equation of Loetsch and Haller was used to calculate volume of wood (Pattanakiat, 2001).

$$V = 0.00007857 \times 0.78\ LD^2$$

Where	V	=	volume of wood
	L	=	log height (m.)
	D	=	diameter at breath height (cm.)
	0.78	=	form factor

3.4 General Data of the Study Area

Khao So, which is one of the mountain under Phu Luang National Reserved Forest, was the study area. Data on geography, topography and climate, describes in the following based on Phu Luang National Reserved Forest information.

3.4.1 Geography

Phu Luang National Reserved Forest is located at Nakhon Ratchasima province. It covers Tambon Ta Khop, Lam Nang Kaeo, Udom Sap in Amphoe Pak Thong Chai, Tambon Laroeng, Wang Mi, Wang Nam Khieo in Amphoe Wang Nam Khieo and Tambon Wang Katha, Pong Ta Long, Khlong Muang in Amphoe Pak Chong. It is composed of numerous mountains as Khao Lung Chang, Khao So, Khao Cha Long Tong, Khao Cha wae, Khao Pead, Khao Khieo, and Khao Sakaerat. It is located at the latitude of $14^{\circ} 30'$ to $14^{\circ} 40'$ north and longitude $101^{\circ} 44'$ to $101^{\circ} 57'$ east.

3.4.2 Topography

The altitude is varied from 240 to 800 meters above mean sea level and 15% to 45% in slope range. Khao So, which is the highest mountain of Phu Luang National Reserved Forest, lies on the southwest to the northeast and the aspects are varied considerably. The aspect and altitude of Khao So are shown in Figures 1 and 3 respectively.

3.4.3 Climate

Phu Luang National Reserved Forest is located at southeast of center high lands which rely on Khorat plateau. Climate is classified as tropical savanna climate. There seasons are summer (February to May), Rainy season (June to September) and winter (November to January). The average temperature of 30 years record (1968-1997) shown that annual average is 26.9°C with the maximum of temperature 36.7°C and the minimum temperature of 17.4°C occurring in April and December respectively. The annual average rainfall is approximately 1,043.1 mm. The annual average relative humidity is 71%. The maximum average relative humidity is 94% in September and the lowest average relative humidity of 38% occurs in March.

3.4.4 Soil and geology

The parent material of soil in Phu Luang National Reserved Forest is sand stone which has been classify in Phu Phan and Phra Wihan formation. The texture is loamy and classified as Korat series. It's property is low in fertility, good drainage and high leaching.

3.5 Samplings and Location of Research

Fourty-one plots were selected according to various altitudes and all aspects at Khao So. It is covered the area of 36 square kilometers or 21,921 rais (3,507 hectares) and it's location is at the latitude of $14^{\circ}\ 32^{\prime}$ to $14^{\circ}\ 38^{\prime}$ north and longitude $101^{\circ}\ 45^{\prime}$ to $101^{\circ}\ 52^{\prime}$ east. Most of sampling plots were placed according to line transect sampling method along both aspect and altitude directions. Only at eastern aspect, sampling plots show slightly different way because this aspect varied in topography and classified as flat or almost flat. As a result sampling plots, which located at eastern aspects, cannot be placed by line transect method of northern, southern and western aspects but based on only altitude directions as shown in Figure 4.

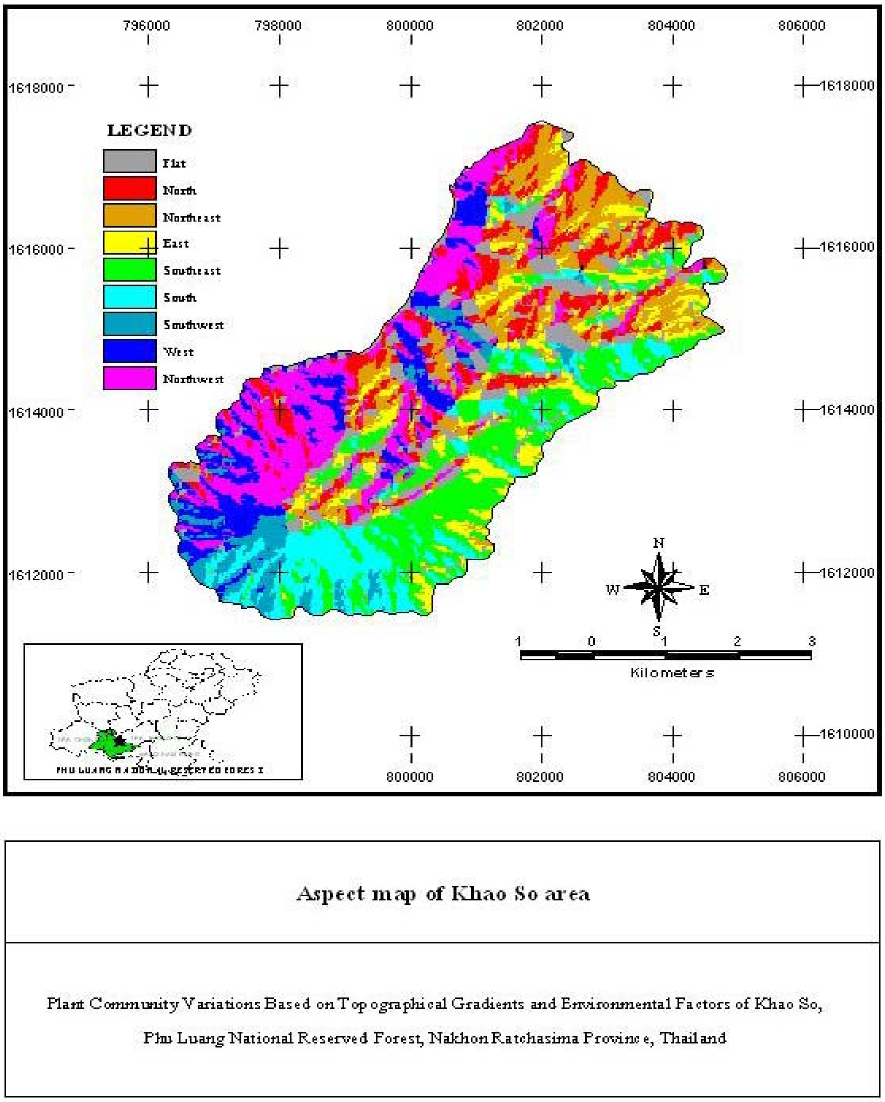


Figure 1. **The aspects variation of Khao So area.**

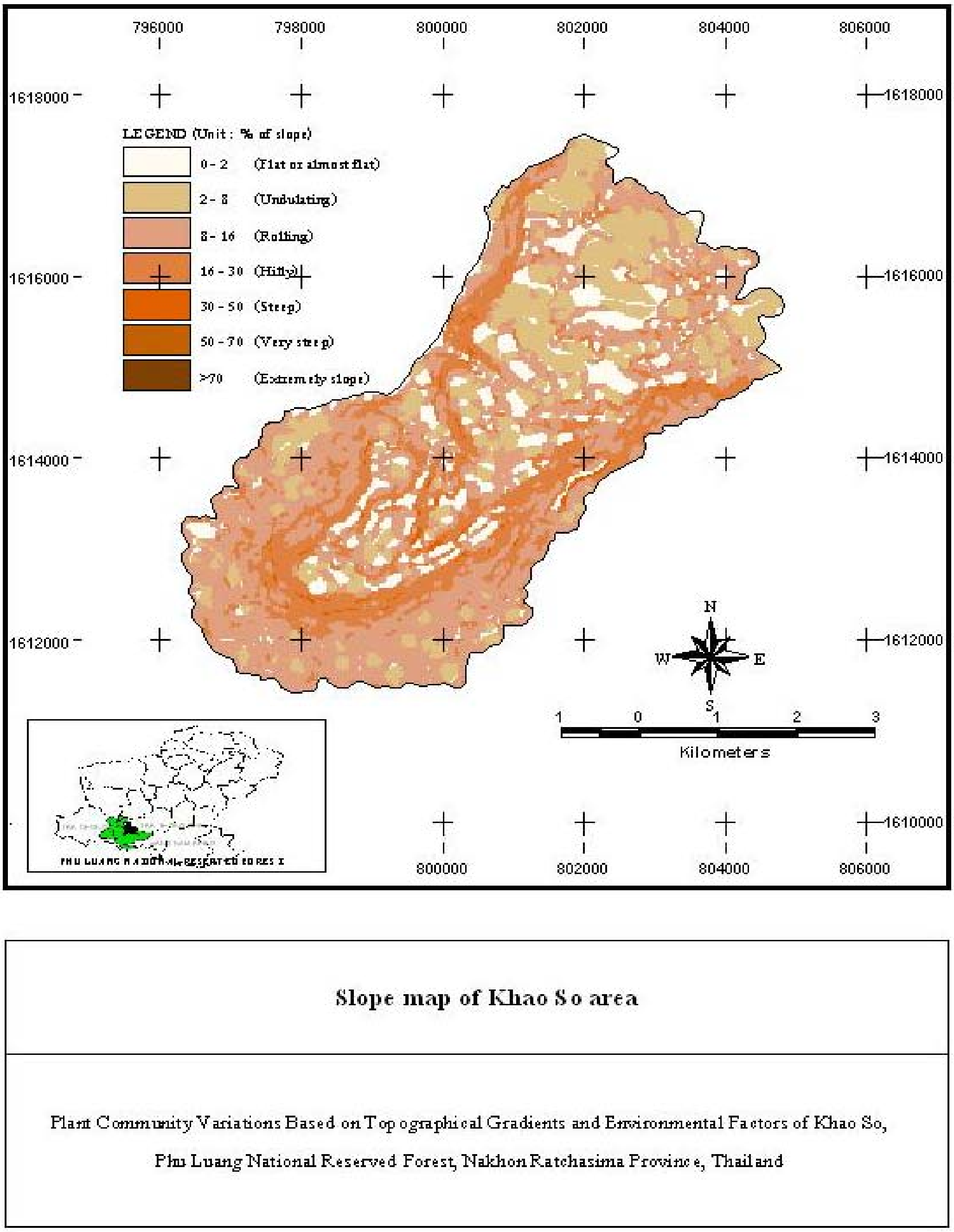


Figure 2. The slope variation of Khao So area.

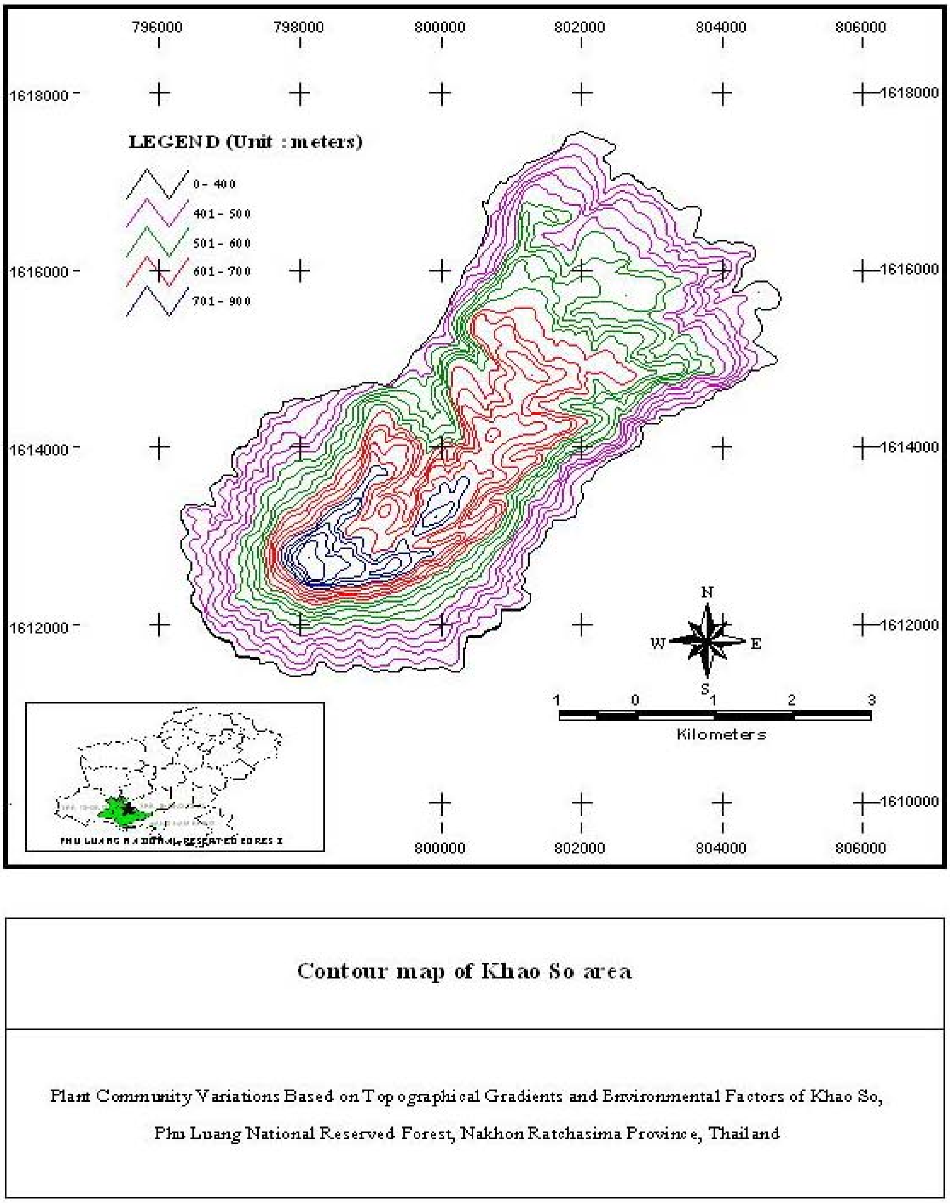
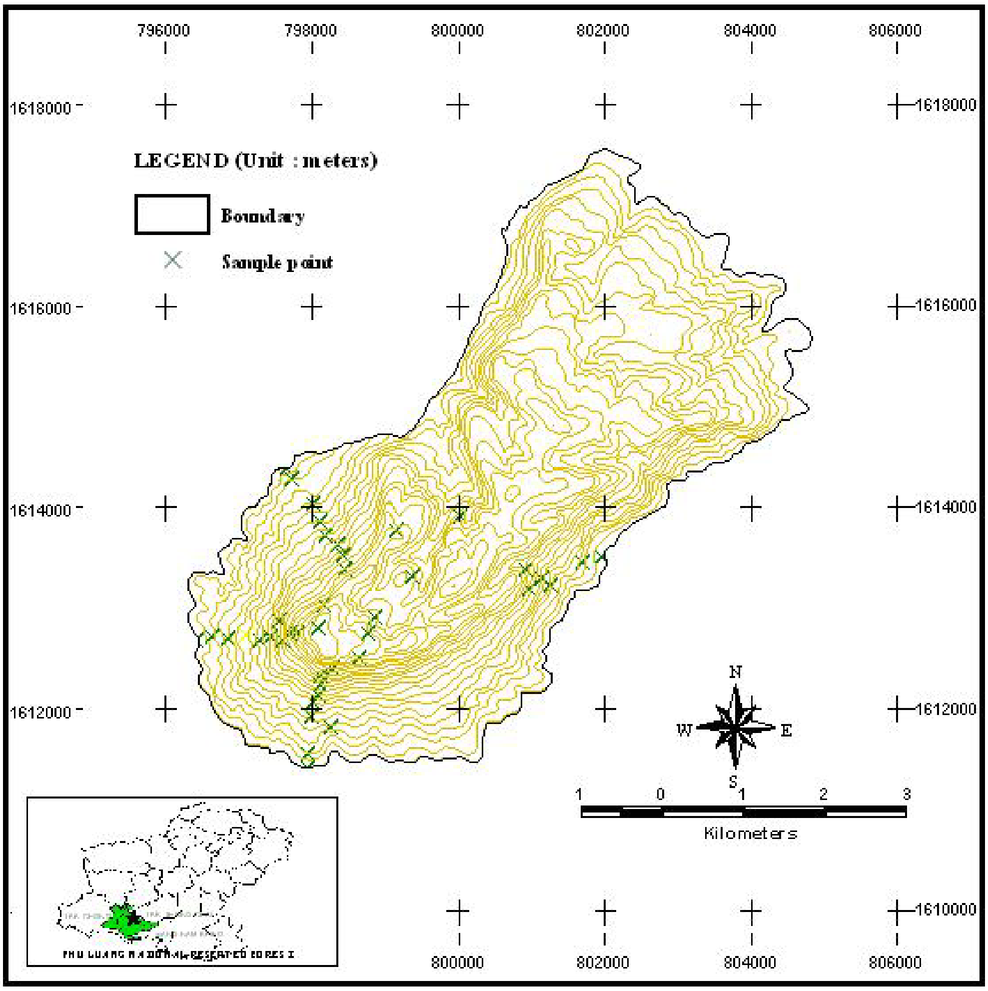


Figure 3. **The various altitude of Khao So area.**



Sample points map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

Figure 4. **The position of sample plots along various altitude.**

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Species Distribution

Plant community, from 41 stands (4.1 hectares) at various aspects and altitudes of Khao So, consisted of 188 species, 130 genera and 52 families of all vegetation (tree, sapling and seedling) with unable to identify 3 species (Appendix Table 1). Trees were included in 51 families, 114 genera, 165 species. Saplings were included in 42 families, 94 genera, 129 species and seedlings were occurred in 36 families, 75 genera and 105 species. These families were identified as Euphorbiaceae, Ebenaceae, Annonaceae, Caesalpiniaceae, Lauraceae, Moraceae, Sapindaceae, Dipterocarpaceae, Guttiferae, Meliaceae, Rubiaceae, Rutaceae, Mimosaceae, Sterculiaceae, Melastomataceae, Myrtaceae, Papilionaceae, Rosaceae, Anacardiaceae, Burseraceae, Labiatae, Lythraceae, Palmae, Theaceae, Apocynaceae, Bignoniaceae, Capparidaceae, Fagaceae, Flacourtiaceae, Myrsinaceae, Oleaceae, Opiliaceae, Sapotaceae, Tiliaceae, Bombacaceae, Celastraceae, Combretaceae, Datiscaceae, Dracaenaceae, Elaeocarpaceae, Gramineae, Irvingiaceae, Myristicaceae, Rhamnaceae, Rhizophoraceae, Simaroubaceae, Thymelaeaceae, Ulmaceae and Violaceae. Each family varied in number of species (Figure 5). Over whole area, the ten most diverse families, which were abundant in species number, were Eupoorbiaceae (12.77%), Ebenaceae (7.45%), Annonaceae (4.79%), Caesalpiniaceae

(3.72%), Lauraceae (3.72%), Moraceae (3.72%), Rubiaceae (3.72%), Sapindaceae (3.72%), Dipterocarpaceae (3.19%) and Meliaceae (3.19%) respectively. For tree, ten families were Euphorbiaceae, Ebenaceae, Moraceae, Annonaceae, Dipterocarpaceae, Rutaceae, Rubiaceae, Lauraceae, Meliaceae and Melastomataceae (Figure 6). Sapling families were in Euphorbiaceae, Ebenaceae, Annonaceae, Rutaceae, Caesalpiniaceae, Lauraceae, Meliaceae, Mimosaceae, Dipterocarpaceae and Guttiferae (Figure 7). Seedling families were Euphorbiaceae, Ebenaceae, Rutaceae, Lauraceae, Caesalpiniaceae, Moraceae, Meliaceae, Annonaceae, Rubiaceae and Melastomataceae (Figure 8). According to species distribution in each family, Euphorbiaceae was as the greatest family in the number of species distributions in all of tree, sapling and seedling. This may be concluded that Euphorbiaceae was a very large and diverse family, composed of 8,100 in number of species (Gardner, Sidisunthorn and Anusarnsunthorn, 2000). In addition, it also showed highest in number of individuals (Figure 9). Normally, this family prefers in moist evergreen forest (Pattanakiat, 2001; Sawangchote, 1998) while the structure of dry evergreen forest at Sakaerat found that Dipterocarpaceae was dominant family (Intrayotha, 1989). Whitmore (1998) and Richards (1952) stated that the dominant family in Southeast Asia is Dipterocarps. This suggests that difference in forest structure and plant community composition between these sites possibly due to topographic factors especially microclimate. Peak of Sakaerat dry evergreen forest was around 700 meter above sea level in height while Khao So is in 820 meters. According to meteological data on Appendix Table 1, Khao So has higher in relative humidity (86.9%) and precipitation (90.3 mm.) than Sakaerat forest. The increasing in altitudes affects to increase in humidity, precipitation and to decrease in temperature of every 100 meters hight (Hanson and Churchill, 1964; Kutintara, 1998).

Over the whole area, it covered with 10,368 woody flora, which dominated on tree at 46%, sapling 35% and seedling 19% (Figure 10). In Figure 11, each species distributed in various number of individuals. Most of the distribution of each species were between 1-10 individuals, 107 species in tree, 85 species in sapling and 68 species in seedling. It covered approximately 70% of total species and the rest of 30% which were more abundant in individuals. The relationships between individuals and species distribution were significant negatively correlation pattern of –0.215, –0.236, –0.236 in tree, sapling and seedling at $p<0.05$ significant level. Hang, W., *et al.*, (2003) recognized that species richness is negatively associated with densities. This study seems to be that the most number of the individual stems belonged to a relatively small number of species.

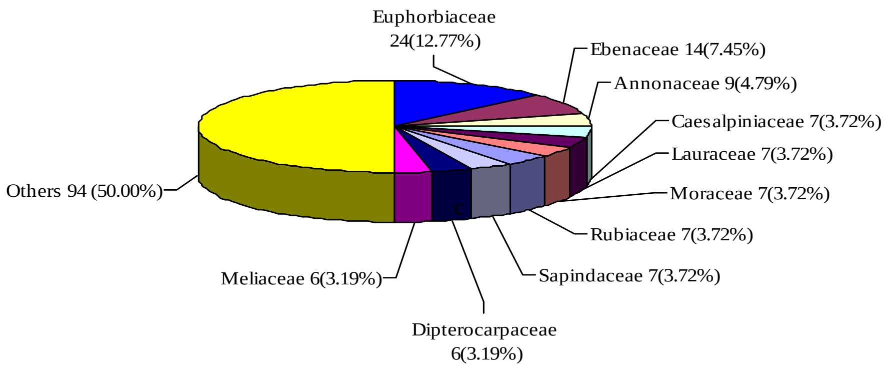


Figure 5. **Number of species and their percentage distribution (in parenthesis) in each family of the study area (total family = 52, total number of species = 188).**

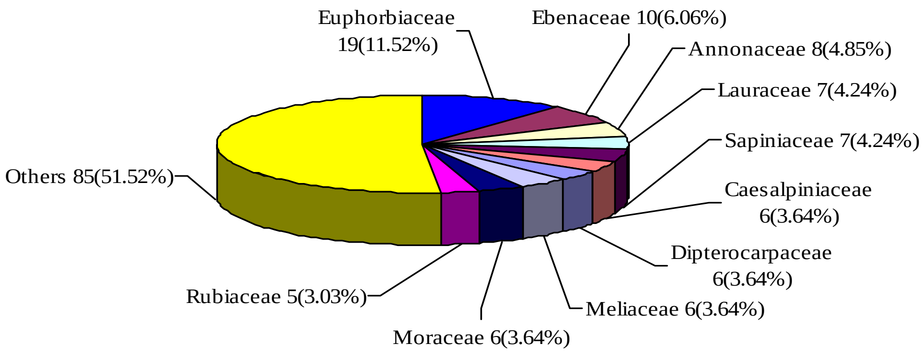


Figure 6. **Number of species and their percentage distribution (in parenthesis) in each family of tree (total family = 51, total number of species = 165).**

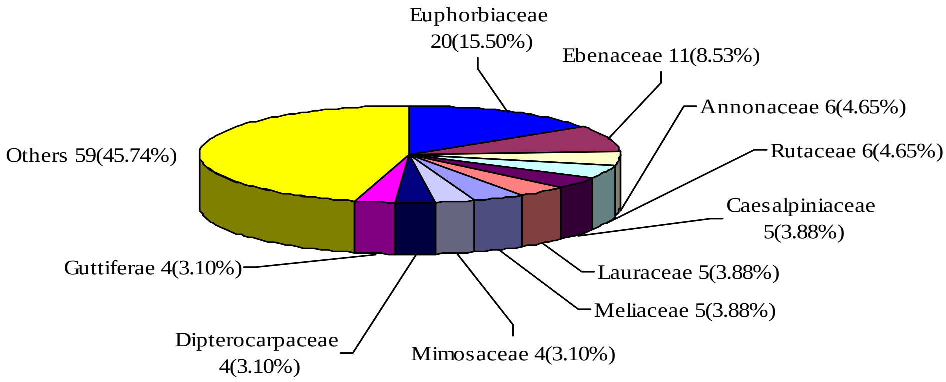


Figure 7. **Number of species and their percentage distribution (in parenthesis) in each family of sapling (total family = 42, total number of species = 129).**

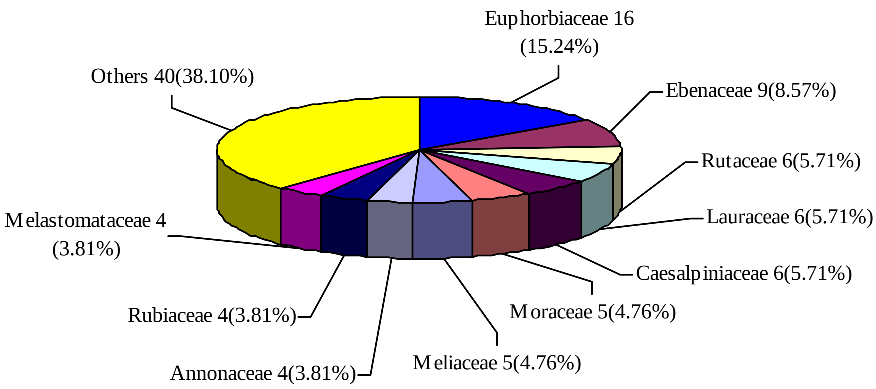


Figure 8. **Number of species and their percentage distribution (in parenthesis) in each family of seedling (total family = 36, total number of species = 105).**

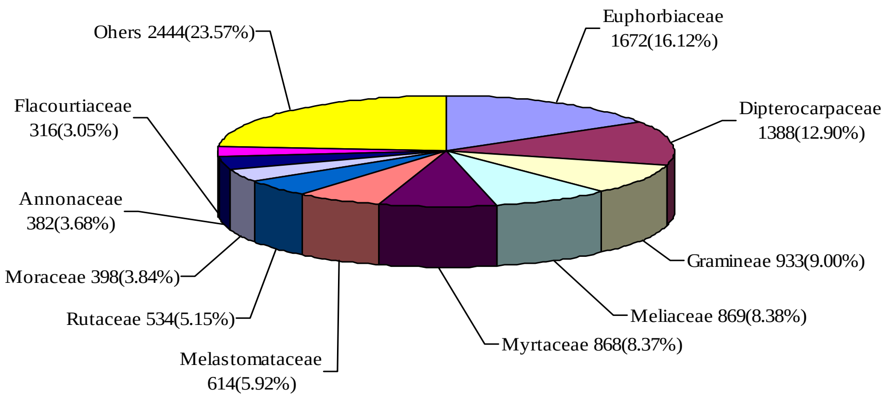


Figure 9. Number of individuals and their percentage distribution (in parenthesis) in each family of the study area (total family = 52, total number of individuals = 10,368).

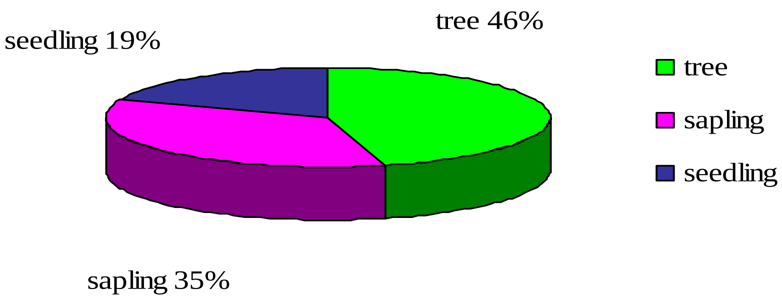


Figure 10. Percentage distribution of vegetation in the study area.

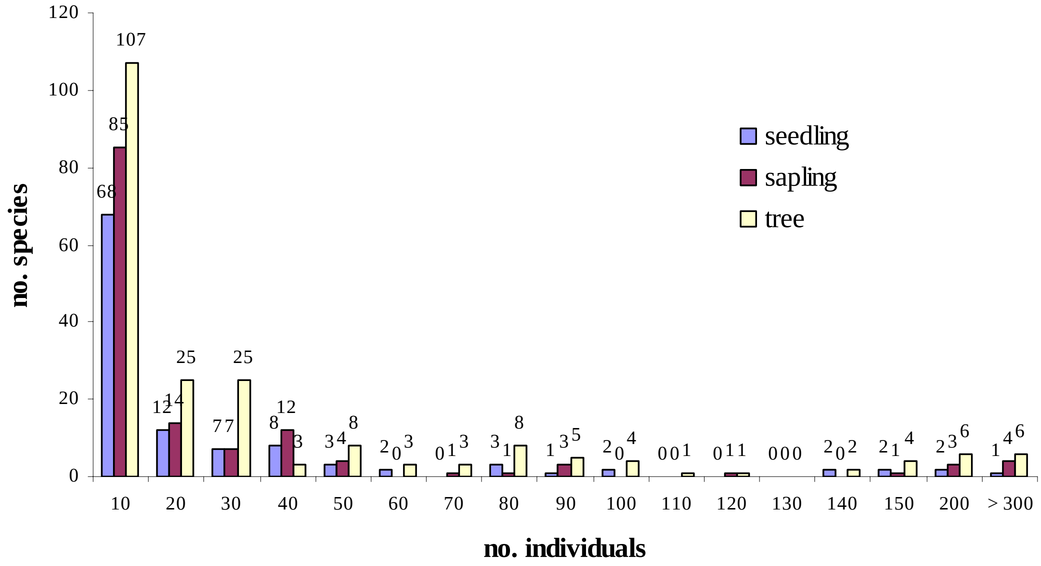


Figure 11. Distribution of species and individual number of trees, saplings and seedlings.

According to species, genus and family distribution patterns over the whole area tended to decline in all of vascular plant (tree, sapling, and seedling). The average numbers of vascular plant were averaged at 80 species, 62 genera and 33 families along altitudes (Table 1). Most of plants at higher altitudes were more likely to be lesser in number of species, genera and families as 680, 720, 760 and 800 meters above sea level. So Pearson correlation analysis was manipulated to find out the correlation between altitudes and species numbers, genera and families. The result showed that altitudes strongly negatively correlated with species richness, genera, families and number of individuals. It was fallen at 0.05 significant level ($P<0.05$) with – 0.649, – 0.527, – 0.738 and – 0.799 respectively. Besides that the result of trendlines on distribution of species, genera and families and individuals along altitudes also supported to Pearson correlation pattern. They tended to linearly decrease with increasing altitudes at – 0.07, – 0.04, – 0.02 and – 1.42 on species, genera, families and individuals respectively (Figure 12 and 13). These values reflected that decreasing of species richness, genera, families and individual numbers in the study area may be driven from altitudinal functions especially on the number of individuals. According to Figure 13, it clearly indicated that the number of individuals decrease along altitudes at –1.42 with R^2 = 0.63. This may be possible that higher altitude results to more open, more frequently disturbed from wind (Givnish and Vazquez, 1998). Inaddition, altitudes affected to plant community indirectly through soil activity. Soil moisture and nitrogen supply decreased significantly with altitudes owing to fewer in litter depth and deposition of soil processes. (Marrs, Proctor, Heaney, and Mountford, 1988). Topographical features of Khao So was high in altitude with high slope therefore soil fertility was easily to reach. As a result it affected the variations in plant community along altitudes in the study area too.

Table 1. Numbers of species, genera and families at various altitudes over the whole area.

	Altitudes (meters)											**Averages**
	400	**440**	**480**	**520**	**560**	**600**	**640**	**680**	**720**	**760**	**800**	**(Unit: No.)**
number of species	89	96	86	81	82	81	89	74	81	84	38	80
number of genera	68	75	62	62	62	64	64	60	64	71	34	62
number of families	34	38	35	34	38	33	35	36	29	28	25	33
Number of indviduals	1095	1172	1093	1088	996	1062	859	960	931	800	312	943

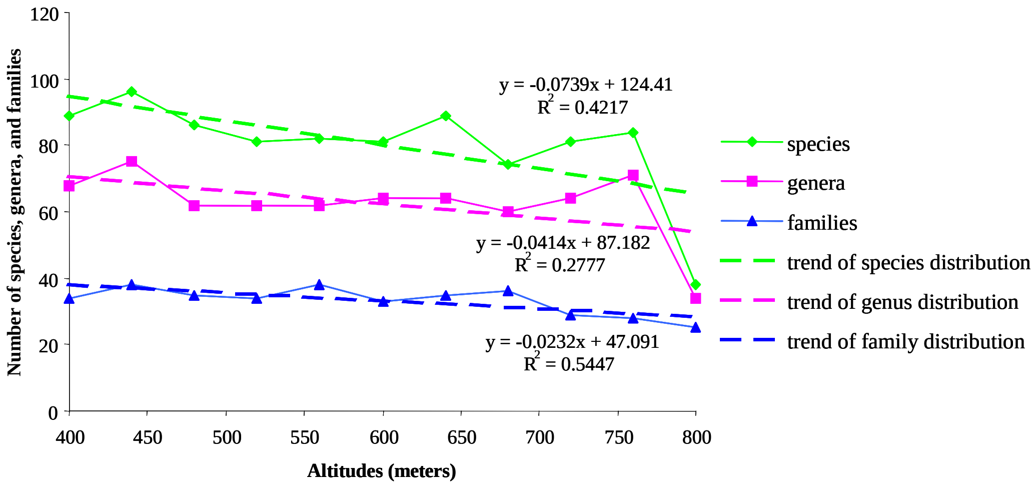


Figure 12. **Distribution of species, genera and families of all vascular plants at various altitudes over the whole area.**

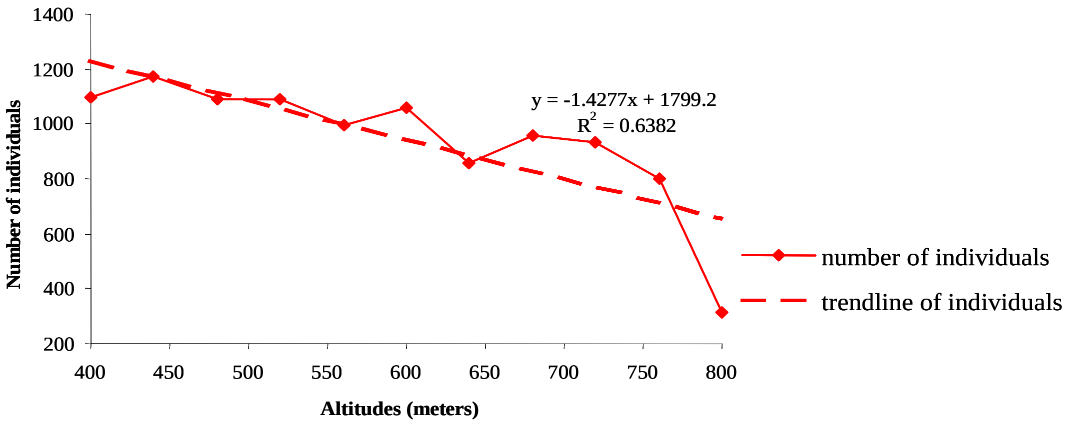


Figure 13. **Distribution of individuals of all vascular plants at various altitudes over the whole area.**

The study on plant community variations based on topographical gradients and environmental factors at Khao So focused on tree, sapling and seedling to find out the realistic pattern in plant community. Therefore number in species, genus, family and total individuals along various altitudes separately were presented in Table 2. The information demonstrated that trees were highest in species, genera, families and individual numbers. Along the altitudes, tree, sapling and seedling varied considerably in species number distribution. For seedlings, it appeared that there were three elevations, which species number was lower than averages, at 400, 520, 560, 600 meters and it peaks at 640 meter. For saplings, the number of species peaks in lower altitude at 440 meter and four elevations are lower than average number. For trees, only at 680 meter the species number was lower than average value. The correlation coefficients between species numbers and altitudes based on Pearson analysis were – 0.374, – 0.723 and – 0.525 in seedling, sapling and tree respectively. The number of sapling and tree distributions were fallen at 0.05 significant level ($P<0.05$). It indicated that species numbers of sapling and tree were strongly negative with altitudes whereas species number of seedling was not significantly associated with altitudes. Furthermore, the trendline of seedling species also slightly declined at – 0.03 when elevation increased (Figure 14). It implied that altitudinal gradients might not be direct process affecting the seedling. It seems to be affected by other factors such as soil factors and climatic factors. Waldern and Kingston, (2003) reported that usually understory affected by the canopy species and light environment.

Considering on genera and families, the distributions on tree, sapling and seedling were declined linearly with altitudes (Figure 15 and Figure 16). The number of genera of seedling and sapling were lowest at 560 meter elevation and highest at 440 meter elevation while tree was lowest at 680 meter elevation and highest at higher 760 meter elevation. For the number of families on seedling, sapling and tree, their distribution varied along altitudes. Sapling and seedling were lowest at higher 720 meter elevation and highest at 560 meter elevation. Tree was lowest at 760 meter elevation and highest at 640 meter elevation. The correlation coefficients between genera and elevations of seedling, sapling and tree were – 0.246, – 0.652 and – 0.493 respectively and sapling was only one fallen at $P<0.05$. For families, the correlation coefficients of seedling, sapling and tree were – 0.428, – 0.472, – 0.665 respectively. Only tree correlation was fallen at 0.05 significant level. From Figures 15 and 16, the results indicated that family distribution was effected by the variation in altitudes more than genus distribution.

For the number of individuals of the whole area, the results pointed out that tree, sapling and seedling decreased in the number of individuals with altitudes as species richness, genera and families distributions. The relationship between altitudes and the number of individuals were – 0.651, – 0.378, – 0.411 on seedling, sapling and tree respectively. Only the number of individuals on seedling was fallen at 0.05 significant level. The numbers of individuals on tree and sapling were not correlated with altitudes. It widely varied from the lower to the upper elevations because most of tree species at higher altitudes dominated by *Bambusa* sp., which was abundant in stems. This possibly resulted in the fluctuation of the total number of tree stems along altitudes. Additionally, the trendlines of tree and sapling conspicuously indicated that sapling individuals sharply declined. However the individuals of tree slightly decreased with higher altitudes due to more competitive with the increasing of tree stems of *Bambusa* sp. according to Figure 17.

Table 2. The number of species, genera, families and individuals of trees, saplings and seedlings at various altitudes.

		Altitudes (meters)											Averages
		400	**440**	**480**	**520**	**560**	**600**	**640**	**680**	**720**	**760**	**800**	**(Unit: No.)**
Seedling	Species	34	46	44	32	31	32	45	36	42	40	11	36
	Genera	29	38	35	28	24	28	38	33	38	37	9	31
	Families	18	21	18	19	27	22	16	20	14	21	9	19
	Individuals	221	187	218	230	207	203	162	196	185	171	36	183
Sapling	Species	49	64	50	53	41	37	48	41	45	42	16	44
	Genera	39	51	39	40	31	35	36	32	40	36	16	36
	Families	22	24	26	23	30	27	19	26	19	22	16	23
	Individuals	383	288	405	518	370	326	297	357	256	345	58	328
Tree	Species	62	64	59	57	64	62	60	50	59	65	28	57
	Genera	51	52	47	45	52	49	47	42	46	55	26	47
	Families	30	33	34	26	32	25	34	31	26	21	19	28
	Individuals	354	326	432	362	659	593	537	449	462	454	121	432

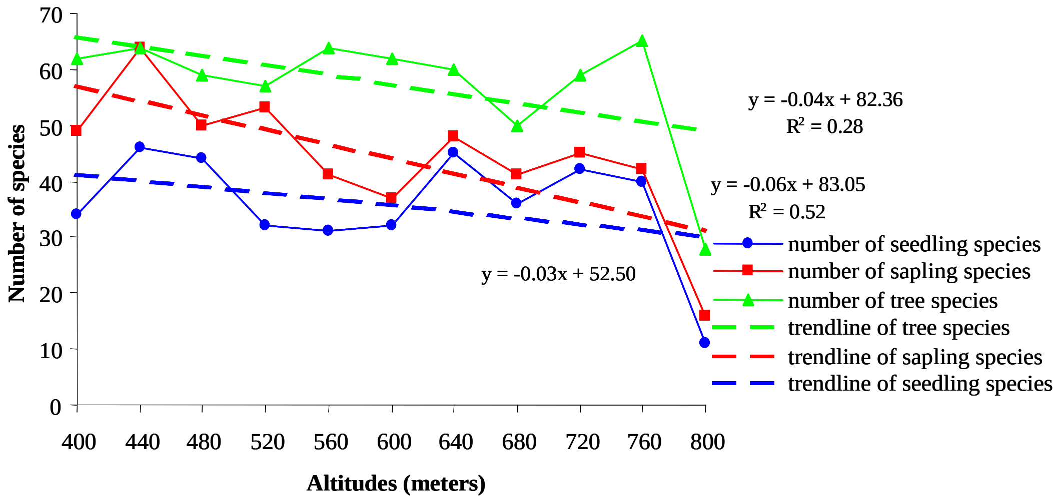


Figure 14. **Distribution patterns of species number of trees, saplings and seedlings at various altitudes.**

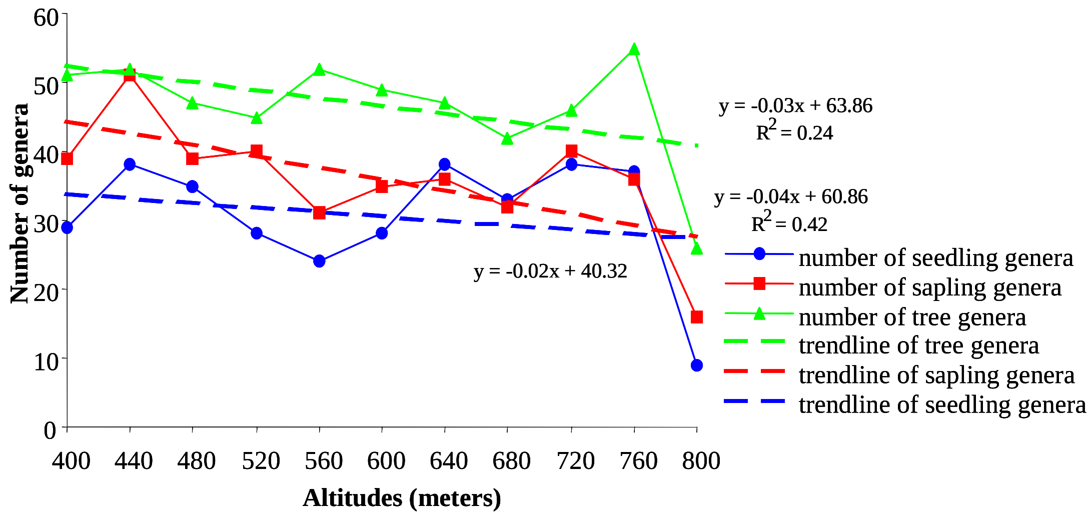


Figure 15. **Distribution patterns of genera of trees, saplings and seedlings at various altitudes.**

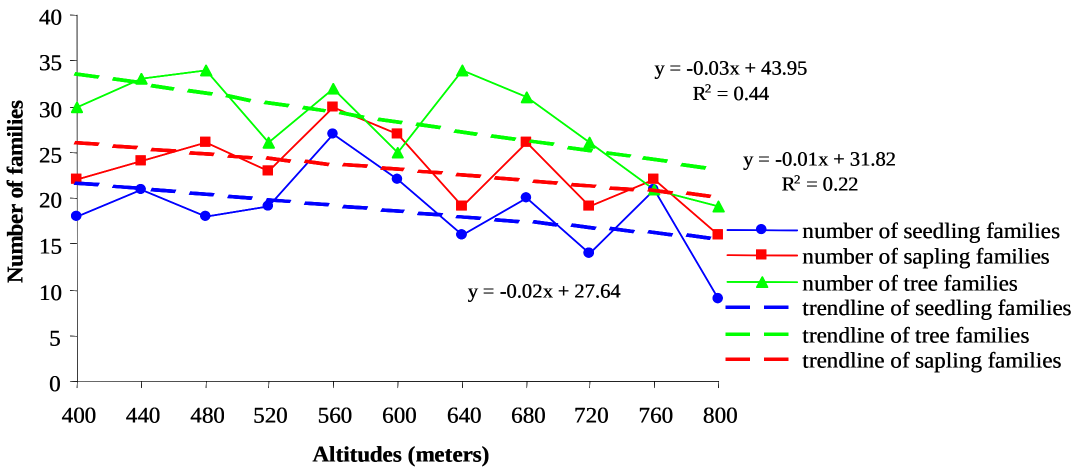


Figure 16. **Distribution patterns of families of trees, saplings and seedlings at various altitudes.**

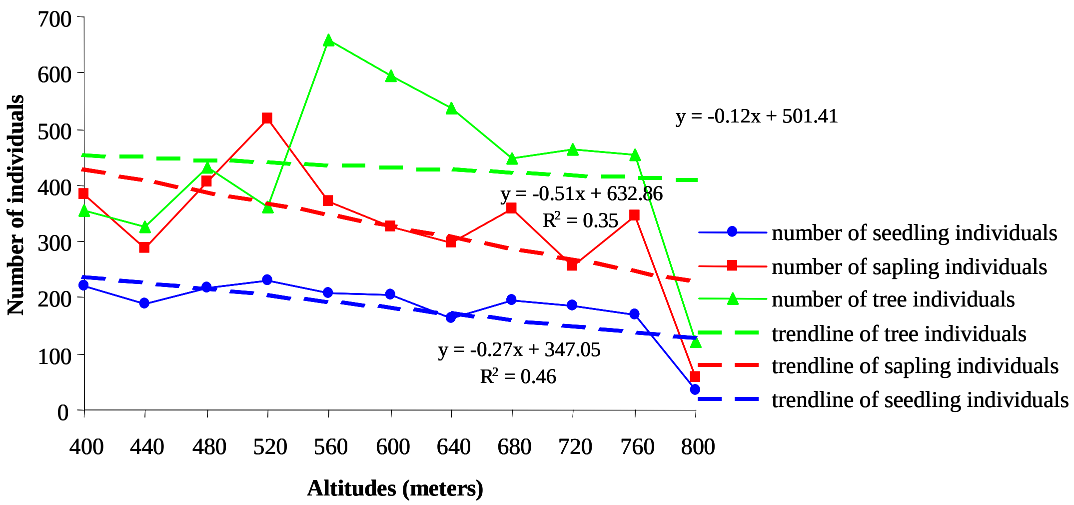


Figure 17. **Distribution patterns of individual number of trees, saplings and seedlings at various altitudes.**

According to the distributions of species, genera, families and individuals over the whole area, altitudes affected to the decreasing in number of individuals more than the number of species, genera and families (Figure 13). Among tree, sapling and seedling communities, the variation of altitudes also resulted to decreasing sharply in the distributions of species, genera, families and individuals excepting on tree individuals. It seemed to be slightly decrease with higher altitudes because of bamboo population. The Sørensen coefficient was used to describe the floristic compositions between aspects at each elevation. It conspicuously demonstrated that dissimilarity coefficients were between 60-90% in species, genera and families as shown in Figure 18. The results also pointed out that the species, genera and families of tree, sapling and seedling distributed differently along aspects. From Figure 19, only the tree distribution tended to be more homogeneity in distribution of species numbers at higher altitudes. Similarity of species number distribution was highest at 720 meter elevation on seeding but at lower elevations were more dissimilarity in species number of tree, sapling and seedling.

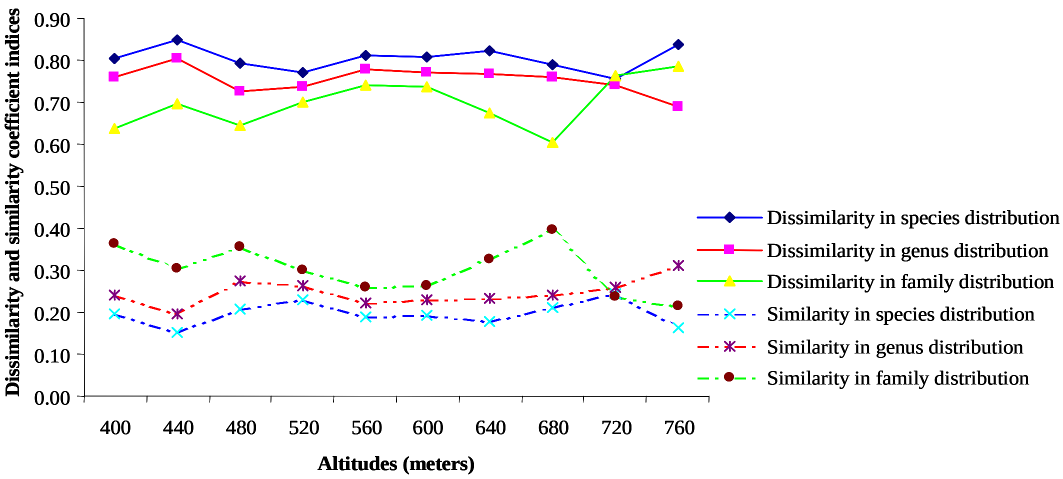


Figure 18. **The Sørensen's coefficients indices of all vascular plants over the whole area among aspects at various altitudes.**

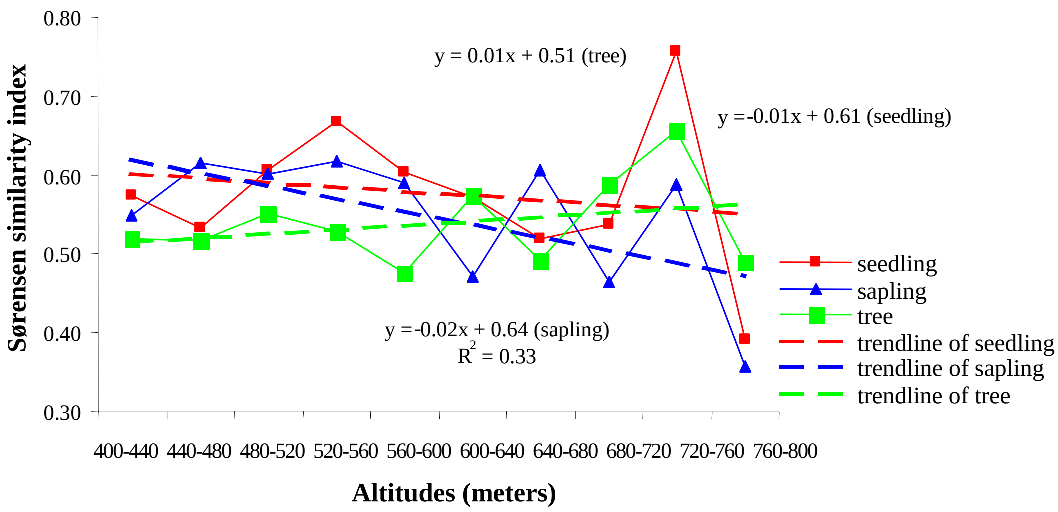


Figure 19. **The Sørensen's similarity indices between pairs of samples found along adjacent elevations of tree, sapling and seedling species distributions over the whole area.**

From Table 3, tree community (≥ 4.5 dbh and > 1.30 meters in height) varied widely along aspects and altitudes. In the north and east aspects, species, genera, families and individual numbers of woody tree were high at higher altitudes, (720-760 mters) and low at lower elevation whereas in the east and south aspects were peaked at lower elevations. Tree species number in each aspect peaked at various elevations as 760, 560, 760, 640 meters and low at 440, 400, 640, 760 meters in the north, east, south and west aspects. For the distribution of genera, it peaked at 760, 560 and 680, 760, 440 meters but low at 400, 440, 640, 760 meters in the north, east, south and west aspects. The number of families peaked at 760, 720, 760, 600 meters and were low at 440, 400, 640, 760 meters in the north, east, south and west aspects. For the distribution of individuals, it was abundant at 720, 560, 600, 480 meters and low at 520, 440, 520, 520 meters in the north, east, south and west aspects respectively. Considering aspects, the west aspect showed lesser in species composition than other aspects. Acording to altitudes, most of stands were located at 520 meter which were lower in species, genera, families and individuals than other altitudes. However, along altitudes and aspects over the whole area, its distribution displayed that the northern and southern aspects were higher in average numbers of species, genera, families and individuals than in the east and west aspects. In general, the east and west aspects were high in sunlight which caused decreasing in moisture. The available moisture is important in plant community, especially deciduous species being generally confines to moisture (Namikawa, Okamoto and Sano, 2000). An increase in soil moisture leads to increase in the number of species on the ground vegetation (Hardtle, Oheimb and Westphal, 2003).

Table 3. **The number of species, genera, families and individuals of trees at various altitudes and aspects.**

Aspects		Altitudes (meters)											Averages
		400	440	480	520	560	600	640	680	720	760	800	(Unit: No.)
North	Species	24	21	30	30	28	36	25	22	29	37	28	28
	Genera	20	21	24	28	26	31	23	21	25	33	26	25
	Families	15	14	18	21	20	22	16	17	18	26	19	19
	Individuals	104	127	104	89	166	125	94	116	184	151	121	126
East	Species	13	11	17	22	28	21	20	26	27	25	28	21
	Genera	12	10	15	19	25	18	17	25	24	22	26	19
	Families	9	10	14	17	18	14	15	17	19	17	19	15
	Individuals	64	34	106	93	320	101	122	80	116	104	121	114
South	Species	31	30	25	21	26	23	9	11	28	35	28	24
	Genera	30	26	23	19	23	19	8	11	24	33	26	22
	Families	22	18	17	15	16	14	8	9	20	23	19	16
	Individuals	114	106	95	71	68	248	219	150	110	145	121	133
West	Species	18	25	20	19	12	22	25	20	13	3	28	18
	Genera	16	22	15	14	12	21	21	16	12	3	26	15
	Families	15	18	13	12	12	18	14	12	10	3	19	13
	Individuals	72	59	127	109	105	119	102	103	52	54	121	90

The relationship between altitudes and the distribution of species, genera, families and total number of individuals in each aspect were carried out by Pearson analysis. The correlation of species and altitudes were 0.427, 0.790, – 0.191, – 0.520 in the north, east, south and west respectively while only the east aspect fallen in a significant at $p<0.05$. It indicated that species distribution on eastern positively correlated with elevations. The correlation between genera and altitudes were 0.504, 0.774, – 0.199, – 0.495 at the north, east, south and west aspects respectively. The correlation between the number of families and altitudes were 0.552, 0.771, – 0.147, – 0.671 at the north, east, south and west aspects. The correlation between the number of individuals and altitudes were 0.495, 0.160, 0.370, – 0.220 at the north, east, south and west aspects. Apparently, at the east aspect the number of species, genera and families were significantly correlated with altitude. At the north and west aspects, only the number of families was significantly correlated with altitudes. For the south aspect, it showed that the distribution in plant community was not correlated with altitude. Most of tree communities at the north and the east aspects increased in species, genera, families and individuals at higher elevations while at the south and the west aspects decreased with higher elevation. Additionally, the trendlines from Figures 20 to 23 showed similarity trend in Pearson correlation. It implied that the north and the east aspects were more likely increasing in species, genera, families and individuals at higher altitudes whereas the south and the west aspects tended to decrease at higher altitudes because of the increasing in slope. However, the correlation coefficients between species, genera, families, and individuals for the whole area were – 0.525, – 0.493, – 0.665, – 0.107, respectively. Only the numbers of species and family were significant correlated. The results clearly indicated that tree communities (≥ 4.5 dbh and > 1.30 meters in height) in the study area tended to decrease at higher elevations. It was also supported by Sørensen coefficient according to Figures 27 and 28. Dissimilarity values were between 50-100% in all aspects while only the west aspect tended to increase at higher elevations (Figure 24).

This indicated that all of tree species compositions are differently distributed along altitudes in all aspects. However, considering for similarity coefficients over the whole area, the numbers of tree species (Figure 19) were between 45-70% in similarity values along altitudes. Whereas it was strongly different, around 0-15% of similarity values along aspects (Figure 25). This meaned that tree communities distributed in vertical direction were more homogeneity in distributions along altitudes than along the aspects.

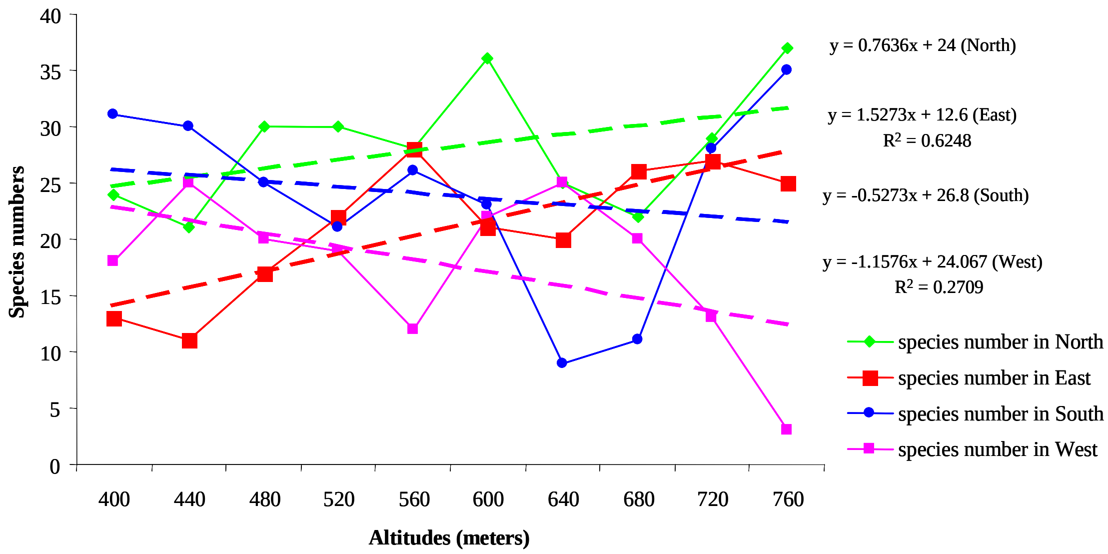


Figure 20. **Distribution of species number of woody trees at various altitudes and aspects.**

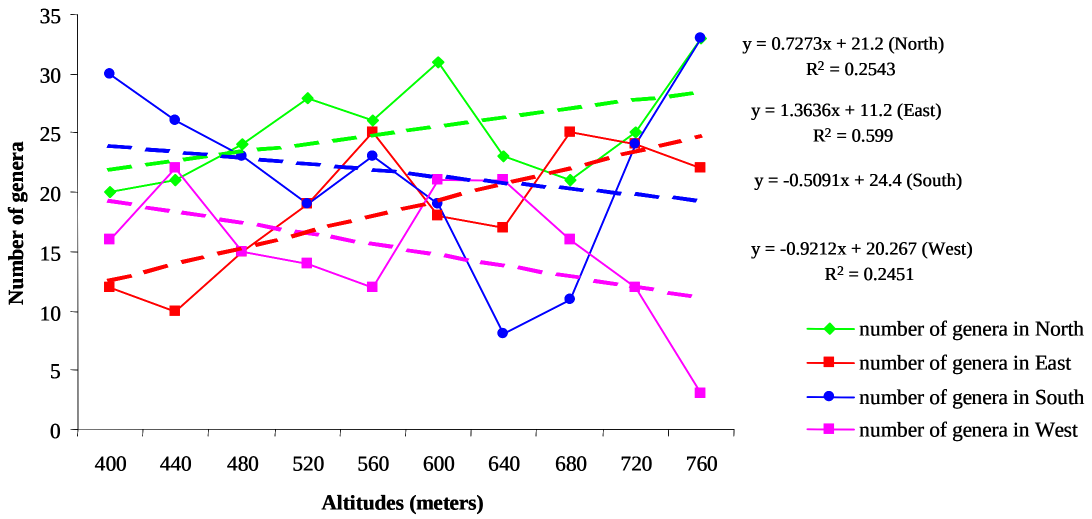


Figure 21. **Distribution patterns of genera of woody tree at various altitudes and aspects.**

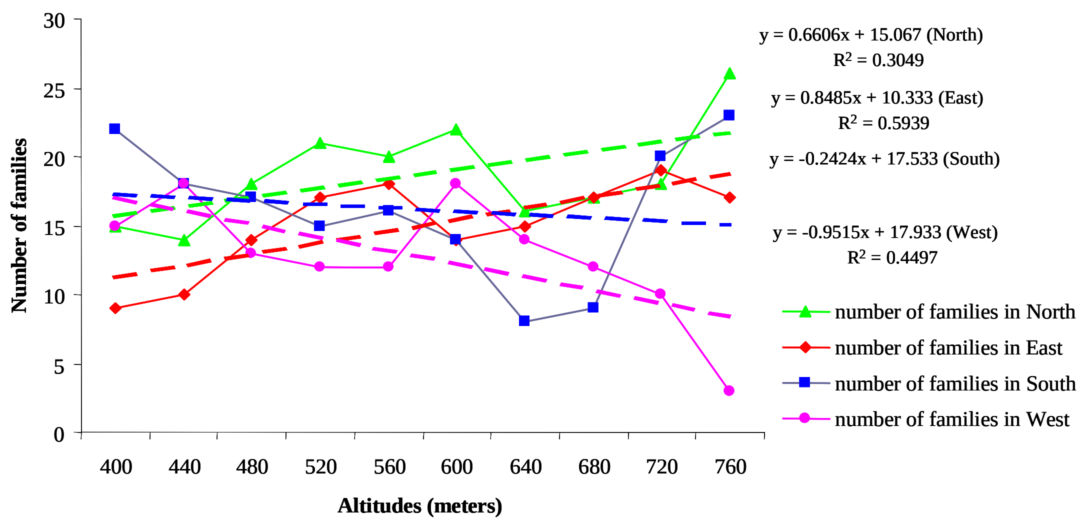


Figure 22. **Distribution patterns of families of woody tree at various altitudes and aspects.**

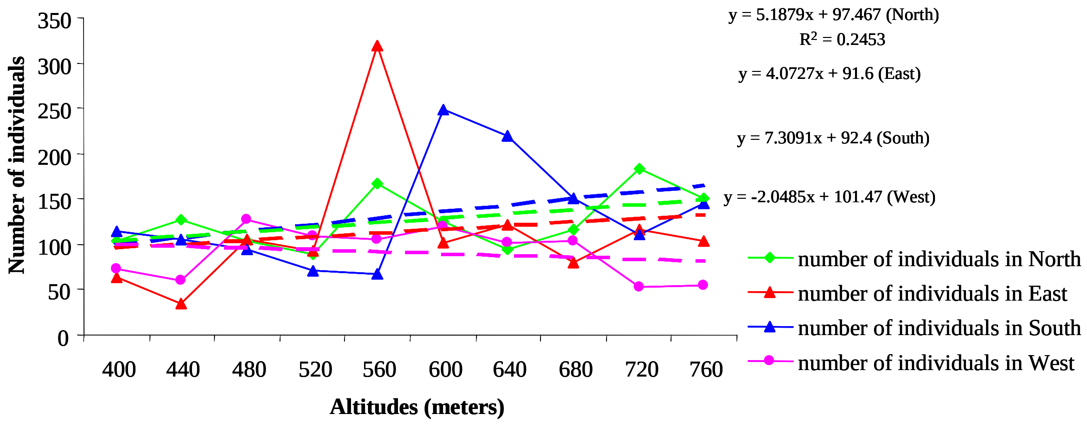


Figure 23. **Distributions of individual number of woody tree at various altitudes and aspects.**

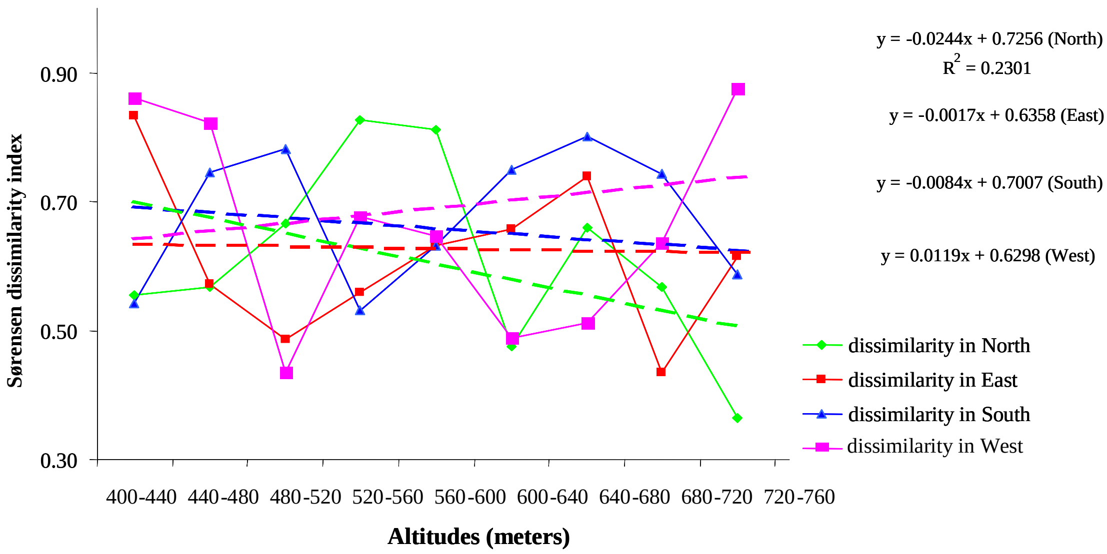


Figure 24. **The Sørensen's dissimilarity index of tree species distribution between pairs of samples found along adjacent elevations of each aspect.**

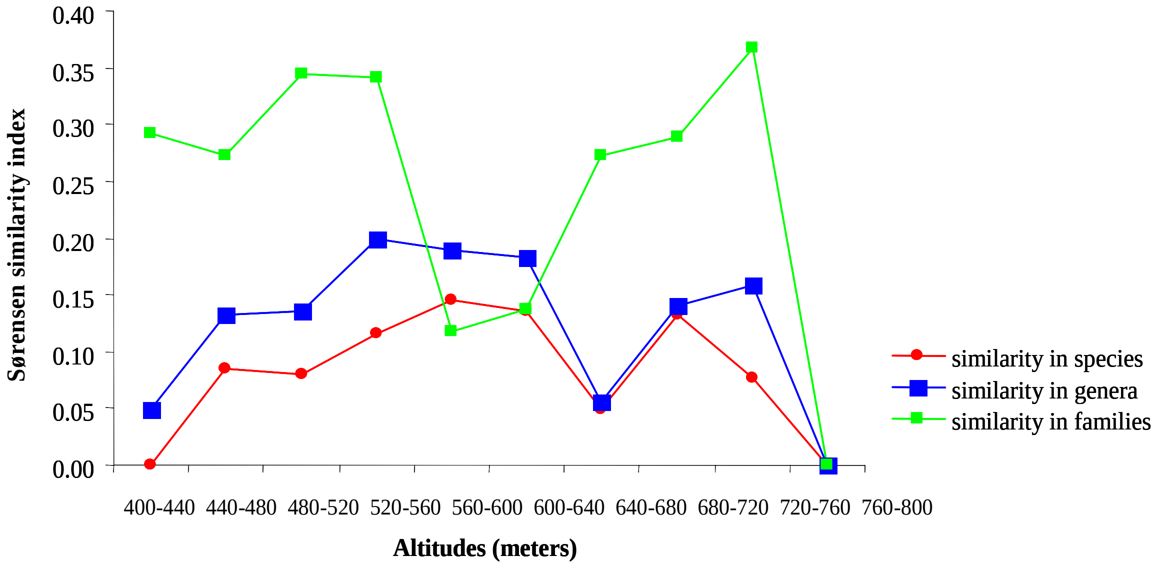


Figure 25. The Sørensen's similarity index of tree found among aspects along altitudinal gradients.

For sapling (≤ 4.5 dbh and > 1.30 meter in height), species distribution in each aspects and altitudes are reported as Table 4. The information shows that most of sapling communities are different in the numbers of distribution along various aspects and altitudes. Species number peaked at lower elevations (440-480 meters) and low at higher elevations (680-760 meters.) in the south and the west aspects. In the north and east aspects, they peaked at 520 and 640 meters and were low at 680 and 600 meters in the north and east aspects respectively. For the distribution on genera, they peaked at 520, 440, 440, 480 meters and were low at 680, 600, 680, 720 metes in the north, east, south and west aspects respectively. The number of families peaked at 520, 400, 720 meters and were low at 680, 600, 680 metes in the north, east and south aspects. For the west aspect, various altitudes showed peaking at 480, 520, 600 meters and lowing at 720 meters. For the distribution on individuals were dominated at the elevation of 400, 480, 520, 520 meters and low at 640, 560, 640, 720 meters in the north, east, south and west aspects respectively. Considering on aspects, the west aspect showed lesser in species composition of tree community. There were seven stands, which are lower in the number of species composition than other aspects, six stands in species, seven stands in genera, seven stands in families and four stands in individual numbers. Considering at 600 meter altitude, most of stands were lower in species, genera, families and individuals than other altitudes. Interestingly, sapling peaked in species composition at 520 meter elevation but it was lowest in species composition of tree community. The results suggested that sapling and tree negatively correlated in distribution. This is may be due to decreasing in tree community at 520 mater resulted to more open and more in available resources for sapling community. Waldern and Kingston (2003) reported that understory affected by the canopy species and light environment. Thus at this elevation had more diverse in sapling community than other elevations. However sapling distribution along altitudes and aspects over the whole area showed that the north and east aspects were higher in average number of species, genera, families and individuals than the south and west aspects. It was slightly different from tree community especially on the east aspect. Due to decrease in species composition in the east aspect, the area had more available resources for sapling. These results confirmed the negative relation between tree and understory. The disturbances within the forest especially when tree removed promoted small gaps which influenced the availability of resources for understory species such as light, water, and nutrients (Marks, 1974; Bormann and Likens, 1979; Barton, 2003) which were critical for establishment and growth.

The relationship between altitudes and species distribution on sapling were – 0.430, 0.510, – 0.568, – 0.572 in the north, east, south and west respectively, where the south and west values were significant correlation. The species number in the south and west aspects were negatively correlated with altitudes. For genus and family distribution, the relationship between altitudes were – 0.226, 0.056, – 0.494, – 0.768 on genus distribution and – 0.100, 0.078, – 0.272, – 0.707 on family distribution in the north, east, south and west respectively. Only the west aspect correlated with elevation significantly. For the relationship pattern on the number of individuals, their correlation coefficients were 0.212, 0.002, – 0.276, – 0.588 at the north, east, south and west aspects. Only at the west aspect, the individual distribution was significantly correlated. From Figures 26 to 28 species, genera and families were similar direction. The distributions at high elevations in the north, south and west aspects tended to decrease whereas only the east aspect it tended to increase at high elevations. For individual distribution, trendlines shown linear at 1.593, 0.018, – 3.290, – 7.490 with altitudes (Figure 29). In the north and east, it tended to increase at higher elevations and decrease in the south and west aspects. Conspicuously, the distributions on the south and west were sharply affected by elevations in all of species, genera, families and number of individuals. This may be caused from some variations in topographic factors like tree community. However, the correlation coefficients between species, genera, families and individuals over the whole area were – 0.723, – 0.652, – 0.472, – 0.595 respectively. The number of species and genera were closely related with altitudes in negative direction. With similarity analysis on species composition (Figure 30), it showed that most of saplings was strongly different in species composition in all aspects, especially in the west aspect, and also tended to increase at higher altitudes. The average dissimilarity values were around 30-90% along altitudes in each aspect (Figure 30). Over the whole area on sapling communities, similarity of species distributions of samples along elevations (Figure 19) were between 35-65% while similarity of aspects (Figure 31) were between 0-25%. Conspicuously, species distribution on sapling are more likely to be distributed along elevation direction. This implied that aspects effectd to the difference in sapling composition more than elevations.

Table 4. The number of species, genera, families and individuals of woody saplings at various altitudes and aspects.

Aspects		**Altitudes (meters)**											**Averages**
		400	**440**	**480**	**520**	**560**	**600**	**640**	**680**	**720**	**760**	**800**	**(Unit: No.)**
North	Species	22	19	22	29	19	23	20	15	20	18	16	21
	Genera	19	16	20	26	16	22	17	15	18	18	16	19
	Families	14	14	14	18	12	17	12	11	15	15	16	14
	Individuals	106	77	78	100	120	93	62	141	91	105	58	97
East	Species	22	22	14	21	22	12	24	22	18	22	16	20
	Genera	19	21	14	17	20	12	19	20	17	20	16	18
	Families	18	14	11	15	14	10	13	17	14	17	16	14
	Individuals	87	82	144	112	72	74	114	88	84	116	58	97
South	Species	22	29	23	20	16	15	14	11	25	14	16	19
	Genera	18	24	20	19	12	15	14	11	21	14	16	17
	Families	14	19	15	14	10	13	13	8	20	11	16	14
	Individuals	81	72	68	161	80	45	32	45	57	92	58	73

Table 4. (Continued).

Aspects		Altitudes (meters)											Averages
		400	440	480	520	560	600	640	680	720	760	800	(Unit: No.)
West	Species	16	19	22	21	13	15	17	20	11	10	16	16
	Genera	16	17	19	19	13	14	15	15	11	10	16	15
	Families	13	12	14	14	12	14	12	12	7	8	16	12
	Individuals	109	57	115	145	98	114	89	83	24	32	58	87

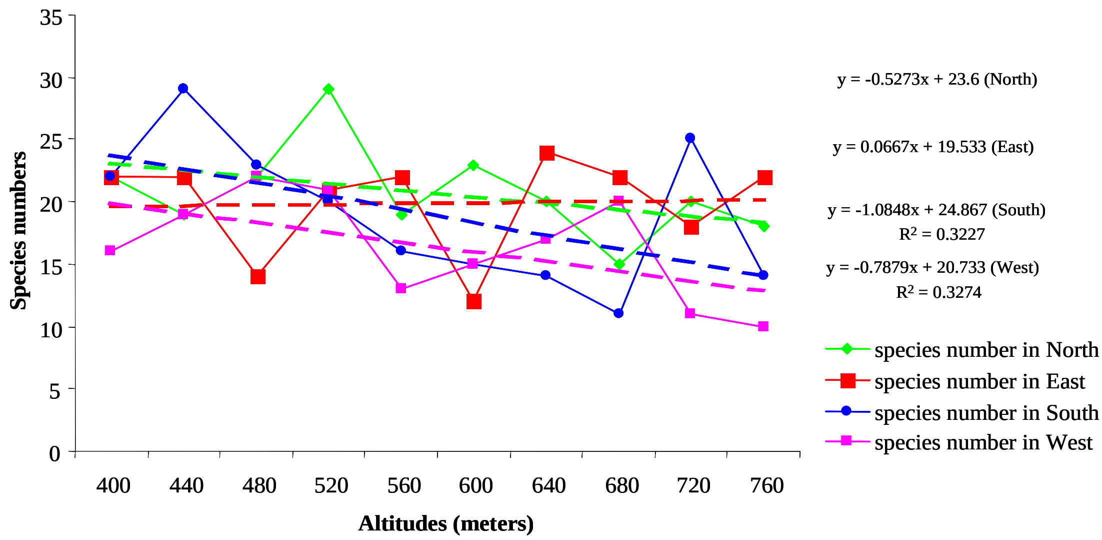


Figure 26. **Distribution of species number of woody sapling at various altitudes and aspects.**

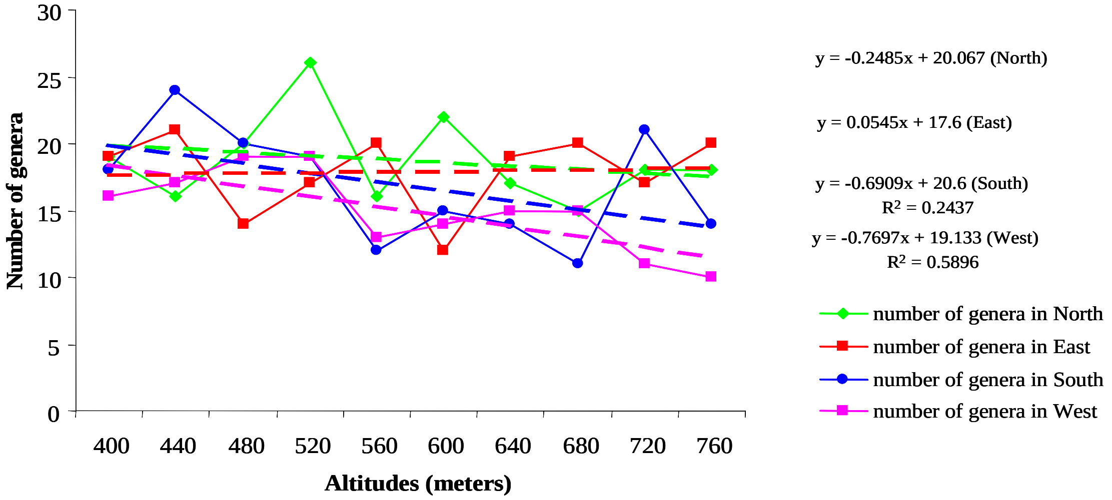


Figure 27. Distribution patterns of genera of woody sapling at various altitides and aspects.

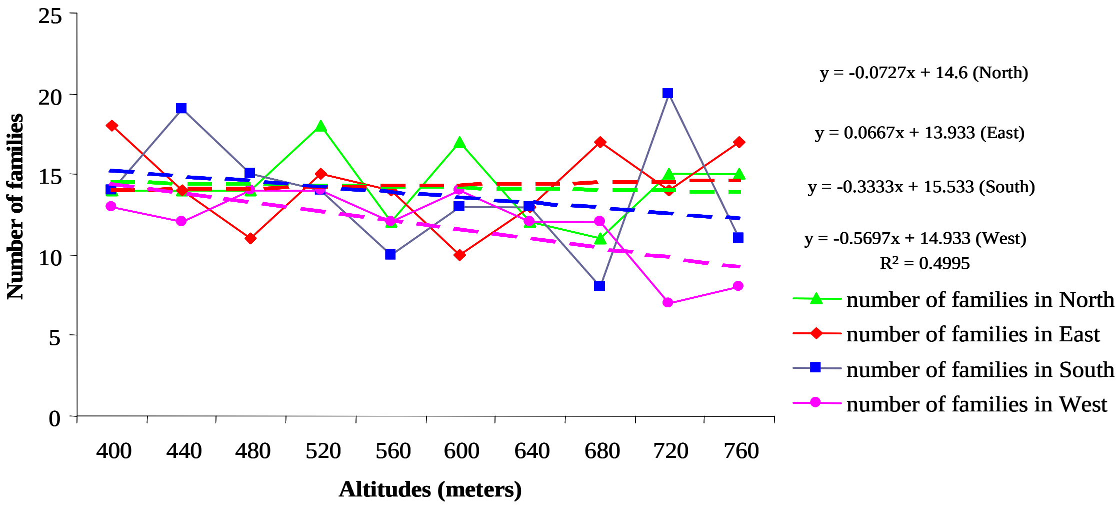


Figure 28. Distribution patterns of families of woody sapling at various altitides and aspects.

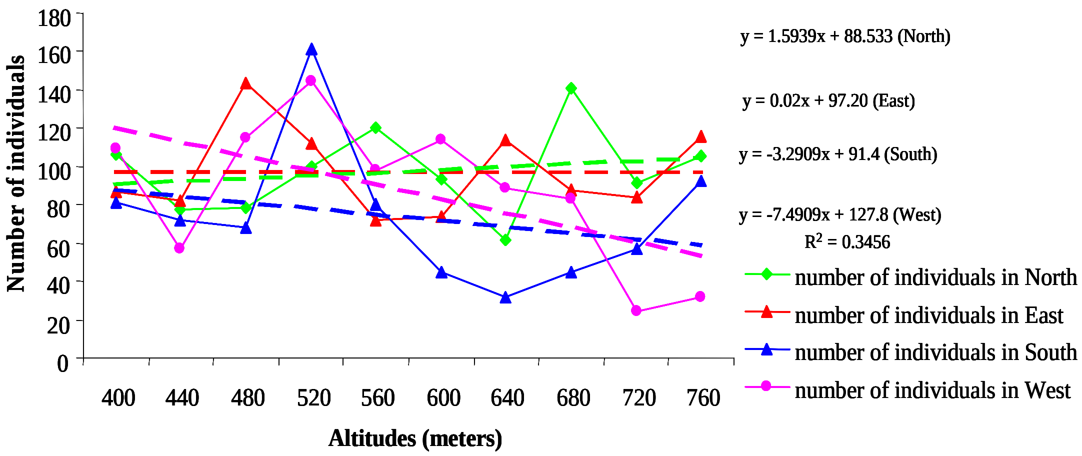


Figure 29. **Distribution of individual number of woody sapling at various altitudes and aspects.**

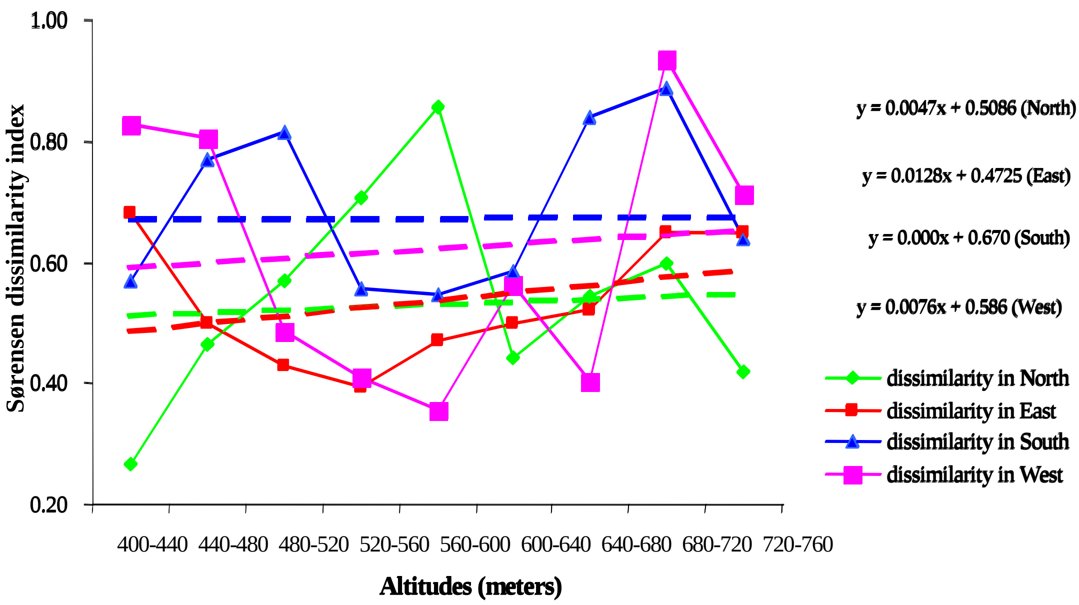


Figure 30. **The Sørensen's dissimilarity index of woody sapling distribution between pairs of samples found along adjacent elevations of each aspect.**

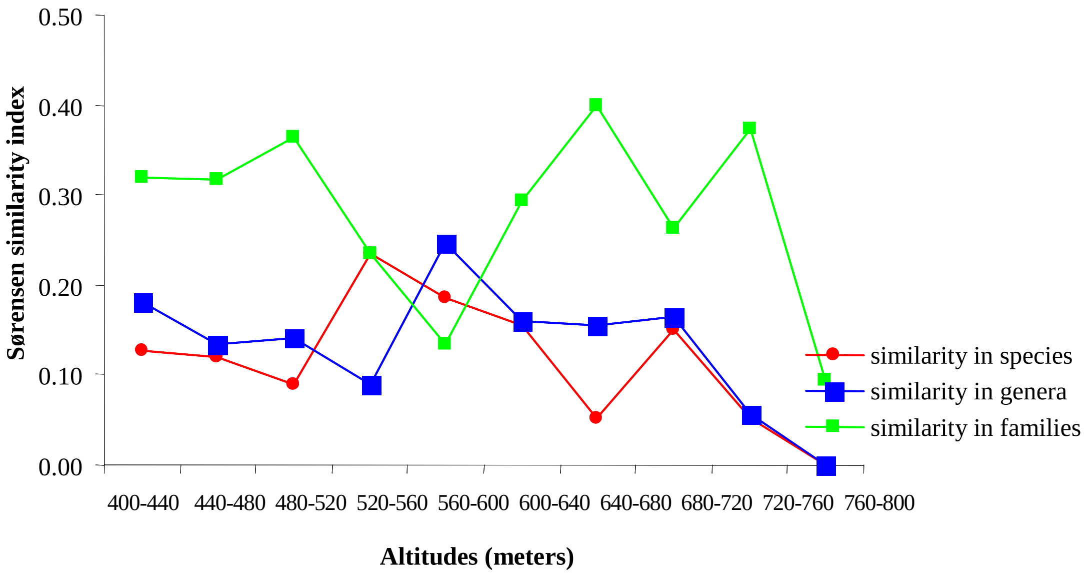


Figure 31. The Sørensen's similarity index of woody sapling found among aspects along altitudinal gradients.

From Table 5, seedling community (< 1.30 meter in height) showed that the number of seedling species peaked at 400, 640, 760, 480 meters and were low at 520 and 640, 400, 680, 760 meters in the north, east, south and west aspects respectively. The distribution of genera peaked at 680 and 400, 720, 480, 480 meters and were low at 520, 400, 560, 760 in the north, east, south and west aspects. The number of families peaked at 720, 640, 480, 440 meters and were low at 520, 400, 680, 760 meters in the north, east, south and west aspects. For the distribution of individuals, they were dominated at 560 and 720, 600, 520, 520 meters and were low at 520, 520, 640, 760 meters in the north, east, south and west aspects. Considering on aspects, the west aspect was still lesser in species composition of tree and sapling communities than other aspects. There were five stands, which were lower in the number of species composition than average value of six stands in genera, seven stands in families and five stands in individual numbers. Considering on altitudes, most of stands located at 560 meter were lower in species, genera, families and individuals than other altitudes. However, seedling distribution along altitudes and aspects over the whole area showed that northern and eastern were higher in average number of species, genus, family and individuals than the south and west aspects. Seedling distribution strongly differed from tree community. Owing to the variation in topographic features on the east aspects, especially slope ranges, tree community tended to decline and slightly lower in distribution than other aspects. As a result it had more open and also more available resources for sapling and seedling. Thus both sapling and seedling distributions seemed to be supported by these variations. The correlations between seedlings and altitudes in each aspect were not significantly associated with altitudes except the individual distribution on the west aspect. The correlations of species numbers and altitudes were – 0.363, 0.423, – 0.61, – 0.323 in the north, east, south and west respectively. For the number of genera, their correlations were – 0.178, 0.502, 0.011, – 0.380 in the north, east, south and west respectively. The correlations between the number of families and altitudes were 0.068, 0.200, 0.360, – 0.028 at the north, east, south and west aspects. For the relationship pattern on the number of individuals, the correlation values were 0.020, – 0.282, – 0.128, – 0.640 at the north, east, south and west aspects where only the west aspect was significant correlated. However, considering over the whole area, the correlation patterns were – 0.374, – 0.246, – 0.428, – 0.681 of species, genera, families and individuals at the north, east, south and west respectively. Only the distribution on individual number correlated with altitudes significantly. On the trendlines in species distribution (Figures 32 to 33), the numbers of species and genera tended to decline linearly with altitudes whereas families and individuals (Figures 34 to 35) tended to increase with altitudes in the north aspect. In the east aspect, the number of species and genera declined along altitudes while the number of families and individuals increased along altitudes. The trendline on the south showed that species and individual distributions were decreased along altitudes and increased in family and individual number along altitudes as shown in Figures 32 to 35. Only the west aspect, it was high in the percentage of slope range, the distributions in species, genera, families and individuals declined with altitudes. Conspicuously, the slope range is one of topographic factors, which can cause to decrease in the numbers of species, genera, families and individuals of all vascular plant including tree, sapling and seedling communities. It occurred on the west aspect. The dissimilarity between pairs of samples tended to increase at the east, south and west aspects. Over the whole area, the Sørensen similarity values in species composition of seedling (Figure 19) were between 45-90% along altitudes, while along aspects (Figure 37) were between 5-20% in similarity values. In seedling compositions were distributed along elevation direction of tree and sapling communities. It was clearly demonstrated that along aspects had more varied in topographic factors.

Table 5. The number of species, genera, families and individuals of seedlings at various altitudes and aspects.

Aspects		Altitudes (meters)											Averages
		400	440	480	520	560	600	640	680	720	760	800	(Unit: No.)
North	Species	20	18	18	13	17	15	13	18	17	16	11	16
	Genera	18	16	17	12	15	15	13	18	16	15	9	15
	Families	12	12	12	7	11	13	11	8	14	12	9	12
	Individuals	54	52	54	37	67	50	36	61	67	42	36	87
East	Species	9	19	16	17	14	15	21	16	19	16	11	16
	Genera	9	18	13	17	12	15	17	15	19	16	9	15
	Families	8	12	9	14	8	11	12	11	13	9	9	12
	Individuals	59	59	62	44	53	70	63	48	56	47	36	87
South	Species	16	13	23	16	12	16	14	11	15	20	11	16
	Genera	15	12	21	16	11	15	13	11	15	19	9	15
	Families	9	9	14	11	9	8	11	8	14	14	9	12
	Individuals	49	36	48	77	34	42	23	31	39	61	36	87
West	Species	13	15	17	15	14	11	15	14	16	10	11	16
	Genera	13	14	15	13	13	11	15	13	14	10	9	15
	Families	9	12	10	9	9	10	11	10	12	8	9	12
	Individuals	59	40	54	72	53	41	40	56	23	21	36	87

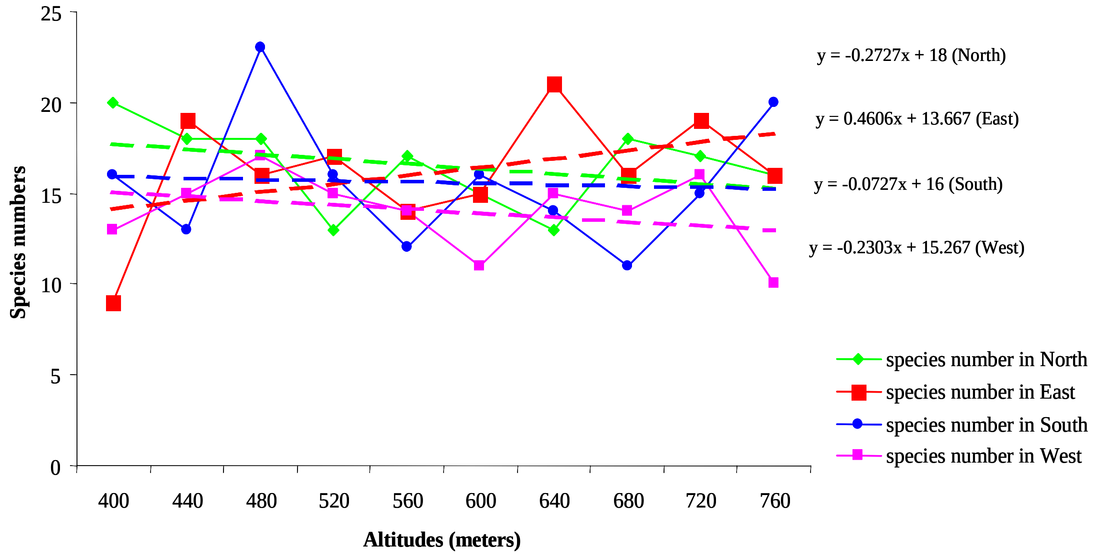


Figure 32. Distribution of species number of seedling at various altitudes and aspects.

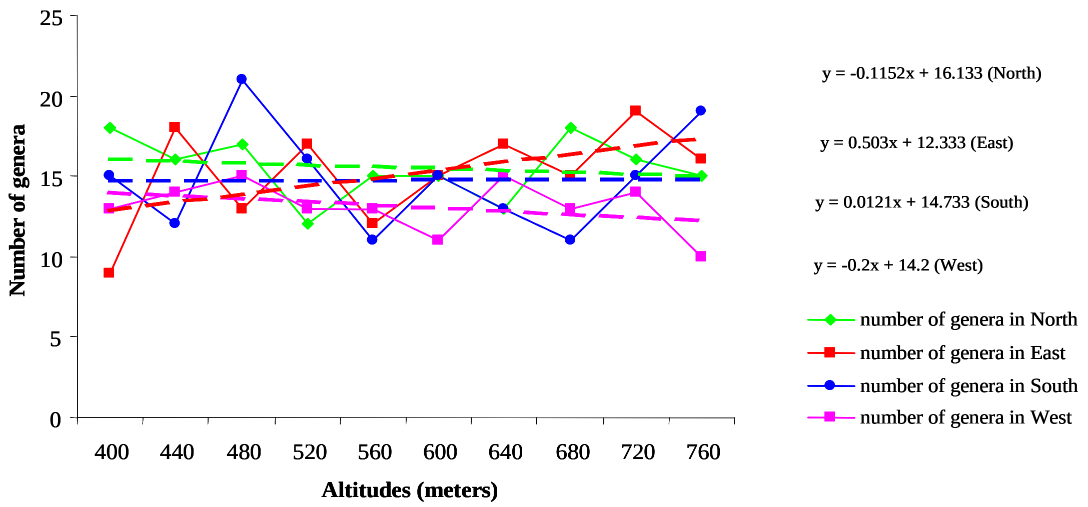


Figure 33. Distribution patterns of genera of seedling at various altitudes and aspects.

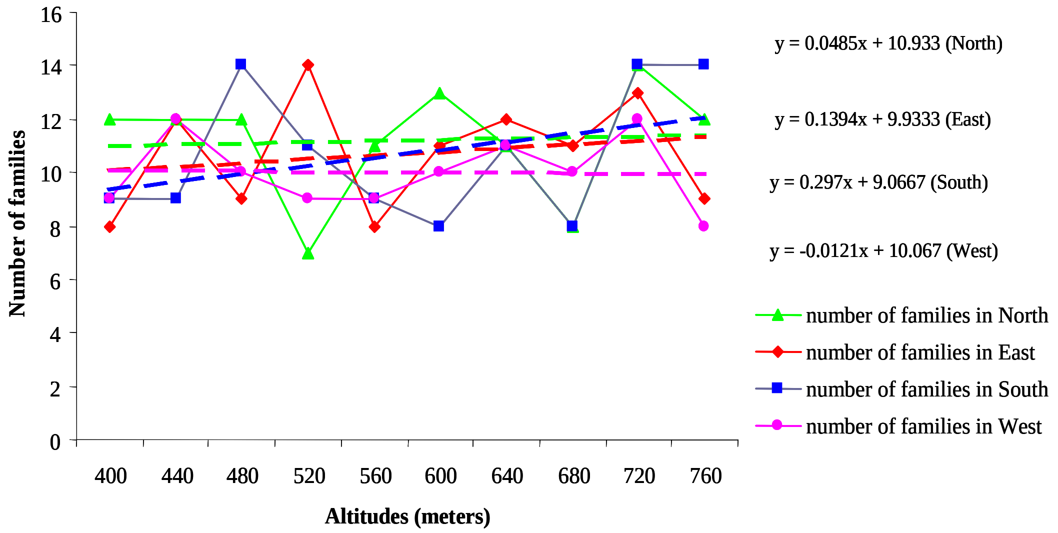


Figure 34. Distribution patterns of families of seedling at various altitudes and aspects.

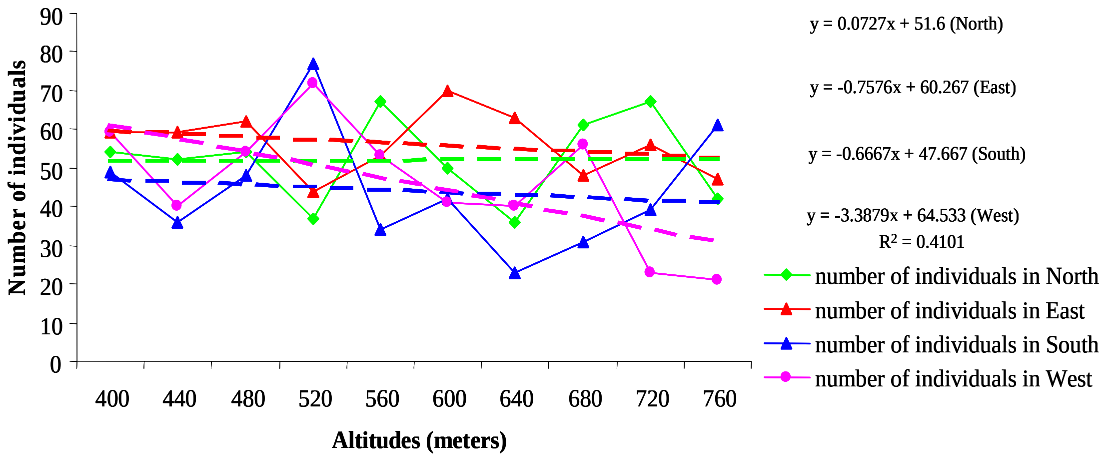


Figure 35. Distribution of individual numbers of woody seedling at various altitudes and aspects.

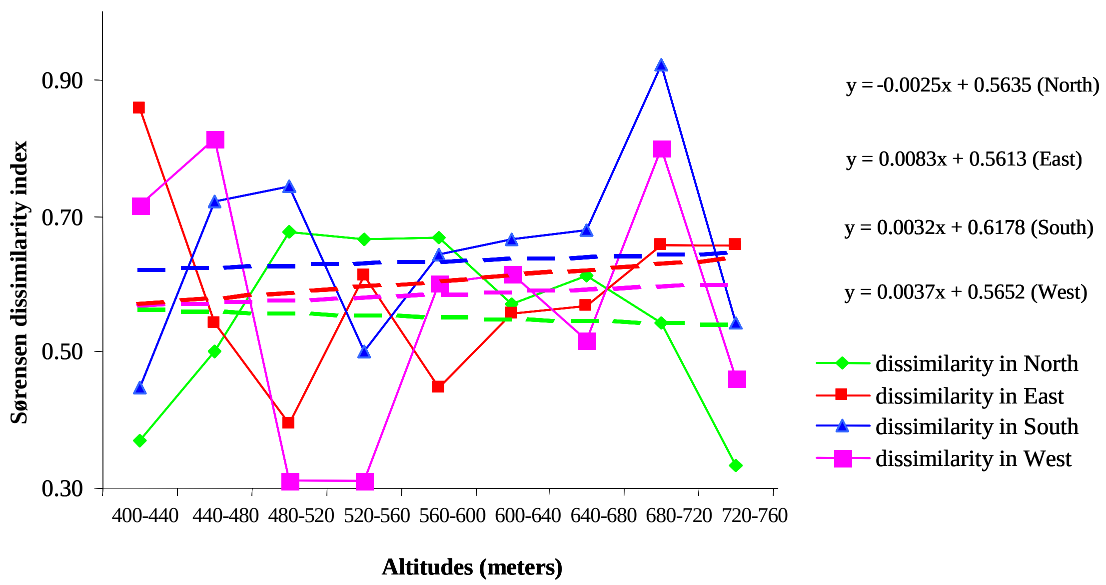


Figure 36. **The Sørensen's dissimilarity index of seedling species distribution between pairs of samples found along adjacent elevations of each aspect.**

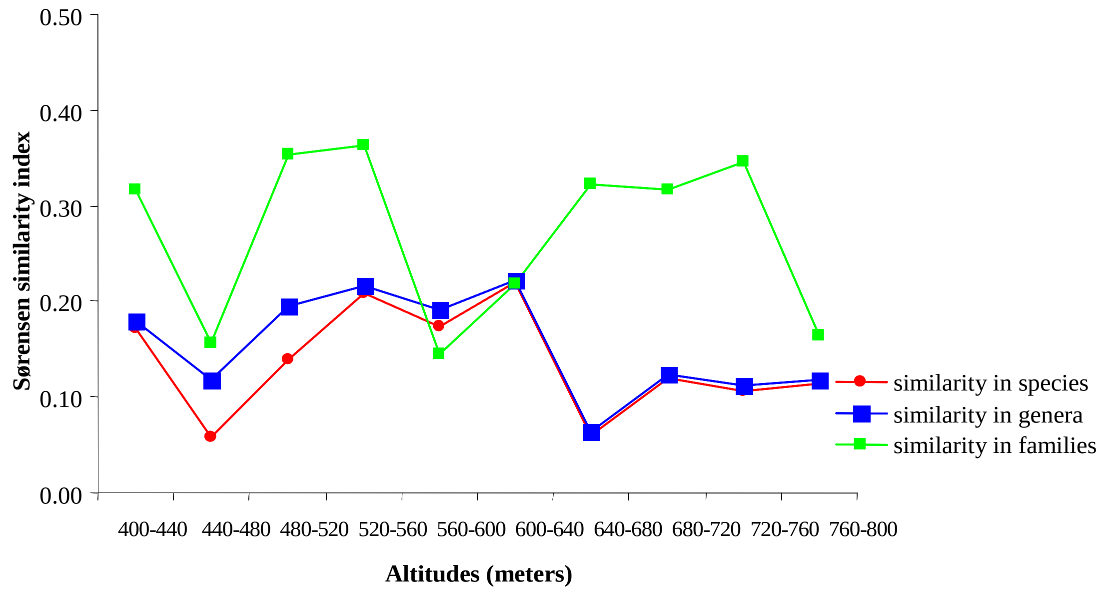


Figure 37. **The Sørensen's similarity index of seedling found among aspects along altitudinal gradients.**

In conclusion, the species distributions (species richness) considerably varied along altitudes and aspects according to Appendix Figures 1 to 3. Most of tree, sapling and seedling distributions dominated at the north aspect while the west aspect was lowest in species distribution. According to topography interpolation, it showed that at the west aspect topographic factors varied considerably especially slope range and aspect directions. Whereas at the north aspect it showed lower in degree of slope. Ingeneral the east and west aspects had high in sunlight than the north and south aspects affecting to decrease in available moisture (Namikawa, Okamoto and Sano, 2000). This may cause variation in plant communities between the north and west aspects. Considering on altitudes, it demonstrated that species distribution of vascular plant were low at 520, 600, 560 meters in tree, sapling and seedling. Tree species distribution peaked at 560, 720 and 760 meters. For sapling, it peaked at 520 meter, where it was low in tree composition. Seedling species distribution peaked at 720 meter. All of species distribution tended to be more similar in species composition along elevations than along the aspects. Thus it clearly demonstrated that topographic factors were the major cause of variation in plant community composition (Hanson and Churchill, 1964; Xiongween, 2001; Kadaval, 1999; Bell, 2000; Vivain, 1997).

4.2 Importance Value Index

Importance values were average of two or more of frequency, dominance and density parameters. It was used to identify dominant species in plant communities because it was not overwhelming influenced by large tree size (as relative dominance) or large numbers of small tree (as relative frequency and relative density) (McCune and Grace, 2002). Therefore it expressed characteristics of each individual species greatly. The study on plant community variations based on topographical gradients and environmental factors was analyzed separately in each altitude and aspect for tree, sapling and seedling communities as shown in Appendix Table 3 to 5.

4.2.1 Importance value index at various altitudes and aspects

4.2.1.1 North aspect

At the north aspect, plant community from 400-800 meters above sea level covered with 129 species, 43 families of all vegetation (tree, sapling and seedling). The common species of all vegetation distributed at the north aspect were *Hopea ferrea* Pierre and *Memecylon ovatum* J.E. Smith. According to phytograph *H. ferrea* showed high in density and dominance values (Figure 38(a)). While *M. ovatum* was less in dominance but it's distribution was in a wide range of altitudes based on a relative frequency value. These individual characteristics seemed to be more successful in ecological performance than others. Therefore *H. ferrea* and *M. ovatum* can be found in tree, sapling and seedling communities along the north aspect. Each altitude species composition and community conspicuously varied as in the following:

Altitude 400 meter above mean sea level: Plant community composed of 24 species in tree, 22 species in sapling and 20 species in seedling. Five dominant species varied among tree, sapling and seedling group. Tree was identified as *H. ferrea*, *Hydnocarpus ilicifolius* King, *Walsura trichostemon* Miq., *Streblus ilicifolius* Corner, and *M. ovatum*, with importance value index (IVI) of 96.25, 37.26, 23.60, 23.32 and 17.01 respectively. Sapling species were *P. evecta*, *S. ilicifolius*, *Acalypha siamensis* Oliv. ex Gage, *Murraya paniculata* Jack, and *Syzygium cumini* Druce, with importance value index (IVI) at 23.28, 21.27, 18.44, 16.28 and 14.00 respectively. Seedling species showed in *M. paniculata*, *S. ilicifolius*, *S. cumini*, *Cleistanthus hirsutulus* Hook. f., and *Croton cascarilloides* Raeusch., with importance value index (IVI) of 31.02, 27.31, 14.91, 13.06 and 13.06 respectively.

Altitude 440 meter above mean sea level: Five dominant species from 21 species in tree, were *H. ferrea*, *W. trichostemon*, *M. ovatum*, *Aglaia pirifera* Hance and *H. ilicifolius*, with 110.91, 30.43, 25.16, 24.44 and 20.64 of importance value index. The five sapling dominant species from 19 species were identified as *A. siamensis*, *A. pirifera*, *H. ferrea*, *M. paniculata*, and *M. ovatum*, with 31.58, 25.58, 17.09, 16.39 and 14.49 of importance value index. For seedling community, five dominant seedling species from 18 species were *M. paniculata*, *H. ferrea*, *A. siamensis*, *C. hirsutulus*, and *Hopea odorata* Roxb., with 28.46, 23.46, 19.62, 17.12 and 17.12 of importance value index respectively.

Altitude 480 meter above mean sea level: This stand composed of 30 species in tree, 22 species in sapling and 18 species. Five dominant tree species were *H. ferrea*, *W. trichostemon*, *Shorea henryana* Pierre, *H. ilicifolius*, and *S. cumini*, at 53.04, 26.52, 25.74, 25.08, 19.95 of importance value index. The five dominant sapling species were *C. hirsutulus*, *S. cumini*, *P. evecta*, *H. ferrea*, and *M. ovatum*, with 25.42, 19.69, 18.41, 15.92, and 13.96 of importance value index. The five dominant seedling species were *C. hirsutulus*, *H. ferrea*, *S. cumini*, *M. scutellatum*, and *A. pirifera*, with 35.04, 25.78, 23.93, 23.93 and 15.10 of importance value index respectively.

Altitude 520 meter above mean sea level: Five dominant tree species from 30 species identified as *Mangifera caloneura* Kurz, *Syzygium siamensis* Craib, *W. trichostemon*, *M. ovatum*, and *H. ilicifolius*, with 60.04, 39.71, 29.80, 16.87, and 16.33 of importance value index. For sapling community, five dominant sapling species from 29 species identified as *W. trichostemon*, *S. siamensis*, *S. ilicifolius*, *Pinanga hookeriana*, and *A. kerrii*, with 28.09, 25.21, 14.55, 11.77 and 10.66 of importance value index. The five dominant seedling species from 13 species were identified as *S. ilicifolius*, *C. cascarilloides*, *Caryota mitis* Lour., *Mallotus philippensis* Muell. Arg., and *Urobotrya siamensis* Hiepko, with 35.26, 27.15, 27.15, 21.74 and 14.50 of importance value index respectively.

Altitude 560 meter above mean sea level: Five dominant tree species from 28 species were *M. ovatum*, *H. ferrea*, *S. cumini*, *W. trichostemon*, and *Manilkara hexandra* Dubard, with IVI values as 85.25, 45.73, 41.06, 25.07, and 10.69 respectively. Five sapling dominant species from 19 species were *H. ferrea*, *W. trichostemon*, *S. cumini*, *H. odorata*, and *M. ovatum*, with IVI values as 50.56, 25.56, 21.94, 20.00 and 17.22. Five seedling dominant species from 17 species were *S. cumini*, *H. ferrea*, *C. cascarilloides*, *M. ovatum*, and *C. hirsutulus*, with IVI values as 31.80, 29.02, 27.32, 25.83 and 15.80 respectively.

Altitude 600 meter above mean sea level: It covered with 36 species in tree group. The five dominant tree species were *Acronychia pedunculata* Miq., *S. siamensis*, *Knema furfuracea* Warb., *Lithocarpus fenestratus* Rehd., and *S. henryana*, with 35.43, 24.69, 23.71, 21.17 and 21.13 of importance value index. The five dominant sapling species from 23 species were *C. hirsutulus*, *Mischocarpus grandis* Radlk., *A. pedunculata*, *Eurycoma longifolia* Jack, and *S. siamensis*, with IVI values at 55.88, 18.17, 16.13, 12.32 and 11.70. Seedling community covered with 15 species. The five dominant seedling species were *C. hirsutulus*, *Ardisia lenticellata* Fletch., *U. siamensis*, *K. furfuracea*, *Ixora cibdela* Craib, and *M. grandis*, with 67.03, 22.90, 17.68, 14.45, 12.45 of IVI values respectively.

Altitude 640 meter above mean sea level: Five dominant tree species from 25 species identified as *S. siamensis*, *Anisoptera costata* Korth., *K. furfuracea*, *M. ovatum*, and *Vitex glabrata* R. Br., with 50.30, 37.80, 28.16, 23.88, and 18.11 of IVI values. The five dominant sapling species from 20 species were *C. hirsutulus*, *S. siamensis*, *M. paniculata*, *I. cibdela*, and *U. siamensis*, with 30.41, 23.20, 19.20, 16.82 and 15.21 of IVI values. For seedling species, the five dominant species from 13 species were *M. paniculata*, *I. cibdela*, *S. siamensis*, *S. ilicifolius*, and *A. lenticellata*, with 27.78, 26.39, 26.39, 20.83, and 19.44 of IVI values respectively.

Altitude 680 meter above mean sea level: Five dominant tree species from 22 species were identified as *H. ferrea*, *S. henryana*, *M. ovatum*, *S. cumini*, and *S. discolor*, with importance values as 54.56, 31.79, 29.87, 27.92, and 23.15. The five dominant sapling species from 15 species were *S. henryana*, *H. ferrea*, *C. hirsutulus*, *M. ovatum*, and *S. ilicifolius*, with 33.25, 25.57, 23.88, 19.62 and 18.48 of IVI value index. Five dominant seedling species from 18 species were *S. cumini*, *Mallotus* *paniculatus* Muell. Arg., *M. ovatum*, *C. hirsutulus*, and *M. paniculata*, with 472.95, 255.78, 139.44, 45.17, and 19.81 of IVI values respectively.

Altitude 720 meter above mean sea level: Five dominant tree species from 29 species were *A. pedunculata*, *Bambusa* sp., *S. henryana*, *S. cumini*, and *Choerospondias axillaris* Burtt & Hill, with 47.86, 43.73, 38.43, 28.88, and 16.58 of importance values. The five dominant sapling species from 20 species identified as *C. hirsutulus*, *S. henryana*, *U. siamensis*, *M. grandis*, and *W. trichostemon*, with 41.95, 24.27, 21.00, 18.78, and 11.06 of IVI values. For seedling from 16 species, the five dominant species were identified as *C. hirsutulus*, *U. siamensis*, *M. grandis*, *S. henryana*, and *S. cumini*, with 54.84, 31.38, 24.76, 12.17 and 9.61 of IVI values respectively.

Altitude 760 meter above mean sea level: Five dominant species from 37 species were *S. henryana*, *A. pedunculata*, *K. furfuracea*, *Quercus ramsbottomii* A. Camus, *M. grandis,* with 26.10, 25.30, 24.77, 19.09, and 18.35 of IVI values and the five dominant sapling species from 18 species were *C. hirsutulus*, *A. pedunculata*, *V. peduncularis*, *M. grandis*, and *S. siamensis*, with 50.00, 28.69, 18.81, 17.86, and 11.01 of IVI values respectively. For seedling, this stand composed of 16 seedling species. The five dominant seedling species were *C. hirsutulus, U. siamensis, S. cumini*, *S. henryana*, and *Memecylon caeruleum* Jack, with 46.88, 24.63, 22.25, 17.49, and 14.04 of IVI values respectively.

4.2.1.2 East aspect

At the east aspect, species community composed of 125 species, 43 families. The common species of all vegetation, tree, sapling and seedling, were *H. ferrea* and *W. trichostemon* as of the north aspect. Although *Bambusa* sp. covered around one -

fourth of the tree community (23.813%) on this aspect, (Figure 38(b)) but it could not be found in sapling and seedling communities. It showed low in relative frequence index but possibly dominated in specific aspects and altitudes. While *W. trichostemon* showed low in importance value but high in frequency value and therefore it could be distributed in all of tree, sapling and seedling communities along various elevations. Each altitude at this aspect covered with different species as in the following:

Altitude 400 meter above mean sea level: This stand composed of 13 species. The five dominant tree species were *Peltophorum dasyrachis* Kurz, *Afzelia xylocarpa* Craib, *Millettia leucantha* Kurz, *H. ferrea*, and *Dalbergia cochinchinensis* Pierre, with 157.29, 40.81, 17.17, 16.07, and 11.51 of IVI values. For sapling, the five dominant sapling species from 22 species were *C. hirsutulus*, *P. dasyrachis*, *Polyalthia evecta* Finet & Gagnep., *M. ovatum*, and *A. lenticellata*, with importance value index (IVI) at 42.22, 18.95, 14.21, 13.06 and 12.92 and the five seedling dominant species from 9 species were *C. hirsutulus*, *Clausena harmandiana* Pierre, *A. siamensis*, *P. dasyrachis*, and *Diospyros ferrea* Bakh., with importance value index (IVI) at 84.50, 26.15, 16.30, 16.30 and 14.61 respectively.

Altitude 440 meter above mean sea level: Five dominant tree species from 11 species were *H. ferrea*, *Maerua siamensis* Pax, *W. trichostemon*, *S. cumini*, and *Lagerstroemia duperreana* Pierre, with 93.63, 51.29, 29.26, 24.15, and 20.96 of importance value index. The five dominant sapling species from 22 species were *Sampantaea amentiflora* Airy Shaw, *Clausena excavata* Burm. f., *C. hirsutulus*, *S. cumini*, and *H. ferrea*, with 21.11, 18.79, 17.45, 16.10 and 13.66 of importance value index. For seedling, it dominated as *S. amentiflora*, *C. excavata*, *Aphanamixis* *polystachya* Parker, *Cladogynos orientalis* Zipp. Ex Span., and *S. cumini*, with 32.57, 19.54, 17.85, 17.85 and 13.03of importance value index respectively.

Altitude 480 meter above mean sea level: This stand composed of 17 species in which *H. ferrea* was highest dominant tree species with values of IVI as 111.08. The second dominant tree species was *S. cumini*, with IVI as 34.71. *W. trichostemon*, *M. ovatum*, *Bauhinia viridescens* Desv., with 34.71, 31.55, 27.96, and 20.54 of importance value index. For sapling, the five dominant sapling species from 14 species were *H. ferrea*, *S. cumini*, *S. ilicifolius*, *S. amentiflora*, and *C. hirsutulus*, with IVI value index at 61.11, 23.61, 19.44, 17.36, and 15.97 respectively. The five dominant seedling species from 16 species were *H. ferrea*, *S. cumini*, *C. hirsutulus*, *S. ilicifolius*, and *A. siamensis*, with 40.53, 36.35, 28.29, 17.37 and 15.76 of importance value index respectively.

Altitude 520 meter above mean sea level: Five dominant tree species from 22 species identified as *H. ferrea*, *Ficus* sp., *H. ilicifolius*, *A. pirifera*, and *Dialium cochinchinense* Pierre, with 82.90, 39.14, 30.35, 28.65, and 14.62 of importance value index. The five dominant sapling species from 21 species identified as *H. ferrea*, *P. evecta*, *C. hirsutulus*, *S. cumini*, and *A. pirifera*, with IVI values at 34.19, 26.98, 24.30, 17.99, and 13.52. For seedling, the five dominant seedling species from 17 species were identified as *P. evecta*, *H. ferrea*, *S. ilicifolius*, *M. paniculata*, *C. hirsutulus*, with 36.93, 26.14, 20.74, 20.74 and 13.07 of importance value index respectively.

Altitude 560 meter above mean sea level: Five dominant tree species from 28 species were *Bambusa* sp., *M. caloneura*, *S. siamensis*, *H. ilicifolius*, and *P. evecta*, with IVI values at 102.00, 21.12, 20.58, 18.24, and 14.33 respectively. The five dominant sapling species from 22 species were *S. siamensis*, *S. ilicifolius*, *M. caloneura*, *P. evecta*, and *C. hirsutulus*, with 24.17, 20.00, 18.61, 15.83, and 12.78 of IVI values. The five dominant seedling species from 14 species were *C. cascarilloides*, *A. siamensis*, *S. ilicifolius*, *M. paniculata*, and *Acalypha kerrii* Craib, with IVI values as 48.78, 28.02, 20.55, 20.55 and 18.66 respectively.

Altitude 600 meter above mean sea level: Five dominant tree species from 21 species were *H. ferrea*, *S. cumini*, *W. trichostemon*, *S. ilicifolius*, with 72.67, 55.84, 34.83, 21.02, and 17.24 of IVI values respectively. For sapling, the five dominant sapling species from 12 species were *M. ovatum*, *H. ferrea*, *W. trichostemon*, *A. siamensis*, and *C. hirsutulus*, with 37.57, 33.20, 31.85, 23.59, and 16.68 of IVI values respectively. In addition, the five dominant seedlings from 15 species were *C. hirsutulus*, *M. ovatum*, *W. trichostemon*, *H. ferrea*, and *C. orientalis*, with 60.35, 20.66, 13.82, 13.82 and 13.82 of IVI values respectively.

Altitude 640 meter above mean sea level: Five dominant treee species from 20 species were identified as *H. ferrea*, *C. macrostigma*, *W. trichostemon*, *Chionanthus microstigma* Gagnep, *Atalantia monophylla* Correa, with 68.32, 44.42, 29.76, 27.41 and 17.20 respectively. The five dominant sapling species from 24 species were *P. evecta*, *W. trichostemon*, *C. microstigma*, *M. ovatum*, and *M. paniculata*, with 30.09, 23.86, 17.28, 14.47, 14.47 of IVI values respectively. For seedling, the five dominant seedling species from 21 species were identified as *W. trichostemon*, *P. evecta*, *S. amentiflora*, *C. excavata*, and *C. microstigma*, with 23.88, 16.45, 16.45, 14.32 and 14.32 of IVI values respectively.

Altitude 680 meter above mean sea level: Five dominant tree species from 26 species were identified as *H. ferrea*, *H. ilicifolius*, *W. trichostemon*, *A. pirifera*, and

S. henryana, with 55.87, 54.49, 26.24, 18.73 and 13.31 of IVI values respectively. The five dominant sapling species from 22 species were *P. evecta*, *H. ferrea*, *M. ovatum*, *S. ilicifolius*, and *A. pirifera*, with importance value index as 29.05, 20.50, 15.95, 15.95, 13.95 respectively. For seedling, the five dominant seedling species from 16 species were *S. ilicifolius*, *M. paniculata*, *A. pirifera*, *I. cibdela*, and *P. evecta*, with importance value index as 27.32, 26.79, 18.99, 16.90 and 14.82 respectively.

Altitude 720 meter above mean sea level: Five dominant tree species from 27 species were *K. furfuracea*, *H. ferrea*, *S. siamensis*, *S. henryana*, and *M. paniculatus*, with 46.23, 36.44, 31.68, 28.50 and 19.28 of IVI values. For sapling, the five dominant sapling species from 18 species were identified as *S. siamensis*, *Phoebe paniculata* Nees, *C. hirsutulus*, *A. lenticellata*, and *M. ovatum*, with 27.76, 23.56, 21.87, 21.30 and 17.11 of IVI values and the five dominant seedling species from 19 species were *A. lenticellata*, *C. hirsutulus*, *K. furfuracea*, *Antiaris toxicaria* Lesch., and *I. cibdela*, with 26.68, 21.32, 17.75, 15.97 and 14.81 of IVI values respectively.

Altitude 760 meter above mean sea level: Five dominant tree species from 25 species were *H. ferrea*, *H. ilicifolius*, *C. hirsutulus*, *Adenanthera microsperma* Teijsm. & Binn., *S. siamensis*, with 99.47, 29.36, 26.29, 15.54, and 13.88 of IVI values and the five dominant sapling species from 22 species were identified as *P. evecta*, *H. ferrea*, *M. ovatum*, *S. ilicifolius*, and *A. pirifera*, with 29.05, 20.50, 15.95, 15.95, and 13.95 of IVI values respectively. For seedling, it composed of 16 seedling species. The five dominant seedling species were *H. ferrea*, *C. cascarilloides*, *A. pirifera*, *A. siamensis*, and *A. polystachya*, with 52.01, 26.00, 21.75, 13.79 and 11.66 of IVI values respectively.

4.2.1.3 South aspect

In the south aspect, it covered with 126 species and 41 families of all vagetation (tree, sapling and seedling). Only *W. trichostemon* acted as a common dominant species of all vegetation at the south aspect. This aspect showed homogenious in plant communities. Particularly on tree community, most of this aspect covered with *Bambusa* sp., with 55.66 of importance value index as Figure 38(c). So the five dominant tree species could not successed in that area, where it was overwhelming with bamboo stems. One of the five dominant species in sapling community became to be the common species in all vegetation. *W. trichostemon* was lower in impostance, relative diminance and relative density indices on tree community. The five dominant species in each altitude of tree, sapling and seedling were reported as in the following:

Altitude 400 meters meter above mean sea level: Five dominant tree species from 31 species were *S. siamensis, Tetrameles nudiflora* R. Br., *M. ovatum*, *S. ilicifolius*, *W. trichostemon*, with importance value index (IVI) of 43.04, 33.27, 22.28, 21.45, and 21.26. The five dominant sapling species from 22 species were *S. ilicifolius*, *W. trichostemon*, *S. siamensis*, *C. hirsutulus*, and *A. pirifera*, with importance value index (IVI) as 35.75, 22.35, 20.35, 19.88, 15.41 respectively. The five dominant seedling species from 16 species were *C. hirsutulus*, *W. trichostemon*, *S. ilicifolius*, *M. paniculata*, and *P. evecta*, with importance value index (IVI) of 28.57, 26.53, 25.71, 23.67 and 16.73 respectively.

Altitude 440 meter above mean sea level: Five dominant tree species from 21 species were *H. ferrea*, *W. trichostemon*, *M. ovatum*, *A. pirifera* and *H. ilicifolius,* with 110.91, 30.43, 25.16, 24.44 and 20.64 of importance value index. The five dominant sapling species from 29 species were *C. hirsutulus*, *S. siamensis*, *E. longifolia A. pedunculata*, and *V. glabrata*, with 29.28, 27.44, 14.94, 10.17, and 9.56 of importance value index respectively. For seedling community, it covered with 13 species and were identified as *C. hirsutulus*, *Dipterocarpus turbinatus* Gaertn., *P. evecta*, *W. trichostemon*, and *Paranephelium longifoliolatum* Lec., with 48.61, 31.94, 23.61, 16.67, 16.67, and 13.89 of importance value index respectively.

Altitude 480 meter above mean sea level: This stand composed of 30 species in which *H. ferrea* was highest dominant tree species with values of IVI as 53.04. The second dominant tree species was *W. trichostemon*, with IVI as 26.52. *S. henryana*, *H. ilicifolius*, and *S. cumini*, with 25.74, 25.08, 19.95 of importance value index respectively. The five dominant sapling from 23 species were *Microcos tomentosa* Linn., *Mallotus peltatus* Muell., *M. philippensis*, *S. henryana*, and *Markhamia stipulata* Seem., with 22.33, 17.11, 16.44, 15.64, and 14.97of importance value index respectively. For seedling, it composed of 23 species. The five dominant seedling species were identified as *M. peltatus*, *C. excavata*, *M. paniculatus*, *S. ilicifolius*, and *M. leucantha*, with 34.68, 18.01, 14.78, 12.70, and 10.62 of importance value index respectively.

Altitude 520 meter above mean sea level: Five dominant tree species from 30 species were identified as *M. caloneura*, *S. siamensis*, *W. trichostemon*, *M. ovatum*, and *H. ilicifolius* with 60.04, 39.71, 29.80, 16.87, and 16.33 of importance value index. The five dominant sapling species from 20 species identified as *C. hirsutulus*, *A. siamensis*, *C. orientalis*, *S. cumini*, and *W. trichostemon*, with 36.14, 24.58, 22.72, 21.23, and 19.99 of importance value index respectively. In addition, the five dominant seedling species from 16 species were identified as *C. hirsutulus*, *S.*

ilicifolius, *C. orientalis*, *S. cumini*, and *A. siamensis*, with 39.38, 25.64, 24.61, 22.02 and 20.99 of importance value index respectively.

Altitude 560 meter above mean sea level: Five dominant tree species from 26 species were *H. ferrea*, *Parkia sumatrana* Miq., *A. pirifera*, *S. henryana*, and *M. caloneura*, with IVI values as 44.57, 35.26, 23.10, 21.33, and 20.95. The five dominant sapling species from 16 species were *A. pirifera*, *S. ilicifolius*, *M. paniculata*, *C. hirsutulus*, and *W. trichostemon*, with IVI values as 31.81, 27.64, 23.61, 20.14, and 19.86 respectively. For seedling, the five seedling dominant species from 12 species were *S. ilicifolius*, *M. paniculata*, *P. evecta*, *C. hirsutulus*, and *M. caeruleum*, with IVI values as 43.53, 30.71, 27.76, 19.76, and 16.82 respectively.

Altitude 600 meter above mean sea level: It covered with 23 species in tree. The highest importance value index shown in *Bambusa* sp., with 145.26 of IVI value. The second was *H. ferrea*, *S. henryana*, *H. ilicifolius*, *W. trichostemon*, with 18.56, 16.81, 11.65, and 10.61 respectively. The five dominant sapling species from 15 species were *H. ferrea*, *C. hirsutulus*, *C. micracantha*, *S. ilicifolius*, and *A. siamensis*, with 38.67, 31.56, 20.89, 16.89, and 16.89 respectively. The five dominant seedlings from 16 species were *C. hirsutulus*, *A. siamensis*, *S. ilicifolius*, *Capparis micracantha* DC., and *S. discolor*, with 32.05, 24.36, 21.06, 21.06, and 13.37 of IVI values respectively.

Altitude 640 meter above mean sea level: Five dominant tree species from 9 species were identified as *Bambusa* sp., *P. longifoliolatum L. duperreana*, *Diospyros malabarica* Kostel., and *Lagerstroemia loudonii* Teijsm. & Binn., with 232.92, 12.90, 10.75, 8.92, 8.56 of IVI values and the five dominant sapling species from 14 species were identified as *C. hirsutulus*, *M. grandis*, *A. siamensis*, *Pterospermum* *diversifolium* Bl., and *I. cibdela*, with 37.66, 25.16, 23.03, 17.76, and 14.64 of IVI values respectively. For seedling, the five dominant seedling species from 14 species were identified as *C. hirsutulus*, *C. micracantha*, *Dalbergia oliveri* Gamble, *A. siamensis*, and *I. cibdela*, with 42.79, 19.22, 19.22, 13.96, and 13.96 of IVI values respectively.

Altitude 680 meter above mean sea level: Five dominant tree species from 11 species were identified as *Bambusa* sp., *H. ferrea*, *W. trichostemon*, *M. grandis*, and *H. ilicifolius*, with importance value index at 170.24, 41.61, 22.66, 13.05, and 12.53 respectively. For sapling, it covered with 11 species. The five dominant sapling species were identified as *C. hirsutulus*, *D. ferrea*, *C. micracantha*, *Suregada multiflorum* Baill., and *M. stipulata*with 58.38, 33.64, 31.52, 17.98 and 11.21 of IVI values and the five dominant seedling species from 11 species were identified as *D. ferrea*, *C. hirsutulus*, *Lepisanthes rubiginosa* Leenh., *A. siamensis*, and *M. paniculata*, with 29.57, 27.24, 26.34, 20.79 and 18.46 of IVI values respectively.

Altitude 720 meter above mean sea level: Five dominant species from 28 species. They were identified as *S. siamensis*, *S. henryana*, *K. furfuracea*, *P. sumatrana*, and *W. trichostemon*, with importance values at 30.44, 30.16, 26.74, 21.92, and 17.85 respectively. The five dominant sapling species from 25 species were *S. siamensis*, *Livistona speciosa* Kurz, *C. hirsutulus*, *E. longifolia* and *A. lenticellata*, with 24.19, 23.56, 15.91, 15.91 and 15.91 of IVI values. For seedling, the five dominant seedling species from 15 species were *C. hirsutulus*, *I. cibdela*, *S. cumini*, *P. evecta*, and *S. siamensis*, with 54.77, 22.26, 20.82, 13.13 and 13.13 of IVI values respectively.

Altitude 760 meter above mean sea level: Five dominant species from 35 species were *M. grandis*, *A. pedunculata*, *S. cumini*, *S. henryana*, and *L. fenestratus*, with 49.14, 32.46, 25.62, 19.41, and 18.62 of IVI values respectively. For sapling, the five dominant species from 18 seedling were *C. hirsutulus*, *S. siamensis*, *I. cibdela*, *M. ovatum*, and *M. caeruleum*, with 56.47, 26.27, 11.82, 11.82, and 11.82 of IVI values respectively.

4.2.1.4 West aspect

At the west aspect, species composition varied conspicuously with elevation from 400 to 800 meters above mean sea level. It composed of 114 species, 38 families. *H. ferrea*, *M. ovatum* and *W. trichostemon* were common dominant species of all community, tree, sapling and seedling. Obviously, *H. ferrea*, *M. ovatum* could be found on the north and west aspects, where they were higher in ecological performance than the other aspects (Figure 38(d)). At each elevation the five dominant species was reported as:

Altitude 400 meter above mean sea level: In this altitude, five dominant tree species from 18 species were *Leucaena leucocephala* de Wit, *H. ferrea*, *W. trichostemon*, *Lepisanthes tetraphylla* Radlk., and *M. ovatum*, with importance value index (IVI) of 75.93, 56.57, 24.37, 21.69 and 19.73 and the five dominant sapling species from 16 species were *W. trichostemon*, *H. ferrea*, *A. siamensis*, *S. cumini*, and *P. evecta*, with importance value index (IVI) at 43.63, 25.32, 24.11, 14.02 and 14.02 respectively. For seedling, the five dominant seedling species from 13 species were *L. leucocephala*, *M. paniculata*, *H. ferrea*, *W. trichostemon*, *A. siamensis*, with importance value index (IVI) at 41.03, 24.88, 23.63, 21.93 and 20.24 respectively.

Altitude 440 meter above mean sea level: Five dominant species from 25 species were *Melia azedarach* Linn., *M. paniculatus*, *C. mitis*, *P. paniculata*, and *M. philippensis*, with 58.76, 42.11, 21.10, 16.97 and 15.59 of importance value index. The five dominant sapling species from 19 species were *S. ilicifolius*, *M. philippensis*, *W. trichostemon*, *A. kerrii*, and *Baccaurea ramiflora* Lour., with importance values at 35.96, 31.58, 19.30, 17.54 and 12.28. For seedling, the five dominant seedling species from 15 species were *S. ilicifolius*, *A. kerrii*, *M. peltatus*, *C. harmandiana*, *S. siamensis*, with 50.08, 28.63, 27.18, 25.40 and 11.45 of importance value index respectively.

Altitude 480 meter above mean sea level: This stand composed of 20 tree species. The five dominant tree species were *H. ferrea*, *S. cumini*, *M. ovatum*, *H. ilicifolius*, and *D. cochinchinense*, with 106.77, 44.69, 38.22, 12.66 and 11.47 of importance value index. Five dominant sapling species from 22 species were *M. ovatum*, *H. ferrea*, *S. cumini*, *C. micracantha*, and *A. pirifera*, with 36.99, 27.61, 25.78, 15.43 and 14.56 of importance value index and the five dominant seedling from 17 species were *C. cascarilloides*, *S. cumini*, *H. odorata*, *H. ferrea*, and *W. trichostemon*, with 35.42, 22.34, 19.21, 16.78 and 11.81 of importance value index respectively.

Altitude 520 meter above mean sea level: Five dominant tree species from 19 species were identified as *H. ferrea, S. cumini*, *W. trichostemon*, *M. ovatum*, and *L. duperreana*, with 83.45, 40.94, 30.58, 24.82 and 19.44 of importance value index respectively. For sapling, the five dominant sapling species from 21 species were identified as *W. trichostemon*, *H. ferrea*, *S. cumini*, *U. siamensis,* and *C. hirsutulus,* with importance value index at 32.12, 30.05, 18.75, 17.37, and 13.78. The five dominant seedling species from 15 species were identified as *C. hirsutulus*, *M. ovatum*, *C. cascarilloides*, *U. siamensis*, *S. cumini*, with 30.82, 22.49, 21.01, 18.97and 18.23 of importance value index respectively.

Altitude 560 meter above mean sea level: Five dominant tree species from 12 species were *H. ferrea*, *S. cumini*, *M. ovatum*, *W. trichostemon*, and *H. ilicifolius*, with IVI values at 113.27, 52.18, 44.69, 35.99 and 22.50 and the five dominant sapling species from 13 species were *H. ferrea*, *S. cumini*, *W. trichostemon*, *M. ovatum*, and *C. micracantha*, with IVI values as 46.57, 38.41, 22.20, 16.16, 16.12 respectively. The five dominant seedling species from 14 species were *H. ferrea*, *C. hirsutulus*, *W. trichostemon*, *M. ovatum*, and *S. ilicifolius*, with IVI values as 39.92, 32.77, 19.96, 19.22 and 17.33 respectively.

Altitude 600 meter above mean sea level: It covered with 22 tree species. The five dominant tree species were *H. ferrea*, *S. cumini*, *L. duperreana*, *W. trichostemon*, *M. ovatum*, with 97.90, 29.85, 23.59, 21.18, and 20.36 of IVI values respectively. The five dominant sapling species from 15 species were identified as *H. ferrea*, *S. cumini*, *P. evecta*, *S. ilicifolius*, and *U. siamensis*, with 59.04, 24.45, 18.76, 17.89, and 14.42 in IVI values respectively. For seedling, the five dominant seedling species from 11 species were *C. hirsutulus*, *P. evecta*, *H. ferrea*, *M. paniculata*, and *U. siamensis*, with 50.81, 35.47, 22.26, 18.09 and 15.65 of IVI values respectively.

Altitude 640 meter above mean sea level: Five dominant tree species from 25 species. They were identified as *H. ferrea*, *H. ilicifolius*, *A. pirifera*, *W. trichostemon*, and *C. hirsutulus*, with 77.02, 37.52, 25.65, 15.04 and 14.25 of IVI values respectively. The five dominant sapling species from 17 species were identified as *P. evecta*, *A. siamensis*, *A. pirifera*, *D. malabarica*, and *C. hirsutulus*, with 36.13, 29.34, 22.63, 20.30, and 15.83 of IVI values respectively. For seedling, the five dominant seedling species from 15 species were *M. paniculata*, *A. polystachya*, *I. cibdela*, *A. siamensis*, and *Diospyros variegata* Kurz, with 23.61, 23.61, 20.56, 18.61 and 18.06 of IVI values respectively.

Altitude 680 meter above mean sea level: Five dominant tree species from 20 species. They were identified as *M. ovatum*, *H. ilicifolius*, *S. cumini*, *D. malabarica*, and *Ficus* sp., with 97.73, 26.95, 24.93, 23.75 and 19.42 respectively. The five dominant sapling species from 20 species were identified as *C. hirsutulus*, *M. paniculata*, *H. ferrea*, *H. odorata*, and *A. siamensis*, with importance value index as 41.74, 23.81, 18.69, 16.28 and 13.11 respectively. For seedling, the five dominant seedling species from 14 species were *C. hirsutulus*, *H. ferrea*, *M. paniculata*, *P. evecta*, and *H. odorata*, with importance value index as 49.78, 31.22, 28.19, 18.02 and 13.20 respectively.

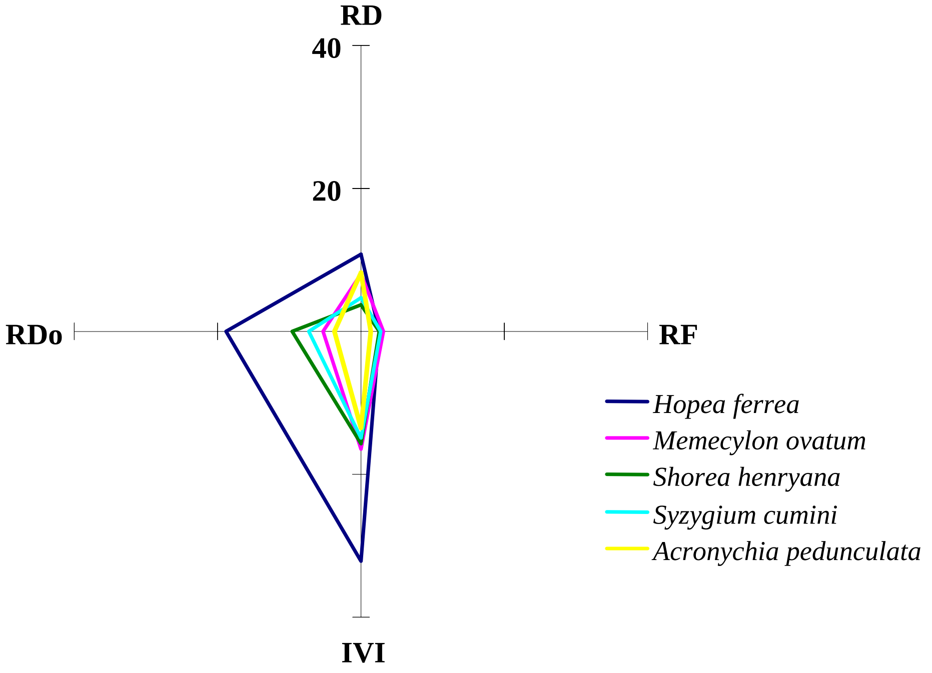
Altitude 720 meter above mean sea level: Five dominant tree species from 13 tree species. They were identified as *Bambusa* sp., *M. caloneura*, *P. paniculata*, *Polyalthia viridis* Craib, and *V. peduncularis*, with 168.97, 15.89, 13.72, 13.27 and 13.27 of IVI values respectively. The five dominant sapling species from 11 species were identified as *M. philippensis*, *Pterospermum acerifolium* Willd., *C. hirsutulus*, *Bambusa* sp., and *E. longifolia* with 52.70, 30.15, 24.26, 18.38 and 14.22 of IVI values respectively. For seedling, the five dominant seedling species from 16 species were identified as *S. henryana*, *A. toxicaria*, *P. viridis*, *M. philippensis*, and *C. hirsutulus*, with 26.68, 26.68, 22.13, 17.79 and 8.89 of IVI values respectively.

Altitude 760 meter above mean sea level: This stand composed of only three species in tree group. As cause it vastly covered with *Bambusa* sp., highest dominant species as 226.62 of IVI value. *Schleichera oleosa* Merr., and *Alstonia scholaris* R. Br., were present in 62.35, 11.03 of IVI values respectively. For sapling, the five dominant species from 10 species were *P. paniculata*, *M. philippensis*, *M. grandis*, *L. rubiginosa* , and *S. oleosa*, with 37.98, 34.86, 27.16, 27.16, and 24.04 in IVI values. The five dominant seedling species from 10 species were identified as *L. rubiginosa*, *P. paniculata*, *M. grandis*, *A. toxicaria*, and *P. evecta*, with 27.62, 27.62, 27.62, 22.86 and 22.86 of IVI values respectively.

4.2.1.5 Top or center aspect

At altitude 800 meter, species composition composed of 38 species, 38 families. Most of plant communities at the top aspect dominated with Myrtaceae. Tree community shows that *S. siamensis* was the dominant species with highest in ecological performance (Figure 38(e)). *S. cumini* dominated on sapling and seedling communities. The five dominant species on tree community were *S. siamensis*, *P. paniculata*, *C. axillaris*, *A. pedunculata* and *K. furfuracea*, with 44.93, 27.18, 26.95, 26.41 and 17.01 of IVI values. The five dominant sapling community from 16 species were *S. cumini*, *C. hirsutulus*, *Rinorea lanceolata* Kuntze, *M. grandis*, and *A. pirifera*, with 34.02, 32.30, 22.30, 21.95 and 15.17 of IVI values respectively. For seedling, the five dominant seedling species from 16 families were identified as *S. cumini*, *C. hirsutulus*, *R. lanceolata* , *M. grandis*, and *A. pirifera*, with 34.02, 32.30, 22.30, 21.95 and 15.17 of IVI values respectively.

(a)



(b)

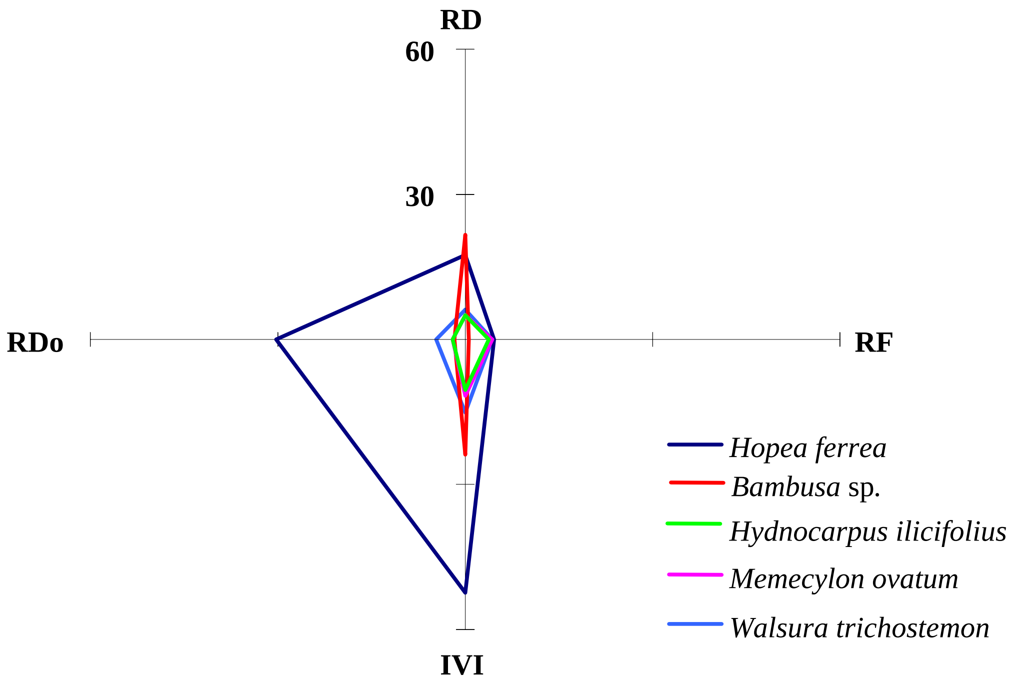
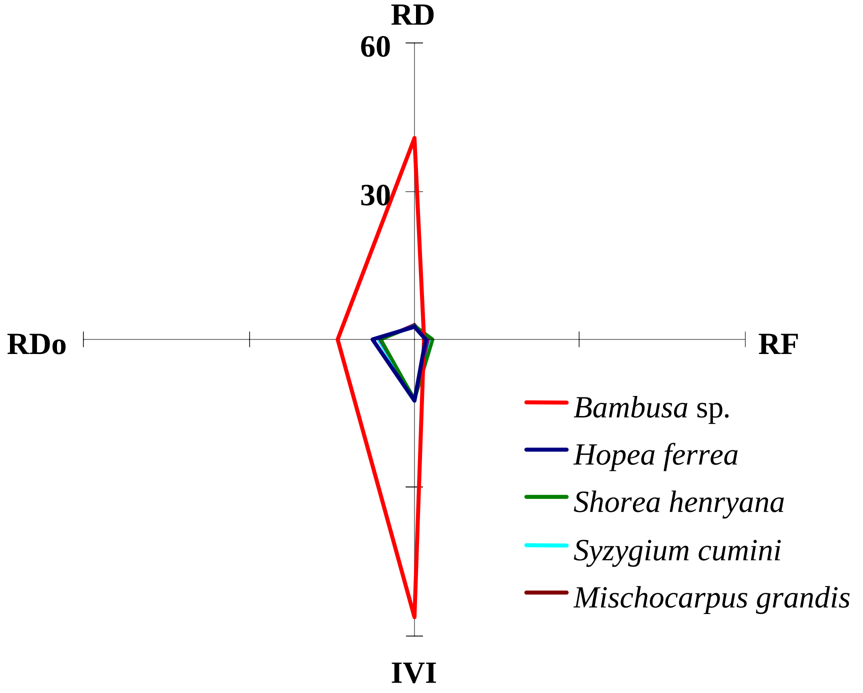


Figure 38. Phytograph of the five dominant tree species along aspects (a) north (b) east (c) south (d) west (e) top aspects and (f) over the whole area.

(c)



(d)

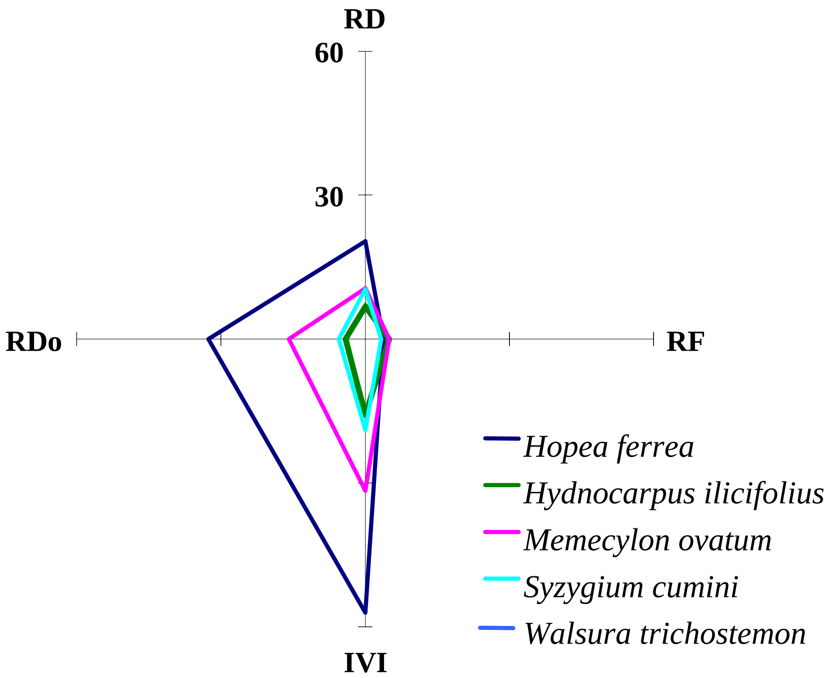
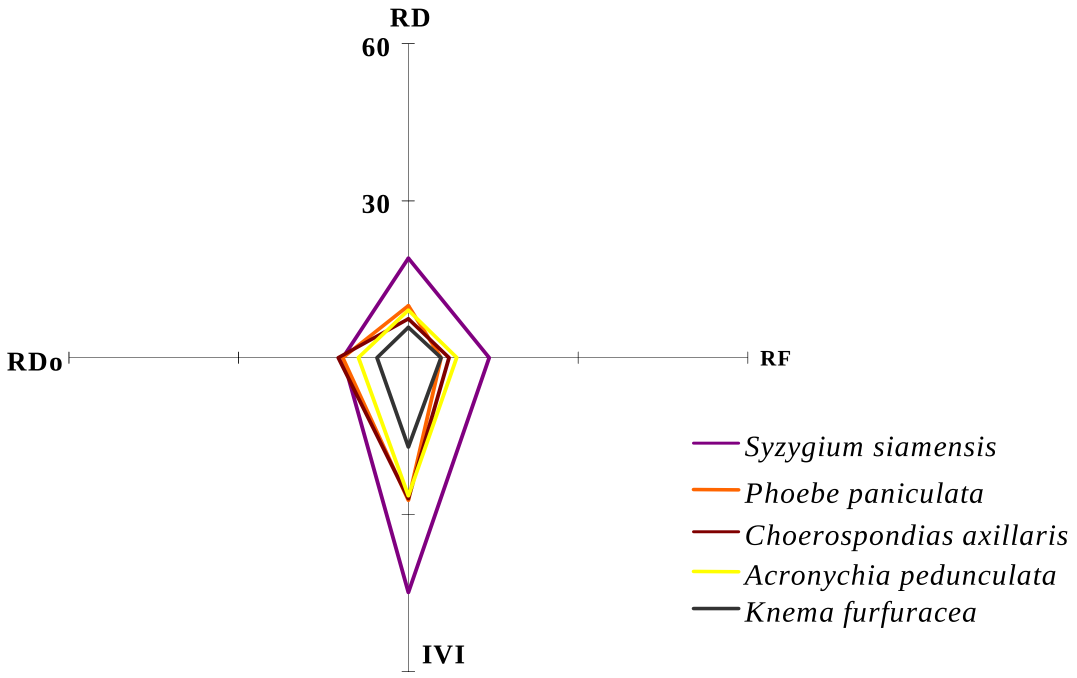


Figure 38. **(Continued).**

(e)



(f)

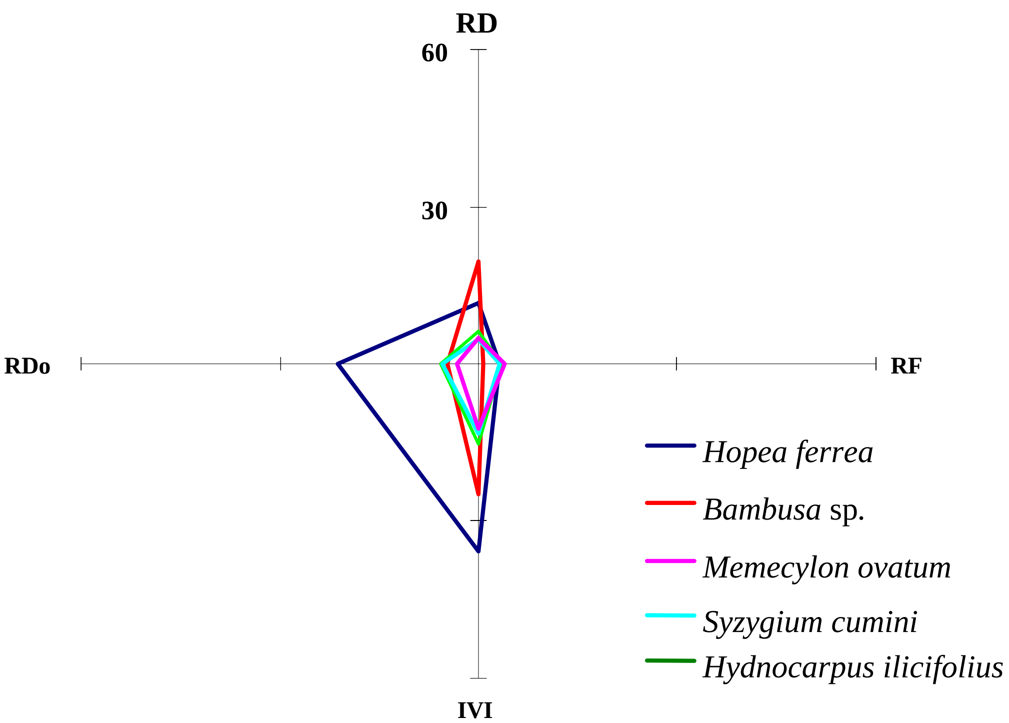


Figure 38. **(Continued).**

For the whole area, *H. ferrea* showed higher in IVI but lower in density than *Bambusa* sp. (Figure 38(e)). The ten dominant of each communities of tree were identified as *H. ferrea*, *Bambusa* sp., *M. ovatum*, *S. cumini*, *H. ilicifolius*, *W. trichostemon*, *S. siamensis*, *S. henryana*, *A. pedunculata*, and *A. pirifera*, with IVI values of 35.07, 20.51, 14.77, 12.47, 12.31, 11.12, 10.03, 9.20, 7.20 and 6.63 respectively in tree species. Sapling species were *C. hirsutulus, H. ferrea, S. cumini*, *W. trichostemon*, *P. evecta*, *M. ovatum*, *S. ilicifolius*, *A. pirifera*, *S. siamensis*, and *M. grandis*, with 22.36, 14.96, 12.20, 9.85, 8.92, 8.61, 7.79, 7.05, 6.79, and 6.38 of IVI values. For seedling, ten dominant seedling species for whole area were identified as *C. hirsutulus*, *H. ferrea*, *M. paniculata*, *P. evecta*, *S. ilicifolius*, *S. cumini*, *W. trichostemon*, *M. ovatum*, *A. siamensis*, and *I. cibdela*, with 31.77, 10.31, 9.17, 8.89, 8.83, 8.39, 7.00, 6.72, 6.72 and 6.59 respectively. More details were shown in Appendix Table 2 to 4.

Most of dominant species varied along altitudes because each species was specific in elevation such as *Bambusa* sp., while *H. ferrea* showed widely range in elevations according to Table 6. Therefore these dominant species at each elevation were used to find out key species in the study area. They divided into as primary dominant and secondary dominant species by means of their relative importance value, (relative density + relative frequency + relative dominant)/3, (McCune and Grace, 2002; Pattanakiat S., 2001). Species, which had the highest importance value at least one elevation, served as primary species and the second highest dominant species at least one acted as secondary species. Thus four species of tree community were identified as primary species, *H. ferrea*, *Bambusa* sp., *M. ovatum*, and *S.*

siamensis, and seven species as secondary dominant species, *P. dasyrachis*, *Ficus* sp., *M. grandis*, *P. paniculata*, *S. henryana*, *S. cumini*, and *W. trichostemon*, with relative importance values according to Table 6 and Figure 39.

Table 6. The relative importance value of tree species along altitudes.

Botanical names	Altitude (meters)										
	400	**440**	**480**	**520**	**560**	**600**	**640**	**680**	**720**	**760**	**800**
Primary dominant species											
Hopea ferrea	13.52	16.86	21.88	16.95	13.51	11.00	11.89	10.76	3.10	9.10	0.00
Bambusa sp.	0.00	0.00	0.00	0.00	14.39	15.01	18.29	12.15	9.46	5.91	0.00
Memecylon ovatum	4.19	3.45	4.76	5.22	10.23	4.55	2.52	12.17	1.75	1.31	3.99
Syzygium siamensis	3.89	3.55	0.00	2.87	1.91	2.17	3.87	0.54	4.49	2.11	11.40
Secondary dominant species											
Peltophorum dasyrachis	8.18	0.00	0.56	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00
Ficus sp.	0.00	0.49	0.00	6.69	0.76	0.00	0.00	2.97	0.00	0.00	0.00
Mischocarpus grandis	0.00	0.00	2.26	0.78	1.18	1.54	0.84	2.61	2.37	6.06	2.61
Phoebe paniculata	0.56	2.52	0.00	0.00	0.81	1.76	0.00	1.15	2.42	1.31	8.35
Shorea henryana	1.40	2.75	2.73	1.76	1.81	3.08	0.62	4.21	8.98	4.78	1.60
Syzygium cumini	2.47	3.67	8.29	4.83	5.01	5.71	1.22	4.50	5.37	2.99	1.67
Walsura trichostemon	4.53	5.55	4.30	5.49	4.54	3.49	3.77	3.38	3.29	2.46	0.00

Conspicuously, *M. ovatum* (Melastomataceae), *H. ferrea* (Dipterocarpaceae) and *S. siamensis* (Myrtaceae) were common species. They presumably had a wide range in amplitude of elevation, while *Bambusa* sp. (Gramineae) had an amplitude range in specific elevation, between 560-760 meters. Apparently *H. ferrea* (Dipterocarpaceae) dominated at lower altitudes and possibly could be found at altitudes less than 760 meter. For the secondary dominant species, *P. dasyrachi* (Caesalpiniaceae) dominated especially at 400 meter and possibly preferred at lower elevation whereas *P. paniculata* (Lauraceae) dominated and prefered at higher elevation. In addition, phytograph over the whole area also confirmed that *H. ferrea* was the greatest performance species in tree community, owing to higher in importance value and relative dominance indices than the others. *Bambusa* sp. was highest in relative density but lowest in frequency. It implied to be slightly distributed along various altitudes and aspects.

Sapling, with similar calculation based upon relative importance value, was found that *C. hirsutulus* (Euphorbiaceae) distributed all of elevations according to Table 7 and Figure 40. It possibly had a wide range in amplitude to elevations, however it prefered at higher elevation while *H. ferrea* (Dipterocarpaceae) preferred at lower elevation. *A. siamensis* (Euphorbiaceae) and *W. trichostemon* (Meliaceae) dominated at middle rank of elevation and decreased at higher altitude whereas *S. siamensis* (Myrtaceae) was more likely to dominate at higher altitude. At highest altitude of study area, only *C. hirsutulus*, *S. siamensis*, and *P. evecta* could be found in sapling community.

Table 7. The relative importance value of sapling species along altitudes.

Botanical names	Altitude (meters)										
	400	440	480	520	560	600	640	680	720	760	800
Primary dominant species											
Cleistanthus hirsutulus	10.51	7.84	6.52	10.69	5.95	12.08	9.73	14.20	13.60	15.74	16.15
Syzygium cumini	5.61	4.58	9.22	7.66	8.24	4.87	1.58	4.08	2.22	2.05	17.01
Polyalthia evecta	6.75	1.72	4.42	6.96	3.51	5.05	10.81	5.06	2.22	0.00	2.53
Hopea ferrea	5.26	4.13	15.40	8.43	13.78	16.37	2.05	9.69	0.00	7.14	0.00
Secondary dominant species											
Acalypha siamensis	9.23	5.08	3.44	10.68	10.00	5.65	5.39	1.55	2.72	0.44	0.00
Walsura trichostemon	2.31	3.56	0.00	2.95	4.86	1.90	2.69	0.99	9.04	9.04	0.00
Syzygium siamensis	5.91	5.15	1.60	5.23	1.35	3.93	5.49	2.39	0.00	2.34	0.00

For seedling, it was found that four species were identified as primary dominant species and 7 species were identified as the secondary dominant species (Table 8 and Figure 41). The primary dominant seeding of Khao So area were *C. hirsutulus* (Euphorbiaceae), *C. cascarilloides* (Euphorbiaceae), *H. ferrea* (Dipterocarpaceae), and *I. cibdela* (Rubiaceae). The secondary dominant seedling showed as *M. grandis* (Sapindaceae), *M. paniculata* (Rutaceae), *P. evecta* (Annonaceae), *S. ilicifolius* (Moraceae), *S. cumini* (Myrtaceae), *U. siamensis* (Opiliaceae), and *W. trichostemon* (Meliaceae). Euphorbiaceae was more common than other families and conspicuously was found at all elevation in *C. hirsutulus,* however probaly preferred at higher altitude. The *C. cascarilloides, H. ferrea,* and *I. cibdela* dominated at most of lower altitude, 560, 480 and 640 meters, and possibly found at altitude less than 760 meter. At higher altitude, only the *C. hirsutulus*, *M. grandis*, and *S. cumini* could be found in seedling.

Table 8. The relative importance value of seedling species along altitudes.

Botanical names	Altitude (meters)										
	400	440	480	520	560	600	640	680	720	760	800
primary dominant species											
Cleistanthus hirsutulus	15.11	8.482	10.47	12.51	9.99	27.16	6.33	16.56	19.12	18.46	30.56
Croton cascarilloides	1.83	0.00	4.19	5.47	10.09	1.59	2.31	1.33	0.69	3.45	0.00
Hopea ferrea	3.73	3.45	11.05	6.39	10.08	4.51	2.31	8.28	0.00	6.90	0.00
Ixora cibdela	2.29	2.25	1.40	1.78	2.64	5.25	8.95	2.91	5.89	2.86	0.00
secondary dominant species											
Mischocarpus grandis	0.00	0.66	0.58	0.00	0.00	2.01	1.08	0.92	5.89	2.86	12.50
Murraya paniculata	10.36	4.23	0.58	2.69	5.19	3.42	6.33	11.96	2.06	3.62	0.00
Polyalthia evecta	5.57	4.50	3.15	7.43	4.47	6.52	4.17	6.34	3.70	3.03	0.00
Streblus ilicifolius	7.47	6.36	5.23	8.95	8.71	3.60	2.31	4.19	0.69	1.05	0.00
Syzygium cumini	3.28	2.52	10.93	6.95	5.52	3.84	0.00	2.25	3.83	2.86	4.17
Urobotrya siamensis	1.22	0.66	3.73	5.30	3.83	5.43	2.93	1.99	6.04	3.15	0.00
Walsura trichostemon	7.01	4.50	3.38	4.47	4.55	2.93	6.48	3.17	1.23	0.76	0.00

4.2.2 Succession characteristics

The general causes of succession or dynamic pattern in natural plant communities are differential species performance as germination requirement, growth rates etc., and different species availability as dispersion, resource availability etc.

(Pickett, Collins and Armesto, 1987). In the forest, plant community, structure and composition also depended on the establishment, survive and growth of understory plants, saplings and seedlings (George and Bazza, 1999). According to ecological performance on dominant species (Table 6-8), some species dominated on only tree communities, especially *Bambusa* sp. Therefore, succession pattern showed completely changing into other species composition. *H. ferrea* showed cyclic succession, replaced by the same species (Glenn-Lewin, Peet and Veblen, 1992), because it dominated in all of communities, tree, sapling and seedling. Khao So was not affected by forest fire so that plant community would changed gradually and continously over time. The dynamics of plant community or succession patterns were shown in natural process as in the following:

4.2.1 Successional trends on tree community

On tree community, succession often is determined by the pool of saplings in the understory that are poised to replace canopy tree as they die (Runkle, 1981; Taylor, Jinyan and ShiQiang, 2004). Local community on trees composes of *H. ferrea* and bamboo communities. With the dynamics plant community, *Bamboosa* sp. would disappear and would be replaced by the other like *C. hirsutulus*, *S. cumini*, *P. evecta*, and *S. siamensis*. For *H. ferrea*, it showed slightly decrease in species populations due to the dynamics of community. *C. hirsutulus* seemed to be more successful than other species in sapling community (Table 7). Therefore the next geaneration of canopy tree would be dominated by *C. hirsutulus*. It covered around 41%; whereas *H. ferrea* covered around 28%. *S. cumini*, and *P. evecta* covered approximately 13 and 15% respectively.

4.2.2 Successional trends on sapling community

Sapling community was influenced by primary dominant seedlings as *C. hirsutulus*, *C. cascarilloides*, *H. ferrea*, and *I. cibdela*. The succession characteristic analysis on sapling appeared that slightly changed in species composition. *H. ferrea* and *C. hirsutulus*, were still dominant communities. Some species disappeared from local community like *S. cumini* and *P. evecta*. It was replaced by *C. cascarilloides*, and *I. cibdela*. Usually *I. cibdela* is a shrub and dominant species of understory plant (Smitinand, 2001). Thus it was rarely found in tree community. Only *H. ferrea* could be developed to canopy structure on tree community (Table 6 to 8). Conspicuoulsly, plant communities of Khao So changed differently depending on species composition, density and ecological performance of the dominant species.

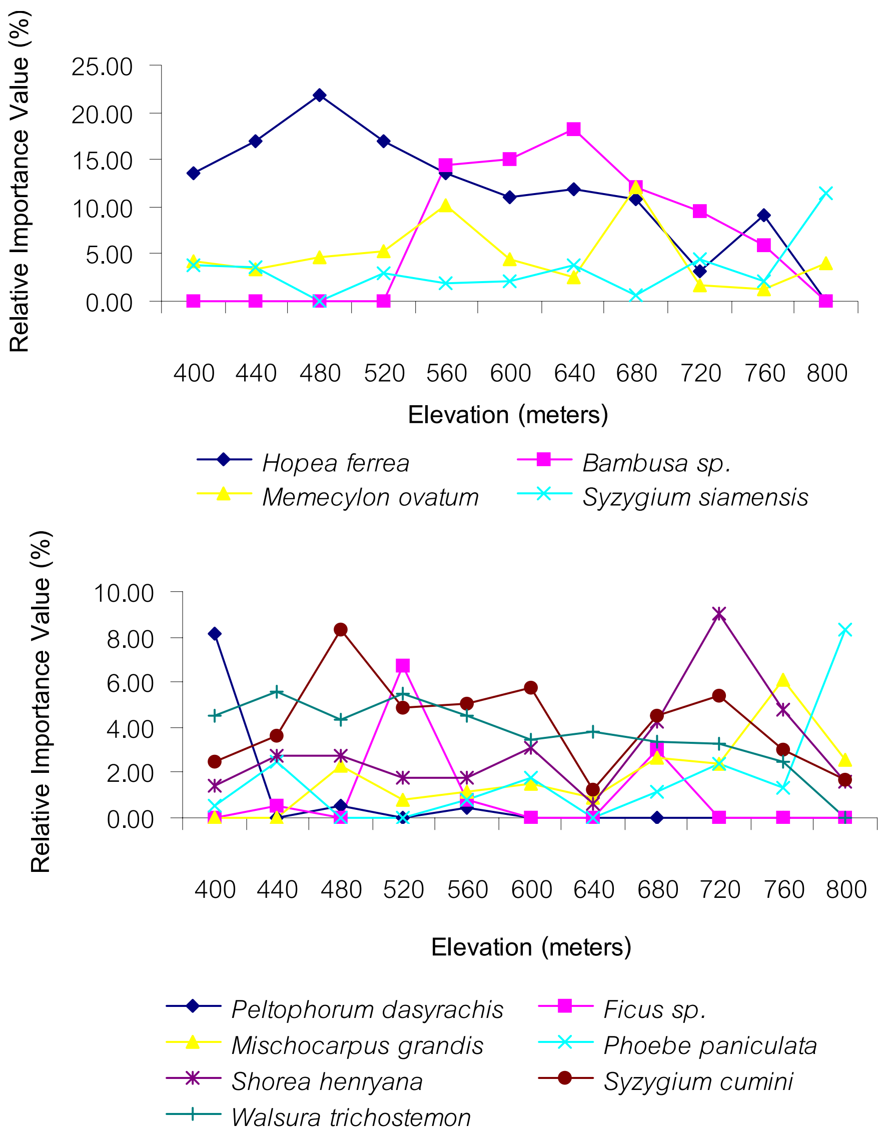
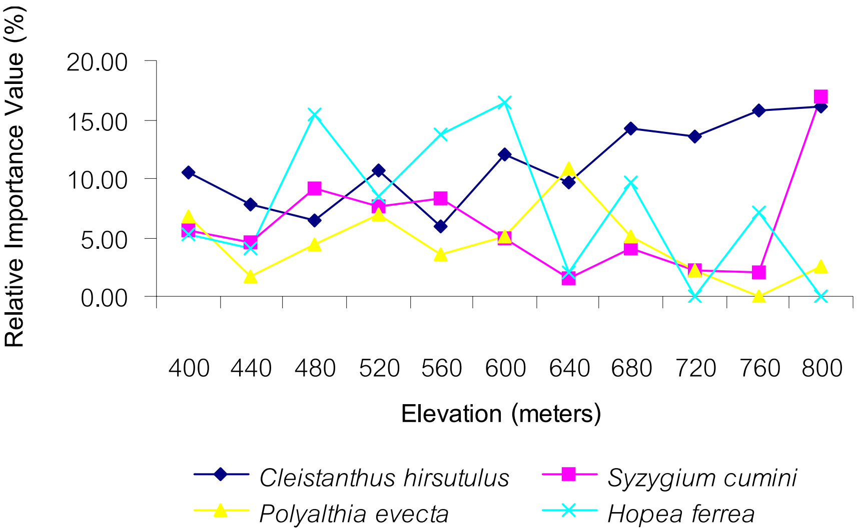


Figure 39. **Relative importance values of dominant tree species as a function of altitude. Upper graph showed distribution for the primary tree dominants, which had the highest importance value for at least one elevation, and lower graph for the secondary dominantswith the second highest value for at least one elevation.**



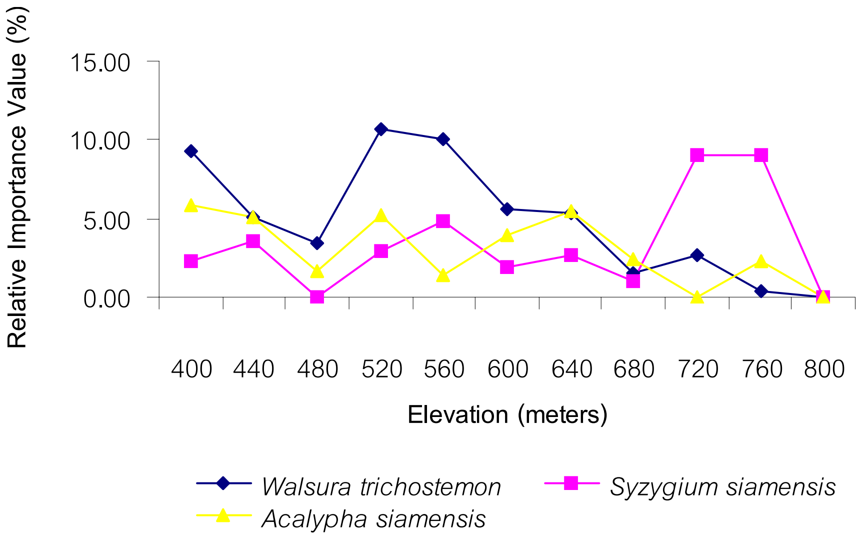
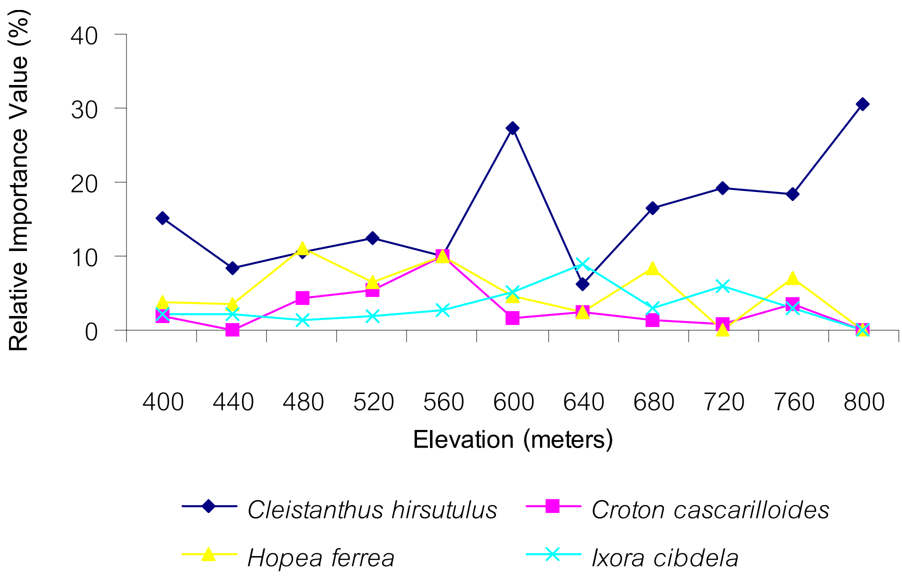


Figure 40. **Relative importance values of dominant sapling species as a function of altitude. Upper graph showed distribution for the primary dominants, which had the highest importance value for at least one elevation, and lower graph for the secondary dominants with the second highest value for at least one elevation.**



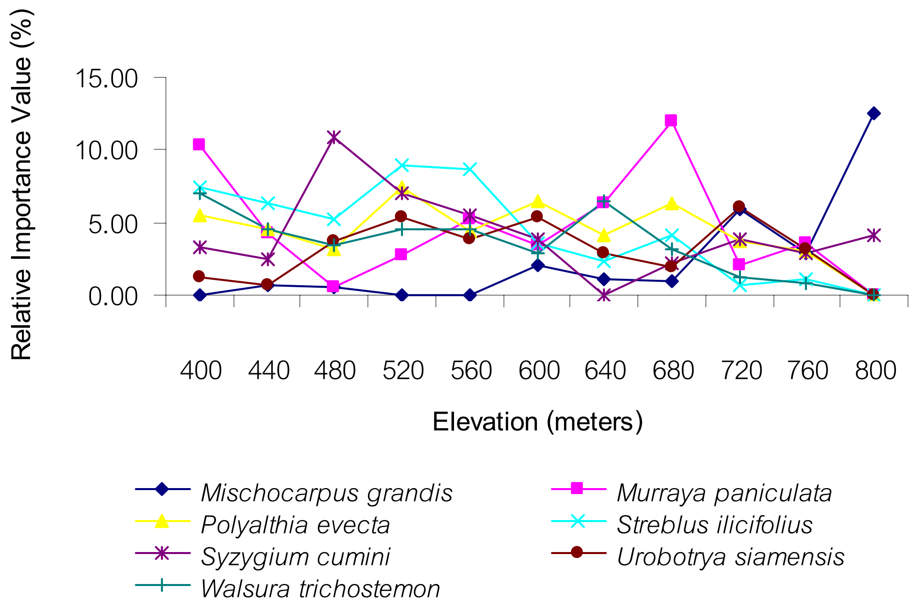


Figure 41. Relative importance values of dominant seedling species as a function of altitude. Upper graph showed distribution for the primary dominants, which had the highest importance value for at least one elevation, and lower graph for the secondary dominants with the second highest value for at least one elevation.

4.3 Shannon Diversity and Evenness Index

The species diversity and evenness of Khao So area for tree, sapling and seedling were shown by means of the Shannon diversity index. The Shannon diversity index based on the assumption that individuals are randomly sampled from an infinitely large population and also assume that all the species from a community are included in the sample (Kent and Coker, 1996). Therefore, it was employed to compare diversity between samples along various altitudes and aspects on this study.

Over the whole area, the species diversity averaged values of Khao So area were 2.34, 2.48, and 2.35 for tree, sapling and seedling communities. For evenness index, the averaged values were 0.74, 0.85, and 0.87 for tree, sapling and seedling communities respectively. Conspicuously, sapling community showed highest in species diversity while tree community showed lowest in species diversity. But the highest species diversity index was shown in tree community at 3.08 value. Thus it implied that tree community varied considerably in species composition along each aspects and altitudes. The species diversity index in dry evergreen forest at Sakearat was 4.46 in tree community (Intrayotha, 1989) higher than in the Khao So. This is might be due to different in method used. Hower, this area clearly defined as a normal diversity in all of plant communities, tree, sapling and seedling (Kent and Coker, 1996). The species diversity indices also indicated that all of plant communities tend to have negative correlation with altitudes especially sapling diversity based on Pearson analysis. The correlation values between species diversity and altitudes for tree, sapling and seedling were – 0.066, – 0.322 and – 0.050 respectively.

Twelve species were defined as threatened species by the World Conservation Union (IUCN, 1994). The critically endangered species (CR) were *A. crassna* (Thymelaeaceae) and *D. turbinatus* (Dipterocarpaceae). The endangered species (EN) were *A. xylocarpa* (Caesalpiniaceae), *A. costata* (Dipterocarpaceae), *D. oliveri* (Papilionaceae), *D. costatus* (Dipterocarpaceae), *H. ferrea* (Dipterocarpaceae), *P. ceylanica* (Rosaceae) and *S. henryana* (Dipterocarpaceae). The vulnerable species (VU) were *D. cochinchinensis* (Papilionaceae), *D. cochinchinense* (Caesalpinaceae) and *H. odorata* (Dipterocarpaceae).

From Table 9 and Figure 42, the averaged Shannon diversity indices of trees along aspects over the whole area were 2.72, 2.21, 2.31, 2.11, 2.34 and the averaged evenness indices were 0.82, 0.73, 0.71, 0.72, 0.74 at the north, east, south, west and the whole area respectively. It was classified as normal diversity in tree community based on Kent (1996). Clearly, tree community at the north and south aspects were much more diverse than the east and west aspects. This result agreed with plant community on Khao Chamao-Khao Wang National Park (Pattanakiat, 2001). In the north aspect as well as the south aspect, they were faced with lower in sunlight than other aspects therefore it might be affected to the complex in topographic, environmental and edaphic factors which could be driven to these variations in species diversity. For the west aspect, tree communities are lower in diversity than the north and south aspects due to some stress of topographic characteristics. Additionally, anthropogenic activities were likely to decrease in species diversity particularly in the east aspect at lower elevations, 400 to 560 meters. The correlation between altitudes and indices was manipulated by Pearson correlation analysis.

Species diversity and evenness indices of tree significantly showed the same direction, increasing in species diversity and evenness value. So plant community at the north aspect displayed that it was highest in evenness value and highest in species diversity as well. The correlation coefficients between species diversity, evenness and altitudes were – 0.066, – 0.140. They seemed to decrease with increase in altitude although they were not significantly correlated.

Table 9. The Shannon diversity index (H´) and evenness index (J) of tree species along various altitudes and aspects.

Aspects	Indices	Altitudes (meters)											Average
		400	440	480	520	560	600	640	680	720	760	800	(Unit: indices)
North	H'	2.56	2.29	2.97	2.88	2.24	3.01	2.76	2.71	2.49	3.08	2.88	2.72
	J	0.81	0.75	0.87	0.85	0.67	0.84	0.86	0.88	0.74	0.85	0.87	0.82
East	H'	1.31	1.93	1.98	2.34	1.19	2.42	2.39	2.66	2.67	2.56	2.88	2.21
	J	0.51	0.80	0.70	0.76	0.36	0.79	0.80	0.82	0.81	0.79	0.87	0.73
South	H'	2.83	2.98	2.95	2.66	3.00	1.16	0.30	0.64	2.98	3.01	2.88	2.31
	J	0.82	0.88	0.92	0.87	0.92	0.37	0.14	0.27	0.89	0.85	0.87	0.71
West	H'	2.18	2.86	2.14	2.44	1.86	2.24	2.72	2.44	1.18	0.31	2.88	2.11
	J	0.76	0.89	0.71	0.83	0.75	0.73	0.85	0.82	0.46	0.28	0.87	0.72
Average	H'	2.22	2.51	2.51	2.58	2.07	2.21	2.04	2.11	2.33	2.24	2.88	2.34
	J	0.72	0.83	0.80	0.83	0.67	0.68	0.66	0.69	0.73	0.69	0.87	0.74

Species diversity values of sapling community along various altitudes and aspects averaged at 2.50, which was higher than of tree and seedling groups. It suggested that sapling community had varities of saplings more than tree and seedling communities. Species diversity index on sapling was significantly correlated with altitudes at – 0.322. It also significantly correlated with evenness index at 0.387. In the west aspect, it was markedly lower in species diversity index of tree community. There were seven sample plots, which were low in species diversity especially at higher elevation. In the east aspect, it showed higher in sapling species diversity than others. According to the analysis of species distributions, this aspect showed lower in tree compositions as species, genera, families and individuals along altitudinal gradients than others, resulting to be thinning canopy layer or small gap. Sapling may be enhanced by penetration of light from that gap (Brown, 1995; Barton, 2003).

Table 10. The Shannon diversity index (H´) and evenness index (J) of sapling species along various altitudes and aspects.

Aspects	Indices	Altitudes (meters)											Average
		400	440	480	520	560	600	640	680	720	760	800	(Unit: indices)
North	H'	2.84	2.63	2.79	3.05	2.17	2.32	2.70	2.41	2.49	2.23	2.31	2.54
	J	0.92	0.89	0.64	0.91	0.74	0.74	0.90	0.89	0.83	0.77	0.83	0.82
East	H'	2.63	2.83	1.98	2.51	2.80	2.18	2.77	2.74	2.60	2.74	2.31	2.55
	J	0.85	0.92	0.75	0.82	0.91	0.88	0.87	0.89	0.90	0.89	0.83	0.86
South	H'	2.62	2.94	2.87	2.39	2.38	2.35	2.40	2.01	2.91	2.15	2.31	2.48
	J	0.85	0.87	0.92	0.80	0.86	0.87	0.91	0.84	0.90	0.81	0.83	0.86
West	H'	2.31	2.56	2.51	2.54	2.13	2.13	2.40	2.54	2.14	2.10	2.31	2.33
	J	0.83	0.87	0.81	0.83	0.83	0.79	0.85	0.85	0.89	0.91	0.83	0.85
Average	H'	2.60	2.74	2.54	2.62	2.37	2.25	2.57	2.43	2.53	2.31	2.31	2.48
	J	0.86	0.89	0.78	0.84	0.83	0.82	0.88	0.87	0.88	0.85	0.83	0.85

For seedling, species diversity was in the same direction as sapling community. Most of sample plots, located at lower elevation, were much more diverse in seedling community than the others. At the north and south aspects, seedling community was still more diverse than the east and west aspects. This might be caused by some topographic and environmental factors of tree community (Nakashizuka *et al.*, 1991; Givnish and Vazquez, 1998). Along elevation, the highest species diversity was found at 640 meter while along aspect it was shown at the east aspect according to Table 11 and Figure 44.

Table 11. The Shannon diversity index (H´) and evenness index (J) of seedling species along various altitudes and aspects.

Aspects	Indices	Altitudes (meters)											Average
		400	440	480	520	560	600	640	680	720	760	800	(Unit: indices)
North	H'	2.73	2.68	2.51	2.37	2.41	2.21	2.36	2.50	2.27	2.39	1.88	2.39
	J	0.91	0.93	0.87	0.93	0.85	0.81	0.92	0.87	0.80	0.86	0.78	0.87
East	H'	1.54	2.76	2.29	2.53	2.17	2.17	2.85	2.57	2.67	2.36	1.88	2.34
	J	0.70	0.94	0.83	0.89	0.82	0.80	0.94	0.93	0.91	0.85	0.78	0.85
South	H'	2.50	2.19	2.77	2.38	2.24	2.53	2.48	2.32	2.32	2.45	1.88	2.37
	J	0.90	0.85	0.88	0.86	0.90	0.91	0.94	0.97	0.86	0.82	0.78	0.88
West	H'	2.17	2.25	2.62	2.45	2.37	2.06	2.48	2.19	2.65	2.22	1.88	2.30
	J	0.85	0.83	0.92	0.90	0.90	0.86	0.92	0.83	0.95	0.96	0.78	0.88
Average	H'	2.23	2.47	2.55	2.43	2.30	2.24	2.54	2.39	2.48	2.35	1.88	2.35
	J	0.84	0.89	0.87	0.90	0.87	0.85	0.93	0.90	0.88	0.87	0.78	0.87

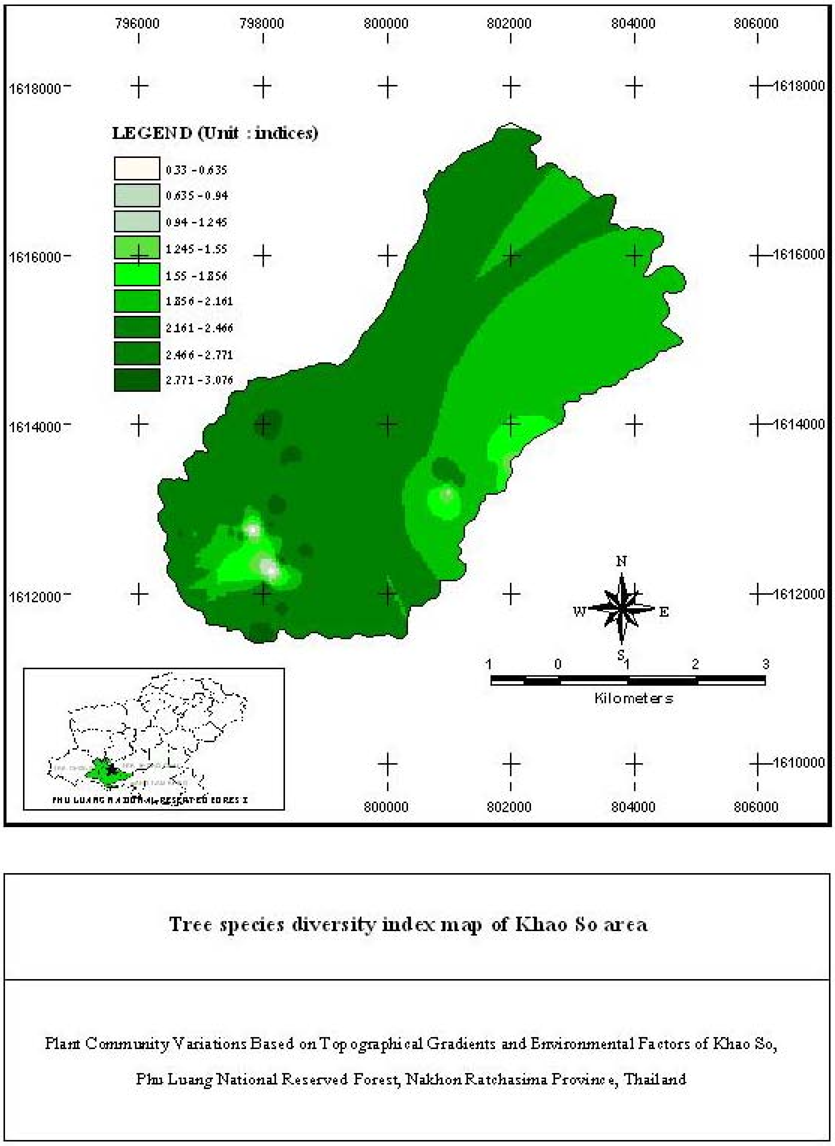


Figure 42. Tree species diversity map of Khao So.

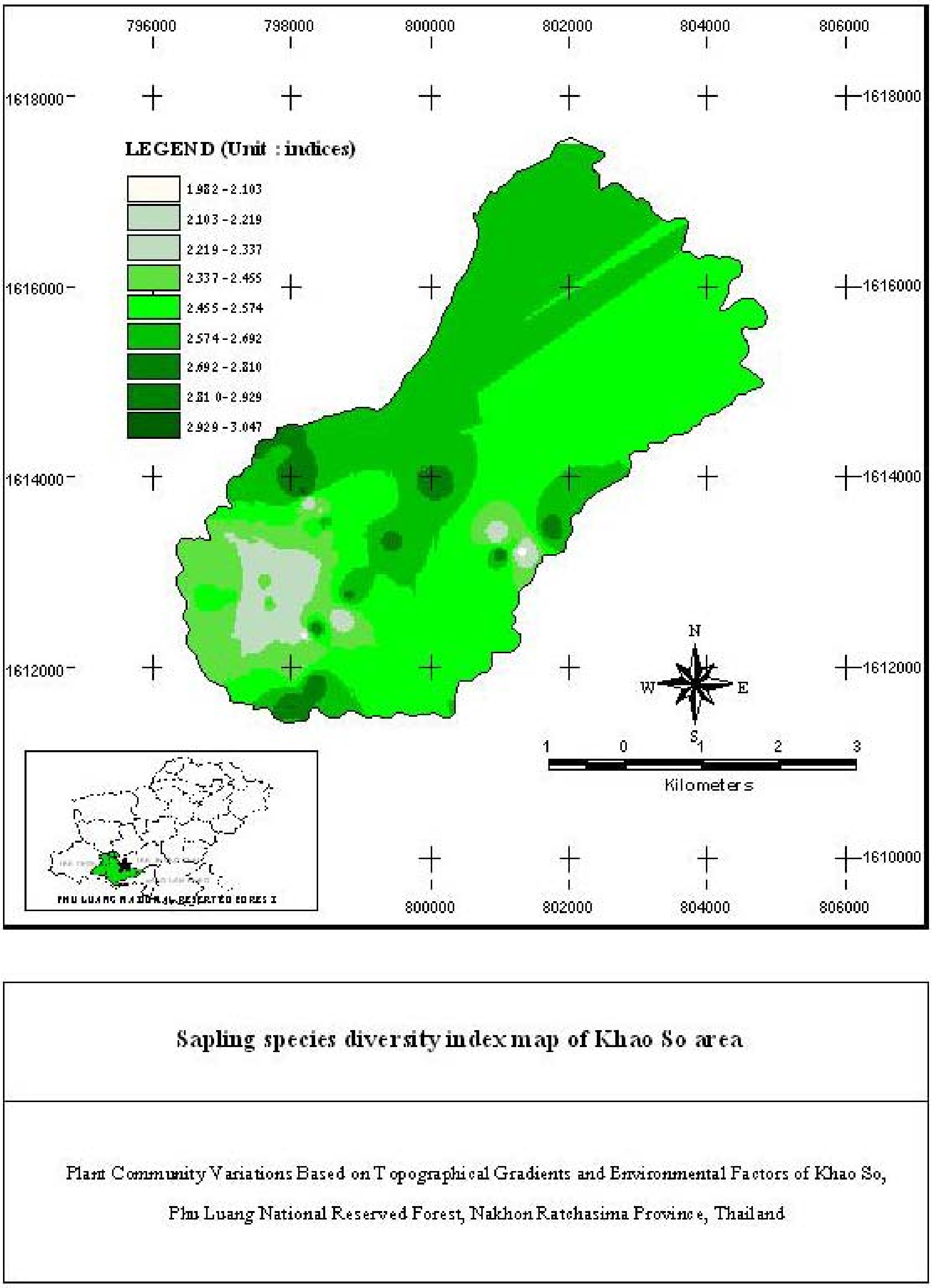


Figure 43. Sapling species diversity map of Khao So.

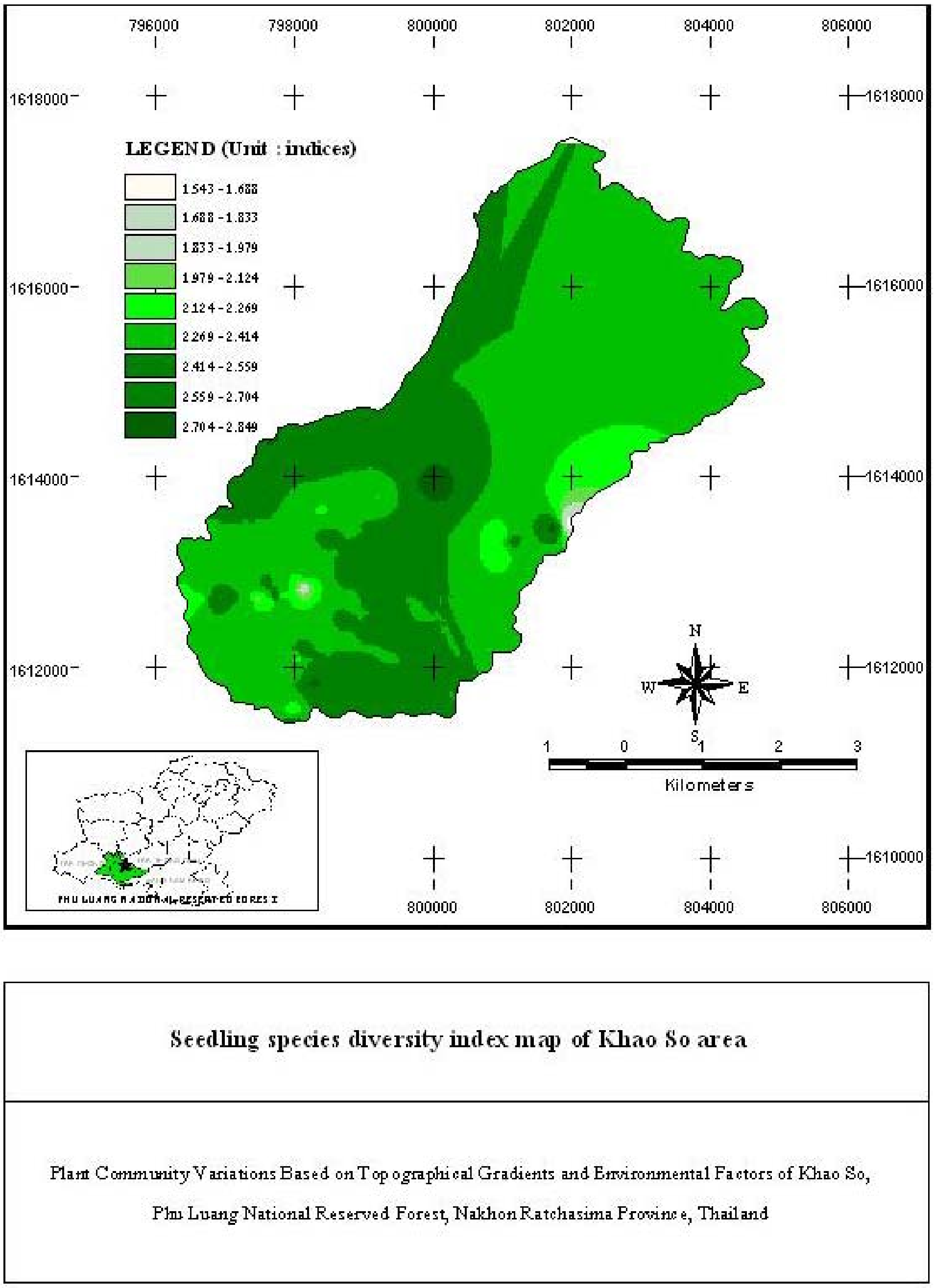


Figure 44. Seedling species diversity map of Khao So.

4.4 Phytosociological and Classification Study

Plant community was analyzed by means of the importance value index of species, genus and family to find out the realistic nature of plant communities. TWINSPAN was utilized for classification (McCune and Grace, 2002). The result was shown in two-way ordered table. Species composition and stand were classified simultaneously into the order of stands on the top and the order of species on the left side of the table. The digit number along row was pseudospecies which represented importance value index of species, genus and family. In addition, in the bottom and the right side were dichotomized keys for stand and species groups. It separated by zeros and ones, which were used to determine the dendrogram of the classifications of species and samples units respectively. Final groups on the last level were mostly similar in species composition. In the study area, the dendrogram of species, genus and family were slightly different so that plant community classification was concentrated in species all of tree, sapling and seedling. More details on genus and family classifications were shown in Appendix Tables 6 to 8 and Figures 4 to 9.

4.4.1 Two way indicator species analysis

4.4.1.1 Tree classification

Tree communities were separated into two main communities. The first dominated by *P. paniculata*, *S. henryana* and *S. siamensis*. The second dominated by *H. ferrea* and *L. duperreana*. Both of these communities varied in sub-communities so that they were classified into 14 sub-communities for stand classification and 35 sub-communities for species classification. They varied in species composition as in the following (Figure 45).

Community A : This community composed of stand 8 and 11. *P. paniculata*, *S. henryana*, *S. siamensis* and *M. leucantha* dominated, while *H. ferrea*, *L. duperreana* could not be found at this community.

Community B : This community composed of stand 25 and 34. *P. paniculata*, *S. henryana* and *S. siamensis* dominated, while *A. pirifera*, *M. caloneura* and *M. leucantha* could not be found at this community.

Community C : This community composed of stand 41. *L. fenestratus, A. pirifera*, *P. paniculata*, *S. henryana* and *S. siamensis* dominated, while *M. caloneura* and *M. leucantha* could not be found at this community.

Community D : This community comprised of stand 21, 33, 37 and 39. It separated from stand 41 so that species composition was *A. pirifera*, *L. fenestratus*, *P. paniculata*, *S. henryana* and *S. siamensis*, whereas *M. caloneura* and *M. leucantha* could not be found at this community.

Community E : This community composed of stand 7 and 35. *A. pirifera*, *P. paniculata*, *S. henryana* and *S. siamensis* dominated, while *L. fenestratus, M. caloneura* and *M. leucantha* could not be found at this community.

Community F : This community composed of stand 3, 19, 29 and 30. *M. caloneura, M. paniculatus, P. paniculata*, *S. henryana* and *S. siamensis* dominated, while *M. leucantha, H. ferrea*, *L. duperreana* could not be found at this community.

Community G : This community consisted of stand 13, 18 and 36. *P. evecta* and *M. caloneura* dominated, while *M. leucantha*, *H. ferrea*, *L. duperreana* could not be found at this community.

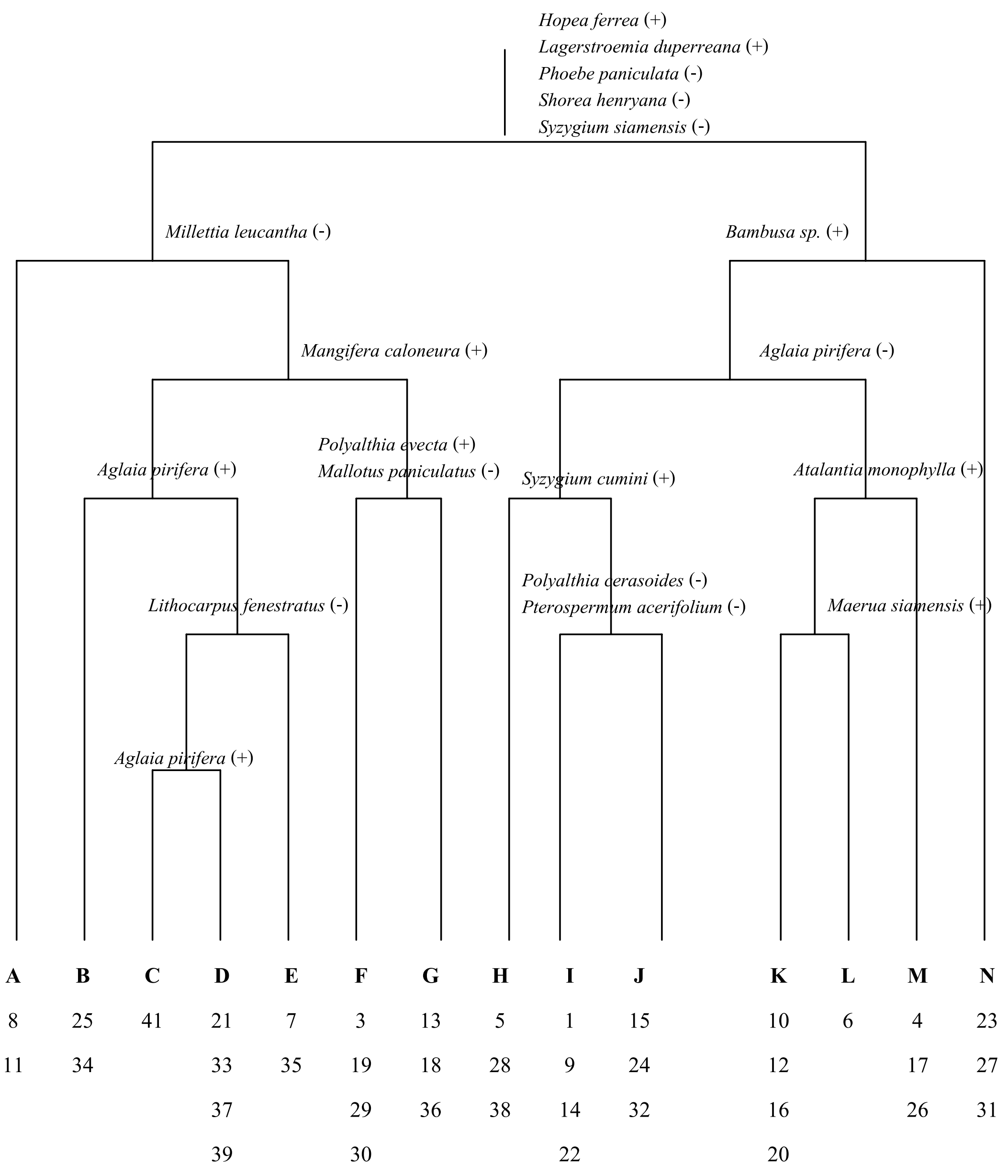
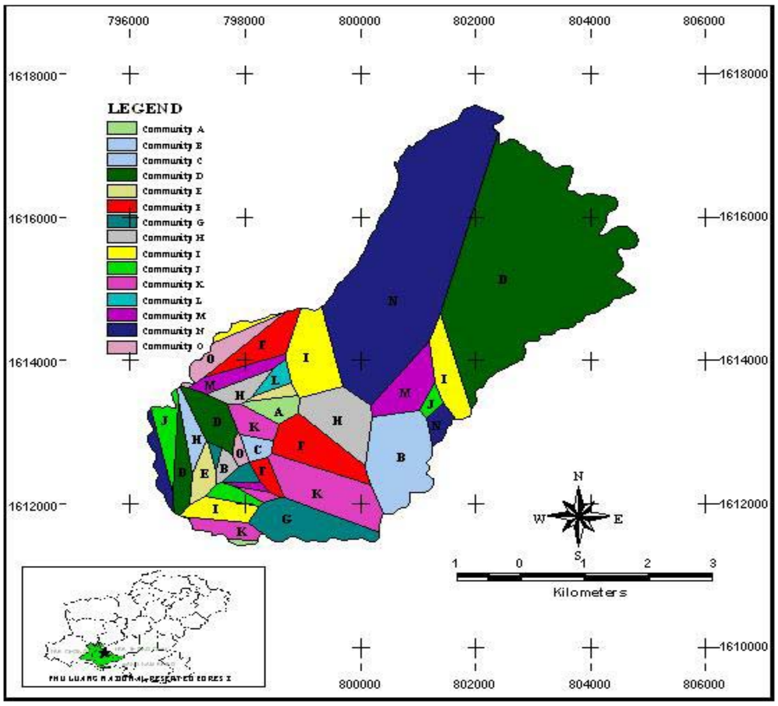


Figure 45. Two-way indicator species analysis dendrogram for tree stands.



Tree community composition map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

Figure 46. Tree community composition of Khao So by Thiessen polygon analysis.

Community H : This community covered with stand 5, 28 and 38. *H. ferrea, L. duperreana* and *A. pirifera* dominated, while *Bambusa* sp., *P. paniculata, S. henryana, S. siamensis* and *S. cumini* could not be found at this community.

Community I : This community composed of stand 1, 9, 14 and 22. *P. cerasoides, P. acerifolium, S. cumini, A. pirifera, H. ferrea* and *L. duperreana* dominated, while *S. henryana, Bambusa* sp., *P. paniculata, S. henryana* and *S. siamensis* could not be found at this community.

Community J : This community composed of stand 15, 24 and 32. *S. cumini, A. pirifera* dominated, while *P. cerasoides, P. acerifolium, S. henryana* and *Bambusa* sp. could not be found at this community.

Community K : This community composed of stand 10, 12, 16 and 20. *H. ferrea* and *L. duperreana* dominated, while *M. siamensis, A. monophylla, A. pirifera* and *Bambusa* sp. could not be found at this community.

Community L : This community composed of stand 6. *M. siamensis, H. ferrea* and *L. duperreana* dominated, while *A. monophylla, A. pirifera* and *Bambusa* sp. could not be found at this community.

Community M : This community composed of stand 4, 17 and 26. *A. monophylla, H. ferrea* and *L. duperreana* dominated, while *A. pirifera* and *Bambusa* sp. could not be found at this community.

Community N : This community composed of stand 23, 27 and 31. *Bambusa* sp., *H. ferrea* and *L. duperreana* dominated, while *P. paniculata, S. henryana* and *S. siamensis* could not be found at this community.

Interestingly, tree stand classification separated into two main communities. Most of plant communities at the north and south facing stands based on *P.*

paniculata, *S. henryana* and *S. siamensis* and the east and west facing stands based on *H. ferrea* and *L. duperreana*. Communities were classified by aspect as community C, D, E, K, L, and N. Tree communities were grouped along elevation direction according to Thiessen polygon analysis (Figure 46) which was in a silmilar way like Sorensen analysis. Species composition was classified into 35 sub-communities at dichotomized key sixth level as follow:

Community A : This community composed of *Carallia brachiata* Merr., *P. diversifolium*, *M. azedarach*, *Ficus hispida* Linn. f., *Artocarpus lakoocha* Roxb., *Wrightia tomentosa* Roem. & Schult., *Pterocarpus macrocarpus* Kurz, and *C. mitis*.

Community B : This community composed of *M. stipulata*, *B. ramiflora*, and *Garcinia speciosa* Wall.

Community C : This community composed of *Garcinia cowa* Roxb., *Dracaena loureiri* Gagnep., *C. micracantha*, *Celtis timorensis* Span., *Stereospermum neuranthum* Kurz, *Celtis tetrandra* Roxb., *Polyalthia lateriflora* King, *Aquilaria crassna* Pierre, *Mitrephora vandiflora* Kurz, *M. caloneura*, *A. triphysa*, *Memecylon scutellatum* Naud., *Aporusa villosa* Baill., *Pterocymbium javanicum* R. Br., *A. polystachya*, and *A. toxicaria*.

Community D : This community composed of *C. excavata*, *A. costata*, *Prunus ceylanica* Miq., *Sapium discolor* Muell. Arg.

Community E : This community composed of *N. hypoleucum*, *Prunus arborea* Kalkm., *D. turbinatus*.

Community F : This community composed of *Cinnamomum iners* Bl., *A. pedunculata*, *Ternstroemia gymnanthera* Bedd., *V. glabrata*, *L. fenestratus*, *Q. ramsbottomii*, *Phoebe lanceolata* Nees, *K. furfuracea*, *C. axillaris*, *Prunus grisea*

Kalkm., *Memecylon cyaneum* de Willd, *Sapium baccatum* Roxb., *Eurya acuminata* DC., *C. cascarilloides*, *Sterculia guttata* Roxb., *Ardisia littoralis* Andr., *Acrocarpus fraxinifolius* Wight & Arn., *M. peltatus*, *H. odorata*, *S. oleosa*, *A. lenticellata*, *Bridelia retusa* Spreng., *Sumbaviopsis albicans* J.J. Smith, *Syzygium thorelii* Gagnep., *Dipterocarpus costatus C.F.*Gaertn.

Community G : This community composed of *Neolitsea zeylanica* Merr., *M. paniculatus*, *C. harmandiana*, Unidentified 3.

Community H : This community composed of *P. paniculata*.

Community I : This community composed of *S. siamensis*.

Community J : This community composed of *S. henryana*, *M. grandis*, *U. siamensis*.

Community K : This community composed of *Ficus altissima* Bl., *Toona ciliata* M. Roem.

Community L : This community composed of *Vitex peduncularis* Wall. ex Schauer, *P. sumatrana*, *Siphonodon celastrineus* Griff., *Polyalthia asterilla* Ridl.

Community M : This community composed of *M. philippensis*.

Community N : This community composed of *M. caeruleum*, *T. nudiflora*, Unidentified 1.

Community O : This community composed of *Litsea glutinosa* C.B. Robinson, Unidentified 2.

Community P : This community composed of *A. kerrii*, *M. leucantha*, *Irvingia malayana* Oliv. ex A. Benn., *Adenanthera pavonina* Linn.

Community Q : This community composed of *P. longifoliolatum*, *Bambusa* sp.

Community R : This community composed of *S. ilicifolius*.

Community S : This community composed of *D. oliveri*.

Community T : This community composed of *Melodorum fruticosum* Lour., *P. evecta*, *Ficus* sp., *P. viridis*.

Community U : This community composed of *M. tomentosa*.

Community V : This community composed of Neolitsea casiaefolia Merr., C. *hirsutulus, P. acerifolium, A. pirifera*, *Aglaia chaudocensis* Pierre, *Lagerstroemia calyculata* Kurz.

Community W : This community composed of *D. ferrea*, *Vitex quinata* Williams.

Community X : This community composed of *W. trichostemon*, *H. ilicifolius*.

Community Y : This community composed of *M. paniculata*, *M. ovatum*, *S. cumini*.

Community Z : This community composed of *Diospyros dasyphylla* Kurz, *S. multiflorum*, *D. cochinchinensis*, *Dehaasia candolleana* Kosterm.

Community AA : This community composed of *Polyalthia cerasoides* Benth. ex Bedd., *D. malabarica*.

Community AB : This community composed of *I. Cibdela*, *E. longifolia*, *L. loudonii*, *H. ferrea*.

Community AC : This community composed of *A. siamensis*, *D. variegata*, *Mammea harmandii* Kosterm.

Community AD : This community composed of *Guioa pleuropteris* Radlk., *Flacourtia rukam* Zoll. & Mor.

Community AE : This community composed of *A. xylocarpa*, *A. microsperma*, *Diospyros kerrii* Craib, *Antidesma bunius* Spreng., *Elaeocarpus robustus* Roxb.

Community AF : This community composed of *D. cochinchinense*, *Canarium subulatum* Guill., *Mammea siamensis* Kosterm.

Community AG : This community composed of *Diospyros gracilis* Fletch., *Phyllanthus emblica* Linn., *Sterculia foetida* Linn., *L. duperreana*.

Community AH : This community composed of *Drypetes hainanensis* Merr.

Community AI : This community composed of *P. dasyrachis*, *M. siamensis*, *Diospyros pilosanthera* Blanco, *M. hexandra*, *Tarenna collinsae* Craib, *Chionanthus microstigma* Gagnep, *L. leucocephala*, *Haldina cordifolia* Ridsd., *Diospyros coaetanea* Fletch., *L. tetraphylla*, *Madhuca pierrei* Lam, *Spondias pinnata* Kurz, *A. monophylla*, *Randia dasycarpa* Bakh. f., *Bombax ceiba* Linn., *Zizyphus mauritiana* Lamk., *Colona auriculata* Craib, *Chionanthus macrostigma* Gagnep, *Cananga latifolia* Finet & Gagnep., *S. amentiflora*, *B. viridescens*, *Bauhinia saccocalyx* Pierre, *Diospyros castanea* Fletch., *Diospyros montana* Roxb., *Drypetes hoaensis* Gagnep., *Cratoxylum cochinchinense* Bl., *Syzygium fruticosa* Roxb.

From species classification, community X, which composed of *W. trichostemon* and *H. ilicifolius*, was the most abundance and ecological performance in tree species classification. While, *P. paniculata*, *S. siamensis*, *M. philippensis*, *S. ilicifolius*, *D. oliveri*, *M. tomentosa* and *D. hainanensis* were separately classified into rare species groups. Espectially, *M. tomentosa* and *D. hainanensis* were uncommon species for tree, sapling and seedling communities. It might be that they usually dominated in moist evergreen forest thus they were clearly classified to rarer group according to TWINSPAN analysis. Whereas *D. oliveri* and *S. ilicifolius* were really indicator species for dry evergreen forest (Kutintara, 1998) but they showed low in abundance and ecological performance of tree, sapling and seedling (around 20% of tree cover) and then they were grouped into rare species group. For *P. paniculata* and *S. siamensis*, they were likely to be higher in the percentage cover (up 50%) of ecological performance but lower in abundance. They could be found in specific community as stand 41, 3, 19, 29, 30 for *P. paniculata* and stand 25, 34, 41, 7, 35, 13, 18 for *S. siamensis*. They differently distributed from others so that they were classified into a rare species community. For genus classification, *Walsura, Hydnocarpus* and *Memeclylon* were mostly abundant genus at nearly all stands. Melastomataceae, Dipterocarpaceae, Euphorbiaceae, Flacourtiaceae, Moraceae, Meliaceae and Myrtaceae were grouped into a mostly ubiquitous family on tree communities.

4.4.1.2 Sapling classification

Sapling communities separated into 13 sub-communities on stand classification and 24 sub-communities on species classification. Generally, It comprised of *C. micracantha, H. ferrea* and *S. henryana* on stand classification. Thus, groups covered with specific species composition as following (Figures 47-48).

Community A : This community composed of stand 31. *C. micracantha, H. ferrea, S. cumini, H. ferrea* and *S. multiflorum* dominated, while *S. siamensis* and *D. malabarica* could not be found at this community.

Community B : This community composed of stand 6 and 26. *S. amentiflora* and *A. monophylla,* dominated, while *S. multiflorum, S. siamensis* and *D. malabarica* could not be found at this community.

Community C : This community composed of stand 4, 5, 10, 12, 15, 16, 17, 20 and 22. *S. amentiflora*, *W. trichostemon*, *H. ferrea*, *S. cumini* and *C. micracantha* dominated, while *D. malabarica*, *P. dasyrachis* and *S. siamensis* could not be found at this community.

Community D : This community composed of stand 1, 9, 14, 23, 24, 29 and 32. *D. malabarica*, *H. ferrea, S. cumini* and *C. micracantha* dominated, while *W. trichostemon, S. amentiflora* and *P. dasyrachis* could not be found at this community.

Community E : This community composed of stand 2. *P. dasyrachis, H. ferrea, S. cumini* and *C. micracantha* dominated, while *S. amentiflora*, *A. monophylla*, *S. multiflorum, S. siamensis* and *D. malabarica* could not be found at this community.

Community F : This community composed of stand 19, 28, 30 and 38. *D. malabarica, S. siamensis, C. micracantha* and *H. ferrea* dominated, while *D. oliveri* could not be found at this community.

Community G : This community composed of stand 3, 13 and 18, separated from stand 19, 28, 30 and 38. So dominated species were *D. malabarica, S. siamensis, C. micracantha* and *H. ferrea* as of community F.

Community H : This community composed of stand 27. *D. oliveri* dominated, while *H. ferrea* and *S. cumini* could not be found at this community.

Community I : This community composed of stand 33. *G. pentaphylla, M. suavis* and *S. henryana* dominated, while *S. celastrineus* could not be found at this community.

Community J : This community composed of stand 25. *D. dasyphylla, M. suavis* and *S. henryana* dominated, while *G. pentaphylla, S. celastrineus, C. micracantha* and *H. ferrea* could not be found at this community.

Community K : This community composed of stand 21, 34, 37 and 39, separated from stand 25. Therefore its dominated species was community J, *D. dasyphylla, M. suavis* and *S. henryana* whereas *G. pentaphylla, S. celastrineus, C. micracantha* and *H. ferrea* could not be found.

Community L : This community composed of stand 7, 35 and 41. *S. celastrineus* and *S. henryana* dominated, while *M. suavis* could not be found at this community.

Community M : This community composed of stand 8 and 36. It separated from group I, J, K, L and M. *C. micracantha* and *H. ferrea* could not be found at this community.

For species classification, sapling communties at Khao So covered with 24 sub-communities on species classification at the sixth level. Community A, and B could be found at most of the east and west facing stands. Community M, N, O and P could be found at the north and south facing stands. Species on community L, *C. hirsutulus*, was the most abundant species. For sapling species classification, only three species were calssified as rare species, *C. excavata*, *I. Cibdela* and *M. peltatus*. Only *I. Cibdela* showed higher in abundance and seemed to be a ubiquitous species but lower in the percentage of cover (around 5%). Therefore it was considered to be a rare species in sapling. Interestingly, it showed commonly in seedling species. *I. Cibdela* was classified into a dominant group based on ecological performance (50%

of percentage cover) for seedling community. It was possibly prefered only at undergrowth canopy (Kutintara, 1998; Simitinand *et al.*, 1977). The species classification composed of various species in each community as in the following:

Community A : This community composed of *H. ilicifolius*, *M. ovatum*, *S. cumini*

Community B : This community composed of *A. siamensis*, *C. micracantha*, *A. monophylla*

Community C : This community composed of *S. multiflorum*, *D. ferrea*, *L. rubiginosa*, *P. emblica*

Community D : This community composed of *P. dasyrachis*, *D. loureiri*, *Diospyros pilosula* Hiern, *D. gracilis*, *C. microstigma*, *L. leucocephala*, *Melientha suavis* Pierre, *Prismatomeris filamentosa* Craib, *C. macrostigma*, *S. amentiflora*, *B. saccocalyx*, *H. ferrea*, *F. rukam*, *D. castanea*, *C. cochinchinense*

Community E : This community composed of *C. orientalis*, *D. pilosanthera*, *T. collinsae*, *I. Malayana*, *M. fruticosum*, *C. axillaris*, *L. glutinosa*, *M. scutellatum*, *D. cochinchinensis*, *D. variegata*, *Diospyros* sp., *S. baccatum*, *C. cascarilloides*, *L. calyculata*, *L. duperreana*, *Terminalia dafeuillana* Pierre ex Laness., *H. odorata*, *V. quinata*, *D. montana*, *D. hoaensis*, *P. viridis*.

Community F : This community composed of *P. cerasoides*, *M. siamensis*.

Community G : This community composed of *D. oliveri*, *L. loudonii*, *D. malabarica*.

Community H : This community composed of *A. xylocarpa*, *A. microsperma*, *Ficus* sp.

Community I : This community composed of *C. tetrandra*, *P. longifoliolatum*, *S. guttata*, *D. hainanensis*, *P. asterilla*.

Community J : This community composed of *G. cowa*, *Miliusa mollis* Pierre, *Pinanga hookeriana* Becc., *Bridelia ovata* Decne., *M. caloneura*, *Croton oblongifolius* Roxb., *T. ciliata*.

Community K : This community composed of *C. excavata*.

Community L : This community composed of *D. dasyphylla*, *C. hirsutulus*, *U. siamensis*, *M. tomentosa*.

Community M : This community composed of *M. paniculata*, *S. ilicifolius*, *D. candolleana*.

Community N : This community composed of *W. trichostemon*, *P. evecta*.

Community O : This community composed of *A. pirifera*, *A. chaudocensis*.

Community P : This community composed of *I. Cibdela*.

Community Q : This community composed of *A. kerrii*, *P. diversifolium*, *G. speciosa*, *C. mitis*.

Community R : This community composed of *P. acerifolium*, *M. stipulata*, *D. kerrii*, *C. harmandiana*.

Community S : This community composed of *M. grandis*, *M. caeruleum*.

Community T : This community composed of *S. siamensis*, *A. polystachya*, *S. thorelii*.

Community U : This community composed of *C. iners*, *Xylia xylocarpa* Taub., *V. peduncularis*, *A. pedunculata*, *S. henryana*, *Glycosmis pentaphylla* Corr., *P. sumatrana*, *P. paniculata*, *A. lenticellata*, *S. albicans*, Unidentified 1.

Community V : This community composed of *V. glabrata*, *L. speciosa*, *R. lanceolata*, *P. lanceolata*, *K. furfuracea*, *S. celastrineus*, *P. ceylanica*, *Photinia stenophylla* Hand., *E. longifolia*, *E. acuminata*, *A. fraxinifolius*, *D. turbinatus*, *A. toxicaria*.

Community W : This community composed of *Agrostistachys indica* Dalzell, *F. hispida*, *B. ramiflora*, *M. philippensis*, *Ailanthus triphysa* Alston, *Bambusa* sp., *M. paniculatus*, *S. discolor*, *A. scholaris*.

Community X : This community composed of *M. peltatus*.

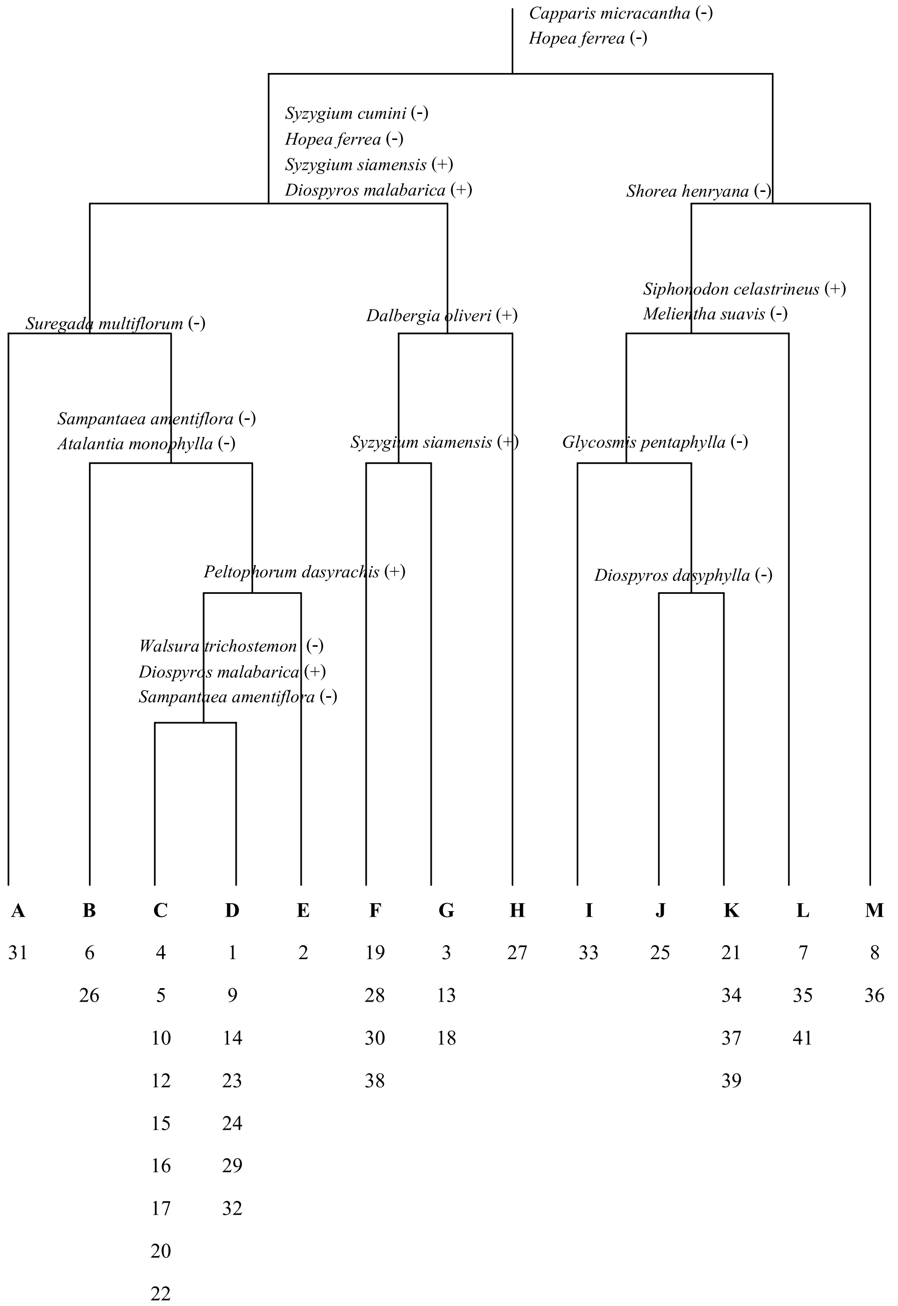


Figure 47. Two-way indicator species analysis dendrogram for sapling stands.

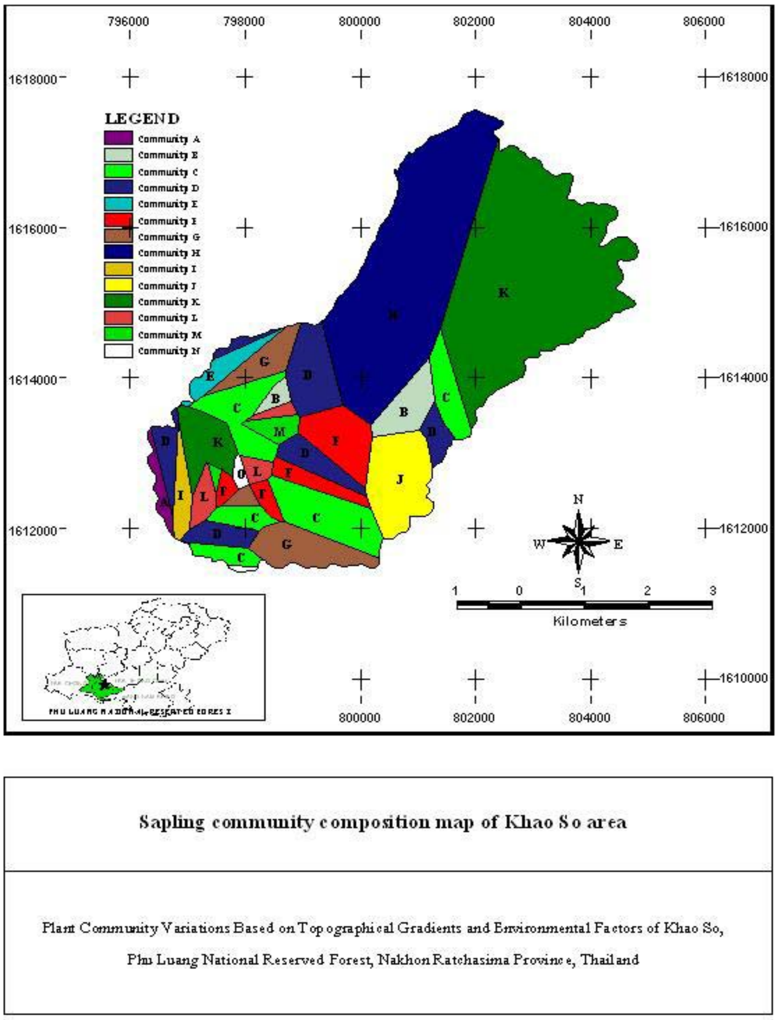


Figure 48. Sapling community composition of Khao So by Thiessen polygon analysis.

4.4.1.3 Seedling classification

The classification of sample stands divided into two dominance-types following the dendrogram, namely *A. siamensis, H. ferrea* and *S. henryana*, *M. grandis* types. Seedling stand classification grouped in to 12 sub-communities (Figures 49-50). Each communities slightly differed in species composition as following:

Community A : This community composed of stand 6 and 26. *A. siamensis, H. ferrea* and *A. monophylla* dominated, while *S. henryana* and *M. grandis* could not be found at this community.

Community B : This community composed of stand 4, 13, 18 and 23. *A. siamensis, A. kerrii, S. ilicifolius, A. toxicaria* and *H. ferrea* dominated, while *A. monophylla, S. henryana* and *M. grandis* could not be found at this community.

Community C : This community composed of stand 10, 15 and 20. *C. orientalis* dominated, while *C. cascarilloides, M. paniculata, A. pirifera, A. kerrii, A. siamensis* and *A. monophylla* could not be found at this community.

Community D : This community composed of stand 12, 16, 17 and 22. *C. cascarilloides* and *C. orientalis* dominated, while *M. paniculata, A. pirifera, A. kerrii, A. siamensis* and *A. monophylla* could not be found at this community.

Community E : This community composed of stand 1, 3, 9, 14, 19 and 30. *M. paniculata, A. pirifera* and *C. orientalis* dominated, while *S. siamensis* could not be found at this community.

Community F : This community composed of stand 24 and 38. *S. siamensis* dominated, while *A. kerrii* and *A. siamensis* could not be found at this community.

Community G : This community composed of stand 5, 28, 29 and 32. *H. ferrea* dominated, while *S. henryana* and *M. grandis* could not be found at this community.

Community H : This community composed of stand 2, 27 and 31. It separated from stand 5, 28, 29 and 32. So species compositions were *H. ferrea* dominated, while *S. henryana* and *M. grandis* could not be found at this community.

Community I : This community composed of stand 7, 25 and 35. *S. henryana*, *M. grandis, I. cibdela* and *A. lenticellata* dominated, while *A. pedunculata, H. ilicifolius* and *C. orientalis* could not be found at this community.

Community J : This community composed of stand 21, 34 and 37. *A. pedunculata* dominated, while *H. ilicifolius* and *C. orientalis* could not be found at this community.

Community K : This community composed of stand 33, 39, 40 and 41. *H. ilicifolius, S. henryana* and *M. grandis* dominated, while *I. cibdela*, *A. lenticellata* could not be found at this community.

Community L : This community composed of stand 11. *C. orientalis, S. henryana* and *M. grandis* dominated, while *A. siamensis* and *H. ferrea* could not be found at this community.

However species composition was grouped into 22 communities at the sixth level and *C. hirsutulus* was identified as the most dominance speices based on the ecological performance and abundance values. It could be found neary all of stands. While *D. gracilis*, *L. leucocephala, S. siamensis* and *C. excavata* were classified as rarer species for seedling community. Usually *S. siamensis* and *C. excavata* were ubiquitous and dominant in tree community. On seedling, they acted as uncommon species becaused they were low in abundance and separated into rarer group. This might be classified as 2-6 pseudospecies (3-50% of cover), which were higher than that of uncommon species. Each community based on species classification classified as:

Community A : This community composed of *D. loureiri*, *Caesalpinia sappan* Linn., *Diospyros bejaudii* Lec., *D. pilosanthera, M. hexandra, C. microstigma*, *Diospyros mollis* Griff., *A. monophylla*, *P. filamentosa*, *S. amentiflora*, *B. saccocalyx*, *Garuga pinnata* Roxb..

Community B : This community composed of *D. gracilis*.

Community C : This community composed of *L. leucocephala*.

Community D : This community composed of *F. rukam, A. polystachya*.

Community E : This community composed of *P. dasyrachis, A. siamensis, D. oliveri*, *C. micracantha*, *D. cochinchinense*, *D. ferrea*, *M. fruticosum*, *D. variegata*, *D. candolleana*, *B. viridescens*, *H. odorata*.

Community F : This community composed of *D. dasyphylla*, *A. triphysa*, *H. ferrea*.

Community G : This community composed of *D. pilosula*, *P. cerasoides*, *P. acerifolium*, *Ixora* sp., *Ixora grandifolia* Zoll. & Morton, *Streblus asper* Lour., *P. diversifolium*, *P. emblica*, *Croton longissimus* Airy Shaw, *S. guttata*, *A. chaudocensis*, *Ficus* sp., *C. mitis*, Unidenfied 2.

Community H : This community composed of *C. orientalis*, *S. ilicifolius*, *C. cascarilloides, C. macrostigma*.

Community I : This community composed of *W. trichostemon*, *M. siamensis*.

Community J : This community composed of *M. paniculata*, *T. collinsae*, *M. ovatum*, *D. hainanensis*.

Community K : This community composed of *M. stipulata*, *P. evecta*, *C. harmandiana*, *S. discolor*.

Community L : This community composed of *M. scutellatum*, *U. siamensis*, *M. tomentosa*.

Community M : This community composed of *M. mollis*, *A. kerrii*, *A. toxicaria*.

Community N : This community composed of *C. hirsutulus*, *A. pirifera*, *H. ilicifolius*.

Community O : This community composed of *I. Cibdela*, *G. pentaphylla*.

Community P : This community composed of *S. multiflorum, M. caeruleum*.

Community Q : This community composed of *V. glabrata*, *P. longifoliolatum*, *L. rubiginosa*, *M. philippensis*.

Community R : This community composed of *S. henryana*, *M. leucantha*, *M. azedarach*, *B. ramiflora*, *P. macrocarpus*, *M. peltatus*, *M. harmandii*.

Community S : This community composed of *C. iners*, *S. celastrineus*, *A. lakoocha*, *M. grandis*, *Bambusa* sp., *P. paniculata*, *S. cumini*, *D. turbinatus*, Unidentified 1.

Community T : This community composed of *A. pedunculata*, *P. lanceolata*, *K. furfuracea*, *F. hispida*, *E. longifolia*, *E. acuminata*, *A. fraxinifolius*, *A. lenticellata*, *S. albicans*, *P. viridis*.

Community U : This community composed of *S. siamensis*.

Community V : This community composed of *C. excavata*.

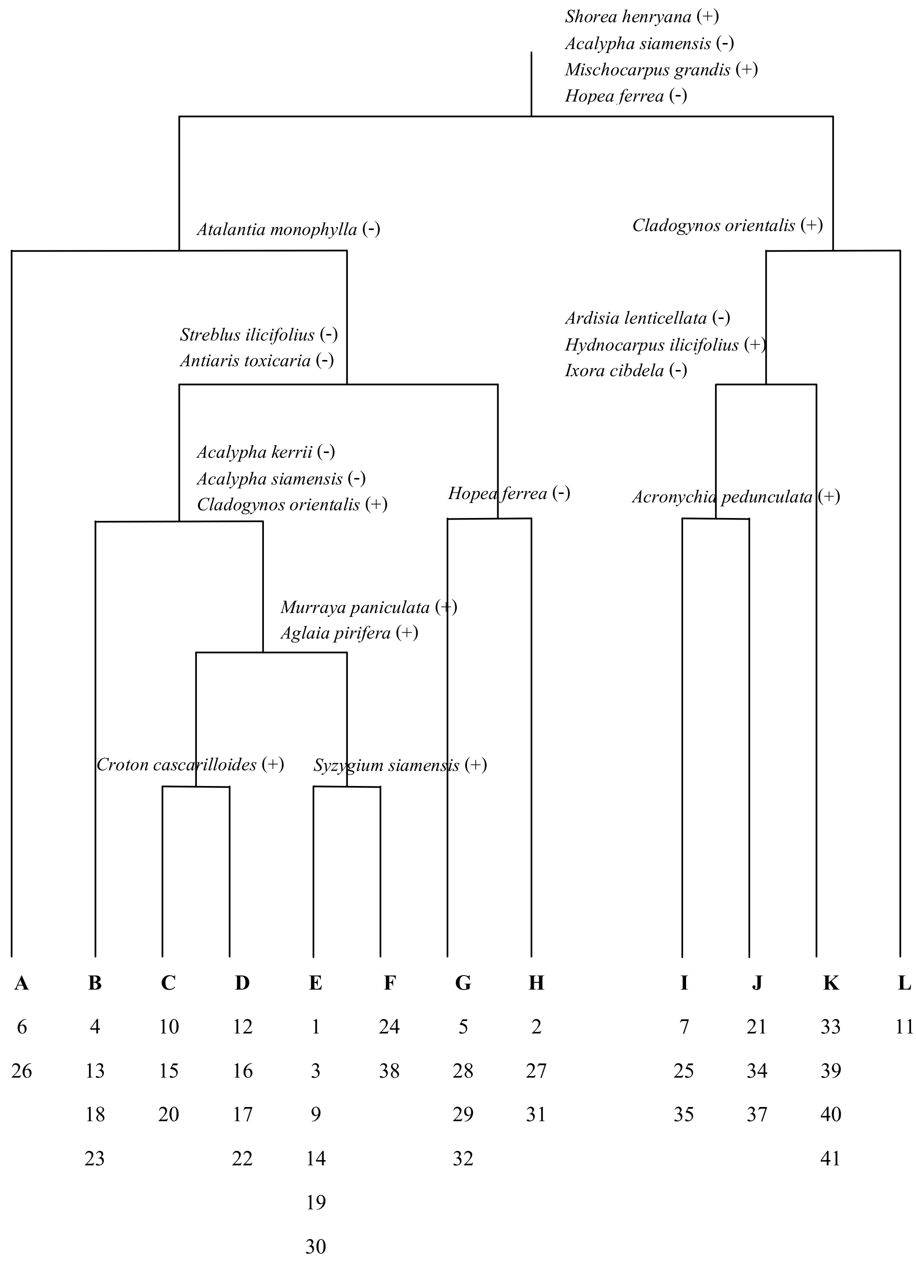
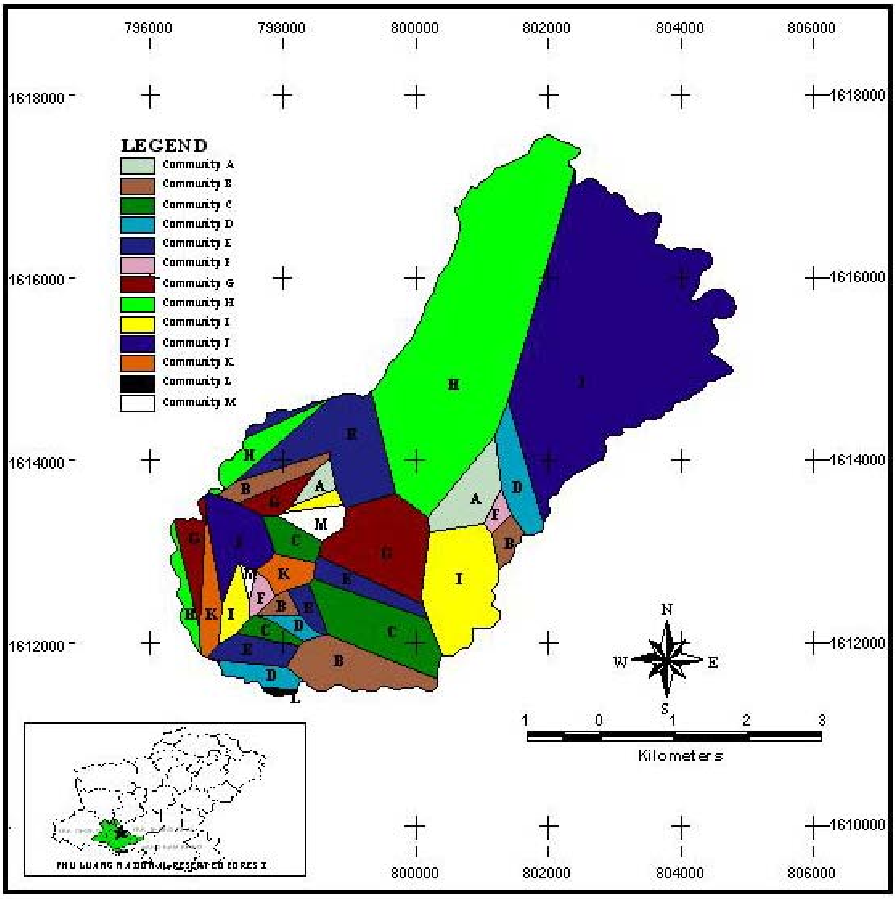


Figure 49. Two-way indicator species analysis dendrogram for seedling stands.



Seedling community composition map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

Figure 50. Seedling community composition of Khao So by Thiessen polygon analysis.

Notably, plant communities at Khao So area composed of various species compositions according to above-dendrograms. Plant communities were classified into 14, 13, 12 sub-communities based upon stand classification and with 35, 24, 22 sub-communities in species classification of tree, sapling and seedling communities respectively. Trees shown in a greater numbers of plant communities of both stand and species classifications. Although it enormously comprised of many communities, two major community types relied upon the *H. ferrea* community and *S. henryana* community in all vegetation (tree, sapling and seedling). Bunyavejchewin (1994) studied on ecology of tropical semi-evergreen rain forest at Sakaerat, Nakhon Ratchasima, Northeast Thailand. He also grouped plant communities into the main communities but their co-dominant species varied along environmental factors. With the differences on plant communities; therefore CCA was used to display that how plant communities floristically related to environmental variables.

4.4.2 Canonical correspondence analysis

From the study, CCA diagrams of tree, sapling, and seedling appeared that ordination classification by species slightly differed from TWINSPAN classification. They closely related to various environmental variables all of tree, sapling and seedling communities. The result of ordination analysis also separated according to aspects as TWINSPAN. So leading dominant species, which classified by an altitude function and TWINSPAN classification, were employed as representative species to demonstrated the relationship pattern between plant communities and environmental variables.

From Figure 51 most of tree community at the north and south facing stands fallen in the left side of two-dimensional ordination, while tree community at the east and west facing stands fallen in another side of diagram. The relationships between tree species and environmental variables exhibited that tree communities depend on seven factors as elevation, moisture, organic matter, bulk density, soil reaction, exchangeable cation of calcium and magnesium in various directions. The first axis significantly related with soil moisture content, elevation and the second axis correlated with exchangeable cation of magnesium, calcium, sodium, bulk density and soil reaction with 0.879 and 0.831 correlation coefficients. Plant species were plotted along their florestically environmental gradients. Therefore indicator species of tree community, *H. ferrea*, *L. duperreana*, *P. paniculata*, *M. paniculatus*, *S. siamensis*, *Bambusa* sp., *M. ovatum* as a primary species from altitude function, are shown via the scatterplot diagrams to illustrate their distribution characteristics as follows:

S. siamensis dominated at the north and south aspects. The scatterplot displayed in unimodal pattern on axis 1, decreasing in plots that scored very hight or very low on that axes. It was influencd by soil moisture content, elevation and exchangeable cation of magnesium, calcium, sodium, bulk density and soil reaction with –0.428 and –0.177 of correlation coefficient values on axes 1 and 2 respectively. This indicated that *S. siamensis* distributed in moist area and low in soil reaction, exchangeable of calcium, magnesium, sodium, and bulk density.

H. ferrea was a nearly ubiquitous species in both axes, but was most abundant in plots falling on the right side of axis 1 (Appendix Figure 10). It seemed to dominate at most of the east and west aspects. The correlation coefficients between *H. ferrea* and ordination on axes 1 and 2 were 0.479, 0.178 respectively. This implied that it prefered in dry area and also possitively correlated with environment factors, exchangeable cation of magnesium, calcium, sodium, bulk density and soil reaction.

Bambusa sp. was nearly rare species except for a few samples along the environmental gradient of Khao So. The scatterplot displayed that it decreased at the end right on axis 1 and the beginning on axis 2. This indicated that *Bambusa* sp. responded to environmental gradient especially altitude at – 0.760 correlation coefficient value. It meant that *Bambusa* sp. usually dominated only at higher elevations.

P. paniculata and *M. paniculatus* were similar in species distribution along environmental gradients. They were abundant at a few stands, espectially at the west aspect. They respond along axes in the same direction, decreasing in plots that fallen in high score on both axes but *M. paniculatus* slightly differed on axis 1, increasing in plots that scored high. The correlation coefficients were – 0.229, – 0.281 for *P. paniculata* and 0.129, -0.361 for *M. paniculatus* on axes 1 and 2 respectively.

L. duperreana and *M. ovatum* were dominated at a few stands in the west and south aspects. The correlation coefficients were 0.117, 0.393 in *L. duperreana* and 0.282, 0.180 in *M. ovatum* along axess 1 and 2 respectively. *L. duperreana* was positively correlated with and influenced by bulk density, soil reaction, exchangeable cation of magnesium, calcium and sodium respectively. While *M. ovatum* positively correlated with and influenced by moisture content and environmental factors.

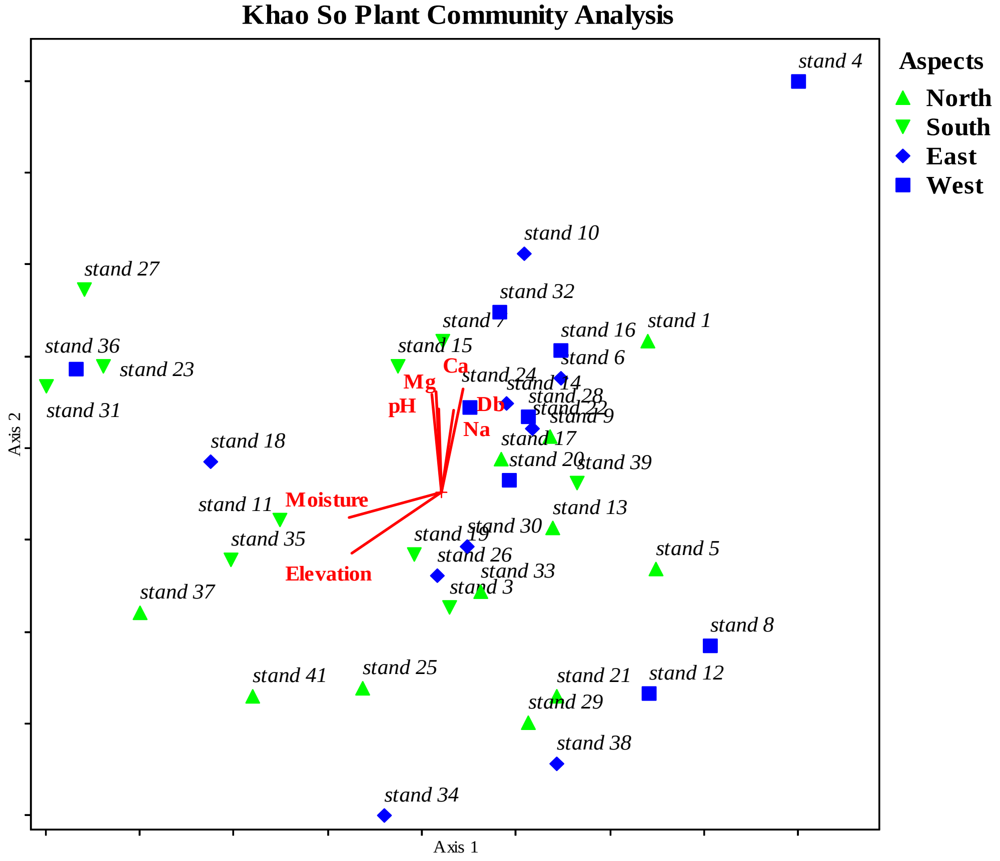


Figure 51. The relationship between tree communities and environmental variables by Canonical Correspondence Analysis (CCA).

Sapling communities were divided into two directions with different environmental variables closely at axis 1 (Figure 52). It implied that sapling distributed along specific gradients especially with elevation, soil moisture content, organic matter, total nitrogen at 0.866 correlation coefficient on axis 1. The second axis based on bulk density and soil reaction with 0.856 correlation value. Sapling stands, which were relied on the right side, based on east and west aspects while the left side of diagram coverd with the north and south facing stands.

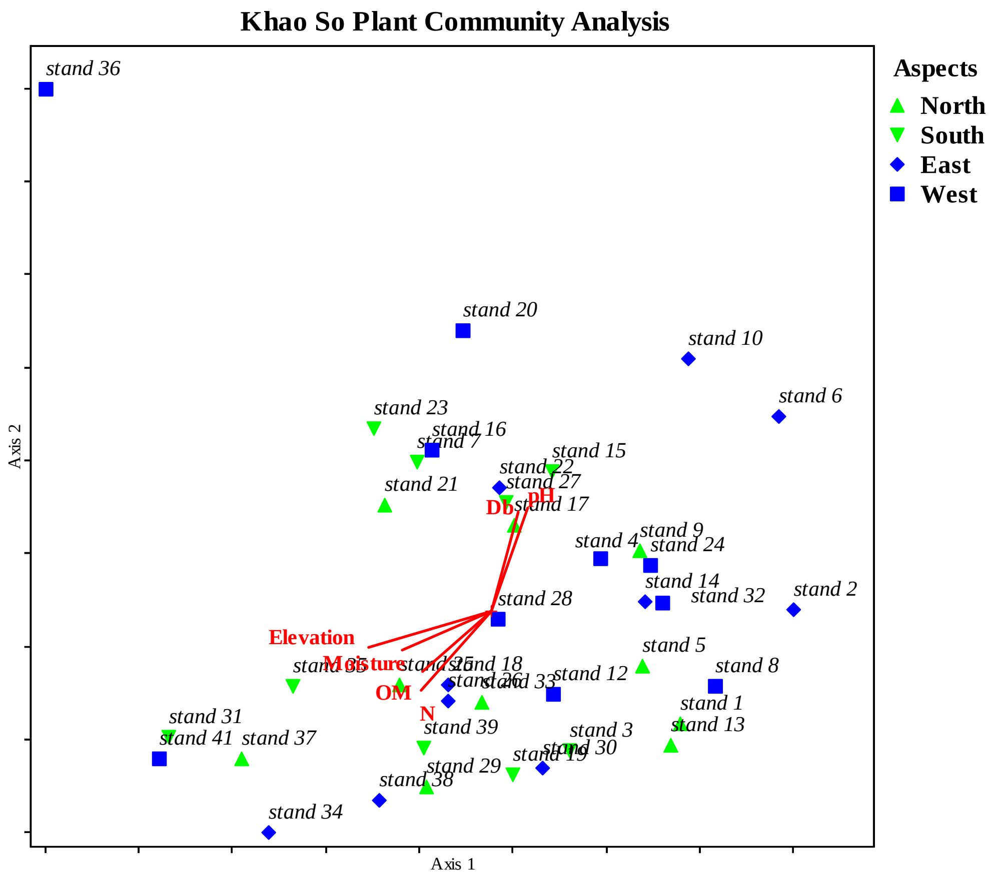


Figure 52. The relationship between sapling communities and environmental variables by Canonical Correspondence Analysis (CCA).

Five primary sapling species were identified on scatterplot diagram according as Appendix Figure 11:

C. hirsutulus was common in sapling species in all aspects. It peaked at the beginning along axis 1. For axis 2, *C. hirsutulus* presented in the middle scored of axis. It was slightly influenced by soil reaction and bulk density whereas environmental factors along axis 1, moisture content had more influenced to *C. hirsutulus* than environmental factors along axis 2. In addition, it showed a unimodal pattern on axis 2, having low abundance in plots that scored very high or very low on this axis. It meant that it was specific in soil reaction and bulkdensity. The correlation coefficients were – 0.349 and 0.034 on axis 1 and 2.

S. cumini and *H. ferrea* were mostly similar in invidual characteristics as tree species. They were ubiquitous species at the east and west aspects. *S. cumini* dominated greatly at the plots which were high in moisture content whereas *H. ferrea* dominated at plots that were lower in moisture content. On axis 2, they were abundant just along environmental gradient at this axis, but they peaked only at the high scored on axis 2. The correlation coefficients of axis 1 and 2 were 0.209, 0.269 for *S. cumini*, and 0.314, 0.372 for *H. ferrea*. They distributed along elevation and soil moisture content gradients.

P. evecta was fallen in the middle of axis 1 and the end of axis 2. It was absent at stands, which very low scored at axes 1 and high scored at axis 2. It showed negatively correlated and influenced by soil reaction and bulk density. While, soil moisture content along axis 1 possitively affected to the abundance of *P. evecta*. Correlation coefficient values were 0.194 and – 0.164 on axis 1 and 2 respectively.

C. micracantha was an indicator species at the east and west aspects. It was slightly affected by environmental factors at Khao So (Appendix Figure 11). *C. micracantha* was abundant in species distribution at the beginning of axis 1. It seemed to be found at moist area. The correlation value along compositional gradients along axes 1 and 2 were 0.042 and 0.072 respectively.

For seedling species, stands were grouped nearly each other in two-dimensional ordination of sample units in species composition space. They expressed that seedling stands were floristically homogeneous in species composition. There was only a few stands separated clearly upon aspect and environmental directions, only five variables showing significant correlations with the sample distribution (Figure 53).

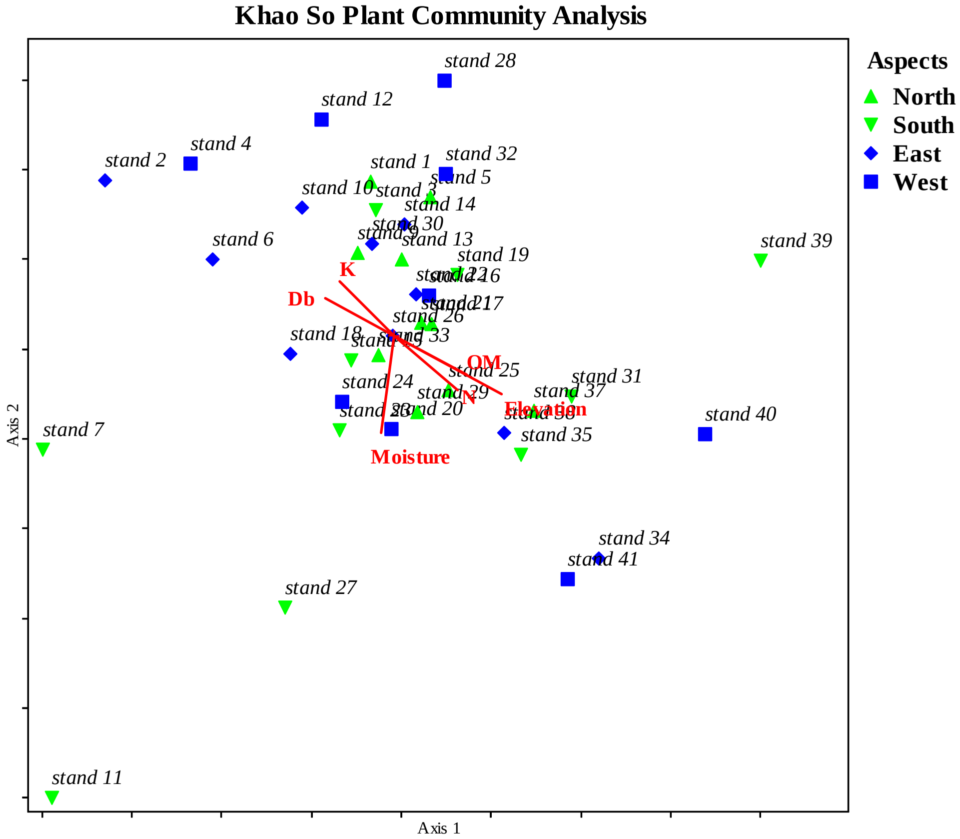


Figure 53. The relationship between seedling communities and environmental variables by Canonical Correspondence Analysis (CCA).

C. hirsutulus and *I. cibdela* responded to environmental gradient in similar direction. They shown distsribution patterns in scatterplot diagram (Appendix Figure 12) and dominated at the east and west aspects. The scatterplot diagrams pointed out a consistent unimodal pattern at all axes. Though they were absent in many stands that falled in favorable portion of gradient, they were common throughout the gradients for seedling community. These species positively correlated with organic matter and elevation and negatively with exchangeable potassium and bulk density along axis 2 with 0.072 and – 0.135 correlation coefficients.

C. cascarilloides, *H. ferrea* and *A. siamensis*. They tended to increase in species abundance along axis 2, having low in soil moisture content. They displayed the unimodal pattern on axis 1, having low abundance in plots that scored very high or very low on organic matter, total nitrogen, and elevation gradients. The correlation coefficients were – 0.56, – 0.020, – 0.240 along axis 1 and 0.155, 0.261, 0.241 along axis 2 in *C. cascarilloides*, *H. ferrea* and *A. siamensis* respectively.

S. henryana and *M. grandis* were unubiquitous species for seedling community. They dominated at only the west facing aspects. The scatterplot showed that they tended to be decreasing at the end of axis 2, having high in exchangeable potassium and bulk density gradients, but increasing along axis 1, having much more in organic matter and total nitrogen at higher elevations. They relied on these variables with 0.375, 0.268 and – 0.395, – 0.489 of correlation coefficients on *S. henryana* and *M. grandis* along axis 1 and 2 respectively.

Phytosociological classification and ordination analysis revealed that species composition form 41 stands in the study area were strongly correlated with soil properties and topographic features espectially, elevation and soil moisture content. They closely correlated with all of plant communities, tree, sapling and seedling. This supported the view that the distributions of plant community at Khao So area were determined by complex interactions of environmental variables. Plant communities separated into two main groups as *S. henryana* and *H. ferrea*. Generally, the relationship between soil characteristics and vegetation were reported in various ways. On dipterocarp forest, Gunung Mulu National Park, (cited in Bunyavejchewin, 1994.) was found that vegetation did not associate with soil. While, many researches

(Austin and Greig-Smith, 1968; Wong and Whitmore, 1970; Ashton, 1976) showed that vegetation in most of tropical rain forests were more strongly related to topography than to soil variables. Several studied had found that soil fertility to be an important factor influencing to species distributions (Ashton, 1964; Bunyavejchewin, 1994; Goldberg, 1982; Kutintara, 1998; Marchand, 1973; Newbery and Proctor, 1984; Sukwong and Kaitpraneet, 1975) This study pointed out that both of variables, topography and edaphic factors, played a major role in determining the tree species distributions particularly elevation, soil moisture content, bulk density, exchangeable cation of magnesium, calcium and sodium, and soil reaction. The results agreed with Wikum and Wali (1974) Kutintara (1975) Bunyavejchevin (1994). They reported that calcium, potassium influenced to species distributions. In Borneo forest at Brunei State, Aston (1976) found that soil moisture content was a main factor controlling species components at Borneo forest. Additionally, plant communities varied along aspects, the north and south aspects being more similar in plant communities than other aspects (Pattanakiat, 2001).

4.5 Soil Characteristics

Soil properties of Khao So were analyzed in every 40 meters at each aspect of plant plots. Soil characteristics varied in physical and chemical properties along altitudes and aspects. Most of soil properties substantially related with elevations as exchangeable calcium, bulk density, exchangeable magnesium, moisture content, total nitrogen, organic matter and soil reaction with – 0.374, – 0.421, – 0.376, 0.387, 0.582, 0.567, – 0.304 coefficient values respectively at $p<0.05$. Along altitudes, the relationship between the percentage of slope significantly correlated with 0.354 in Pearson correlation coefficient. It seemed to be steeper slope at higher elevations. Many studies reported that soil properties were related to topographic positions in different forest ecosystems (Nizeyimana and Bicki, 1992; Chen *et al*., 1997) and are also influenced by vegetation composition. Chen and Hsieh (2004) indicated that the aspects and slope positions could control the movement of water and material and contributed to the spatial differences of soil properties on a mountainous area, which influenced to vegetation composition. Therefore in order to obtain a display of soil and plant relationship, soil factor was classified along topographic position (or slope position) ranking from footslope (400-440 meters), toe slope (480-560 meters), hillslope (600-760 meters) and summit (800 meter) according to Figure 54. The soil properties along slope position were shown in Tables 12 and 13.

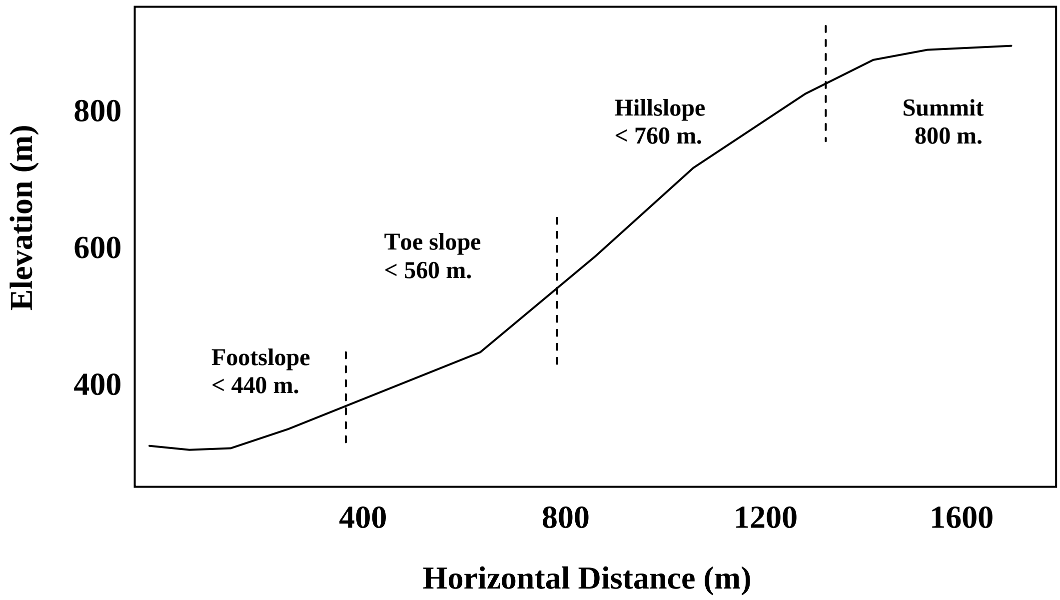


Figure 54. Diagram of study site in four different positions of the slope.

4.5.1 Spatial difference of soil properties along the landscape

Most of soil properties in different slope positions were classified as sandy clay loam in soil texture. Physical properties varied along slope positions as showed in Table 12. The information indicated that the study area was shallow in soil surface (between 26-30 centimeters). The summit and footslope position showed higher in soil surface than elsewhere, whereas almost of hillslope positions, stronger in slope range, were lower soil surface and bulk density. Bulk density values were averaged at 1.40, 1.49, 1.30, 1.44 g/cm^3 at footslope, toe slope, hillslope and summit respectively. The moisture content was reported approximately between 5.00-14.00%. The percentage of slope range varied considerably along topographic position. At hillslope positions, the degree of slope range showed higher than others. Most of organic matter contents in the study site were classified as medium to high level (Landon, 1991). The hillslope position displayed greatly in organic matter composition at 3.18%, 5.51%, 4.22% and 3.70% at north, east, south and west. This was because that at hillslope position, ground floor dominated by bamboo forest that might be easy to decay according to vegetation zones along topographic positions in Table 15. For available phosphorus, it was low in all of position (USDA, 1970). This might due to available phosphorous derives from mineral source as weathering processes. In the forest area, it was depended on ground litter, where it was little in available phosphorous cycling. So it was a limiting nutrient for tropical forests (Whitmore, 1990). Total nitrogen was in medium level in all positions (Landon, 1991). Soil reaction values were between very strong acid – moderately acid (Soil Survey Division Staff, 1993). At higher elevation, especially on summit showed strongly acid whereas at lower elevations were higher in pH, especially footslope position. Cation exchange capacity on footslope and hillslope were in medium level (Landon, 1991) and were moderately low at lower hillslope. The summit positions and most of footslope positions showed greater in cation exchange capacity. Exchangeable of calcium, sodium and potassium were low at almost positions, excepting only footslope position being medium level in exchangeable calcium. For exchangeable of magnesium, it showed in medium values at all positions (Landon, 1991). Conspicuously, soil properties on the study area considerably varied along slope positions. Generally, soil properties on different slope position were significantly affected by the degree of soil development and leaching processes (Chen *et al.*, 1997). So soils on summit position showed less exchangeable Ca, Mg, K, and Na possibly due to high leaching. Soils could significantly accumulate these soluble ions from the summit and deposit on the footslope position where leaching prcoess is weaker and soil enrichment was stronger ($p<0.05$) according to Table 14. At the footslope, these cations of CEC, Ca, Mg, K and Na showed relatively higher than other positions in all aspects, possibly owing to the accumulation processed on footslope. In addition, at the summit position, it showed lowest in soil reaction, seemingly owing to leaching process as the other cation. These results agreed with Huggett (1975) and Hseu *et al.*, (2004) that generally the movement of soil nutrients and materials seemed to mobile, transport and accumulate from upper to lower slope positions.

Organic content varied along landscape positions. Differences in the amount of organic matter were probably due to some reasons as the differences of litter decomposition rate. Especially, lower hillslope position was markedly lower than positions. Although this position was highest in stem density but it more likely lesser in site opening (gap), resulting to lesser decomposition (Marrs *et al*., 1988), while hillslope position seemed to be more open to sunlight that might be more suitable for decay and decompose processes. The second reason was due to the difference in leaf structure characteristics. According to vegetation zones along the topographic positions (Table 15), it indicated that on hillslope position plant community mainly dominated by the species of Gaminaea, which was smaller and thinner leaves. These characters might accelerate and were favorable to decomposition processes.

4.5.2 Correlations among soil properties

The correlation matrices for soils showed several sets of significant relationships (Table 14). The amount of organic matter significantly positive correlated to total nitrogen, available phosphorous and cation exchange capacity. Total nitrogen was of course directly correlated with organic matter (Tsui *et al*., 2004). It thus appeared that the lower hillslope was lower in organic matter and also lower in total nitrogen. The highest positive correlation was found in pH, in descending order, and exchangeable calcium, magnesium and sodium, which were intercorrelated each other as well. These finding follow the general principle that concentration of basic cations should increased with increasing soil pH (Bohn, McNeal and O'Connor, 1985; Bigelow and Canham, 2002).

4.5.3 The effect of slope on soil properties

Slope is regarded as one of the most important abiotic factors that control the pedogenic processes in a local scale. Steeper slopes contribute to greater runoff, as well as to greater translocation of surface materials to downslope area through surface erosion and movement of the soil mass (Hall, 1983). The study area was on a mountainous area. Slope position not only had significant effect on the majority of soil properties but there were a number of soil properties, which found to be strongly correlated with the steepness of slope also. In ordination diagrams (Figure 55), the slope range displayed in both axes of soil chemical and physical properties. It illustrated that higher elevation tended to increase in slope range (diagram a) which related to increase in available phosphorous (diagram b). This might be derived from weathering process on that greater slope. Additionally, community types were separated by slope range according to Table 15. The hillslope position was highest in slope range and therefore plant community differed from others. Especially, Gramineae dominated at only a stronger slope range, where was greater in sunlight. Conspicuously, slopes and slope positions significantly affected the movement and accumulation of soil solution, leading to a variation of soil properties and plant communities along transects in this study area. For soil properties along various altitudes and aspects, they were shown in Appendix Figures 13 to 24.

Table 12. Comparison of soil physical properties at various aspects along landscape positions.

Aspects	Landscape positions	Elevation (meters)	Surface layer depth (cm)	Db (g/cm^3)	Kc (%)	Slope (%)	Soil Particles Sand (%)	Silt (%)	Clay (%)	Texture
North	Footslope	400-440	30.00	1.23	7.22	13.19	47.98	19.22	32.80	sandy clay loam
	Toe slope	480-560	24.00	1.42	4.78	13.23	62.75	16.20	21.05	sandy clay loam
	Hillslope	600-760	23.00	1.19	11.41	16.15	50.78	22.88	26.34	sandy clay loam
East	Footslope	400-440	25.00	1.48	5.88	7.76	62.10	20.08	17.82	sandy loam
	Toe slope	480-560	29.00	1.49	5.67	18.11	55.13	23.41	21.45	sandy loam
	Hillslope	600-760	23.00	1.23	12.88	14.52	54.58	14.95	30.46	sandy clay loam
South	Footslope	400-440	30.00	1.44	13.44	14.32	53.72	19.20	27.08	sandy clay loam
	Toe slope	480-560	29.00	1.46	12.48	12.66	53.99	18.12	27.89	sandy clay loam
	Hillslope	600-760	22.00	1.31	13.26	22.69	50.18	19.48	30.34	sandy clay loam
West	Footslope	400-440	29.00	1.45	8.67	11.83	47.82	22.74	29.44	sandy clay loam
	Toe slope	480-560	31.00	1.56	5.54	11.86	60.59	14.28	25.13	sandy clay loam
	Hillslope	600-760	25.00	1.48	8.75	23.42	53.69	19.62	26.69	sandy clay loam
Centre	Summit	800	30.00	1.44	10.50	3.37	54.52	17.88	27.60	sandy clay loam

Table 13. Comparison of soil chemical properties at various aspects along landscape positions.

Aspects	Landscape positions	Elevation (meters)	Avail. P (ppm)	pH	Total N (%)	OM (%)	CEC (me-100g-s)	Exchangeable (me-100g-s) Ca	Mg	K	Na
North	Footslope	400-440	5.31	5.22	0.34	3.05	12.23	5.59	2.11	0.04	0.33
	Toe slope	480-560	3.17	4.96	0.20	1.72	4.37	0.54	0.95	0.03	0.31
	Hillslope	600-760	7.28	4.73	0.45	3.18	10.59	0.67	0.53	0.05	0.19
East	Footslope	400-440	1.50	5.25	0.22	1.42	6.61	1.49	1.00	0.07	0.26
	Toe slope	480-560	1.63	5.27	0.32	2.29	5.96	1.19	1.22	0.05	0.28
	Hillslope	600-760	4.30	4.35	0.47	5.51	11.49	0.57	0.43	0.06	0.19
South	Footslope	400-440	11.44	5.62	0.36	3.37	17.23	7.43	2.94	0.06	0.36
	Toe slope	480-560	7.42	5.74	0.42	3.26	12.34	4.37	2.61	0.05	0.59
	Hillslope	600-760	4.15	5.13	0.49	4.22	10.97	2.78	1.77	0.05	0.36
West	Footslope	400-440	4.63	5.76	0.22	2.34	15.63	6.48	2.00	0.07	0.35
	Toe slope	480-560	3.63	5.36	0.22	2.20	7.58	3.17	1.43	0.06	0.30
	Hillslope	600-760	3.45	4.90	0.36	3.70	9.56	3.66	2.29	0.06	0.53
Centre	Summit	800	4.00	4.10	0.34	3.28	8.51	0.41	0.69	0.03	0.12

Table 14. Pearson correlation coefficients between soil properties and slope.

	Slope	pH	OM	Total N	Avail. P	CEC	Exchangeable Ca	Exchangeable Mg	Exchangeable Na	Exchangeable K
Slope	1.000	-0.279*	0.282*	0.380**	-0.006	0.001	-0.345*	-0.372**	-0.238	-0.121
pH	-0.279*	1.000	-0.162	-0.254	0.037	-0.068	0.859**	0.714**	0.691**	-0.061
OM	0.282*	-0.162	1.000	0.560**	0.283*	0.469**	0.041	-0.033	0.030	0.045
Total N	0.380**	-0.254	0.560**	1.000	0.424**	0.710**	0.056	-0.124	-0.068	0.031
Avail.P	-0.006	0.037	0.283*	0.424**	1.000	0.573**	0.280*	0.058	0.030	-0.167
CEC	0.001	-0.068	0.469**	0.710**	0.573**	1.000	0.460**	0.273*	0.209	0.154
Exch.Ca	-0.345*	0.859**	0.041	0.056	0.280*	0.460**	1.000	0.801**	0.670**	-0.004
Exch.Mg	-0.372**	0.714**	-0.033	-0.124	0.058	0.273*	0.801**	1.000	0.739**	-0.006
Exch.Na	-0.238	0.691**	0.030	-0.068	0.030	0.209	0.670**	0.739**	1.000	0.010
Exch.K	-0.121	-0.061	0.045	0.031	-0.167	0.154	-0.004	-0.006	0.010	1.000

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

Table 15. Vegetation Zones along the topographic positions in the study site.

Region	Footslope	Toe slope	Hillslope	Summit
Elevation	400-440 msl	480-560 msl	600-760 msl	800 msl
Plant density	8795/ha	11336/ha	9986/ha	2150/ha
Number of species	125	132	141	38
Major families	Euphorbiaceae	Dipterocarpaceae	Euphorbiaceae	Myrtaceae
	Meliaceae	Euphorbiaceae	Gramineae	Euphorbiaceae
	Dipterocarpaceae	Myrtaceae	Dipterocarpaceae	Melastomataceae
Major species	Hopea ferrea	*Hopea ferrea*	*Bambusa* sp.	*Cleistanthus hirsutulus*
	Cleistanthus hirsutulus	*Syzygium cumini*	*Cleistanthus hirsutulus*	*Syzygium siamensis*
	Walsura trichostemon	*Bambusa* sp.	*Hopea ferrea*	*Syzygium cumini*
	Streblus ilicifolius	*Memecylon ovatum*	*Memecylon ovatum*	*Phoebe paniculata*
	Memecylon ovatum	*Walsura trichostemon*	*Acronychia pedunculata*	*Mischocarpus grandis*
Special species	*Dipterocarpus turbinatus*	*Pinanga hookeriana*	*Sapium baccatum*	*Rinorea lanceolata*
	Dracaena loureiri	*Polyalthia asterilla*	*Livistona speciosa*	*Ardisia littoralis*
	Prismatomeris filamentosa	*Streblus asper*	*Schleichera oleosa*	
	Croton oblongifolius	*Carallia brachiata*	*Diospyros kerrii*	
	Terminalia dafeuillana	*Protium serratum*	*Acrocarpus fraxinifolius*	
	Garuga pinnata	*Wrightia tomentosa*	*Caesalpinia sappan*	
	Dipterocarpus costatus	*Diospyros montana*	Melientha suavis	
		Ixora sp.	*Xylia xylocarpa*	
		Croton longissimus	*Ficus altissima*	
		Pterocymbium javanicum	*Memecylon cyaneum*	
			Agrostistachys indica	

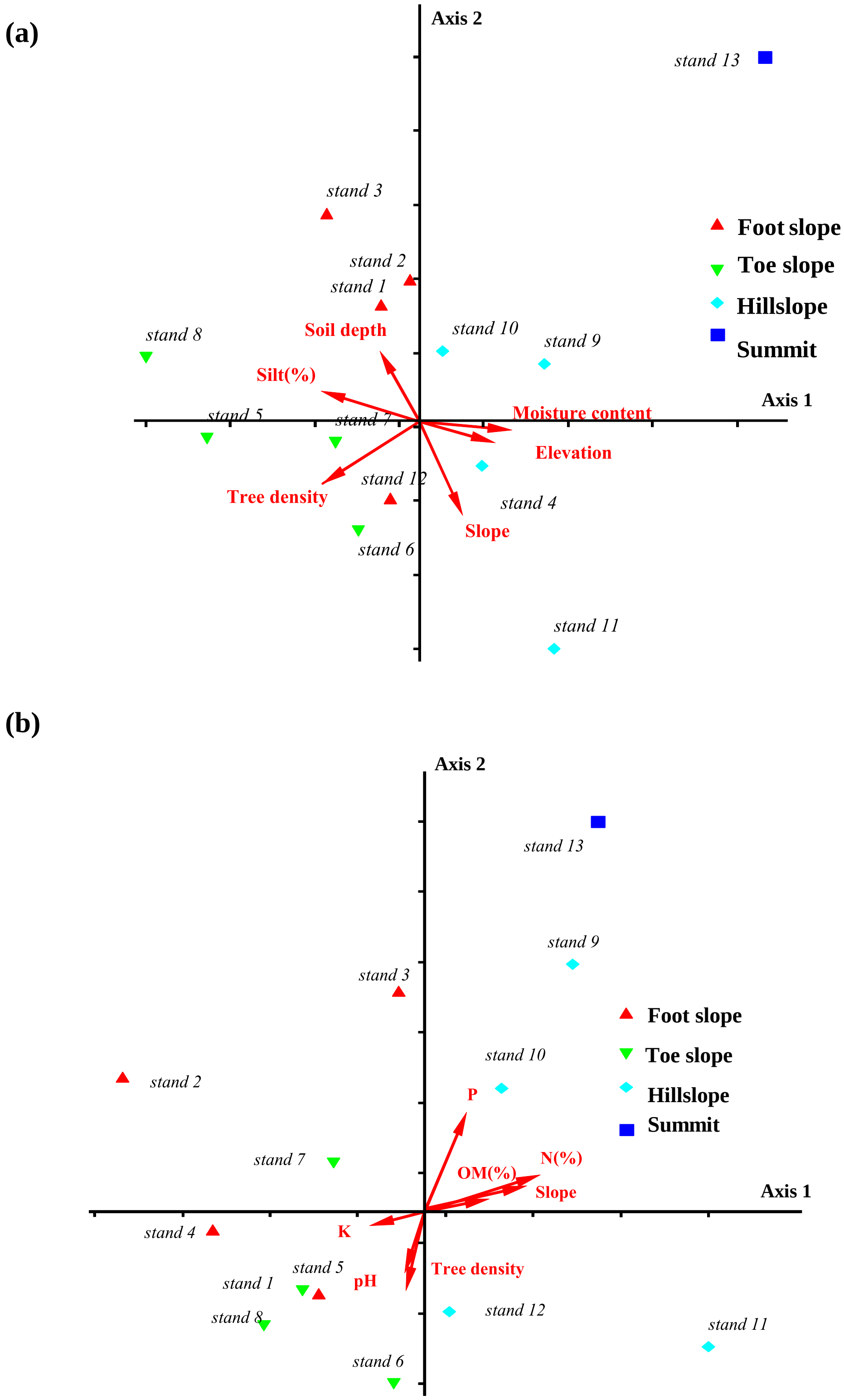


Figure 55. **Ordination diagram based on CCA analysis of soil data in the physical properties (a) and chemical properties (b) along slope position types.**

4.6 Vegetation and Environmental Factors Relationships

The correlations from ordination analysis supported the view that no single environmental factor could explain fully the distribution of plant communities. So topographic and soil parameters were used for stepwise multiple regressions to develop predictive equations for the direction in basal area and volume distribution for tree species. For horizontal direction, the values of basal area (m^2/hectare) were dependent variables to identify the relationship of vegetation and soil characteristics along aspects. The model was shown according as:

Y = 147.517 – 50.20 elevation – 0.175 bulk density + 0.021 calcium + 0.227 cation exchange capacity – 0.059 effective soil depth + 0.229 potassium – 0.417 magnesium + 0.199 moisture content + 0.224 nitrogen – 18.145 sodium - 0.77 organic matter + 0.184 phosphorus + 0.001 pH + 0.069 sand – 0.055 silt + 0.001 clay

Where R = 0.524, R^2 = 0.275, R^2 adj = 0.235, Standard error of estimate = 9.559, F = 6.829, Significant value = 0.003

Stepwise multiple regression equation for horizontal direction indicated that the basal area negatively correlated with elevation and exchangeable of calcium. This might be mainly caused that at higher elevation where was higher in slope rank promoted the occurrence of windthrow, which possibly could reduce the overall basal cover (Bunyavejchewin, 1994). For vertical direction, the values of volume (m^3/hectare) acted as independent variable. The relationship model for volume and environmental factors was shown as in the following:

Y = 1188.167 - 1000.590 elevation + 0.211 bulk density + 0.157 calcium + 523.042 cation exchange capacity – 0.059 effective soil depth + 0.141 potassium – 354.039 magnesium + 0.012 moisture content – 0.116 nitrogen + 0.053 sodium - 0.226 organic matter + 0.098 phosphorus + 0.378 pH + 788.209 sand – 0.144 silt - 0.412 clay

Where R = 0.674, R^2 = 0.454, R^2 adj = 0.390, Standard error of estimate = 135.259, F = 7.082, Significant value = 0.012

The model of vertical directions showed that it strongly correlated with elevation, cation exchange capacity, and exchangeable cation of magnesium. Typically, elevation factor displayed the importance role in the variation of both basal area and volume of plant communities at Khao So. Similarly there was decreasing in overall basal area and volume cover at higher elevation. Furthermore, the leading dominant species, *H. ferrea* and *S. henryana* demonstrated that they seemed to be related to different soil fertility. They showed in individual models as follows:

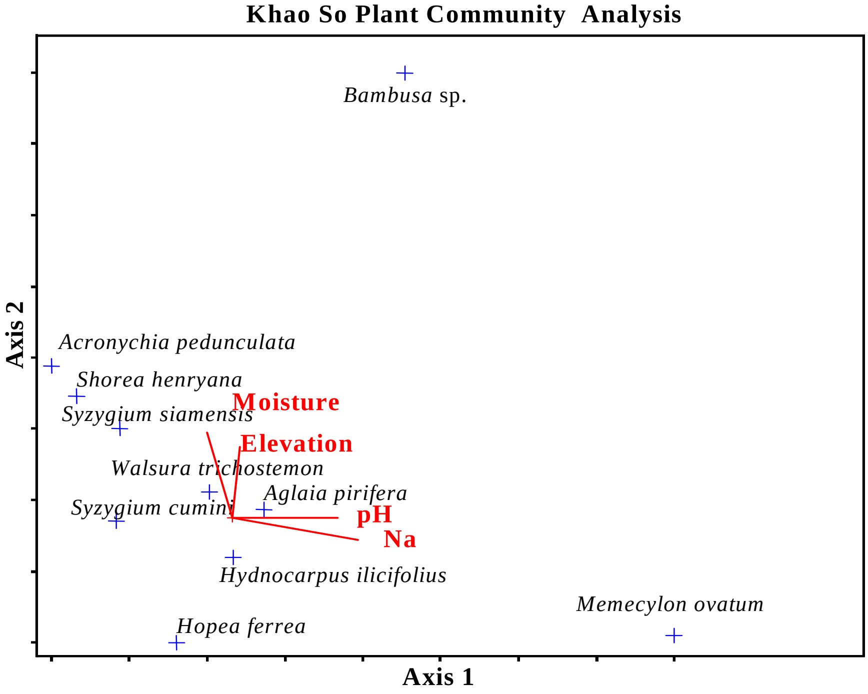
Table 16. Stepwise multiple regression equations for environmental variables against (a) basal area and (b) volume of the leading dominant species.

species	equations
Hopea ferrea (a)	Y = 4.051 + 0.476 soil reaction (R^2 = 0.682, P = 0.010)
Hopea ferrea (b)	Y = 901.564 – 1.174 elevation – 128.246 bulk density (R^2 = 0.836, P = 0.00)
Shorea henryana (a)	Y = -2.178 + 6.197 total nitrogen – 0.608 organic matter (R^2 = 0.357, P = 0.07)
Shorea henryana (b)	Y = -0.832 + 0.334 available phosphorous + 0.221 cation exchange capacity – 0.595 exchangeable cation of calcium (R^2 = 0.376, P = 0.01)

According to these models, *S. henryana* showed that it relatively found on fertility soil more than *H. ferrea*, but its basal area and volume cover were lower than of *H. ferrea*. It might dut to soil factors and topographic features especially soil pH and moisture content. Greatest basal area and volume on *S. henryana* occurred on sites where was low in soil pH. The availability of nitrogen was inhibited by low soil pH (Bunyavejchewin, 1994; Black, 1968). Additionally, soil pH served as an indicator of the two major nutrients, calcium and magnesium. Calcium played a significant role in the absorption of and selectivity for cations and was also an indicator of forest soil fertility (Waring and Major, 1964). So, low availability of calcium in acid soils might decrease availability of the other nutrients to plant growth. *S. henryana*, occupied on higher altitude and strong slope areas, soil fertility easily leaching. Additionally, it might be affected by windthrow resulting in broken and removed canopy tree. These could possibly reduced the basal area and volume cover of *S. henryana*.

The relationships between soil characteristics and growth directions reported that *H. ferrea* and *S. henryana*, which was the leading species of main groups of plant communities at Khao So, correlated and separated with environmental factors according to Figure 56. Basal area cover of *S. henryana* markedly associated with more fertilizes than *H. ferrea*. It agreed with stepwise multiple regression analysis. Additionally, Ordination diagrams also implied that dry evergreen forest contained of two main communities, *H. ferrea* and *S. henryana* groups, which absolutely differed in individual characteristics especially, growth directions. Soil reaction, exchangeable cation of sodium, soil moisture content and elevation values were better predicted in the growth of main plant communities at dry evergreen forest according to Figure 56(a). These agreed with Wikum and Wali (1974) Kutintara (1975) Bunyavejchevin (1994). Two main communities separated into the direction of moisture content. At higher in moisture content, it dominated by *S. henryana* and the its associated species such as *S. siamensis, P. paniculata*, *M. paniculatus*, *M. leucantha*, *A. pirifera*, *M. caloneura*, *L. fenestratus* and *P. evecta.* Whereas the area that at low in moisture content but high in exchangeable of sodium, it contained of *H. ferrea*, *L. duperreana, Bambusa sp.*, *A. pirifera, P. cerasoides, P. acerifolium, M. siamensis* and *A. monophylla* according to Figure 56(b).

(a)



(b)

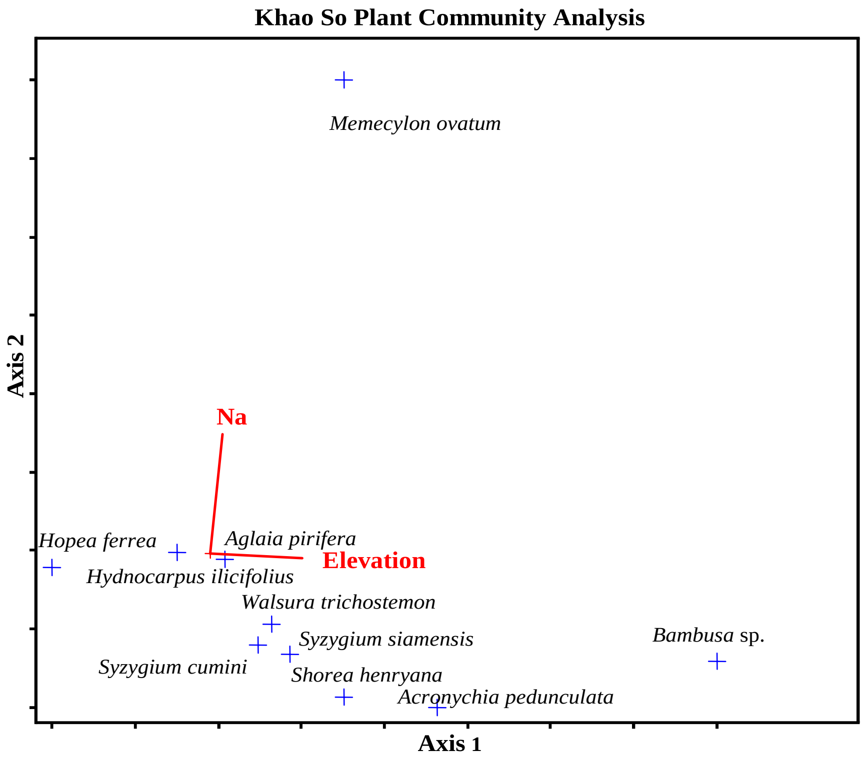


Figure 56. The ordination diagrams of (a) basal area and (b) volume along environmental gradients.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

From 41 stands (4.1 hectares) at various aspects and altitudes of Khao So, it composed of 188 species, 130 genera and 52 families of all vegetation (tree, sapling and seedling). The most common family was Euphorbiaceae. The most ubiquitous species was *Hopea ferrea.* Most of the distributions in each species were between 1-10 of individual numbers. On the whole area, species distributions along various altitudes and aspects indicated that all of the number of species, genera, families and individuals tended to decrease linearly along higher altitudes. Especially, the number of individuals was more negatively related with elevations at – 0.799 statistically. Plant communities of Khao So distributed differently along aspects with dissimilarity coefficients were between 60-90% based on the Sorensen indices. Only the distribution of tree, its tended to be more homogeneity in distribution of species number at higher altitudes. This study also showed that tree, sapling and seedling varied considerably in distributions along altitudes and aspects as in the following;

5.1 Plant Community Characteristics along Topographical Gradients

5.1.1 Species distribution

On tree community (≥ 4.5 dbh and > 1.30 meters in height), the west aspect showed fewer in species composition than other aspects. Considering on altitudes, most of stands, where were located at 520 meters, were lower in species, genera, families and individuals than other altitudes. However, over the whole area, its distribution displayed that the northern and southern aspects were higher in average numbers of species, genus, family and individuals than the east and west aspects.

For sapling (≤ 4.5 dbh and > 1.30 meters in height), species distribution in each aspects and altitudes were reported that the west aspect shows fewer in species composition as in the tree community. Along altitudes, sapling peaked in species composition at 520 meters, where it was lowest in species composition of tree community. Whereas at 600 meters most of sapling stands were lower in species, genera, families and individuals than other altitudes. So sapling distributions along altitudes and aspects over the whole area revealed that the north and east aspects were higher in average numbers of species, genus, family and individuals than the south and west aspects.

Seedling community (< 1.30 meters in height) showed that the numbers of seedling distributed similar to way sapling community. The west aspect was still lesser in species compositions and the north and east aspects were higher in average numbers of species, genus, family and individual than the south and west aspects. Considering on altitudes, most of stands, that were located at 560 meters, were lower in species, genera, families and individuals than other altitudes.

According to the Sorensen index, it demonstrated that all of vegetation at Khao So tended to distributed in the vertical direction, along altitudes than in the horizontal direction along aspects. The results were confirmed by similarity coefficient at 45-70% along altitudes whereas along aspects similarity was between 5-30% for tree species distributions. For sapling species distribution, it was between

35-60% and 0-25% along altitudes and aspects respectively. The Sorensen similarity value for seedling was 45-90% and 5-20% along altitudes and aspects respectively.

5.1.2 Important value index

Plant communities along these various altitudes could be classified into primary and secondary species based on ecological performance. Nineteen dominant species grouped into two taxa depending upon their importance value along altitudes. The groups, which had the highest relative importance values at least on elevation, serve as the primary dominant species and the second highest relative importance values at least on elevation, serve as secondary dominant species. The primary tree dominant species included in four species as *Hopea ferrea* (Dipterocarpaceae), *Bambusa* sp. (Garmineae), *Memecylon ovatum* (Melastomataceae), and *Syzygium siamensis* (Myrataceae). The secondary tree dominant species displayed in seven species, as *Peltophorum dasyrachis* (Caesalpiniaceae), *Ficus* sp. (Moraceae), *Mischocarpus grandis* (Sapindaceae), *Phoebe paniculata* (Lauraceae), *Shorea henryana* (Dipterocarpaceae), *Syzygium cumini* (Myrtaceae), *Walsura trichostemon* (Meliaceae). For sapling, the primary sapling dominant species covered with four species as *Cleistanthus hirsutulus* (Euphorbiaceae), *Syzygium cumini* (Myrtaceae), *Polyalthia evecta* (Annonaceae), and *Hopea ferrea* (Dipterocarpaceae). The secondary sapling dominant species displayed in three species as *Acalypha siamensis* (Euphorbiaceae), *Walsura trichostemon* (Meliaceae) and *Syzygium siamensis* (Myrtaceae). For seedling, four species as *Cleistanthus hirsutulus* (Euphorbiaceae), *Croton cascarilloides* (Euphorbiaceae), *Hopea ferrea* (Dipterocarpaceae), and *Ixora cibdela* (Rubiaceae) were indentified as primary seedling dominant species.

Secondary seedling dominant species were *Mischocarpus grandis* (Sapindaceae), *Murraya paniculata* (Rutaceae), *Polyalthia evecta* (Annonaceae), *Streblus ilicifolius* (Moraceae), *Syzygium cumini* (Myrtaceae), *Urobotrya siamensis* (Opiliaceae), and *Walsura trichostemon* (Meliaceae). Conspicuously, *Bambusa* sp. showed highest in density but lowest in frequency. *Hopea ferrea* showed lower in density but highest in importance value index and dominance according to phytograph. So plant communities along altitudinal function indicated that *Hopea ferrea* was ubiquitous species and likely to be more successful in ecological performance in almost elevations whereas *Bambusa* sp., more slightly in frequency, was uncommon species and could be found in specific elevations in the study area.

5.1.3 Species diversity

The Shannon diversity of Khao So area was averaged at 2.34, 2.48, and 2.35 in tree, sapling and seedling communities. Conspicuously, tree community showed lowest in species diversity especially at western aspects. This was might be due to anthropogenic activities in the past several years and environmental heterogeneity (Bell, Lechowicz and Waterway, 2000; Marcial, Espinosa and Linera, 2001; Nakashizuka, Yusop and Nik, 1991; Givnish and Vazquez, 1998; Pattanakiat, 2001). This area clearly defined as a high diversity in all of plant communities, tree, sapling and seedling (Kent and Coker, 1996). The species diversity indices along aspects also indicated that on the northerly and southerly tree and seedling communities were much more diverse in species diversity than others. While sapling community at the north and east aspects showed greater in species diversity than others. In addition, species diversity tended to be negative correlation with altitudes especially sapling diversity based on Pearson analysis. The correlation values between species diversity and altitudes for tree, sapling and seedling were – 0.066, – 0.322 and – 0.050 respectively. Twelve species were defined as threatened species (IUCN, 1994). The critically endangered species (CR) were *Aquilaria crassna* (Thymelaeaceae) and *Dipterocarpus turbinatus* (Dipterocarpaceae). The endangered species (EN) were *Afzelia xylocarpa* (Caesalpiniaceae), *Anisoptera costata* (Dipterocarpaceae), *Dalbergia oliveri* (Papilionaceae), *Dipterocarpus costatus* (Dipterocarpaceae), *Hopea ferrea* (Dipterocarpaceae), *Prunus ceylanica* (Rosaceae) and *Shorea henryana* (Dipterocarpaceae). The vulnerable species (VU) were *Dalbergia cochinchinensis* (Papilionaceae), *Dialium cochinchinense* (Caesalpinaceae) and *Hopea odorata* (Dipterocarpaceae).

5.2 Relative Patterns between Plant Characteristics and Some Environmental Factors

5.2.1 Relative patterns between communities and environmental factors

Plant community classification by two-way indicator species analysis divided plant communities into 14, 13, 12 for stand classification, and 35, 24, 22 sub-communities for species classification on trees, saplings, and seedlings respectively. for stand and species classification at sixth level respectively. Generally, these grouped on stand classifications based on two main types. The first type associated with *Hopea ferrea*, *Lagerstroemia duperreana*, *Bambusa* sp., *Syzygium cumini*, *Aglaia pirifera*, *Polyalthia cerasoides*, *Pterospermum acerifolium*, *Maerua siamensis* and *Atalantia monophylla*. Another type associated with *Shorea henryana*, *Phoebe paniculata*, *Syzygium siamensis*, *Millettia leucantha*, *Aglaia pirifera*, *Mangifera* *caloneura*, *Lithocarpus fenestratus* and *Polyalthia evecta*. For species classification, it indicated that seven species on tree community were classified into rare species group as *Phoebe paniculata*, *Syzygium siamensis*, *Mallotus philippensis*, *Streblus ilicifolius*, *Dalbergia oliveri*, *Microcos tomentosa* and *Drypetes hainanensis*. Only three species on saplings were separately classified into rare species group as *Clausena excavate*, *Ixora cibdela* and *Mallotus peltatus*. For seedling species, three species as *Diospyros gracilis*, *Leucaena leucocephala* and *Clausena excavate* were classified as rare species group. These communities separately classified and associated with various variables. Apparently, CCA exhibited that topographical and environmental factors significantly correlated with plant communities. Trees separated into floristic patterns along elevation, moisture content, bulk density, soil reaction, exchangeable cation of calcium, magnesium and sodium variables. While, saplings correlated strongly with bulk density, soil reaction, moisture content, elevation, organic matter, total nitrogen factors. Seedling correlated with organic matter, total nitrogen, elevation, soil moisture content, bulk density and exchangeable cation of potassium gradients.

5.2.2 Relative patterns between soil characteristics

Soil properties varied in physical and chemical characteristics along transect in this study area. Slope and slope position significantly affected the movement and accumulation of chemical soil properties, leading to a variation of soil properties. Significant differences among slope positions were found for most soil properties studied. Conspicuously, the contents of cation exchange capacity (CEC), exchangeable cation of calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), and soil reaction (pH) value were highest at the footslope position (Tsui, Chen and Hsieh, 2004; Tokuchi, Takeda, Yoshida and Iwatsubo, 1999). Additionally, CCA showed clearly separation of soil properties along plant communities, illustrating distinct difference between soils of each slope position. Difference in soil properties along transects was also contributed to slope processes specially, soil depth, silt composition, exchangeable of potassium and soil reaction decreased from gentle slope to deep slope while available phosphorus increased along slope range. Furthermore, Pearson product showed the correlation between soil properties. Soil reaction negatively correlated with exchangeable cation of calcium, sodium and magnesium statistically (Bohn *et al*., 1985). In contrast, exchangeable of calcium, magnesium, sodium and soil reaction were negatively related to slope significantly.

5.2.3 Relative patterns between growth direction and environmental factors

The distribution of basal area and volume cover of plant community at Khao So area positively correlated with calcium, cation exchange capacity, potassium, moisture content, phosphorus and pH. The model of two main types of plant community explained that *Hopea ferrea* and *Shorea henryana* groups absolutely differed in individual characteristics especially, growth directions. Soil reaction, exchangeable cation of sodium, soil moisture content and elevation values were better predicted in the growth of main plant communities at the study area. *Shorea henryana* group seemed to dominate at higher in moisture content whereas *Hopea ferrea* group dominated at lower in soil moisture content.

RECOMMENDATIONS

Vascular plants of Khao So were clearly classified into many communities based on this study; whereas aerial photography could be classified into only a few communities. Therefore the results provided more accurate and useful data for the study area as:

1. The relationship between plant communities and environmental factors showed that *Hopea ferrea* significantly correlated with the amount of exchangeable sodium in soil. It should be introduced this species into soil salinity area for forest plantation on other areas, especially in the northeast of Thailand.

2. The results showed that at the north and east aspects of Khao So were higher species diversity than other aspects. So these aspects should be focused for planning and zoning area to support the eco-tourism activities because these aspects composed of many types of forests and plant communities with high species diversity. They also close to Lam Phra Phloeng Dam, which make them more attractive for eco-tourism than other aspects.

3. The study on plant communities of Khao So also indicated threatened species or rare species groups of dry evergreen forest, served as indicator species of the study area. Thus biodiversity conservation and management should be considered on these rare species. In addition, the study on fauna should be also considered to find out the priorities for biodiversity conservation of Phu Luang National Reserved Forest.

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APPENDICES

Appendix Table 1. Meteological data at Sakaerat and Lam Phra Phloeng stations.

Sakaerat Station *

Month	Temperature (C°)			Rainfall	Relative humidity
	Mean min.	Mean max.	Mean average	(mm.)	(%)
January	18.3	30.3	24.3	1.0	85.8
Febuary	18.5	32.6	25.6	12.6	82.9
March	21.9	35.4	28.7	39.2	80.1
Aprial	22.7	34.2	28.4	96.7	83.7
May	22.6	33.7	28.2	91.1	87.6
June	22.8	33.1	27.9	58.2	85.7
July	22.8	31.8	27.3	53.9	83.7
August	22.6	34.2	28.4	106.9	81.8
September	22.1	31.0	26.6	181.6	91.1
October	21.1	28.8	29.9	183.9	93.0
November	19.2	27.3	27.9	57.4	91.4
December	15.8	27.2	25.8	0.0	87.8
Averages	**20.8**	**31.6**	**27.4**	**73.5**	**86.2**

Lam Phra Phloeng Station**

Month	Temperature (C°)			Rainfall	Relative humidity
	Mean min.	Mean max.	Mean average	(mm.)	(%)
January	27.1	21.0	17.7	88.2	86.6
Febuary	29.3	22.1	23.4	137.1	86.8
March	30.2	25.6	27.9	88.7	86.4
Aprial	26.2	23.8	3.2	106.1	92.0
May	30.8	24.2	25.6	117.1	98.5
June	29.7	26.0	27.0	236.0	84.9
July	28.9	24.8	26.7	197.3	92.6
August	26.5	24.0	25.4	38.3	67.0
September	26.6	22.8	23.9	4.4	91.2
October	25.5	22.2	23.9	5.1	62.3
November	24.6	18.8	21.3	18.0	99.4
December	23.6	16.4	20.3	46.9	94.6
Averages	**27.4**	**22.6**	**22.2**	**90.3**	**86.9**

<u>Notes</u>

* from Sakarat Environmental Research Station

** from Northeastern Meteorological Center

Appendix Table 2. The species list of vegetation at Khao So. (T=Tree, S=Shrub, ST=Shrubby Tree, P=Palm).

No.	Lacal names	Scientific name	Species Abbreviation	Families	Life form
1	Khang poi	*Acalypha kerrii* Craib	*A. kerrii*	EUPHORBIACEAE	S/ST
2	Cha khoi	*Acalypha siamensis* Oliv. ex Gage	*A. siamensis*	EUPHORBIACEAE	T
3	Sadao chang	*Acrocarpus fraxinifolius* Wight & Arn.	*A. fraxinifolius*	CAESALPINIACEAE	T
4	Ka uam	*Acronychia pedunculata* Miq.	*A. pedunculata*	RUTACEAE	T
5	Ma klam ta kai	*Adenanthera microsperma* Teijsm. & Binn.	*A. microsperma*	MIMOSACEAE	T
6	Ma klam ton	*Adenanthera pavonina* Linn.	*A. pavonina*	MIMOSACEAE	T
7	Ma kha mong	*Afzelia xylocarpa* Craib	*A. xylocarpa*	CAESALPINIACEAE	T
8	Prayong baiyai	*Aglaia chaudocensis* Pierre	*A. chaudocensis*	MELIACEAE	S/ST
9	Khang khao	*Aglaia pirifera* Hance	*A. pirifera*	MELIACEAE	S/ST
10	Hang kwang	*Agrostistachys indica* Dalzell	*A. indica*	EUPHORBIACEAE	ST
11	Mayom pa	*Ailanthus triphysa* Alston	*A. triphysa*	SIMAROUBACEAE	T
12	Tin pet	*Alstonia scholaris* R. Br.	*A. scholaris*	APOCYNACEAE	T
13	Krabak	*Anisoptera costata* Korth.	*A. costata*	DIPTEROCARPACEAE	T
14	Yang nong	*Antiaris toxicaria* Lesch.	*A. toxicaria*	MORACEAE	T
15	Mamao dong	*Antidesma bunius* Spreng.	*A. bunius*	EUPHORBIACEAE	ST
16	Ta suea	*Aphanamixis polystachya* Parker	*A. polystachya*	MELIACEAE	T
17	Mueat lot	*Aporusa villosa* Baill.	*A. villosa*	EUPHORBIACEAE	T
18	Kritsana	*Aquilaria crassna* Pierre ex H. Lec.	*A. crassna*	THYMELAEACEAE	T
19	Ta pet ta kai	*Ardisia lenticellata* Fletch.	*A. lenticellata*	MYRSINACEAE	S
20	Ram yai	*Ardisia littoralis* Andr.	*A. littoralis*	MYRSINACEAE	S/ST
21	Mahat	*Artocarpus lakoocha* Roxb.	*A. lakoocha*	MORACEAE	T
22	Manao phi	*Atalantia monophylla* Correa	*A. monophylla*	RUTACEAE	ST
23	Mafai	*Baccaurea ramiflora* Lour.	*B. ramiflora*	EUPHORBIACEAE	T
24	Phai	*Bambusa* sp.	*Bambusa sp.*	GRAMINEAE	B
25	Siao pa	*Bauhinia saccocalyx* Pierre	*B. saccocalyx*	CAESALPINIACEAE	T
26	Siao fom	*Bauhinia viridescens* Desv.	*B. viridescens*	CAESALPINIACEAE	ST
27	Ngio ban	*Bombax ceiba* Linn.	*B. ceiba*	BOMBACACEAE	T
28	Maka	*Bridelia ovata* Decne.	*B. ovata*	EUPHORBIACEAE	ST
29	Teng nam	*Bridelia retusa* Spreng.	*B. retusa*	EUPHORBIACEAE	T
30	Fang	*Caesalpinia sappan* Linn.	*C. sappan*	CAESALPINIACEAE	ST
31	Sakae saeng	*Cananga latifolia* Finet & Gagnep.	*C. latifolia*	ANNONACEAE	T
32	Makok kluean	*Canarium subulatum* Guill.	*C. subulatum*	BURSERACEAE	T
33	Chingchi	*Capparis micracantha* DC.	*C. micracantha*	CAPPARIDACEAE	S/ST

Appendix Table 2. (Continued).

No.	Lacal names	Scientific name	Species Abbreviation	Families	Life form
34	Chiang phra nang ae	*Carallia brachiata* Merr.	*C. brachiata*	RHIZOPHORACEAE	T
35	Tao rang	*Caryota mitis* Lour.	*C. mitis*	PALMAE	P
36	Khi non khai	*Celtis tetrandra* Roxb.	*C. tetrandra*	ULMACEAE	T
37	Kaeng khi phraruang	*Celtis timorensis* Span.	*C. timorensis*	ULMACEAE	T
38	Pra dong daeng	*Chionanthus macrostigma* Gagnep	*C. macrostigma*	OLEACEAE	T
39	Kra dong daeng	*Chionanthus microstigma* Gagnep	*C. microstigma*	OLEACEAE	T
40	Mamue	*Choerospondias axillaris* Burtt & Hill	*C. axillaris*	ANACARDIACEAE	T
41	Chiat	*Cinnamomum iners* Bl.	*C. iners*	LAURACEAE	T
42	Chetta phangkhi	*Cladogynos orientalis* Zipp. Ex Span.	*C. orientalis*	EUPHORBIACEAE	S
43	Hatsa khun	*Clausena excavata* Burm. f.	*C. excavata*	RUTACEAE	S/ST
44	Song fa	*Clausena harmandiana* Pierre	*C. harmandiana*	RUTACEAE	S/ST
45	Kaeo nam	*Cleistanthus hirsutulus* Hook. f.	*C. hirsutulus*	EUPHORBIACEAE	ST
46	Po phran	*Colona auriculata* Craib	*C. auriculata*	TILIACEAE	ST
47	Tio kliang	*Cratoxylum cochinchinense* Bl.	*C. cochinchinense*	GUTTIFERAE	T
48	Plao nam ngoen	*Croton cascarilloides* Raeusch.	*C. cascarilloides*	EUPHORBIACEAE	S
49	Plao noi	*Croton longissimus* Airy Shaw	*C. longissimus*	EUPHORBIACEAE	S
50	Plao luang	*Croton oblongifolius* Roxb.	*C. oblongifolius*	EUPHORBIACEAE	S/ST
51	Pha yung	*Dalbergia cochinchinensis* Pierre	*D. cochinchinensis*	PAPILIONACEAE	T
52	Chingchan	*Dalbergia oliveri* Gamble	*D. oliveri*	PAPILIONACEAE	T
53	Si rai bai yai	*Dehaasia candolleana* Kosterm.	*D. candolleana*	LAURACEAE	T
54	Khleng	*Dialium cochinchinense* Pierre	*D. cochinchinense*	CAESALPINIACEAE	T
55	I do	*Diospyros bejaudii* Lec.	*D. bejaudii*	EBENACEAE	T
56	Tako phanom	*Diospyros castanea* Fletch.	*D. castanea*	EBENACEAE	T
57	Lam ta khwai	*Diospyros coaetanea* Fletch.	*D. coaetanea*	EBENACEAE	T
58	Chan khao	*Diospyros dasyphylla* Kurz	*D. dasyphylla*	EBENACEAE	T
59	Lambit	*Diospyros ferrea* Bakh.	*D. ferrea*	EBENACEAE	T
60	Kacha	*Diospyros gracilis* Fletch.	*D. gracilis*	EBENACEAE	T
61	Ma phlap	*Diospyros kerrii* Craib	*D. kerrii*	EBENACEAE	T
62	Tako suan	*Diospyros malabarica* Kostel.	*D. malabarica*	EBENACEAE	T
63	Ma kluea	*Diospyros mollis* Griff.	*D. mollis*	EBENACEAE	T
64	Tan fai phi	*Diospyros montana* Roxb.	*D. montana*	EBENACEAE	T
65	Ka ling	*Diospyros pilosanthera* Blanco	*D. pilosanthera*	EBENACEAE	T
66	Hang nu	*Diospyros pilosula* Hiern	*D. pilosula*	EBENACEAE	T
67	Phlap	*Diospyros sp.*	*Diospyros sp.*	EBENACEAE	T
68	Phaya rak dam	*Diospyros variegata* Kurz	*D. variegata*	EBENACEAE	T

Appendix Table 2. (Continued).

No.	Lacal names	Scientific name	Species Abbreviation	Families	Life form
69	Yang pai	*Dipterocarpus costatus* C.F.Gaertn.	*D. costatus*	DIPTEROCARPACEAE	T
70	Yang daeng	*Dipterocarpus turbinatus* Gaertn. f.	*D. turbinatus*	DIPTEROCARPACEAE	T
71	Chan pha	*Dracaena loureiri* Gagnep.	*D. loureiri*	DRACAENACEAE	T
72	Song kradong hin	*Drypetes hainanensis* Merr.	*D. hainanensis*	EUPHORBIACEAE	T
73	Thian khamoi	*Drypetes hoaensis* Gagnep.	*D. hoaensis*	EUPHORBIACEAE	T
74	Sathon rok	*Elaeocarpus robustus* Roxb.	*E. robustus*	ELAEOCARPACEAE	T
75	Plai san	*Eurya acuminata* DC.	*E. acuminata*	THEACEAE	S/ST
76	Pla lai phueak	*Eurycoma longifolia* Jack	*E. longifolia*	SIMAROUBACEAE	S/ST
77	Krang	*Ficus altissima* Bl.	*F. altissima*	MORACEAE	T
78	Ma duea	*Ficus hispida* Linn. f.	*F. hispida*	MORACEAE	T
79	Sai	*Ficus sp.*	*Ficus sp.*	MORACEAE	T
80	Ta khop thai	*Flacourtia rukam* Zoll. & Mor.	*F. rukam*	FLACOURTIACEAE	T
81	Cha muang	*Garcinia cowa* Roxb.	*G. cowa*	GUTTIFERAE	T
82	Phawa	*Garcinia speciosa* Wall.	*G. speciosa*	GUTTIFERAE	T
83	Ta khram	*Garuga pinnata* Roxb.	*G. pinnata*	BURSERACEAE	T
84	Khoei tai	*Glycosmis pentaphylla* Corr.	*G. pentaphylla*	RUTACEAE	S
85	Hom klai	*Guioa pleuropteris* Radlk.	*G. pleuropteris*	SAPINDACEAE	ST
86	Kwao	*Haldina cordifolia* Ridsd.	*H. cordifolia*	RUBIACEAE	T
87	Ta khian hin	*Hopea ferrea* Pierre	*H. ferrea*	DIPTEROCARPACEAE	T
88	Ta khian tong	*Hopea odorata* Roxb.	*H. odorata*	DIPTEROCARPACEAE	T
89	Kra bao klak	*Hydnocarpus ilicifolius* King	*H. ilicifolius*	FLACOURTIACEAE	T
90	Krabok	*Irvingia malayana* Oliv. ex A. Benn.	*I. malayana*	IRVINGIACEAE	T
91	Khem pa	*Ixora cibdela* Craib	*I. cibdela*	RUBIACEAE	S
92	khem yai	*Ixora grandifolia* Zoll. & Morton	*I. grandifolia*	RUBIACEAE	S
93	Khem	*Ixora sp.*	*Ixora sp.*	RUBIACEAE	S
94	Lueat khwai bai yai	*Knema furfuracea* Warb.	*K. furfuracea*	MYRISTICACEAE	T
95	Ta baek daeng	*Lagerstroemia calyculata* Kurz	*L. calyculata*	LYTHRACEAE	T
96	Ta baek plueak bang	*Lagerstroemia duperreana* Pierre	*L. duperreana*	LYTHRACEAE	T
97	Salao	*Lagerstroemia loudonii* Teijsm. & Binn.	*L. loudonii*	LYTHRACEAE	T
98	Ma huat	*Lepisanthes rubiginosa* Leenh.	*L. rubiginosa*	SAPINDACEAE	ST
99	Ma fueang chang	*Lepisanthes tetraphylla* Radlk.	*L. tetraphylla*	SAPINDACEAE	T
100	Kra thin thai	*Leucaena leucocephala* de Wit	*L. leucocephala*	MIMOSACEAE	ST/T
101	Ko phuang	*Lithocarpus fenestratus* Rehd.	*L. fenestratus*	FAGACEAE	T
102	Mi men	*Litsea glutinosa* C.B. Robinson	*L. glutinosa*	LAURACEAE	T
103	Kho	*Livistona speciosa* Kurz	*L. speciosa*	PALMAE	T

Appendix Table 2. (Continued).

No.	Lacal names	Scientific name	Species Abbreviation	Families	Life form
104	Ma sang	*Madhuca pierrei* Lam	*M. pierrei*	SAPOTACEAE	T
105	Chaeng	*Maerua siamensis* Pax	*M. siamensis*	CAPPARIDACEAE	T
106	Soi dao	*Mallotus paniculatus* Muell. Arg.	*M. paniculatus*	EUPHORBIACEAE	T
107	Salat	*Mallotus peltatus* Muell. Arg.	*M. peltatus*	EUPHORBIACEAE	S/ST
108	Makai khat	*Mallotus philippensis* Muell. Arg.	*M. philippensis*	EUPHORBIACEAE	T
109	Saraphi dok yai	*Mammea harmandii* Kosterm.	*M. harmandii*	GUTTIFERAE	T
111	Mamuang pa	*Mangifera caloneura* Kurz	*M. caloneura*	ANACARDIACEAE	T
112	Ket	*Manilkara hexandra* Dubard	*M. hexandra*	SAPOTACEAE	T
113	Khae hua mu	*Markhamia stipulata* Seem.	*M. stipulata*	BIGNONIACEAE	T
114	Lian	*Melia azedarach* Linn.	*M. azedarach*	MELIACEAE	T
115	Phak wan	*Melientha suavis* Pierre	*M. suavis*	OPILIACEAE	S
116	Lamduan	*Melodorum fruticosum* Lour.	*M. fruticosum*	ANNONACEAE	S
117	Phlong khi khwai	*Memecylon caeruleum* Jack	*M. caeruleum*	MELASTOMATACEAE	T
118	Phlong bai yai	*Memecylon cyaneum* de Willd	*M. cyaneum*	MELASTOMATACEAE	S
119	Phlong yai	*Memecylon ovatum* J.E. Smith	*M. ovatum*	MELASTOMATACEAE	S/ST
120	Mueat chi	*Memecylon scutellatum* Naud.	*M. scutellatum*	MELASTOMATACEAE	S/ST
121	Phlapphla	*Microcos tomentosa* Linn.	*M. tomentosa*	TILIACEAE	T
122	Ching chap	*Miliusa mollis* Pierre	*M. mollis*	ANNONACEAE	ST
123	Khra cho	*Millettia leucantha* Kurz	*M. leucantha*	PAPILIONACEAE	T
124	Pha – bang	*Mischocarpus grandis* Radlk.	*M. grandis*	SAPINDACEAE	T
125	Ma puan	*Mitrephora vandiflora* Kurz	*M. vandiflora*	ANNONACEAE	T
126	Kaeo	*Murraya paniculata* Jack	*M. paniculata*	RUTACEAE	S/ST
127	Hian	*Neolitsea casiaefolia* Merr.	*N. casiaefolia*	LAURACEAE	T
128	Ian	*Neolitsea zeylanica* Merr.	*N. zeylanica*	LAURACEAE	T
129	Kho laen	*Nephelium hypoleucum* Kurz	*N. hypoleucum*	SAPINDACEAE	T
130	Lamyai pa	*Paranephelium longifoliolatum* Lec.	*P. longifoliolatum*	SAPINDACEAE	T
131	Luk ding	*Parkia sumatrana* Miq.	*P. sumatrana*	MIMOSACEAE	T
132	A rang	*Peltophorum dasyrachis* Kurz	*P. dasyrachis*	CAESALPINIACEAE	T
133	Lae buk	*Phoebe lanceolata* Nees	*P. lanceolata*	LAURACEAE	T
134	Sa thip	*Phoebe paniculata* Nees	*P. paniculata*	LAURACEAE	T
135	Pat nam	*Photinia stenophylla* Hand.-Mazz.	*P. stenophylla*	ROSACEAE	ST
136	Ma kham pom	*Phyllanthus emblica* Linn.	*P. emblica*	EUPHORBIACEAE	T
137	Mak iak	*Pinanga hookeriana* Becc.	*P. hookeriana*	PALMAE	S
138	Yang don	*Polyalthia asterilla* Ridl.	*P. asterilla*	ANNONACEAE	T
139	Ka chian	*Polyalthia cerasoides* Benth. ex Bedd.	*P. cerasoides*	ANNONACEAE	T

Appendix Table 2. (Continued).

No.	Lacal names	Scientific name	Species Abbreviation	Families	Life form
140	Nom noi	*Polyalthia evecta* Finet & Gagnep.	*P. evecta*	ANNONACEAE	S
141	Kluai i hen	*Polyalthia lateriflora* King	*P. lateriflora*	ANNONACEAE	ST
142	Yang on	*Polyalthia viridis* Craib	*P. viridis*	ANNONACEAE	T
143	Phut pa	*Prismatomeris filamentosa* Craib	*P. filamentosa*	RUBIACEAE	S/ST
144	Ma faen	*Protium serratum* Engl.	*P. serratum*	BURSERACEAE	T
145	Taeng chang	*Prunus arborea* Kalkm. var. montana Kalkm.	*P. arborea*	ROSACEAE	T
146	Op choei	*Prunus ceylanica* Miq.	*P. ceylanica*	ROSACEAE	T
147	Nut ton	*Prunus grisea* Kalkm.	*P. grisea*	ROSACEAE	T
148	Pradu	*Pterocarpus macrocarpus* Kurz	*P. macrocarpus*	PAPILIONACEAE	T
149	Po i keng	*Pterocymbium javanicum* R. Br.	*P. javanicum*	STERCULIACEAE	T
150	Kanan pling	*Pterospermum acerifolium* Willd.	*P. acerifolium*	STERCULIACEAE	T
151	Lam pang	*Pterospermum diversifolium* Bl.	*P. diversifolium*	STERCULIACEAE	T
152	Ko talap	*Quercus ramsbottomii* A. Camus	*Q. ramsbottomii*	FAGACEAE	T
153	Nam khet	*Randia dasycarpa* Bakh. f.	*R. dasycarpa*	RUBIACEAE	S/ST
154	Ko kriam	*Rinorea lanceolata* (Wall.) Kuntze	*R. lanceolata*	VIOLACEAE	S
155	Sam phan ta	*Sampantaea amentiflora* Airy Shaw	*S. amentiflora*	EUPHORBIACEAE	S
156	Pho bai	*Sapium baccatum* Roxb.	*S. baccatum*	EUPHORBIACEAE	T
157	Ta khian thao	*Sapium discolor* Muell. Arg.	*S. discolor*	EUPHORBIACEAE	T
158	Ta khro	*Schleichera oleosa* Merr.	*S. oleosa*	SAPINDACEAE	T
159	Khiam khanong	*Shorea henryana* Pierre	*S. henryana*	DIPTEROCARPACEAE	T
160	Maduk	*Siphonodon celastrineus* Griff.	*S. celastrineus*	CELASTRACEAE	T
161	Makok	*Spondias pinnata* Kurz	*S. pinnata*	ANACARDIACEAE	T
162	Samrong	*Sterculia foetida* Linn.	*S. foetida*	STERCULIACEAE	T
163	Po daeng	*Sterculia guttata* Roxb.	*S. guttata*	STERCULIACEAE	S/ST
164	Khae sai	*Stereospermum neuranthum* Kurz	*S. neuranthum*	BIGNONIACEAE	T
165	Khoi	*Streblus asper* Lour.	*S. asper*	MORACEAE	T
166	Khoi nam	*Streblus ilicifolius* Corner	*S. ilicifolius*	MORACEAE	S/ST
167	Tong pha	*Sumbaviopsis albicans* J.J. Smith	*S. albicans*	EUPHORBIACEAE	T
168	Khan thong phayabat	*Suregada multiflorum* Baill.	*S. multiflorum*	EUPHORBIACEAE	S/ST
169	Wa	*Syzygium cumini* Druce	*S. cumini*	MYRTACEAE	T
170	Wa dong	*Syzygium fruticosa* Roxb.	*S. fruticosa*	MYRTACEAE	T
171	Chomphu nam	*Syzygium siamensis* Craib	*S. siamensis*	MYRTACEAE	T
172	Wa nam	*Syzygium thorelii* Gagnep.	*S. thorelii*	MYRTACEAE	T
173	Khem khao	*Tarenna collinsae* Craib	*T. collinsae*	RUBIACEAE	S

Appendix Table 2. (Continued).

No.	Lacal names	Scientific name	Species Abbreviation	Families	Life form
174	Ta baek krai	*Terminalia dafeuillana* Pierre ex Laness.	*T. dafeuillana*	COMBRETACEAE	T
175	Kai daeng	*Ternstroemia gymnanthera* Bedd.	*T. gymnanthera*	THEACEAE	T
176	Som phong	*Tetrameles nudiflora* R. Br.	*T. nudiflora*	DATISCACEAE	T
177	Yom hom	*Toona ciliata* M. Roem.	*T. ciliata*	MELIACEAE	T
178	Phak wan mao	*Urobotrya siamensis* Hiepko	*U. siamensis*	OPILIACEAE	S
179	Khai nao	*Vitex glabrata* R. Br.	*V. glabrata*	LABIATAE	T
180	Ka sam pik	*Vitex peduncularis* Wall. ex Schauer	*V. peduncularis*	LABIATAE	T
181	Ta phun thao	*Vitex quinata* Williams var. puberula Mold.	*V. quinata*	LABIATAE	ST
182	Kat lin	*Walsura trichostemon* Miq.	*W. trichostemon*	MELIACEAE	T
183	Mok man	*Wrightia tomentosa* Roem. & Schult.	*W. tomentosa*	APOCYNACEAE	T
184	Daeng	*Xylia xylocarpa* Taub.	*X. xylocarpa*	MIMOSACEAE	T
185	Phutsa	*Zizyphus mauritiana* Lamk.	*Z. mauritiana*	RHAMNACEAE	ST
186	Unidentified 1	Unidentified 1	*Unidentified 1*	Unidentified 1	T
187	Unidentified 2	Unidentified 2	*Unidentified 2*	Unidentified 2	T
188	Unidentified 3	Unidentified 3	*Unidentified 3*	Unidentified 3	T

Appendix Table 3. **The importance value index of tree species along various altitudes of Khao So area.**

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Hopea ferrea Pierre	40.57	50.59	65.63	50.84	40.54	33.00	35.66	32.29	9.30	27.31	0.00	35.07
Bambusa sp.	0.00	0.00	0.00	0.00	43.18	45.04	54.87	36.45	28.38	17.72	0.00	20.51
Memecylon ovatum J.E. Smith	12.58	10.34	14.29	15.65	30.69	13.66	7.56	36.52	5.25	3.94	11.98	14.77
Syzygium cumini Druce	7.41	11.01	24.86	14.50	15.04	17.13	3.66	13.49	16.11	8.97	5.00	12.47
Hydnocarpus ilicifolius King	13.89	12.61	13.08	17.83	10.55	8.81	13.45	19.57	7.53	9.83	8.21	12.31
Walsura trichostemon Miq.	13.59	16.65	12.91	16.48	13.61	10.46	11.31	10.13	9.86	7.38	0.00	11.12
Syzygium siamensis Craib	11.66	10.64	0.00	8.60	5.73	6.51	11.61	1.61	13.48	6.34	34.21	10.03
Shorea henryana Pierre	4.21	8.26	8.20	5.29	5.43	9.25	1.85	12.62	26.95	14.33	4.79	9.20
Acronychia pedunculata Miq.	1.67	5.31	1.61	0.00	0.00	8.57	0.00	4.52	20.99	15.10	21.41	7.20
Aglaia pirifera Hance	7.89	8.44	3.88	9.39	4.70	4.66	4.94	10.86	5.36	6.08	6.74	6.63
Mischocarpus grandis Radlk.	0.00	0.00	6.79	2.35	3.54	4.62	2.53	7.84	7.11	18.19	7.83	5.53
Phoebe paniculata Nees	1.67	7.55	0.00	0.00	2.43	5.27	0.00	3.46	7.25	3.93	25.04	5.14
Knema furfuracea Warb.	0.00	4.95	0.00	0.00	0.00	5.21	5.08	1.96	15.27	7.08	14.87	4.95
Choerospondias axillaris Burtt & Hill	0.00	4.84	0.00	0.00	0.00	3.62	0.00	0.00	6.99	6.75	23.37	4.14
Cleistanthus hirsutulus Hook. f.	3.69	2.47	1.60	3.07	0.00	3.70	5.96	4.26	6.91	10.14	0.00	3.80
Parkia sumatrana Miq.	2.36	4.79	1.37	0.00	8.64	1.30	3.32	6.77	8.92	4.24	0.00	3.79
Mallotus paniculatus Muell. Arg.	0.00	9.15	1.36	1.50	1.41	1.60	3.32	0.00	6.52	3.44	10.06	3.49
Diospyros malabarica Kostel.	4.54	0.00	5.51	6.65	2.86	3.31	3.47	7.30	1.42	2.85	0.00	3.45

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Streblus ilicifolius Corner	11.03	1.49	1.69	3.26	3.75	6.86	1.94	5.16	0.00	2.63	0.00	3.44
Diospyros variegata Kurz	1.50	5.96	4.90	8.18	0.00	5.35	4.11	2.17	0.00	1.30	0.00	3.04
Ficus sp.	0.00	1.47	0.00	20.08	2.28	0.00	0.00	8.91	0.00	0.00	0.00	2.98
Memecylon caeruleum Jack	3.98	1.47	5.48	2.13	1.24	1.58	2.56	0.00	4.04	3.32	6.78	2.96
Lagerstroemia duperreana Pierre	3.80	1.97	5.07	8.67	1.76	5.65	4.63	0.00	0.00	0.00	0.00	2.87
Mangifera caloneura Kurz	3.46	0.00	0.00	10.75	8.32	0.00	0.00	5.99	1.57	1.35	0.00	2.86
Toona ciliata M. Roem.	2.42	0.00	1.89	0.00	0.00	3.00	0.00	1.83	1.99	5.02	15.03	2.83
Unidentified 1	4.15	4.32	0.00	0.00	0.00	6.30	3.96	0.00	0.00	4.54	6.40	2.70
Pterospermum acerifolium Willd.	0.00	4.17	3.51	1.47	1.66	1.97	2.28	0.00	1.59	4.69	7.61	2.63
Polyalthia evecta Finet & Gagnep.	2.15	1.62	2.78	5.16	3.29	3.97	2.78	1.76	1.31	3.08	0.00	2.54
Peltophorum dasyrachis Kurz	24.55	0.00	1.68	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	2.51
Microcos tomentosa Linn.	3.84	0.00	5.11	4.98	2.92	3.40	0.00	2.41	1.52	3.22	0.00	2.49
Dialium cochinchinense Pierre	0.00	1.87	7.61	8.05	1.98	2.59	0.00	1.61	0.00	2.73	0.00	2.40
Diospyros ferrea Bakh.	0.00	0.00	3.07	4.14	0.00	3.40	2.37	1.83	4.45	6.87	0.00	2.38
Aphanamixis polystachya Parker	0.00	1.92	0.00	3.41	3.29	1.21	5.96	4.03	5.71	0.00	0.00	2.32
Irvingia malayana Oliv. ex A. Benn.	0.00	0.00	10.60	3.99	0.00	0.00	0.00	2.78	4.36	1.40	0.00	2.10
Lithocarpus fenestratus Rehd.	0.00	0.00	0.00	0.00	1.65	2.33	0.00	0.00	1.36	10.93	5.95	2.02
Vitex peduncularis Wall. ex Schauer	1.64	0.00	0.00	0.00	2.80	0.00	0.00	0.00	1.47	2.04	13.58	1.96

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Unidentified 3	0.00	1.54	0.00	0.00	0.00	5.54	0.00	0.00	2.32	1.56	9.27	1.84
Anisoptera costata Korth.	0.00	2.13	0.00	0.00	5.51	0.00	11.81	0.00	0.00	0.00	0.00	1.77
Quercus ramsbottomii A. Camus	0.00	5.71	0.00	0.00	0.00	3.39	0.00	0.00	3.97	6.05	0.00	1.74
Melodorum fruticosum Lour.	0.00	0.00	3.61	2.90	1.98	3.88	1.56	0.00	1.47	3.03	0.00	1.67
Afzelia xylocarpa Craib	11.01	0.00	0.00	1.50	0.00	2.96	2.55	0.00	0.00	0.00	0.00	1.64
Siphonodon celastrineus Griff.	4.20	1.68	0.00	3.60	1.80	0.00	0.00	2.04	1.26	3.35	0.00	1.63
Dehaasia candolleana Kosterm.	0.00	1.51	2.51	3.13	2.89	2.44	0.00	1.61	0.00	2.89	0.00	1.54
Adenanthera microsperma Teijsm. & Binn.	0.00	7.32	0.00	2.87	0.00	1.19	0.00	0.00	0.00	5.46	0.00	1.53
Unidentified 2	0.00	0.00	0.00	2.00	1.48	1.28	0.00	1.83	0.00	0.00	10.13	1.52
Prunus arborea Kalkm. var. montana Kalkm.	3.43	2.54	0.00	0.00	1.40	0.00	0.00	0.00	3.93	4.11	0.00	1.40
Mallotus philippensis Muell. Arg.	2.16	4.28	2.16	1.40	0.00	0.00	2.45	1.64	1.30	0.00	0.00	1.40
Paranephelium longifoliolatum Lec.	2.43	0.00	3.69	2.44	0.00	1.28	1.79	1.72	1.45	0.00	0.00	1.35
Millettia leucantha Kurz	3.10	3.26	5.44	2.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30
Baccaurea ramiflora Lour.	0.00	1.47	2.58	0.00	1.41	0.00	0.00	2.01	2.21	0.00	4.57	1.29
Leucaena leucocephala de Wit	10.79	1.48	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	1.28
Cinnamomum iners Bl.	0.00	0.00	0.00	0.00	0.00	1.17	0.00	0.00	0.00	2.47	10.19	1.26

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Sapium discolor Muell. Arg.	0.00	2.63	0.00	0.00	0.00	0.00	0.00	7.11	3.84	0.00	0.00	1.23
Mammea siamensis Kosterm.	3.54	1.74	3.03	0.00	1.43	0.00	2.31	0.00	0.00	1.24	0.00	1.21
Vitex glabrata R. Br.	0.00	1.50	0.00	0.00	0.00	1.17	4.84	0.00	3.07	2.32	0.00	1.17
Vitex quinata Williams var. puberula Mold.	1.50	1.88	0.00	2.13	1.72	3.09	0.00	0.00	0.00	2.46	0.00	1.16
Drypetes hainanensis Merr.	3.76	0.00	1.58	1.48	2.73	0.00	3.18	0.00	0.00	0.00	0.00	1.16
Phoebe lanceolata Nees	0.00	1.84	0.00	1.51	1.49	2.01	2.13	0.00	2.48	1.24	0.00	1.15
Tetrameles nudiflora R. Br.	10.51	0.00	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15
Nephelium hypoleucum Kurz	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	2.93	3.00	4.57	1.12
Polyalthia viridis Craib	0.00	1.49	1.53	1.45	0.00	1.40	1.82	1.61	1.47	1.25	0.00	1.09
Prunus grisea Kalkm.	0.00	0.00	0.00	0.00	0.00	3.39	0.00	0.00	0.00	0.00	8.32	1.06
Acalypha kerrii Craib	2.26	1.49	1.60	0.00	0.00	1.35	3.71	0.00	1.26	0.00	0.00	1.06
Mammea harmandii Kosterm.	0.00	0.00	6.90	0.00	1.49	1.25	1.94	0.00	0.00	0.00	0.00	1.05
Melia azedarach Linn.	0.00	7.33	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05
Murraya paniculata Jack	1.47	1.47	0.00	0.00	0.00	0.00	2.29	4.99	0.00	1.24	0.00	1.04
Sampantaea amentiflora Airy Shaw	0.00	0.00	4.46	1.71	2.74	0.00	2.13	0.00	0.00	0.00	0.00	1.00
Neolitsea casiaefolia Merr.	0.00	1.84	0.00	0.00	0.00	0.00	1.67	1.52	0.00	1.25	4.53	0.98
Adenanthera pavonina Linn.	2.50	0.00	0.00	4.28	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.97

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Urobotrya siamensis Hiepko	0.00	0.00	0.00	3.23	0.00	0.00	1.48	0.00	4.10	1.61	0.00	0.95
Sapium baccatum Roxb.	0.00	0.00	0.00	0.00	0.00	3.64	0.00	0.00	6.56	0.00	0.00	0.93
Dipterocarpus turbinatus Gaertn. f.	2.67	7.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.92
Aglaia chaudocensis Pierre	0.00	0.00	1.34	0.00	0.00	1.20	1.65	2.19	1.31	2.32	0.00	0.91
Suregada multiflorum Baill.	0.00	1.50	0.00	1.65	0.00	3.48	0.00	1.82	0.00	1.42	0.00	0.90
Diospyros gracilis Fletch.	2.98	1.51	0.00	0.00	3.20	1.40	0.00	0.00	0.00	0.00	0.00	0.83
Sumbaviopsis albicans J.J. Smith	0.00	1.80	0.00	0.00	0.00	1.48	2.87	0.00	1.51	1.29	0.00	0.81
Phyllanthus emblica Linn.	4.12	0.00	0.00	1.74	0.00	1.16	0.00	1.54	0.00	0.00	0.00	0.78
Chionanthus macrostigma Gagnep	0.00	0.00	0.00	0.00	0.00	0.00	8.56	0.00	0.00	0.00	0.00	0.78
Litsea glutinosa C.B. Robinson	0.00	0.00	1.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.90	0.75
Bauhinia viridescens Desv.	2.63	1.53	3.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73
Ailanthus triphysa Alston	2.67	1.47	0.00	0.00	0.00	0.00	0.00	2.53	1.34	0.00	0.00	0.73
Dalbergia cochinchinensis Pierre	1.94	0.00	0.00	1.53	0.00	3.06	0.00	0.00	0.00	1.25	0.00	0.71
Polyalthia cerasoides Benth. ex Bedd.	1.47	0.00	1.46	0.00	2.05	2.65	0.00	0.00	0.00	0.00	0.00	0.69
Maerua siamensis Pax	0.00	4.52	0.00	0.00	0.00	1.41	1.51	0.00	0.00	0.00	0.00	0.68
Chionanthus microstigma Gagnep	0.00	0.00	0.00	0.00	1.30	0.00	6.02	0.00	0.00	0.00	0.00	0.67
Dipterocarpus costatus C.F.Gaertn.	0.00	7.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64
Artocarpus lakoocha Roxb.	0.00	0.00	3.51	1.49	0.00	0.00	0.00	2.03	0.00	0.00	0.00	0.64

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Aquilaria crassna Pierre ex H. Lec.	0.00	0.00	0.00	0.00	2.14	0.00	2.52	2.14	0.00	0.00	0.00	0.62
Atalantia monophylla Correa	1.50	0.00	0.00	0.00	1.82	0.00	3.40	0.00	0.00	0.00	0.00	0.61
Hopea odorata Roxb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.38	0.58
Ficus hispida Linn. f.	0.00	2.14	2.94	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.58
Dalbergia oliveri Gamble	0.00	0.00	2.22	0.00	0.00	1.92	0.00	2.16	0.00	0.00	0.00	0.57
Ardisia littoralis Andr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.29	0.57
Caryota mitis Lour.	0.00	2.87	0.00	1.83	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.54
Ficus altissima Bl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	4.29	0.00	0.53
Neolitsea zeylanica Merr.	0.00	1.87	0.00	0.00	0.00	1.56	0.00	0.00	2.21	0.00	0.00	0.51
Manilkara hexandra Dubard	0.00	0.00	0.00	0.00	3.28	0.00	2.21	0.00	0.00	0.00	0.00	0.50
Diospyros kerrii Craib	0.00	0.00	0.00	0.00	0.00	0.00	2.22	3.22	0.00	0.00	0.00	0.49
Drypetes hoaensis Gagnep.	1.72	0.00	0.00	1.41	0.00	0.00	2.15	0.00	0.00	0.00	0.00	0.48
Diospyros dasyphylla Kurz	1.47	2.21	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.48
Polyalthia asterilla Ridl.	0.00	0.00	0.00	0.00	5.23	0.00	0.00	0.00	0.00	0.00	0.00	0.48
Prunus ceylanica Miq.	0.00	0.00	0.00	1.41	1.57	0.00	0.00	0.00	2.24	0.00	0.00	0.47
Schleichera oleosa Merr.	0.00	0.00	0.00	0.00	0.00	0.00	2.12	0.00	0.00	3.08	0.00	0.47
Lagerstroemia loudonii Teijsm. & Binn.	0.00	1.87	1.34	0.00	0.00	0.00	1.88	0.00	0.00	0.00	0.00	0.46
Eurya acuminata DC.	0.00	0.00	0.00	1.57	0.00	1.66	0.00	0.00	1.73	0.00	0.00	0.45

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Garcinia speciosa Wall.	1.47	1.90	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	0.00	0.44
Lagerstroemia calyculata Kurz	1.47	0.00	0.00	0.00	1.41	0.00	1.82	0.00	0.00	0.00	0.00	0.43
Pterospermum diversifolium Bl.	0.00	1.47	1.34	1.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Acalypha siamensis Oliv. ex Gage	0.00	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	3.13	0.00	0.39
Clausena harmandiana Pierre	0.00	3.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.39
Ixora cibdela Craib	0.00	0.00	1.41	0.00	1.54	0.00	0.00	0.00	1.30	0.00	0.00	0.39
Clausena excavata Burm. f.	0.00	0.00	0.00	1.38	0.00	0.00	0.00	0.00	2.52	0.00	0.00	0.36
Cratoxylum cochinchinense Bl.	0.00	2.20	1.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35
Celtis tetrandra Roxb.	0.00	0.00	0.00	2.09	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.35
Canarium subulatum Guill.	1.67	0.00	1.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Markhamia stipulata Seem.	0.00	1.63	1.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Cananga latifolia Finet & Gagnep.	2.16	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Lepisanthes tetraphylla Radlk.	3.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Pterocymbium javanicum R. Br.	0.00	0.00	0.00	1.50	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Pterocarpus macrocarpus Kurz	1.67	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Capparis micracantha DC.	1.75	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.30
Diospyros castanea Fletch.	0.00	0.00	3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Antiaris toxicaria Lesch.	1.68	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	0.28

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Bauhinia saccocalyx Pierre	0.00	0.00	0.00	0.00	0.00	0.00	3.05	0.00	0.00	0.00	0.00	0.28
Mallotus peltatus Muell. Arg.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58	1.42	0.00	0.27
Eurycoma longifolia Jack	0.00	0.00	0.00	0.00	0.00	0.00	2.94	0.00	0.00	0.00	0.00	0.27
Diospyros montana Roxb.	0.00	0.00	1.37	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
Flacourtia rukam Zoll. & Mor.	0.00	0.00	1.41	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.24
Madhuca pierrei Lam	0.00	0.00	0.00	0.00	2.59	0.00	0.00	0.00	0.00	0.00	0.00	0.24
Wrightia tomentosa Roem. & Schult.	0.00	0.00	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Memecylon cyaneum de Willd	0.00	0.00	0.00	0.00	0.00	1.21	0.00	0.00	1.31	0.00	0.00	0.23
Guioa pleuropteris Radlk.	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Carallia brachiata Merr.	0.00	0.00	2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Dracaena loureiri Gagnep.	2.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Diospyros pilosanthera Blanco	0.00	0.00	0.00	0.00	2.07	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Sterculia guttata Roxb.	0.00	2.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Croton cascarilloides Raeusch.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.01	0.00	0.00	0.18
Zizyphus mauritiana Lamk.	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.16
Stereospermum neuranthum Kurz	0.00	0.00	0.00	0.00	1.66	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Polyalthia lateriflora King	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Bridelia retusa Spreng.	0.00	0.00	0.00	0.00	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.15

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Celtis timorensis Span.	0.00	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Colona auriculata Craib	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.15
Ternstroemia gymnanthera Bedd.	0.00	0.00	0.00	0.00	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.14
Spondias pinnata Kurz	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Aporusa villosa Baill.	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Lepisanthes rubiginosa Leenh.	1.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Syzygium thorelii Gagnep.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.00	0.14
Ardisia lenticellata Fletch.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.14
Terminalia dafeuillana Pierre ex Laness.	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Sterculia foetida Linn.	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.14
Syzygium fruticosa Roxb.	0.00	0.00	0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Elaeocarpus robustus Roxb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41	0.00	0.13
Haldina cordifolia Ridsd.	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Randia dasycarpa Bakh. f.	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Acrocarpus fraxinifolius Wight & Arn.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36	0.00	0.00	0.12
Garcinia cowa Roxb.	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Diospyros coaetanea Fletch.	0.00	0.00	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Alstonia scholaris R. Br.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.12

Appendix Table 3. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Ixora grandifolia Zoll. & Morton	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.12
Tarenna collinsae Craib	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Bombax ceiba Linn.	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Mitrephora vandiflora Kurz	0.00	0.00	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Antidesma bunius Spreng.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.00	0.11
Memecylon scutellatum Naud.	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00	0.00	0.00	0.00	0.11

Appendix Table 4. The importance value index of sapling species along various altitudes of Khao So area.

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Cleistanthus hirsutulus Hook. f.	21.01	15.68	13.04	21.37	11.89	24.16	19.46	28.40	27.20	31.48	32.30	22.36
Hopea ferrea Pierre	10.53	8.25	30.80	16.86	27.57	32.75	4.11	19.39	0.00	14.27	0.00	14.96
Syzygium cumini Druce	11.22	9.16	18.45	15.31	16.49	9.73	3.16	8.16	4.44	4.09	34.02	12.20
Walsura trichostemon Miq.	18.47	10.16	6.88	21.37	20.00	11.30	10.77	3.10	5.45	0.88	0.00	9.85
Polyalthia evecta Finet & Gagnep.	13.51	3.43	8.85	13.92	7.03	10.10	21.62	10.13	4.44	0.00	5.06	8.92
Memecylon ovatum J.E. Smith	7.89	8.34	16.73	8.14	11.62	12.92	6.67	12.66	6.85	2.92	0.00	8.61
Streblus ilicifolius Corner	14.33	8.25	10.09	8.95	14.59	9.15	2.56	11.53	1.01	5.26	0.00	7.79
Aglaia pirifera Hance	6.87	8.60	6.64	3.05	8.92	2.21	7.27	8.44	1.01	9.35	15.17	7.05
Syzygium siamensis Craib	4.61	7.12	0.00	5.90	9.73	3.81	5.39	1.97	18.07	18.07	0.00	6.79
Mischocarpus grandis Radlk.	0.00	3.65	1.72	0.81	1.62	6.94	2.83	4.78	12.46	13.44	21.95	6.38
Murraya paniculata Jack	10.94	7.56	0.00	1.23	7.84	3.81	13.00	13.23	0.00	7.01	5.06	6.33
Acalypha siamensis Oliv. ex Gage	11.81	10.29	3.20	10.45	2.70	7.86	10.98	4.78	0.00	4.67	0.00	6.07
Capparis micracantha DC.	7.16	3.43	5.16	8.52	10.54	8.84	2.83	11.82	0.00	0.88	0.00	5.38
Urobotrya siamensis Hiepko	3.31	0.91	2.95	6.71	1.62	11.63	10.24	3.10	6.62	5.84	0.00	4.81
Shorea henryana Pierre	0.76	0.91	2.95	0.00	1.35	2.52	4.71	11.80	12.39	6.72	5.06	4.47
Ixora cibdela Craib	3.57	4.00	0.74	2.85	2.43	3.16	6.40	3.38	3.43	7.60	5.06	3.87
Eurycoma longifolia Jack	0.00	4.00	0.00	0.00	0.00	4.08	0.00	0.00	5.22	3.51	15.17	2.91
Hydnocarpus ilicifolius King	5.37	1.26	4.43	4.86	2.16	4.11	0.00	5.07	3.98	0.00	0.00	2.84

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Diospyros malabarica Kostel.	2.81	2.74	2.21	4.51	1.62	1.90	7.14	3.66	0.00	3.51	0.00	2.74
Acronychia pedunculata Miq.	0.00	2.74	0.00	0.00	0.00	5.34	0.00	0.00	6.46	14.59	0.00	2.65
Phoebe paniculata Nees	0.00	0.91	0.00	0.00	0.00	0.95	0.00	0.00	10.51	6.73	5.06	2.20
Sampantaea amentiflora Airy Shaw	1.52	5.51	6.64	0.81	4.05	0.00	5.39	0.00	0.00	0.00	0.00	2.18
Memecylon caeruleum Jack	0.00	1.82	0.74	1.62	2.16	2.86	0.94	1.13	4.05	0.88	6.78	2.09
Rinorea lanceolata (Wall.) Kuntze	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.30	2.03
Mallotus philippensis Muell. Arg.	0.00	6.51	3.20	1.43	0.00	0.00	0.00	0.85	5.22	4.39	0.00	1.96
Ardisia lenticellata Fletch.	2.83	0.91	0.00	0.00	0.00	1.57	2.90	0.00	10.99	0.88	0.00	1.82
Acalypha kerrii Craib	0.00	3.65	1.97	2.24	3.24	0.00	4.44	0.00	1.01	2.05	0.00	1.69
Knema furfuracea Warb.	0.00	0.91	0.00	1.43	0.00	2.82	0.00	0.00	3.04	0.00	10.11	1.66
Cladogynos orientalis Zipp. Ex Span.	1.52	0.91	4.18	7.41	1.62	0.95	0.00	1.13	0.00	0.00	0.00	1.61
Hopea odorata Roxb.	2.54	1.82	1.23	0.00	5.95	0.00	0.00	4.22	0.00	0.00	0.00	1.43
Microcos tomentosa Linn.	1.02	0.00	4.18	0.00	0.81	0.00	0.94	3.10	2.02	2.63	0.00	1.34
Diospyros ferrea Bakh.	2.54	0.91	1.47	1.23	2.43	0.00	0.94	4.22	0.00	0.00	0.00	1.25
Clausena excavata Burm. f.	2.54	5.60	1.47	1.23	0.00	0.00	0.00	0.00	1.01	0.00	0.00	1.08
Mammea siamensis Kosterm.	0.00	0.91	2.21	0.00	1.89	0.00	2.56	1.69	0.00	2.05	0.00	1.03
Prunus ceylanica Miq.	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	3.20	0.00	6.78	0.96
Siphonodon celastrineus Griff.	0.00	0.91	0.74	0.00	0.81	0.95	0.00	0.00	2.02	0.00	5.06	0.95

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Pterospermum acerifolium Willd.	1.52	0.00	4.43	0.62	0.00	0.00	0.00	0.00	3.04	0.88	0.00	0.95
Aglaia chaudocensis Pierre	0.76	0.00	0.00	0.81	2.16	0.00	3.84	0.00	0.00	1.76	0.00	0.85
Sumbaviopsis albicans J.J. Smith	0.00	1.26	0.00	0.00	0.00	1.26	0.94	0.00	3.04	2.05	0.00	0.78
Mallotus peltatus Muell. Arg.	0.00	2.17	3.20	0.00	0.00	0.00	1.89	1.13	0.00	0.00	0.00	0.76
Cinnamomum iners Bl.	0.00	1.26	0.00	0.00	0.00	1.90	0.00	0.00	3.43	1.76	0.00	0.76
Melodorum fruticosum Lour.	1.52	0.00	3.20	1.43	0.00	1.26	0.00	0.00	0.00	0.88	0.00	0.75
Livistona speciosa Kurz	0.00	0.00	0.00	0.00	0.00	1.26	0.00	0.00	5.61	0.88	0.00	0.70
Antiaris toxicaria Lesch.	0.00	0.91	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.06	0.63
Diospyros variegata Kurz	0.76	1.82	0.00	2.43	0.00	0.00	0.94	0.85	0.00	0.00	0.00	0.62
Clausena harmandiana Pierre	0.00	0.91	0.00	0.00	1.89	0.00	0.94	0.85	2.02	0.00	0.00	0.60
Chionanthus microstigma Gagnep	0.00	0.00	0.00	0.00	0.00	0.00	6.53	0.00	0.00	0.00	0.00	0.59
Lepisanthes rubiginosa Leenh.	0.76	0.91	0.74	0.00	0.00	0.00	0.00	0.85	0.00	3.21	0.00	0.59
Vitex peduncularis Wall. ex Schauer	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.54	0.00	0.59
Markhamia stipulata Seem.	0.00	0.00	2.95	0.00	0.00	0.95	0.00	1.41	1.01	0.00	0.00	0.57
Polyalthia cerasoides Benth. ex Bedd.	0.00	0.00	1.47	0.00	0.81	0.00	2.22	1.69	0.00	0.00	0.00	0.56
Drypetes hainanensis Merr.	0.00	0.00	0.74	0.81	0.81	0.00	1.28	0.85	0.00	1.46	0.00	0.54
Croton cascarilloides Raeusch.	0.76	0.00	1.72	2.43	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.52

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Atalantia monophylla Correa	0.76	2.17	0.98	0.00	0.81	0.00	0.94	0.00	0.00	0.00	0.00	0.52
Leucaena leucocephala de Wit	3.07	2.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Tarenna collinsae Craib	1.52	0.00	3.44	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51
Baccaurea ramiflora Lour.	0.00	2.52	1.97	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.50
Vitex glabrata R. Br.	0.00	2.52	0.00	0.00	0.00	0.00	0.00	0.00	2.02	0.88	0.00	0.49
Dalbergia cochinchinensis Pierre	2.31	0.91	0.74	0.00	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.47
Pterospermum diversifolium Bl.	0.00	1.82	0.74	0.62	0.00	0.00	1.95	0.00	0.00	0.00	0.00	0.47
Diospyros gracilis Fletch.	0.76	0.00	0.00	0.00	0.81	0.00	3.50	0.00	0.00	0.00	0.00	0.46
Peltophorum dasyrachis Kurz	4.09	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45
Mangifera caloneura Kurz	0.00	0.00	0.00	0.62	4.05	0.00	0.00	0.00	0.00	0.00	0.00	0.42
Dehaasia candolleana Kosterm.	0.00	0.00	0.74	0.81	0.00	0.00	1.89	0.00	1.01	0.00	0.00	0.40
Phoebe lanceolata Nees	0.76	1.26	0.00	0.00	0.00	0.00	0.00	0.00	2.02	0.00	0.00	0.37
Unidentified 1	0.00	0.00	0.00	0.00	0.00	0.00	0.94	1.13	1.01	0.88	0.00	0.36
Memecylon scutellatum Naud.	0.00	0.00	2.21	0.62	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.36
Glycosmis pentaphylla Corr.	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	2.41	0.00	0.00	0.30
Phyllanthus emblica Linn.	0.00	0.00	0.00	1.62	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.27
Suregada multiflorum Baill.	0.00	0.00	0.74	0.00	0.00	0.00	0.00	2.25	0.00	0.00	0.00	0.27

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Afzelia xylocarpa Craib	0.76	0.00	0.00	0.00	0.00	0.00	2.22	0.00	0.00	0.00	0.00	0.27
Eurya acuminata DC.	0.00	0.00	0.00	0.00	0.00	0.95	0.00	0.00	2.02	0.00	0.00	0.27
Schleichera oleosa Merr.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.92	0.00	0.27
Dracaena loureiri Gagnep.	0.00	2.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
Miliusa mollis Pierre	1.02	0.00	0.00	1.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26
Diospyros dasyphylla Kurz	0.00	1.82	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.25
Lagerstroemia loudonii Teijsm. & Binn.	0.00	1.82	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.25
Bauhinia saccocalyx Pierre	0.00	2.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Vitex quinata Williams var. puberula Mold.	0.00	0.00	0.00	0.62	0.81	1.26	0.00	0.00	0.00	0.00	0.00	0.24
Chionanthus macrostigma Gagnep	0.00	0.00	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.23
Prismatomeris filamentosa Craib	0.00	2.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23
Diospyros pilosula Hiern	0.00	0.00	0.00	0.00	0.00	0.00	1.62	0.00	0.00	0.88	0.00	0.23
Garcinia speciosa Wall.	1.52	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Syzygium thorelii Gagnep.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.22
Pinanga hookeriana Becc.	0.00	0.00	0.00	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Dalbergia oliveri Gamble	0.76	0.00	0.00	0.62	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.21

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Lagerstroemia calyculata Kurz	2.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Polyalthia viridis Craib	0.00	0.00	0.74	0.62	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.20
Protium serratum Engl.	0.00	0.00	2.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20
Irvingia malayana Oliv. ex A. Benn.	0.00	0.00	0.00	0.62	0.00	1.57	0.00	0.00	0.00	0.00	0.00	0.20
Cratoxylum cochinchinense Bl.	0.00	1.26	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
Melientha suavis Pierre	0.00	0.00	0.00	0.00	0.00	0.00	1.95	0.00	0.00	0.00	0.00	0.18
Ficus sp.	0.00	0.00	0.00	1.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.18
Flacourtia rukam Zoll. & Mor.	0.00	0.00	0.00	1.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.18
Caryota mitis Lour.	0.00	0.91	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Mallotus paniculatus Muell. Arg.	0.00	0.91	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Parkia sumatrana Miq.	0.00	0.91	0.00	0.00	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.17
Diospyros kerrii Craib	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	1.01	0.00	0.00	0.17
Lagerstroemia duperreana Pierre	1.02	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Alstonia scholaris R. Br.	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Dipterocarpus turbinatus Gaertn. f.	0.00	1.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Bambusa sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79	0.00	0.00	0.16
Aphanamixis polystachya Parker	0.00	0.00	0.00	0.00	0.81	0.95	0.00	0.00	0.00	0.00	0.00	0.16

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Sapium baccatum Roxb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	0.00	0.00	0.00	0.15
Xylia xylocarpa Taub.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.46	0.00	0.13
Polyalthia asterilla Ridl.	0.00	0.00	0.00	0.62	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Garcinia cowa Roxb.	0.76	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Litsea glutinosa C.B. Robinson	0.76	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13
Ficus hispida Linn. f.	0.00	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Acrocarpus fraxinifolius Wight & Arn.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.09
Agrostistachys indica Dalzell	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.09
Photinia stenophylla Hand.-Mazz.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.09
Sapium discolor Muell. Arg.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.09
Adenanthera microsperma Teijsm. & Binn.	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.09
Diospyros castanea Fletch.	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.09
Ailanthus triphysa Alston	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
Celtis tetrandra Roxb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.08
Diospyros sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.08
Paranephelium longifoliolatum Lec.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.08

Appendix Table 4. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Sterculia guttata Roxb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.00	0.00	0.00	0.08
Toona ciliata M. Roem.	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Bridelia ovata Decne.	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Choerospondias axillaris Burtt & Hill	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Croton oblongifolius Roxb.	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Terminalia dafeuillana Pierre ex Laness.	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Dialium cochinchinense Pierre	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Diospyros pilosanthera Blanco	0.00	0.00	0.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Diospyros montana Roxb.	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Drypetes hoaensis Gagnep.	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Unidentified 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix Table 5. The importance value index of seedling species along various altitudes of Khao So area.

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Cleistanthus hirsutulus Hook. f.	30.23	16.96	20.94	25.02	19.98	54.33	12.65	33.12	38.24	36.92	61.11	31.77
Hopea ferrea Pierre	7.47	6.89	22.11	12.77	20.15	9.03	4.63	16.56	0.00	13.79	0.00	10.31
Murraya paniculata Jack	20.72	8.47	1.17	5.39	10.39	6.84	12.65	23.92	4.12	7.23	0.00	9.17
Polyalthia evecta Finet & Gagnep.	11.13	9.00	6.30	14.86	8.94	13.05	8.33	12.68	7.41	6.06	0.00	8.89
Streblus ilicifolius Corner	14.93	12.72	10.47	17.90	17.43	7.19	4.63	8.38	1.37	2.10	0.00	8.83
Syzygium cumini Druce	6.56	5.04	21.86	13.90	11.04	7.69	0.00	4.50	7.66	5.72	8.33	8.39
Walsura trichostemon Miq.	14.03	9.00	6.76	8.95	9.11	5.85	12.96	6.34	2.45	1.51	0.00	7.00
Memecylon ovatum J.E. Smith	8.24	5.29	1.17	12.16	14.39	6.70	1.54	10.02	1.91	4.20	8.33	6.72
Acalypha siamensis Oliv. ex Gage	11.13	7.68	7.67	10.51	9.59	9.66	5.86	6.85	1.37	3.62	0.00	6.72
Ixora cibdela Craib	4.57	4.50	2.79	3.56	5.28	10.50	17.90	5.83	11.78	5.72	0.00	6.59
Urobotrya siamensis Hiepko	2.44	1.32	7.47	10.60	7.66	10.86	5.86	3.99	12.07	6.31	0.00	6.23
Croton cascarilloides Raeusch.	3.67	0.00	8.38	10.95	20.19	3.17	4.63	2.66	1.37	6.90	0.00	5.63
Mischocarpus grandis Radlk.	0.00	1.32	1.17	0.00	0.00	4.02	2.16	1.84	11.78	5.72	25.00	4.82
Shorea henryana Pierre	0.00	0.00	3.50	0.00	0.00	1.83	3.09	2.66	9.62	10.60	16.67	4.36
Aglaia pirifera Hance	3.80	3.18	6.30	2.26	1.28	0.00	0.00	7.67	4.12	7.23	11.11	4.27
Cladogynos orientalis Zipp. Ex Span.	3.67	5.04	6.76	12.08	8.32	4.51	1.54	1.33	0.00	2.10	0.00	4.12
Memecylon caeruleum Jack	0.00	0.00	0.00	0.00	4.80	1.83	0.00	2.66	3.29	7.82	16.67	3.37

Appendix Table 5. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Memecylon scutellatum Naud.	0.00	0.00	6.30	1.13	0.00	1.34	0.00	0.00	0.00	0.00	25.00	3.07
Capparis micracantha DC.	1.22	2.64	2.34	6.52	2.55	5.85	6.79	5.32	0.00	0.00	0.00	3.02
Ardisia lenticellata Fletch.	2.44	0.00	0.00	0.00	0.00	5.85	4.32	0.00	9.82	4.54	0.00	2.45
Aphanamixis polystachya Parker	4.12	5.04	0.00	2.26	1.28	1.34	4.94	3.99	0.00	3.03	0.00	2.36
Hydnocarpus ilicifolius King	1.67	1.32	3.71	2.26	0.00	0.00	1.54	2.66	1.91	1.51	8.33	2.27
Diospyros ferrea Bakh.	4.12	1.32	2.79	1.13	6.07	3.17	1.54	4.50	0.00	0.00	0.00	2.24
Clausena excavata Burm. f.	3.67	6.89	3.96	0.00	0.00	2.68	5.86	0.00	0.00	1.51	0.00	2.23
Clausena harmandiana Pierre	5.48	7.15	3.25	0.00	0.00	1.83	2.16	1.84	0.00	2.10	0.00	2.16
Syzygium siamensis Craib	0.00	2.64	0.00	0.00	1.28	2.68	5.86	0.00	6.04	3.62	0.00	2.01
Sampantaea amentiflora Airy Shaw	0.00	9.28	1.17	0.00	1.28	0.00	8.33	0.00	0.00	0.00	0.00	1.82
Antiaris toxicaria Lesch.	0.00	0.00	1.17	0.00	0.00	0.00	1.54	0.00	10.16	6.06	0.00	1.72
Hopea odorata Roxb.	1.22	5.04	4.63	1.56	1.28	0.00	0.00	3.68	0.00	0.00	0.00	1.58
Lepisanthes rubiginosa Leenh.	0.00	0.00	2.79	1.13	0.00	1.34	0.00	6.65	1.37	3.62	0.00	1.54
Acalypha kerrii Craib	0.00	6.61	1.17	1.56	4.31	1.83	0.00	0.00	1.37	0.00	0.00	1.53
Mallotus peltatus Muell. Arg.	0.00	6.11	7.63	0.00	0.00	0.00	2.16	0.00	0.00	0.00	0.00	1.45
Mallotus philippensis Muell. Arg.	0.00	1.32	0.00	3.39	0.00	0.00	0.00	1.33	5.50	3.62	0.00	1.38
Leucaena leucocephala de Wit	10.90	2.39	0.00	0.00	0.00	0.00	0.00	1.84	0.00	0.00	0.00	1.38

Appendix Table 5. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Unidentified 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.45	1.51	11.11	1.37
Tarenna collinsae Craib	1.67	0.00	2.34	1.13	1.28	0.00	4.94	0.00	1.37	1.51	0.00	1.29
Siphonodon celastrineus Griff.	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	3.03	8.33	1.17
Drypetes hainanensis Merr.	2.44	0.00	0.00	2.69	1.28	0.00	6.17	0.00	0.00	0.00	0.00	1.14
Mammea siamensis Kosterm.	2.44	0.00	2.34	0.00	1.28	0.00	3.09	1.84	0.00	1.51	0.00	1.14
Unidentified 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.75	9.34	0.00	1.10
Eurycoma longifolia Jack	0.00	2.64	0.00	0.00	0.00	1.83	3.09	1.33	1.37	1.51	0.00	1.07
Knema furfuracea Warb.	0.00	1.32	0.00	0.00	0.00	3.67	0.00	0.00	6.58	0.00	0.00	1.05
Diospyros gracilis Fletch.	1.22	1.86	2.34	0.00	1.28	0.00	3.09	0.00	0.00	0.00	0.00	0.89
Sapium discolor Muell. Arg.	0.00	0.00	0.00	0.00	0.00	2.82	0.00	2.35	3.83	0.00	0.00	0.82
Phoebe paniculata Nees	0.00	1.86	0.00	0.00	0.00	0.00	0.00	0.00	1.37	5.13	0.00	0.76
Vitex glabrata R. Br.	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	4.12	1.51	0.00	0.65
Melodorum fruticosum Lour.	0.00	2.64	0.00	0.00	0.00	2.68	0.00	1.84	0.00	0.00	0.00	0.65
Diospyros variegata Kurz	0.00	2.64	0.00	0.00	0.00	0.00	4.01	0.00	0.00	0.00	0.00	0.61
Dialium cochinchinense Pierre	0.00	3.18	0.00	0.00	0.00	0.00	3.40	0.00	0.00	0.00	0.00	0.60
Miliusa mollis Pierre	1.22	0.00	1.17	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
Dipterocarpus turbinatus Gaertn. f.	0.00	6.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
Chionanthus microstigma Gagnep	0.00	0.00	0.00	0.00	0.00	0.00	5.86	0.00	0.00	0.00	0.00	0.53

Appendix Table 5. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Microcos tomentosa Linn.	0.00	0.00	1.63	0.00	0.00	0.00	0.00	1.33	1.37	1.51	0.00	0.53
Acronychia pedunculata Miq.	0.00	0.00	0.00	0.00	0.00	1.34	0.00	0.00	2.75	1.51	0.00	0.51
Diospyros dasyphylla Kurz	2.90	0.00	1.17	0.00	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.49
Chionanthus macrostigma Gagnep	3.67	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.47
Glycosmis pentaphylla Corr.	1.22	1.32	0.00	0.00	0.00	0.00	0.00	2.66	0.00	0.00	0.00	0.47
Paranephelium longifoliolatum Lec.	0.00	3.18	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.43
Manilkara hexandra Dubard	0.00	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41
Polyalthia viridis Craib	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	3.29	0.00	0.00	0.40
Caesalpinia sappan Linn.	0.00	0.00	0.00	0.00	0.00	0.00	4.32	0.00	0.00	0.00	0.00	0.39
Dalbergia oliveri Gamble	1.22	0.00	0.00	0.00	0.00	0.00	3.09	0.00	0.00	0.00	0.00	0.39
Caryota mitis Lour.	0.00	0.00	0.00	4.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39
Atalantia monophylla Correa	0.00	1.32	0.00	0.00	0.00	0.00	1.54	0.00	1.37	0.00	0.00	0.39
Pterospermum diversifolium Bl.	0.00	1.32	0.00	0.00	0.00	2.68	0.00	0.00	0.00	0.00	0.00	0.36
Flacourtia rukam Zoll. & Mor.	0.00	0.00	1.17	0.00	1.28	0.00	0.00	1.33	0.00	0.00	0.00	0.34
Suregada multiflorum Baill.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.62	0.00	0.33
Bambusa sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	2.10	0.00	0.32
Sumbaviopsis albicans J.J. Smith	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.91	1.51	0.00	0.31
Peltophorum dasyrachis Kurz	3.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30

Appendix Table 5. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Prismatomeris filamentosa Craib	0.00	3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
Markhamia stipulata Seem.	0.00	0.00	1.17	0.00	0.00	0.00	0.00	1.84	0.00	0.00	0.00	0.27
Streblus asper Lour.	0.00	0.00	0.00	0.00	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Pterospermum acerifolium Willd.	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.23
Ailanthus triphysa Alston	0.00	0.00	0.00	1.13	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.22
Acrocarpus fraxinifolius Wight & Arn.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.45	0.00	0.00	0.22
Dracaena loureiri Gagnep.	0.00	2.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22
Millettia leucantha Kurz	0.00	0.00	2.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Bauhinia saccocalyx Pierre	0.00	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Garuga pinnata Roxb.	0.00	1.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Croton longissimus Airy Shaw	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Ixora sp.	0.00	0.00	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
Aglaia chaudocensis Pierre	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14
Bauhinia viridescens Desv.	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.14
Dehaasia candolleana Kosterm.	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.14
Diospyros bejaudii Lec.	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.14
Diospyros pilosanthera Blanco	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.14
Phoebe lanceolata Nees	0.00	0.00	0.00	0.00	0.00	0.00	1.54	0.00	0.00	0.00	0.00	0.14

Appendix Table 5. (Continued).

Scientific name	Altitude (meters)											Average
	400	440	480	520	560	600	640	680	720	760	800	
Artocarpus lakoocha Roxb.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	0.14
Cinnamomum iners Bl.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.12
Eurya acuminata DC.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.12
Ficus hispida Linn. f.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.12
Vitex peduncularis Wall. ex Schauer	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.12
Croton oblongifolius Roxb.	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Diospyros mollis Griff.	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Diospyros pilosula Hiern	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Ficus sp.	0.00	0.00	0.00	0.00	1.28	0.00	0.00	0.00	0.00	0.00	0.00	0.12
Polyalthia cerasoides Benth. ex Bedd.	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Baccaurea ramiflora Lour.	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Ixora grandifolia Zoll. & Morton	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Mammea harmandii Kosterm.	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Melia azedarach Linn.	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Pterocarpus macrocarpus Kurz	0.00	0.00	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Phyllanthus emblica Linn.	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Sterculia guttata Roxb.	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10

Appendix Table 6. Two-way ordered table by TWINSPAN analysis for trees.

Species no.	Species name	Stand no. 12342333 3 123113 23 121231112 12223 / 815411379753990386588194254202606476371	Dichotomous key for species
7	*Carallia brachiata*	-3-------------------------------------	000000
55	*Pterospermum diversifolium*	11-------------2-----------------------	000000
60	*Melia azedarach*	64-------------------------------------	000000
63	*Ficus hispida*	33-------------------------------------	000000
74	*Artocarpus lakoocha*	-3-----------1-1-----------------------	000000
84	*Wrightia tomentosa*	-3-------------------------------------	000000
111	*Pterocarpus macrocarpus*	-1-------------------------------------	000000
146	*Caryota mitis*	4--------------2-----------------------	000000
28	*Markhamia stipulata*	-2-------1-----------------------------	000001
73	*Baccaurea ramiflora*	13-21-------1-2------------------------	000001
96	*Garcinia speciosa*	2---------11---------------------------	000001
3	*Garcinia cowa*	----------------1----------------------	000010
6	*Dracaena loureiri*	-----------1---------------------------	000010
10	*Capparis micracantha*	-------------1-------------------------	000010
21	*Celtis timorensis*	---------------1-----------------------	000010
29	*Stereospermum neuranthum*	----------------1----------------------	000010
37	*Celtis tetrandra*	--------------22-----------------------	000010
43	*Polyalthia lateriflora*	-----------1---------------------------	000010
52	*Aquilaria crassna*	--2---------21-------------------------	000010
70	*Mitrephora vandiflora*	----------------1----------------------	000010
79	*Mangifera caloneura*	-----------3412643--1------1-----------	000010
82	*Ailanthus triphysa*	1-----1----2-2-------------------------	000010
85	*Memecylon scutellatum*	------------1--------------------------	000010
86	*Aporusa villosa*	-----------1---------------------------	000010
108	*Pterocymbium javanicum*	------------2--1-----------------------	000010
141	*Aphanamixis polystachya*	--33-1---1---1333--1-------------------	000010
159	*Antiaris toxicaria*	-----------1----1----------------------	000010
12	*Clausena excavata*	---1------1----1-----------------------	000011
49	*Anisoptera costata*	2-4---------3--------------------------	000011
91	*Prunus ceylanica*	---2-----------11----------------------	000011
135	*Sapium discolor*	------1--21--4-------------------------	000011
40	*Nephelium hypoleucum*	----1-1-1-----1--3---------------------	000100
142	*Prunus arborea*	------13-213----1----------------------	000100
157	*Dipterocarpus turbinatus*	---------4-2---------------------------	000100
8	*Cinnamomum iners*	----21---------------------------------	000101
19	*Acronychia pedunculata*	---144444331-4------------1-2----------	000101
24	*Ternstroemia gymnanthera*	-----1---------------------------------	000101

```
000000000000000000111111111111111111111
001111111111111111000000000000000000111
  0000000001111111000000000011111111
  0011111110000111000111111100000111
    0000011          000011100001
    01111
```

Dichotomous key for stands

Appendix Table 6. (Continued).

Species no.	Species name	Stand no. 12342333 3 123113 23 121231112 12223 815411379753990386588194254202606476371	Dichotomous key for species
30	*Vitex glabrata*	--31-112-1-----------------------------	000101
44	*Lithocarpus fenestratus*	----14133----------------------1-------	000101
45	*Quercus ramsbottomii*	-----2-3133----------------------------	000101
54	*Phoebe lanceolata*	--2--2---23-1------------1-------------	000101
61	*Knema furfuracea*	2-4434-4-34---2------------------------	000101
80	*Choerospondias axillaris*	---1433233-----------------------------	000101
90	*Prunus grisea*	----22---------------------------------	000101
99	*Memecylon cyaneum*	---1-1---------------------------------	000101
102	*Sapium baccatum*	-----23---1----------------------------	000101
105	*Eurya acuminata*	-----2----2----1-----------------------	000101
106	*Croton cascarilloides*	------1--------------------------------	000101
107	*Sterculia guttata*	---------1-----------------------------	000101
113	*Ardisia littoralis*	----1----------------------------------	000101
115	*Acrocarpus fraxinifolius*	----------1----------------------------	000101
119	*Mallotus peltatus*	------11-------------------------------	000101
136	*Hopea odorata*	----1----------------------------------	000101
138	*Schleichera oleosa*	--2------------------------------------	000101
139	*Ardisia lenticellata*	-------1-------------------------------	000101
147	*Bridelia retusa*	--1------------------------------------	000101
150	*Sumbaviopsis albicans*	--21-1--11-----------------------------	000101
156	*Syzygium thorelii*	----------1----------------------------	000101
161	*Dipterocarpus costatus*	---------4-----------------------------	000101
15	*Neolitsea zeylanica*	2----1----2----------------------------	000110
128	*Mallotus paniculatus*	4133221123-----11----------------------	000110
130	*Clausena harmandiana*	1--------1-----------------------------	000110
153	*Unidentified 3*	1---2---1-2----------------------------	000110
114	*Phoebe paniculata*	3--1423213-1311--3------------------3--	000111
11	*Syzygium siamensis*	--54441214443-144---3--12------------2-	00100
38	*Shorea henryana*	32-41444334344311-111-43------------3-2	001010
92	*Mischocarpus grandis*	-4-323334-2-231-1--3—-2--31-----------3	001010
95	*Urobotrya siamensis*	---2---1--3----2--------------1----1---	001010
51	*Ficus altissima*	-------3--------------------1----------	001011
162	*Toona ciliata*	----32113-----2------21----------------	001011
18	*Vitex peduncularis*	----3--1---1-----3----------------2----	00110
62	*Parkia sumatrana*	---3---1-242433-1-132-1---1------------	00110
72	*Siphonodon celastrineus*	--------11112-22----2--1---------------	00110
158	*Polyalthia asterilla*	------------1---2-----------------1----	00110
		000000000000000000111111111111111111111	
		001111111111111111000000000000000000111	
		00000000011111110000000000011111111	
		00111111100001110001111111100000111	
		0000011 000011100001	
		01111	
		Dichotomous key for stands	

Appendix Table 6. (Continued).

Species no.	Species name	Stand no. 12342333 3 123113 23 121231112 12223 815411379753990386588194254202606476371	Dichotomous key for species
75	*Mallotus philippensis*	33---------1--11-212-------------------	00111
100	*Memecylon caeruleum*	--3-2212113-1--------22-----122--------	0100
129	*Tetrameles nudiflora*	-----------4----------------2----------	0100
151	*Unidentified 1*	2-2-22-22--1------21-2--1-1------------	0100
83	*Litsea glutinosa*	----1------------------------1---------	0101
152	*Unidentified 2*	----31------------------------2---1---2	0101
33	*Acalypha kerrii*	-11------1-2-------2----------------1--	0110
42	*Millettia leucantha*	24----------------1----2---------------	0110
50	*Irvingia malayana*	-4----11--2---3-------33---------------	0110
68	*Adenanthera pavonina*	-----------23--1---------3--------1----	0110
59	*Paranephelium longifoliolatum*	-1------------13-3---22-------------13-	0111
94	*Bambusa sp.*	------4-2-------66------------------666	0111
41	*Streblus ilicifolius*	--2------1-413-21---342-3121---1----2--	10000
9	*Dalbergia oliveri*	-3----------------------2-------------2	100010
58	*Melodorum fruticosum*	-1-1-----------12--11-2-111---------2--	100011
89	*Polyalthia evecta*	2----1--2------132-3-21211-11-------2--	100011
116	*Ficus sp.*	1------------1-12------4---3-----------	100011
160	*Polyalthia viridis*	1-------------1--3-21-1--1----------1--	100011
98	*Microcos tomentosa*	-3---111---122-------111-32-1-----1----	100100
13	*Neolitsea casiaefolia*	----1---1---------11-------1-----------	100101
23	*Cleistanthus hirsutulus*	--21-1223-22--2--22341-112-21------11--	100101
25	*Pterospermum acerifolium*	-2--2-11-3--1------22-112--------------	100101
32	*Aglaia pirifera*	----21122233423122441334-323--------2-2	100101
112	*Aglaia chaudocensis*	--1--1-------1------3-1----------------	100101
132	*Lagerstroemia calyculata*	----------------1------------------1---	100101
57	*Diospyros ferrea*	--23-1-31--------------23---122-------2	10011
140	*Vitex quinata*	--------21-----2--------2------2-1--1--	10011
26	*Walsura trichostemon*	3-21-23323342-442-43-4424243434444443-4	1010
46	*Hydnocarpus ilicifolius*	3122212222233363334444443434333433233-3	1010
22	*Murraya paniculata*	--2-----------1---1--------3-----1-----	1011
101	*Memecylon ovatum*	1-4231-2--343423324123236446444433622--	1011
154	*Syzygium cumini*	-412134-4333-41---2-11334444444642422--	1011
5	*Diospyros dasyphylla*	-----------1------2--------1-----------	110000
31	*Suregada multiflorum*	--------1------1--1-----3-11-----------	110000
93	*Dalbergia cochinchinensis*	--------1----------------13------------	110000
125	*Dehaasia candolleana*	------------1---1---3-21-211--------1--	110000
16	*Polyalthia cerasoides*	----------------2----11-2-----------1--	110001
		000000000000000000111111111111111111111	
		001111111111111111000000000000000000111	
		0000000001111111000000000011111111	
		0011111110000111000111111100000111	
		0000011 000011100001	
		01111	
		Dichotomous key for stands	

Appendix Table 6. (Continued).

Species no.	Species name	Stand no.	Dichotomous key for species
		12342333 3 123113 23 121231112 12223	
		815411379753990386588194254202606476371	
144	*Diospyros malabarica*	---1----1-----131--11121-2143----31-22-	110001
35	*Ixora cibdela*	---1-------------------------1----1----	11001
104	*Eurycoma longifolia*	--1----------------------------------2-	11001
118	*Lagerstroemia loudonii*	-1------------------------------3----2-	11001
134	*Hopea ferrea*	--14--------466-2-666666666366666646324	11001
2	*Acalypha siamensis*	--------------------3---------------1--	1101
97	*Diospyros variegata*	3-----------------331111-331-23-----2--	1101
123	*Mammea harmandii*	-1-----------------1--3------2----1-1--	1101
14	*Guioa pleuropteris*	---------------------2-----------------	111000
137	*Flacourtia rukam*	----------------------1-1--------------	111000
67	*Adenanthera microsperma*	------------------3-3--2--1------------	111001
69	*Diospyros kerrii*	-------------------2-------2-----------	111001
78	*Antidesma bunius*	--------------------1------------------	111001
124	*Elaeocarpus robustus*	--------------------1------------------	111001
39	*Dialium cochinchinense*	--------1----1----1-1-33--2--33---2----	11101
77	*Canarium subulatum*	---------------------1-------1---------	11101
122	*Mammea siamensis*	------------------12121------1-1-1-----	11101
20	*Diospyros gracilis*	---------------------1--2------2211----	11110
66	*Phyllanthus emblica*	-----------1---------2--1-----2-------2	11110
121	*Sterculia foetida*	-------------------------------------2-	11110
133	*Lagerstroemia duperreana*	----------------------2-144-113-4212-3-	11110
131	*Drypetes hainanensis*	------------1--------21-------1--213---	111110
1	*Peltophorum dasyrachis*	-----------------------------1-1-------	111111
4	*Maerua siamensis*	-----1--------------------------6--1---	111111
17	*Diospyros pilosanthera*	----------------------------------2----	111111
27	*Manilkara hexandra*	----------------------------------32---	111111
34	*Tarenna collinsae*	----------------------------------1----	111111
47	*Chionanthus microstigma*	----------------------------------14---	111111
48	*Leucaena leucocephala*	-------------------1------------26-----	111111
53	*Haldina cordifolia*	----------------------------1----------	111111
56	*Diospyros coaetanea*	----------------------------------1----	111111
64	*Lepisanthes tetraphylla*	---------------------------------4-----	111111
71	*Madhuca pierrei*	----------------------------------2----	111111
76	*Spondias pinnata*	------------------------------1--------	111111
81	*Atalantia monophylla*	---------------------------------123---	111111
87	*Randia dasycarpa*	----------------------------------1----	111111
88	*Bombax ceiba*	----------------------------------1----	111111

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000000000000000000111111111111111111111
001111111111111111000000000000000000111
  0000000001111111000000000011111111
  0011111110000111000111111100000111
    0000011          000011100001
    01111
```

Dichotomous key for stands

Appendix Table 6. (Continued).

Species no.	Species name	Stand no. 12342333 3 123113 23 121231112 12223 815411379753990386588194254202606476371	Dichotomous key for species
103	*Zizyphus mauritiana*	-----------------------------------1---	111111
109	*Colona auriculata*	-----------------------------------1---	111111
110	*Chionanthus macrostigma*	-----------------------------------4---	111111
117	*Cananga latifolia*	---------------------------------21----	111111
120	*Sampantaea amentiflora*	-------------------------2--13-1--12---	111111
126	*Bauhinia viridescens*	------------------1---------4----3-----	111111
127	*Bauhinia saccocalyx*	-----------------------------------3---	111111
143	*Diospyros castanea*	-----------------------------2---------	111111
145	*Diospyros montana*	-----------------------------11--------	111111
148	*Drypetes hoaensis*	------------------------------1--2-2---	111111
149	*Cratoxylum cochinchinense*	-----------------------------1--3------	111111
155	*Syzygium fruticosa*	------------------------------1--------	111111

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000000000000000000111111111111111111111
001111111111111111000000000000000000111
  00000000011111110000000000011111111
  00111111100001110001111111100000111
    0000011          000011100001
    01111
```

Dichotomous key for stands

Appendix Table 7. Two-way ordered table by TWINSPAN analysis for saplings.

Species no.	Species name	Stand no.
		`3 2  1111122  12223 1233 112322333 34 3`
		`166450256702194349229808338735147975186`
			Dichotomous key for species

38	*Hydnocarpus ilicifolius*	---111-11111233-311---332---2------1---	0000
79	*Memecylon ovatum*	-13333423334232-23232-33111--223--21-2-	0000
120	*Syzygium cumini*	-31324443442333-4331-1113---21----234--	0000
2	*Acalypha siamensis*	-2-442-421-43113-13--4---124-----------	000100
10	*Capparis micracantha*	4-123-313332312433321111-212-----------	000100
62	*Atalantia monophylla*	-21---1--1--------------1--------------	000100
27	*Suregada multiflorum*	3--------------------------------------	000101
44	*Diospyros ferrea*	4-1-1-21-2--1-1----11---1--------------	000101
50	*Lepisanthes rubiginosa*	2---1--------------1-------------------	000101
52	*Phyllanthus emblica*	3-------2------------------------------	000101
1	*Peltophorum dasyrachis*	-1-----------------3-------------------	000110
5	*Dracaena loureiri*	-3-------------------------------------	000110
14	*Diospyros pilosula*	--1------------------------------------	000110
20	*Diospyros gracilis*	--21-----1-----------------------------	000110
39	*Chionanthus microstigma*	--3------------------------------------	000110
40	*Leucaena leucocephala*	-3-3-----------------------------------	000110
72	*Melientha suavis*	--2------------------------------------	000110
81	*Prismatomeris filamentosa*	-3-------------------------------------	000110
87	*Chionanthus macrostigma*	--2------------------------------------	000110
94	*Sampantaea amentiflora*	-432-321-22----------------------------	000110
97	*Bauhinia saccocalyx*	-3-------------------------------------	000110
104	*Hopea ferrea*	-3243641454423446432-144-----1---------	000110
107	*Flacourtia rukam*	--1----1-------------------------------	000110
111	*Diospyros castanea*	--1------------------------------------	000110
117	*Cratoxylum cochinchinense*	-2----1--------------------------------	000110
6	*Cladogynos orientalis*	-1---3-411-121----1-------1------------	000111
17	*Diospyros pilosanthera*	------1--------------------------------	000111
30	*Tarenna collinsae*	-----12-1---2--------------------------	000111
41	*Irvingia malayana*	--------------1-1----------------------	000111
45	*Melodorum fruticosum*	------12-----3-2---2-------------------	000111
61	*Choerospondias axillaris*	-------------------1-------------------	000111
64	*Litsea glutinosa*	--------1---1--------------------------	000111

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000000000000000000000000000011111111111
000000000000000000001111111100000000011
0111111111111111111100000001000000111
  00111111111111111110000111 011111
    00000000000000001         01111
    0000000001111111
```

Dichotomous key for stands

Appendix Table 7. (Continued).

Species no.	Species name	Stand no.	Dichotomous key for species
		`3 2  1111122  12223 1233 112322333 34 3` `166450256702194349229808338735147975186`	
65	*Memecylon scutellatum*	`---------1---31------------------------`	000111
70	*Dalbergia cochinchinensis*	`----1-----------1--3-------------------`	000111
75	*Diospyros variegata*	`--1-2---2---1-----1--------------------`	000111
76	*Diospyros sp.*	`------------------1--------------------`	000111
80	*Sapium baccatum*	`-----------------1---------------------`	000111
85	*Croton cascarilloides*	`------1-21--11-----------1-------------`	000111
101	*Lagerstroemia calyculata*	`-------------------1-------------------`	000111
102	*Lagerstroemia duperreana*	`-------------------3-------------------`	000111
103	*Terminalia dafeuillana*	`---------1---------1-------------------`	000111
105	*Hopea odorata*	`----2-1--4--2-----31-------------------`	000111
109	*Vitex quinata*	`--------1-1----2-----------------------`	000111
113	*Diospyros montana*	`--------1------------------------------`	000111
115	*Drypetes hoaensis*	`--------1------------------------------`	000111
125	*Polyalthia viridis*	`--------------1------------------------`	000111
16	*Polyalthia cerasoides*	`------2-----------2-12-----------------`	00100
95	*Mammea siamensis*	`----1-----2--2----1--211---------------`	00100
9	*Dalbergia oliveri*	`-------1-----------1-------2-----------`	00101
92	*Lagerstroemia loudonii*	`-2-------------------------2-----------`	00101
112	*Diospyros malabarica*	`-2-----1----12321-3-14112113---------1-`	00101
51	*Afzelia xylocarpa*	`---1-----------------1-----3-----------`	00110
53	*Adenanthera microsperma*	`---------------------------2-----------`	00110
91	*Ficus sp.*	`-------------------------1-2-----------`	00110
32	*Celtis tetrandra*	`----------------------11---------------`	001110
46	*Paranephelium longifoliolatum*	`----------------------11---------------`	001110
86	*Sterculia guttata*	`----------------------11---------------`	001110
100	*Drypetes hainanensis*	`--1----------1--------11-11------------`	001110
123	*Polyalthia asterilla*	`--------------------1----1-------------`	001110
3	*Garcinia cowa*	`------------------------11-------------`	001111
8	*Miliusa mollis*	`------------------------12-------------`	001111
57	*Pinanga hookeriana*	`-------------------------3-------------`	001111
58	*Bridelia ovata*	`------------------------1--------------`	001111
60	*Mangifera caloneura*	`-------------------------13------------`	001111
84	*Croton oblongifolius*	`------------------------1--------------`	001111

```
000000000000000000000000000011111111111
000000000000000000001111111100000000011
0111111111111111111100000000100000111
  00111111111111111110000111 011111
    00000000000000001         01111
    0000000001111111
```

Dichotomous key for stands

Appendix Table 7. (Continued).

Species no.	Species name	Stand no.	Dichotomous key for species
		3 2 1111122 12223 1233 112322333 34 3	
		166450256702194349229808338735147975186	
126	*Toona ciliata*	-------------------------1------------	001111
15	*Clausena excavata*	-3-1-1-1-----------2--------------11---	01000
4	*Diospyros dasyphylla*	----2----------------------1---------	01001
22	*Cleistanthus hirsutulus*	6333332431333444244443223234446454434-4	01001
73	*Urobotrya siamensis*	--21-1113-1321123----333111-432-321----	01001
77	*Microcos tomentosa*	---------1-------2-1-------21------1---	01001
21	*Murraya paniculata*	22333------13-12-24-4333313--32-231-21-	0101
36	*Streblus ilicifolius*	-----3131-3-4223331-4-33434--31---11-4-	0101
96	*Dehaasia candolleana*	-------1-----1-------1-----2---1-------	0101
24	*Walsura trichostemon*	-2443223444422122-1-3-22443-3212--1--3-	011
66	*Polyalthia evecta*	2-4322233--243433-233444--3-1--2--212--	011
28	*Aglaia pirifera*	----4-3-----333--22-44333-2--12-22-132-	100
88	*Aglaia chaudocensis*	--2-----------------2---11---2---------	100
31	*Ixora cibdela*	-21-1-1--1—-2-222--1--33122313-1222-2-3	1010
29	*Acalypha kerrii*	--1----------------12---33--1-------33	1011
43	*Pterospermum diversifolium*	------------------------1-3---------2-	1011
74	*Garcinia speciosa*	-----------------------2------------1-	1011
114	*Caryota mitis*	------------------------1-----------1-	1011
23	*Pterospermum acerifolium*	------1------11----2------------------4	110
25	*Markhamia stipulata*	3--------------2----------------------3	110
54	*Diospyros kerrii*	------------------1------------1-------	110
99	*Clausena harmandiana*	----------2------1---1------2-----1----	110
69	*Mischocarpus grandis*	---------------2-3-------1243-33342242-	11100
78	*Memecylon caeruleum*	-1------1----1--1-----11-13-11221-112--	11100
11	*Syzygium siamensis*	--------------1-----3-22444-24343644---	11101
110	*Aphanamixis polystachya*	--------------------------1---1--------	11101
121	*Syzygium thorelii*	------------------------1---------2---	11101
7	*Cinnamomum iners*	----------------------------1-22111----	111100
12	*Xylia xylocarpa*	---------------------------------2-----	111100
18	*Vitex peduncularis*	-1-------------------------------3------	111100
19	*Acronychia pedunculata*	----------------------------2-32443---3	111100
33	*Shorea henryana*	-----------------4---2--1-2-432323112--	111100
35	*Glycosmis pentaphylla*	----------------------------2-----1----	111100
		000000000000000000000000000001111111111	
		0000000000000000000001111111100000000011	
		011111111111111111111000000001000000111	
		00111111111111111111110000111 011111	
		00000000000000001 01111	
		0000000001111111	
		Dichotomous key for stands	

Appendix Table 7. (Continued).

Species no.	Species name	Stand no.
		`3 2  1111122  12223 1233 112322333 34 3`
		`166450256702194349229808338735147975186`
			Dichotomous key for species

48	*Parkia sumatrana*	`------------------------------1---1----`	111100
89	*Phoebe paniculata*	`----------------------------1-1411122--`	111100
108	*Ardisia lenticellata*	`-------------------3---------3141-13---`	111100
118	*Sumbaviopsis albicans*	`-----------------------------112111----`	111100
119	*Unidentified 1*	`2---------------------------11--1------`	111100
26	*Vitex glabrata*	`-------------------------------1-121---`	111101
34	*Livistona speciosa*	`------------------------------1-1--4---`	111101
37	*Rinorea lanceolata*	`------------------------------------4--`	111101
42	*Phoebe lanceolata*	`------------------------1---1-----11---`	111101
47	*Knema furfuracea*	`-------------------------2----22--1-3--`	111101
55	*Siphonodon celastrineus*	`--------------------1---------1---122--`	111101
67	*Prunus ceylanica*	`-------------------------1--2-------2--`	111101
68	*Photinia stenophylla*	`-----------------------------------1---`	111101
82	*Eurycoma longifolia*	`------------------------------1----2---`	111101
83	*Eurya acuminata*	`------------------------------1----2---`	111101
90	*Acrocarpus fraxinifolius*	`-----------------------------------1---`	111101
122	*Dipterocarpus turbinatus*	`----------------------------------2----`	111101
124	*Antiaris toxicaria*	`------------------------------------21-`	111101
13	*Agrostistachys indica*	`--------------------------------------3`	111110
49	*Ficus hispida*	`-------------------------------------2-`	111110
56	*Baccaurea ramiflora*	`-----------------------------------1-3-`	111110
59	*Mallotus philippensis*	`2------------------------2-----------46`	111110
63	*Ailanthus triphysa*	`-------------------------------------1-`	111110
71	*Bambusa sp.*	`--------------------------------------3`	111110
98	*Mallotus paniculatus*	`-------------------------------------1-`	111110
106	*Sapium discolor*	`--------------------------------------3`	111110
116	*Alstonia scholaris*	`----------------------------------1--1-`	111110
93	*Mallotus peltatus*	`----------------------11-----2-------3-`	111111

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000000000000000000000000000011111111111
000000000000000000001111111100000000011
0111111111111111111100000000100000111
  00111111111111111110000111 011111
    00000000000000001         01111
    0000000001111111
```

Dichotomous key for stands

Appendix Table 8. Two-way ordered table by TWINSPAN analysis for seedlings.

Species no.	Species name	Stand no.	Dichotomous key for species
		` 2 1121121112   11323 223 23 2323333441` `664383050267213949048589227175514739011`	
4	*Dracaena loureiri*	2--------------------------------------	000000
11	*Caesalpinia sappan*	-3-------------------------------------	000000
14	*Diospyros bejaudii*	-1-------------------------------------	000000
16	*Diospyros pilosanthera*	-1-------------------------------------	000000
23	*Manilkara hexandra*	3--------------------------------------	000000
40	*Chionanthus microstigma*	-3-------------------------------------	000000
52	*Diospyros mollis*	1--------------------------------------	000000
57	*Atalantia monophylla*	11-------------------------------------	000000
68	*Prismatomeris filamentosa*	2--------------------------------------	000000
81	*Sampantaea amentiflora*	43----1----1--------------2------------	000000
86	*Bauhinia saccocalyx*	2--------------------------------------	000000
93	*Garuga pinnata*	2--------------------------------------	000000
18	*Diospyros gracilis*	221---1-11-----------------------------	000001
41	*Leucaena leucocephala*	2-4------------------------3-----------	00001
92	*Flacourtia rukam*	----2----------1--------1--------------	000100
95	*Aphanamixis polystachya*	3-3-22-2----------3-3-4----------------	000100
1	*Peltophorum dasyrachis*	-------------------------3-------------	000101
2	*Acalypha siamensis*	2-424434321-21112---33321334---2-------	000101
8	*Dalbergia oliveri*	-------------------------23------------	000101
9	*Capparis micracantha*	-1---4--113111-12----23-2-33-----------	000101
34	*Dialium cochinchinense*	---------------------33----------------	000101
44	*Diospyros ferrea*	------1--2-32-1-23---1---324-----------	000101
45	*Melodorum fruticosum*	-----3---------------2--2--------------	000101
64	*Diospyros variegata*	---------------------23----------------	000101
84	*Dehaasia candolleana*	--------------------------2------------	000101
85	*Bauhinia viridescens*	----------------------2----------------	000101
91	*Hopea odorata*	---------311-1-------3--3--------------	000101
3	*Diospyros dasyphylla*	------1-------3---------1--------------	000110
58	*Ailanthus triphysa*	----------------2------1---------------	000110
89	*Hopea ferrea*	-24---42433431-44-3464234--------------	000110
12	*Diospyros pilosula*	-----------1---------------------------	000111
15	*Polyalthia cerasoides*	-------------1-------------------------	000111
21	*Pterospermum acerifolium*	---------------1-----------------------	000111
29	*Ixora sp.*	---------2-----------------------------	000111
32	*Ixora grandifolia*	------1--------------------------------	000111
36	*Streblus asper*	----3----------------------------------	000111
43	*Pterospermum diversifolium*	-------------------3-------------------	000111

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		Dichotomous key for stands	

Appendix Table 8. (Continued).

Species no.	Species name	Stand no. 2 1121121112 11323 223 23 2323333441 664383050267213949048589227175514739011	Dichotomous key for species
51	*Phyllanthus emblica*	----------1----------------------------	000111
72	*Croton longissimus*	--------2------------------------------	000111
73	*Sterculia guttata*	-------1-------------------------------	000111
76	*Aglaia chaudocensis*	---2-----------------------------------	000111
79	*Ficus sp.*	----2----------------------------------	000111
96	*Caryota mitis*	---4-----------------------------------	000111
103	*Unidentified 2*	-------1-------------------------------	000111
5	*Cladogynos orientalis*	3-1---24323232-1-3--2-2-1-------------2	0010
37	*Streblus ilicifolius*	--1444343---2443444-21-1-----42-------3	0010
71	*Croton cascarilloides*	-3-442---44423----2-4-------------1----	0010
74	*Chionanthus macrostigma*	-1-----------3-------------------------	0010
22	*Walsura trichostemon*	244222333322324---2--2--2--333----21---	0011
82	*Mammea siamensis*	-1---------1---1--2-2-2--3------------2	0011
19	*Murraya paniculata*	-14-4211----144-444324434--3-4--33-2---	010
30	*Tarenna collinsae*	-3-----1-2-1-2------------------1--1---	010
67	*Memecylon ovatum*	--32---23-444211221--2-4-22-2-2----3-2-	010
88	*Drypetes hainanensis*	-3-2---------11-22-----------2---------	010
24	*Markhamia stipulata*	---------------------------3----------2	0110
60	*Polyalthia evecta*	-3222211123122334434232333--4-32321-4--	0110
87	*Clausena harmandiana*	-2-----------------221-2-4------------3	0110
90	*Sapium discolor*	-----3---------------------3----3------	0110
59	*Memecylon scutellatum*	----------1----4---2-----------------4-	01110
63	*Urobotrya siamensis*	-3-32-11333122-22223----1-2----3144---2	01110
65	*Microcos tomentosa*	---------2-------------1-----------1---	01110
7	*Miliusa mollis*	---2---2------1-----------------------2	01111
28	*Acalypha kerrii*	---232--------------------------------2	01111
100	*Antiaris toxicaria*	3-1--244143423142-23---2----2-42-42--2-	01111
20	*Cleistanthus hirsutulus*	2---34444243634433152334464443664466462	100
27	*Aglaia pirifera*	---------1----33323-42-2----2-2-1-11-32	100
39	*Hydnocarpus ilicifolius*	-------------2-23-1--121----------21-22	100
31	*Ixora cibdela*	23---55---13332-3232-141--3-24433213--2	101
35	*Glycosmis pentaphylla*	--------------1--------2----2----------	101
26	*Suregada multiflorum*	--------------------2--------------2---	11000
66	*Memecylon caeruleum*	--------2--------32------------2-323-3-	11000
25	*Vitex glabrata*	--------------------------2-----121----	11001
46	*Paranephelium longifoliolatum*	--------------------------2-3----------	11001
50	*Lepisanthes rubiginosa*	---------------12-------2--4---2----4-2	11001
56	*Mallotus philippensis*	---4-----------------------2----2--23--	11001
33	*Shorea henryana*	---------------1----2-22-----2-21332333	110100

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  000011111111111111110000111000111
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      000111100000011
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Dichotomous key for stands

Appendix Table 8. (Continued).

Species no.	Species name	Stand no. 2 1121121112 11323 223 23 2323333441 664383050267213949048589227175514739011	Dichotomous key for species
38	*Millettia leucantha*	--------------------------------------3	110100
47	*Melia azedarach*	--------------------------------------2	110100
54	*Baccaurea ramiflora*	--------------------------------------2	110100
75	*Pterocarpus macrocarpus*	--------------------------------------2	110100
80	*Mallotus peltatus*	-----------------------------2--------4	110100
83	*Mammea harmandii*	--------------------------------------2	110100
6	*Cinnamomum iners*	----------------------------------1----	110101
53	*Siphonodon celastrineus*	--------------------------2------2-1-2-	110101
55	*Artocarpus lakoocha*	------------------------------------3--	110101
61	*Mischocarpus grandis*	-----2-----------------2--3-2-232-42442	110101
62	*Bambusa sp.*	------------------------------------3--	110101
77	*Phoebe paniculata*	2----------------------------------14--	110101
98	*Syzygium cumini*	---------------------------------22--3-	110101
99	*Dipterocarpus turbinatus*	--------------------------------2--4---	110101
102	*Unidentified 1*	-----------------------------22-3--24-2	110101
17	*Acronychia pedunculata*	-------------------------------2121----	110110
42	*Phoebe lanceolata*	-----------------------------2---------	110110
48	*Knema furfuracea*	------------------------------233------	110110
49	*Ficus hispida*	--------------------------------1------	110110
69	*Eurycoma longifolia*	-----------------------1----3322---1---	110110
70	*Eurya acuminata*	------------------------------2--------	110110
78	*Acrocarpus fraxinifolius*	------------------------------3--------	110110
94	*Ardisia lenticellata*	--------------2-----2--------32442-1---	110110
97	*Sumbaviopsis albicans*	--------------------------------22-----	110110
101	*Polyalthia viridis*	----------------------------4----------	110110
10	*Syzygium siamensis*	----2--------------22--------432-52----	110111
13	*Clausena excavata*	333--3----------------------5----2----3	111

```
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  0000000000000000000111111100000001111
  000011111111111111100001110001 11
      000000011111111
      000111100000011
```
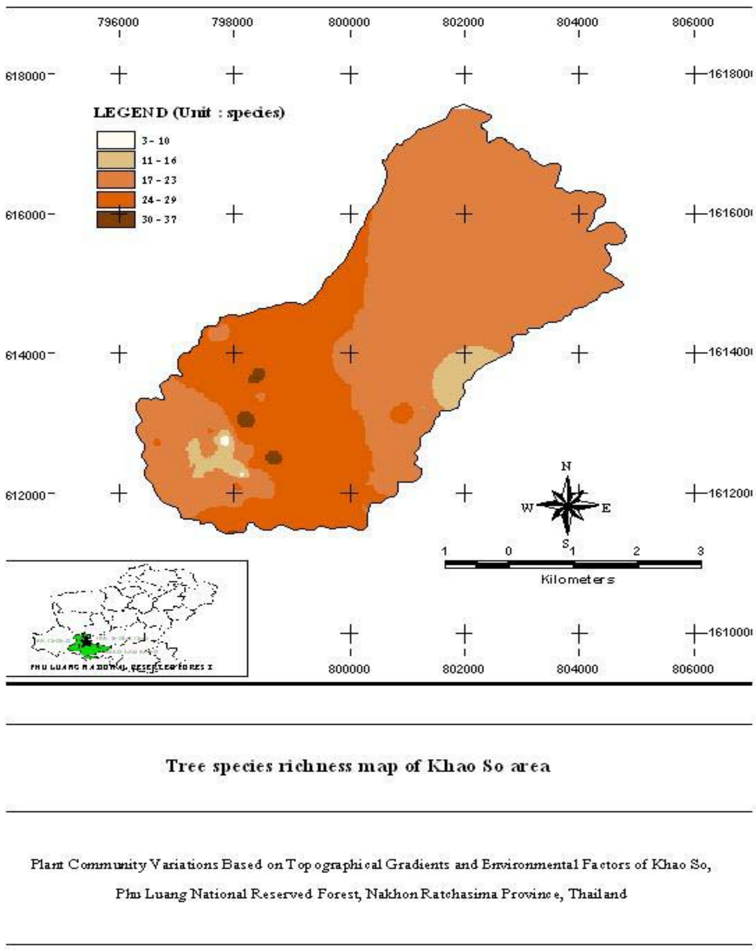

Dichotomous key for stands

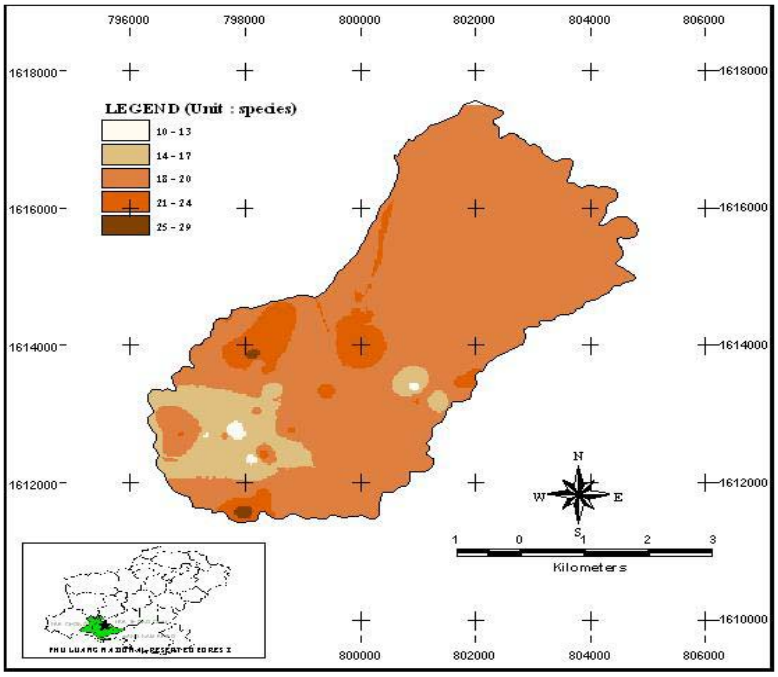
Appendix Table 9. Canonical coefficients of environmental variables along axes.

Variables	Tree stands		Sapling stands		Seedling stands	
	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Moisture content	-0.513	-0.159	-0.529	-0.252	-0.092	-0.676
Effective soil depth	0.21	0.092	0.206	0.127	-0.374	0.048
Bulkdensity	0.063	0.531	0.156	0.632	-0.466	0.264
Elevation	-0.501	-0.395	-0.729	-0.237	0.729	-0.404
Aspect degree	0.089	0.053	-0.093	0.147	0.124	0.094
Slope degree	-0.361	0.297	-0.187	0.159	0.310	0.013
Organic matter	-0.198	-0.317	-0.407	-0.385	0.491	-0.267
Available nitrogen	-0.315	-0.351	-0.418	-0.51	0.431	-0.372
Available phosphorus	0.031	-0.231	-0.124	-0.341	0.145	-0.018
Cation exchange capacity	0.081	0.134	-0.153	-0.264	-0.090	-0.179
Exchangeable cation of potassium	0.162	0.142	0.305	-0.055	-0.377	0.382
Exchangeable cation of calcium	0.117	0.661	0.078	0.266	-0.276	0.163
Exchangeable cation of magnesium	-0.031	0.650	0.233	0.245	-0.328	0.018
Exchangeable cation of sodium	-0.018	0.538	0.269	0.282	-0.170	0.043
Soil reaction	-0.059	0.628	0.214	0.661	-0.187	0.229
% clay	-0.091	0.075	-0.321	-0.327	0.130	-0.375
% sand	0.228	-0.204	0.276	0.26	0.010	0.320
% silt	-0.298	0.274	-0.121	-0.086	-0.161	-0.134
R *	0.879	0.831	0.866	0.856	0.914	0.858

* Pearson correlation between species and environmental variables



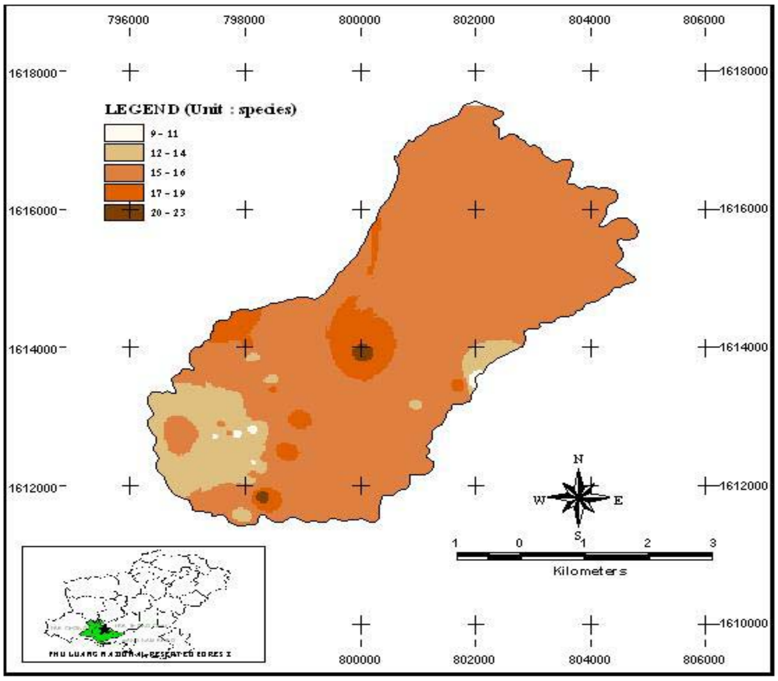
Appendix Figure 1. **Tree species richness along various altitudes and aspects of Khao So area.**



Sapling species richness map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

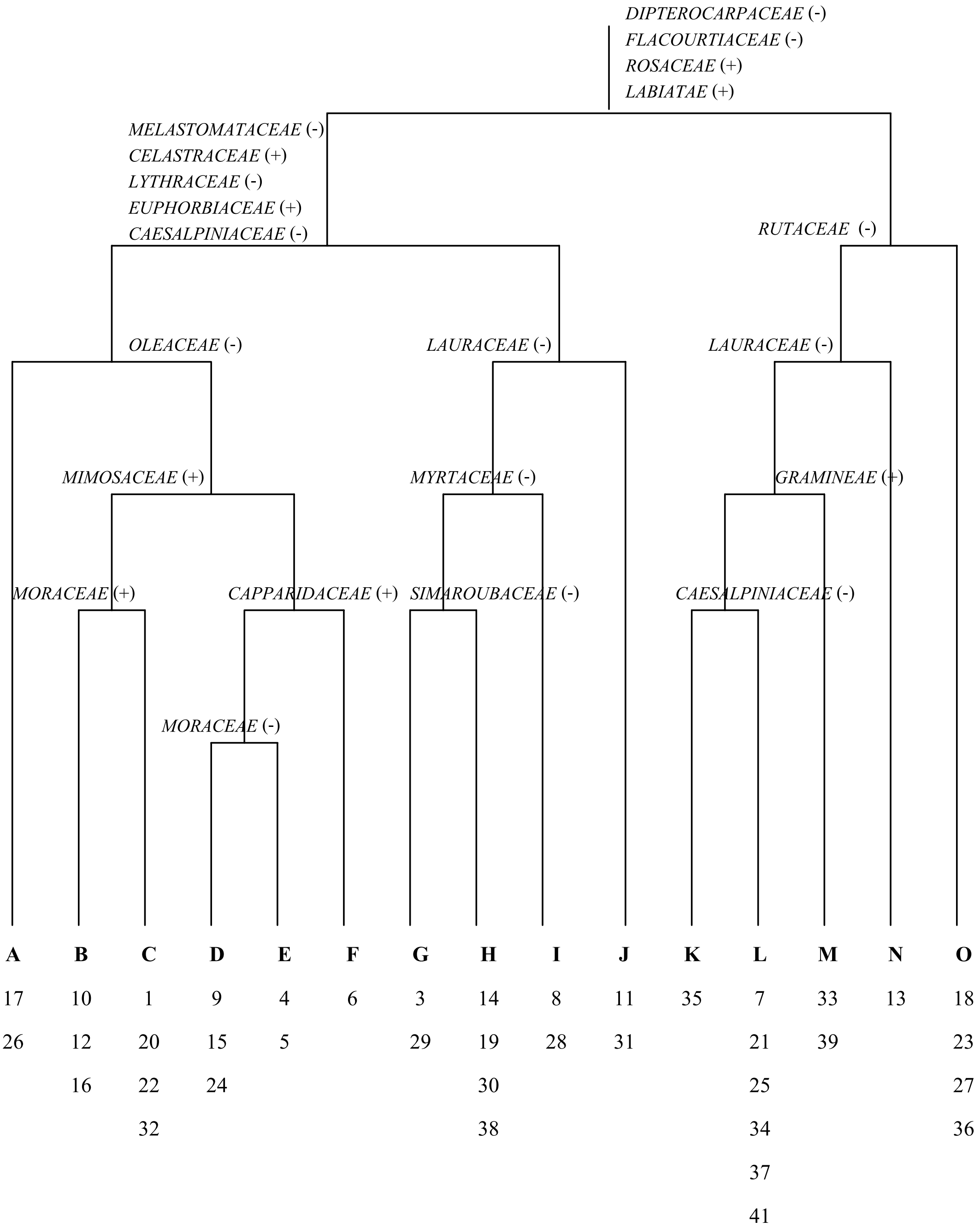
Appendix Figure 2. **Sapling species richness along various altitudes and aspects of Khao So area.**



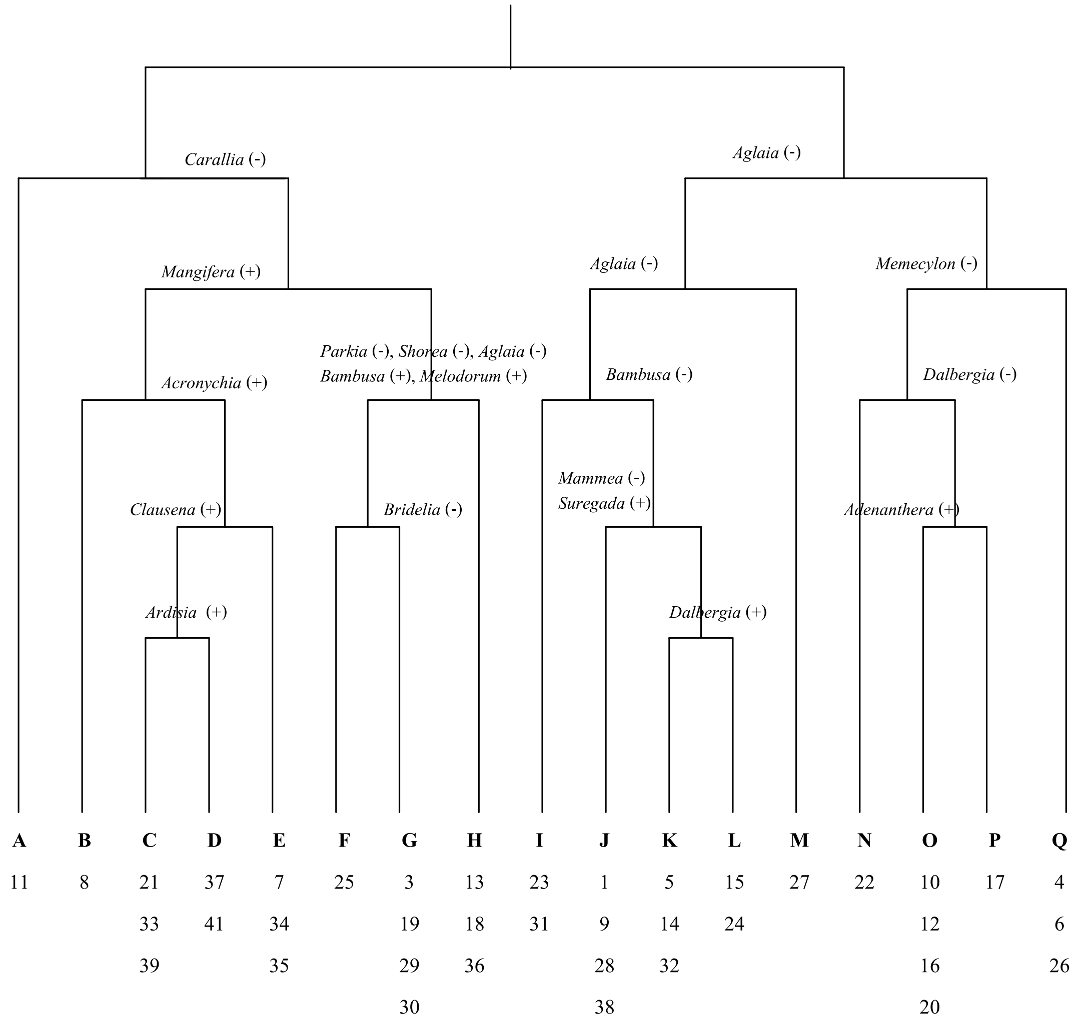
Seedling species richness map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

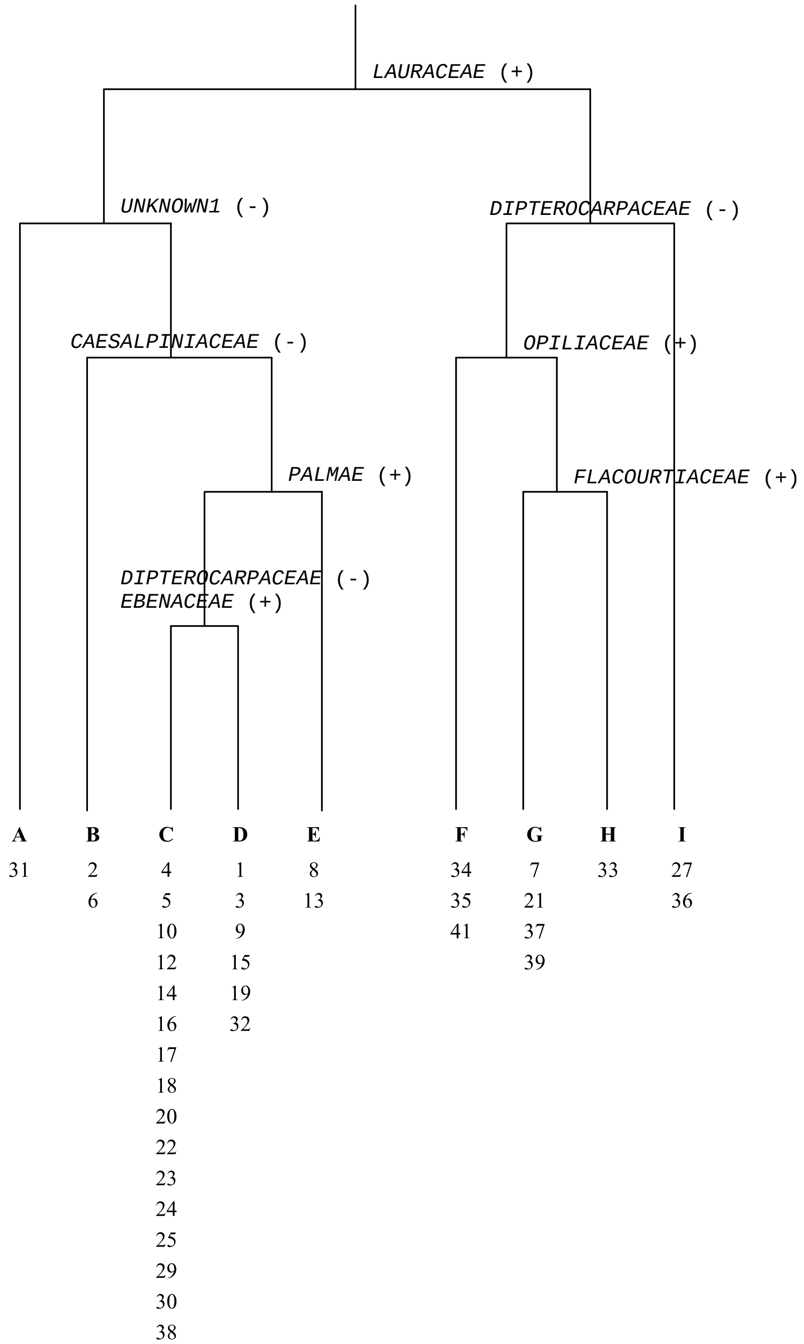
Appendix Figure 3. **Seedling species richness along various altitudes and aspects of Khao So area.**



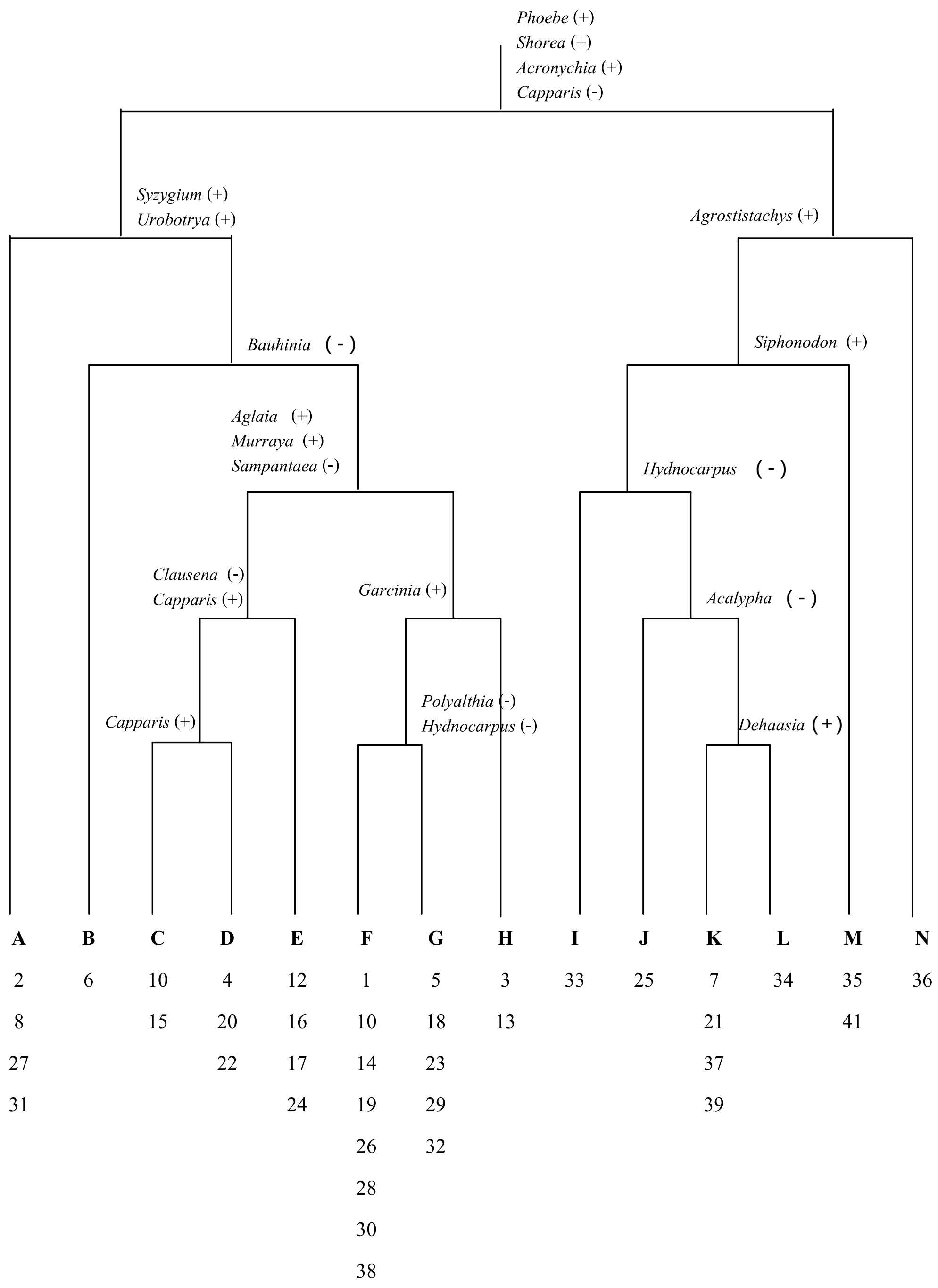
Appendix Figure 4. **Two-way indicator analysis dendrogram for tree stands. by families.**



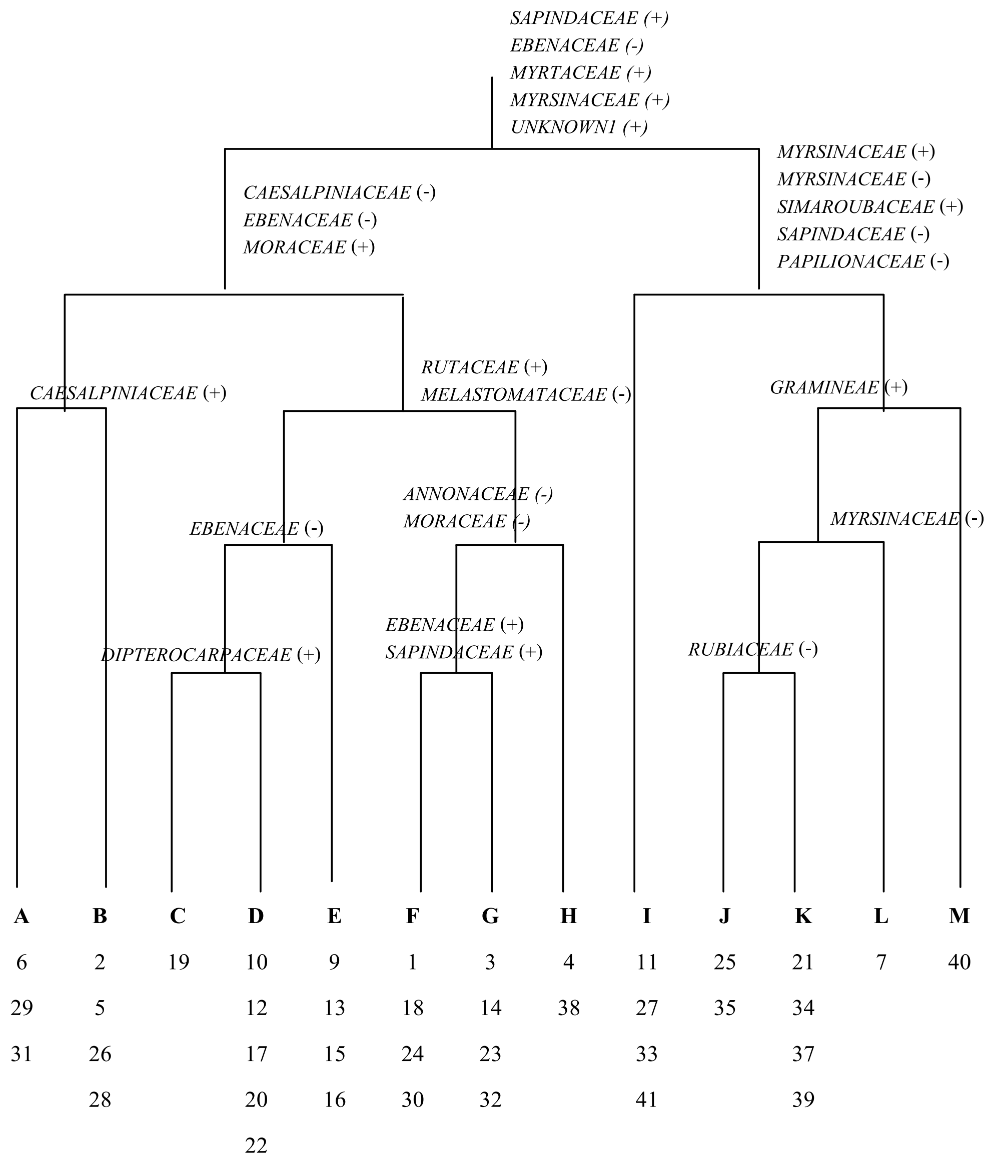
Appendix Figure 5. Two-way indicator analysis dendrogram for tree stands by genera.



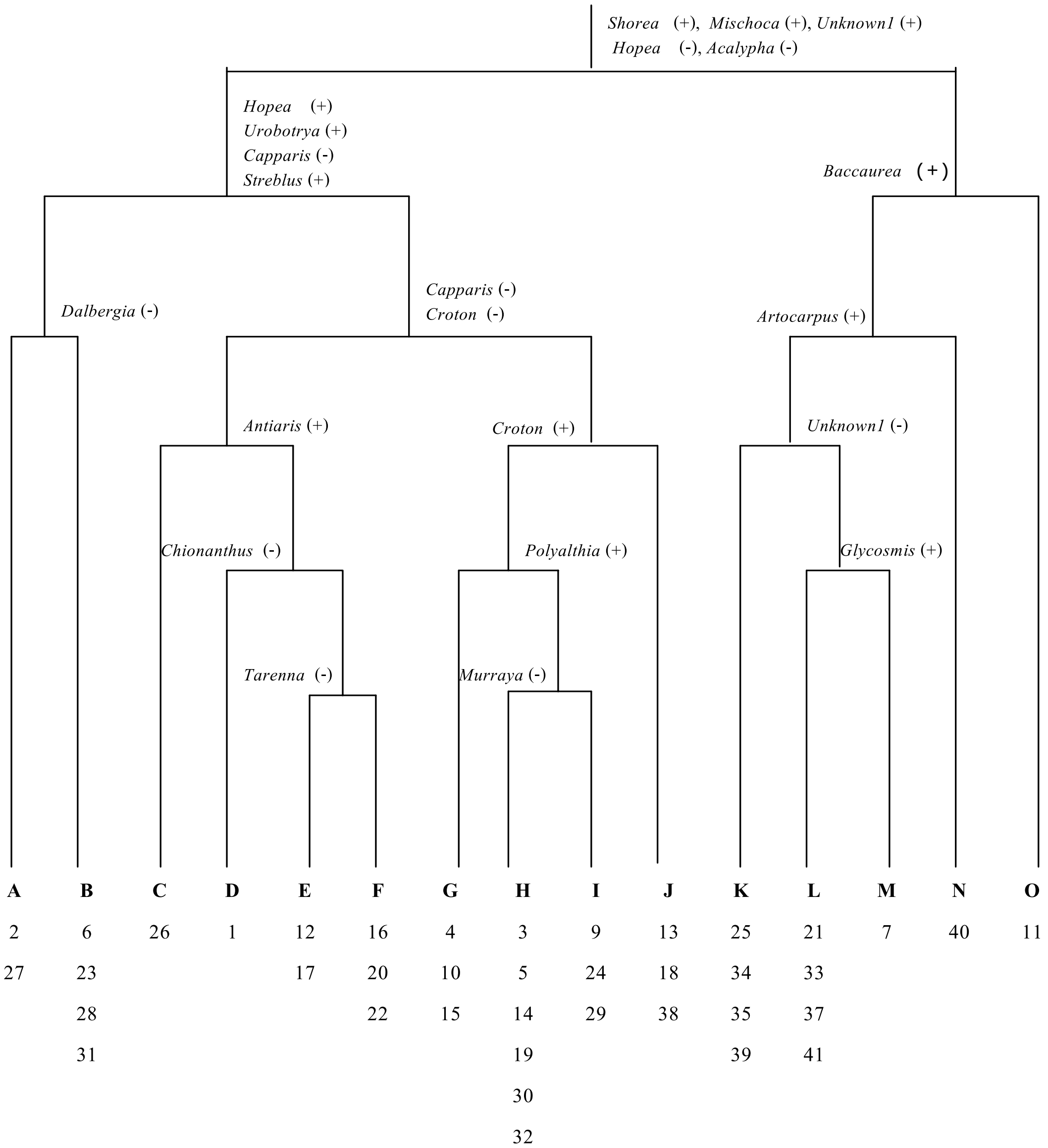
Appendix Figure 6. Two-way indicator analysis dendrogram for sapling stands by families.



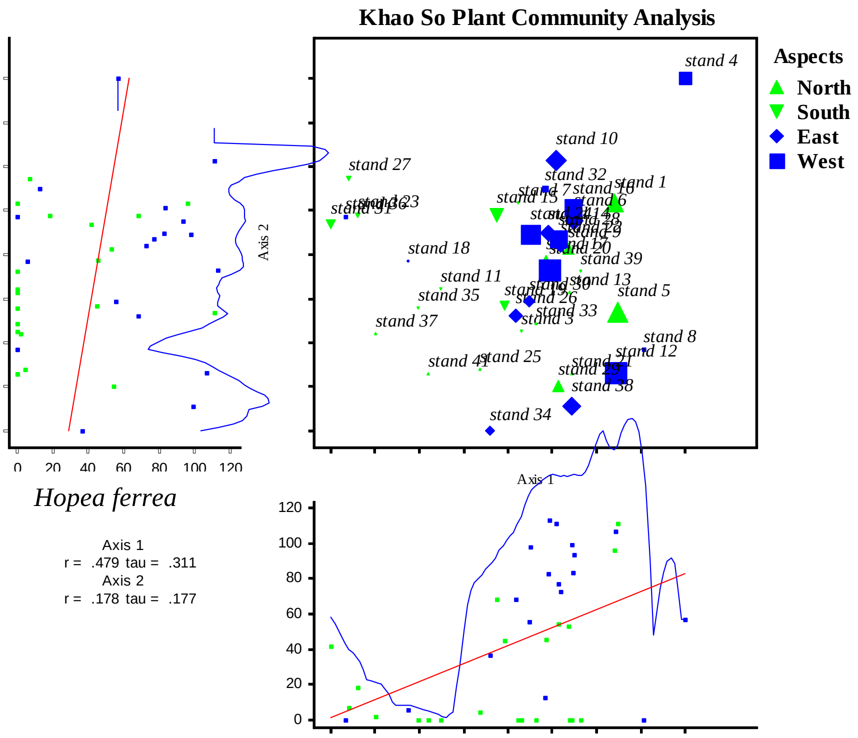
Appendix Figure 7. Two-way indicator analysis dendrogram for sapling stands by genera.

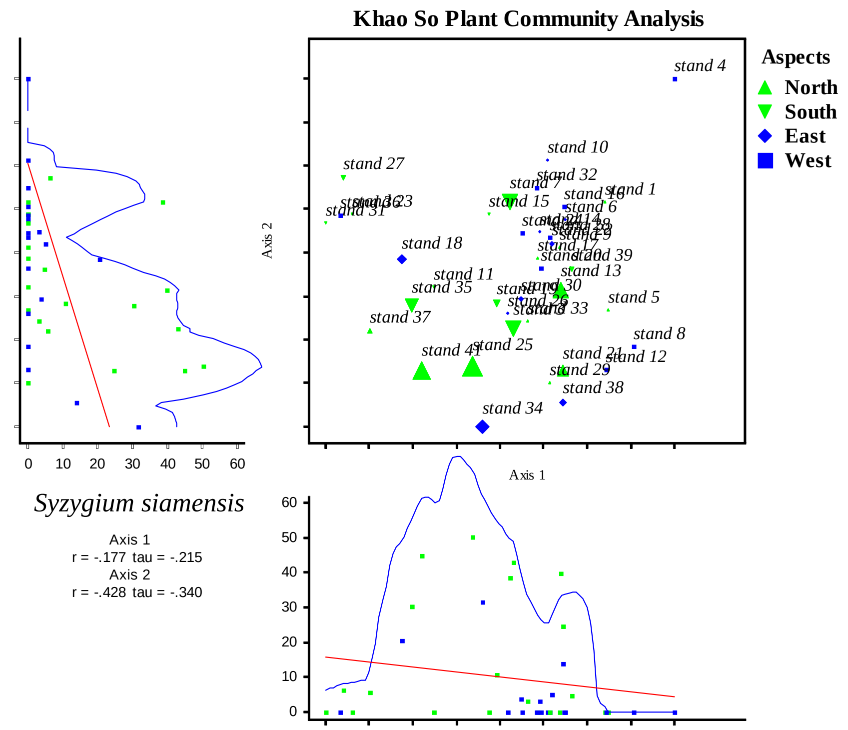


Appendix Figure 8. **Two-way indicator analysis dendrogram for seedling stands by families.**

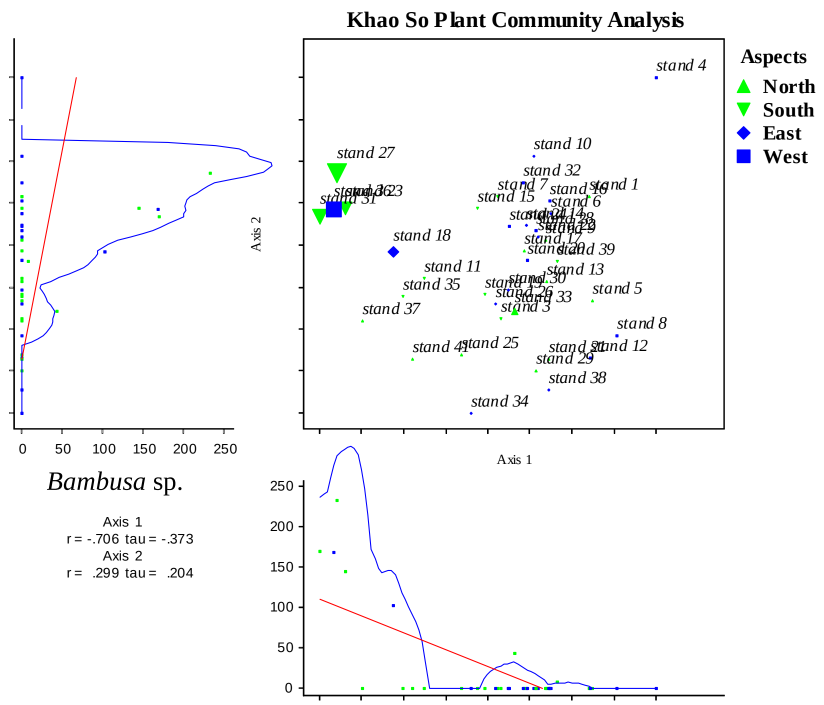


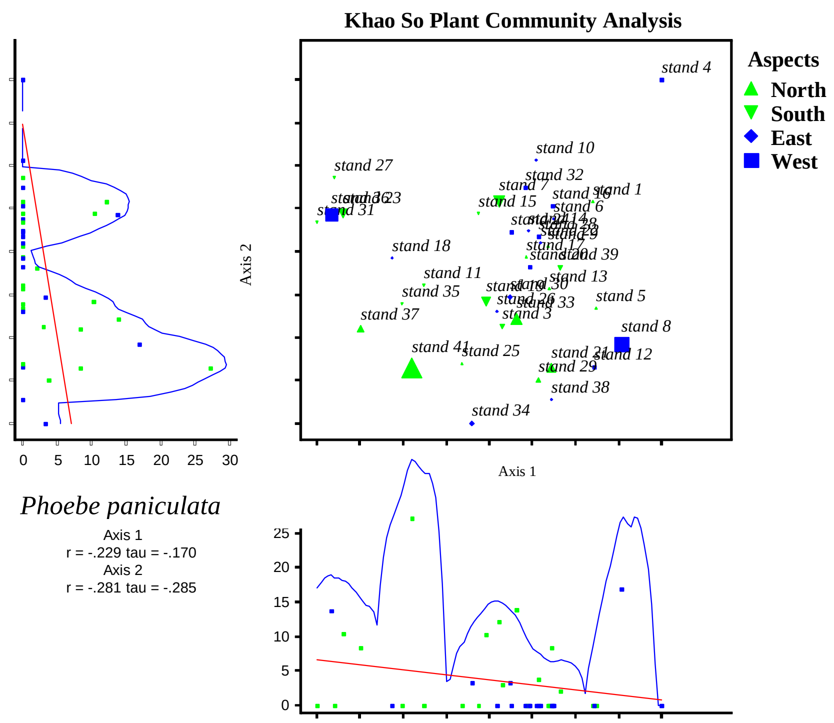
Appendix Figure 9. **Two-way indicator analysis dendrogram for seedling stands by genera.**



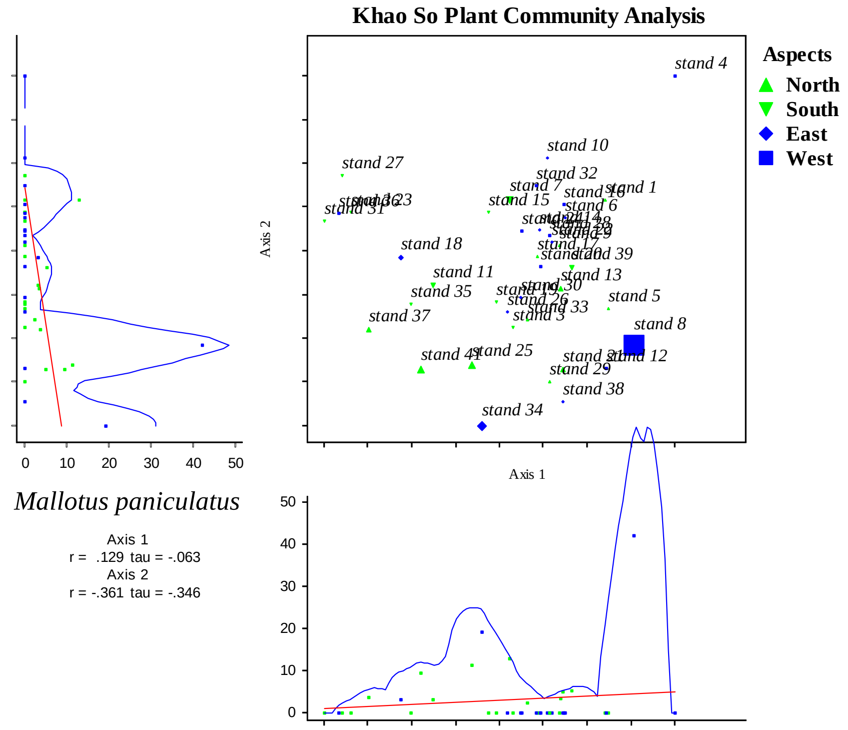


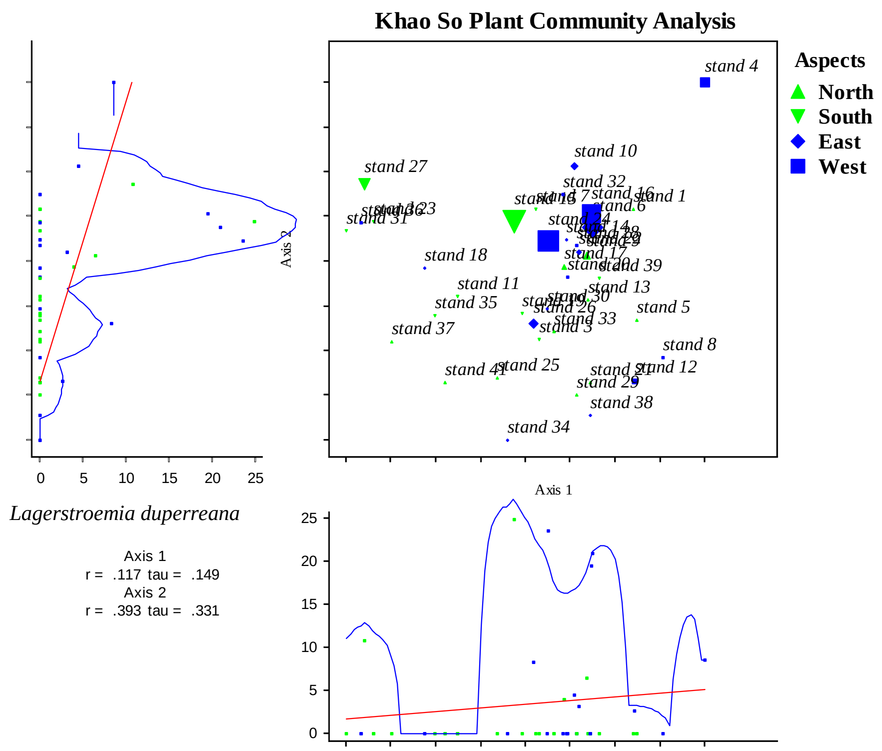
Appendix Figure 10. **Scatterplot of primary trees species in relationship along environmental gradients.**



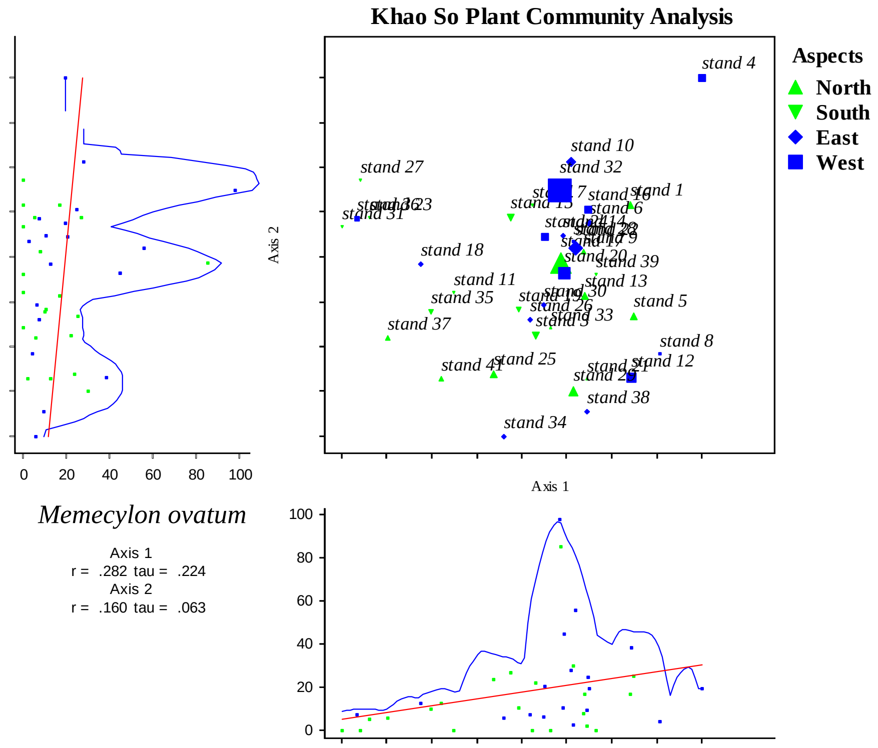


Appendix Figure 10. **(Continued).**

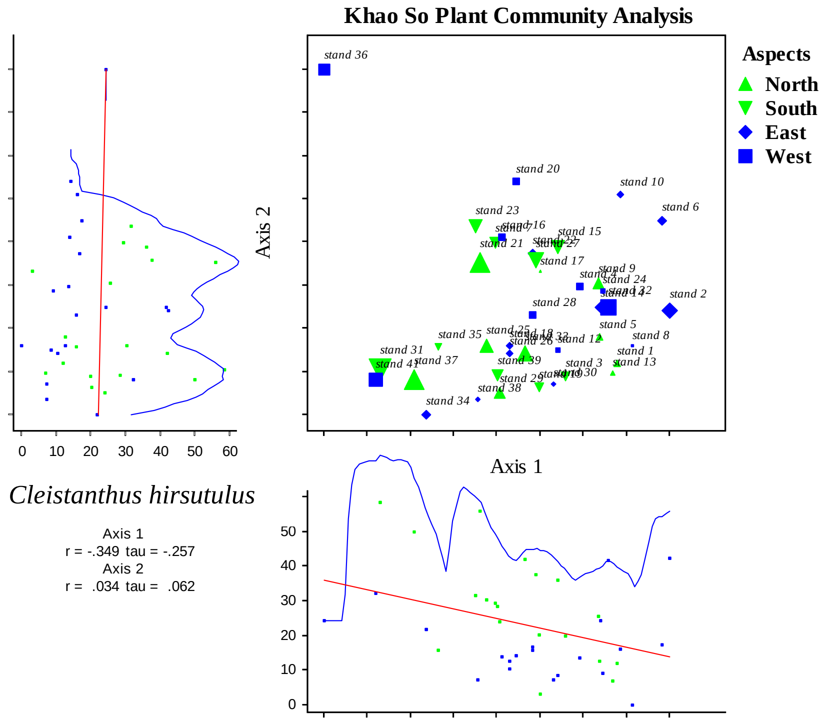


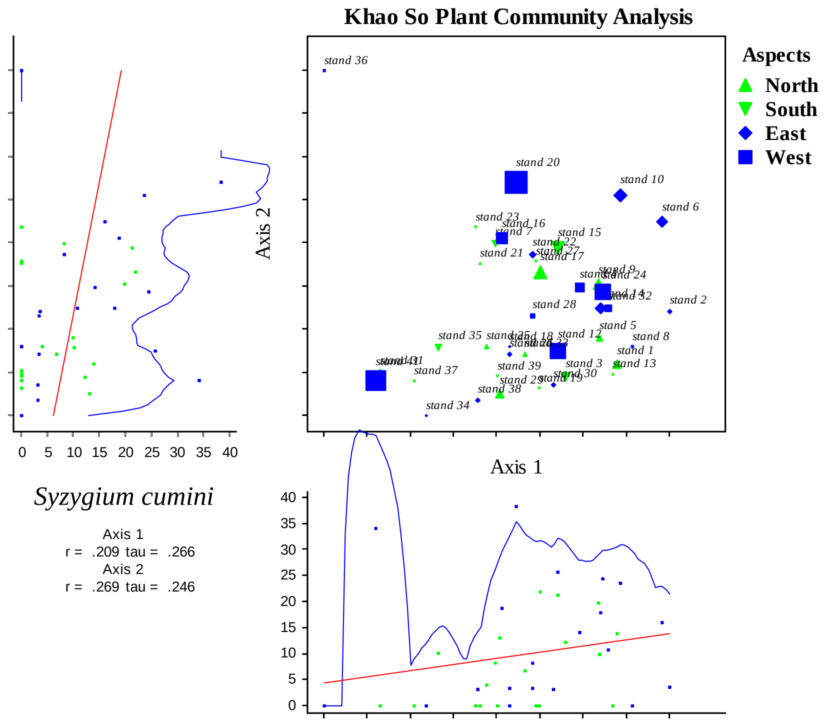


Appendix Figure 10. **(Continued).**

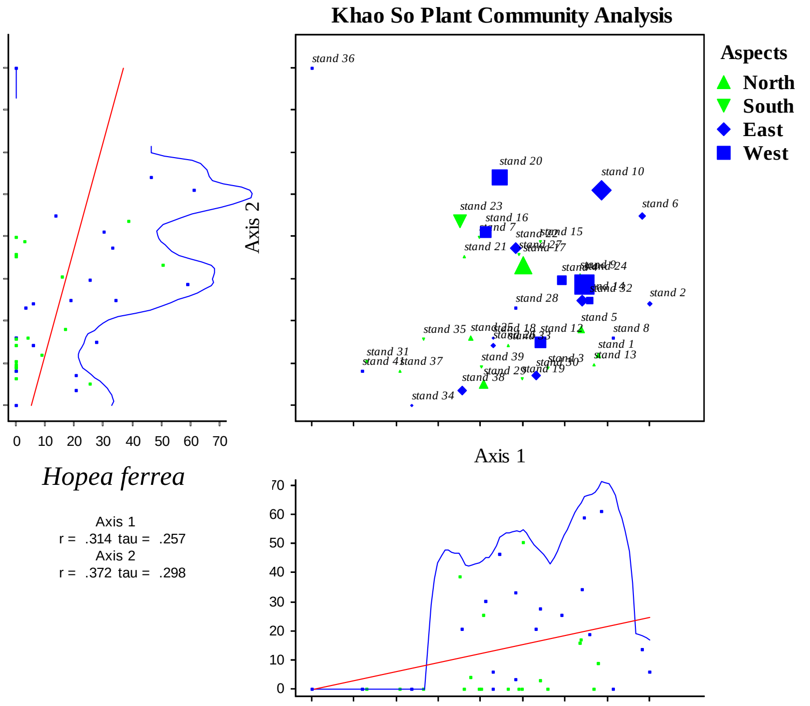


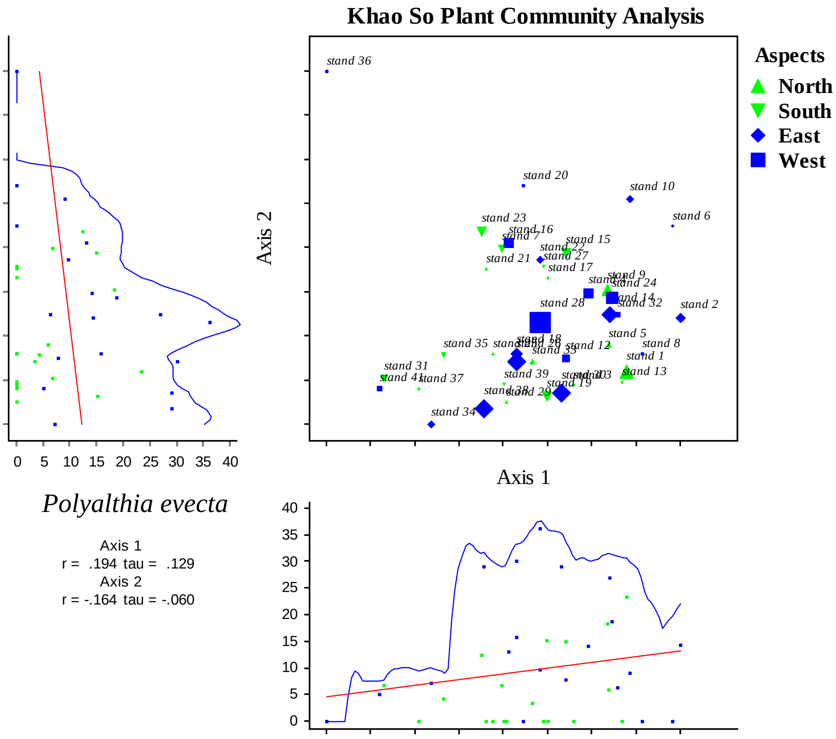
Appendix Figure 10. (Continued).



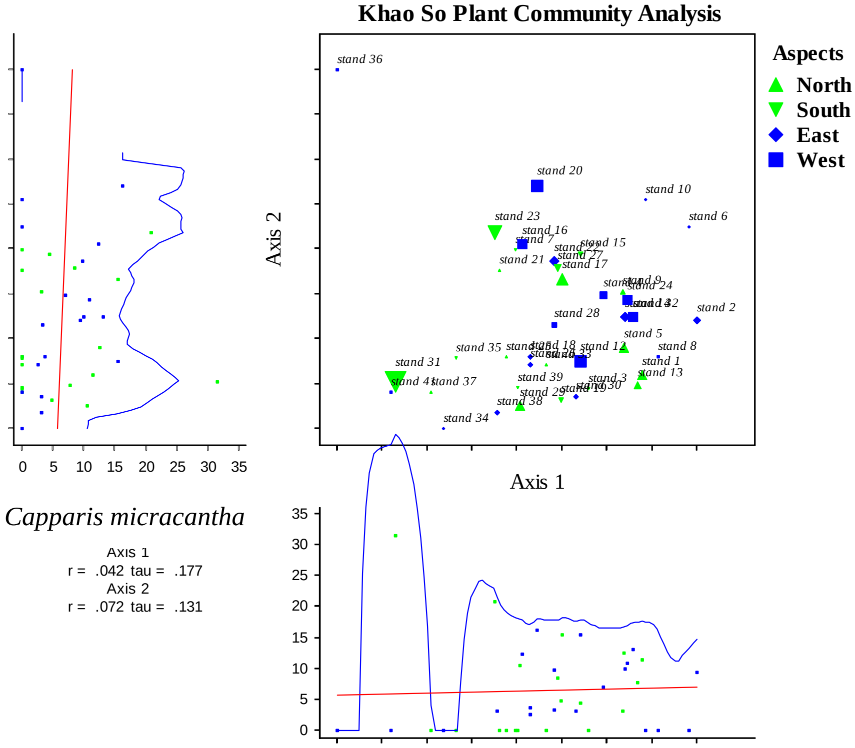


Appendix Figure 11. **Scatterplot of primary sapling species in relationship along environmental gradients.**

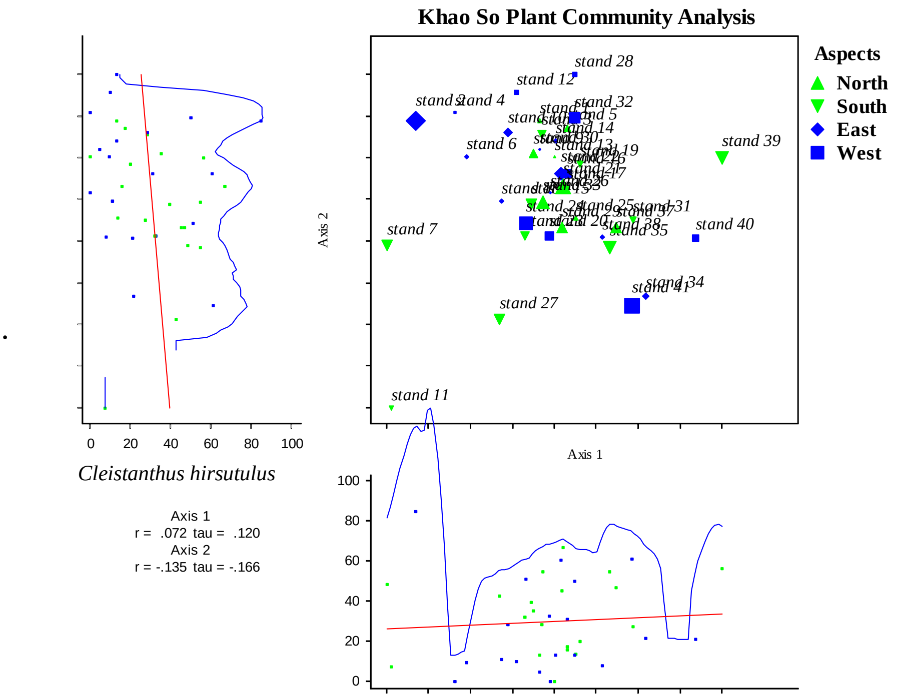


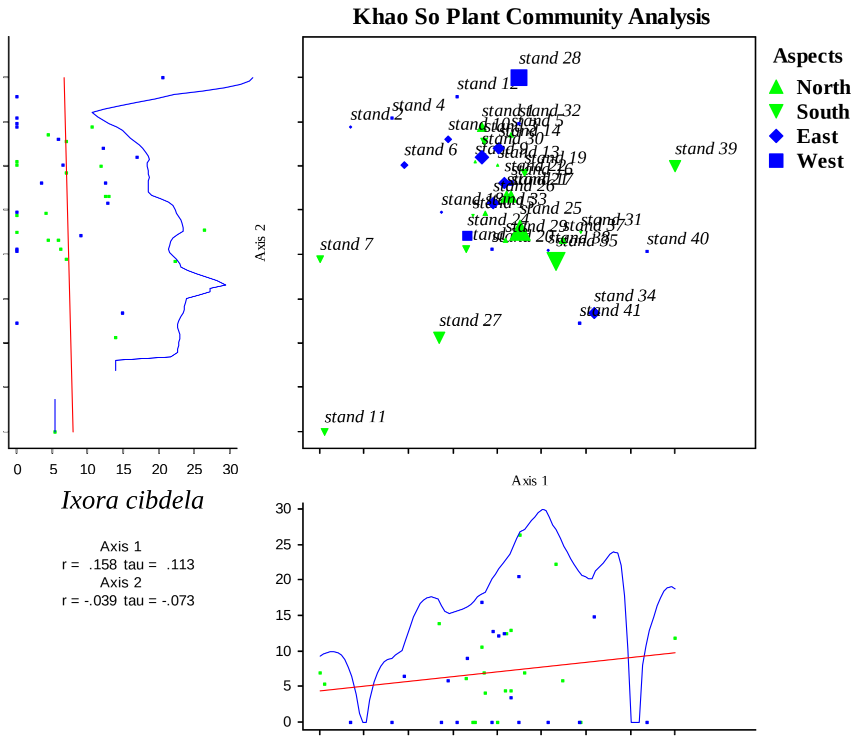


Appendix Figure 11. (Continued).

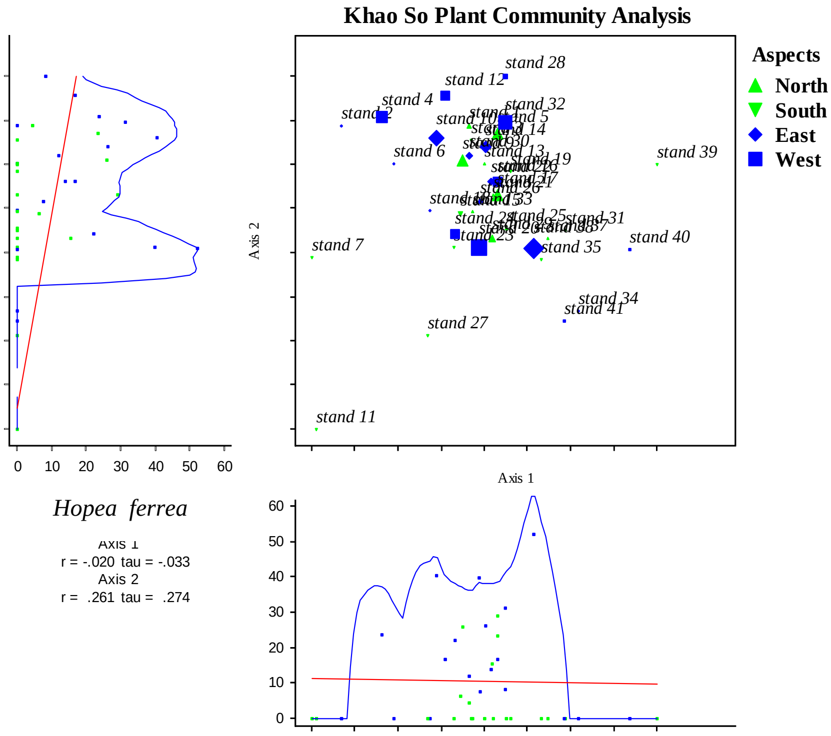


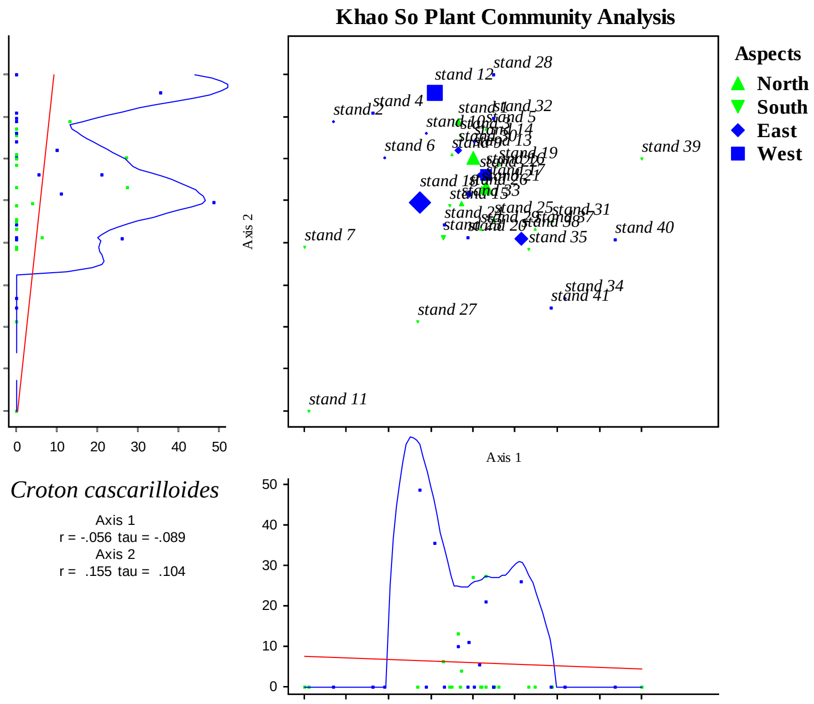
Appendix Figure 11. (Continued).



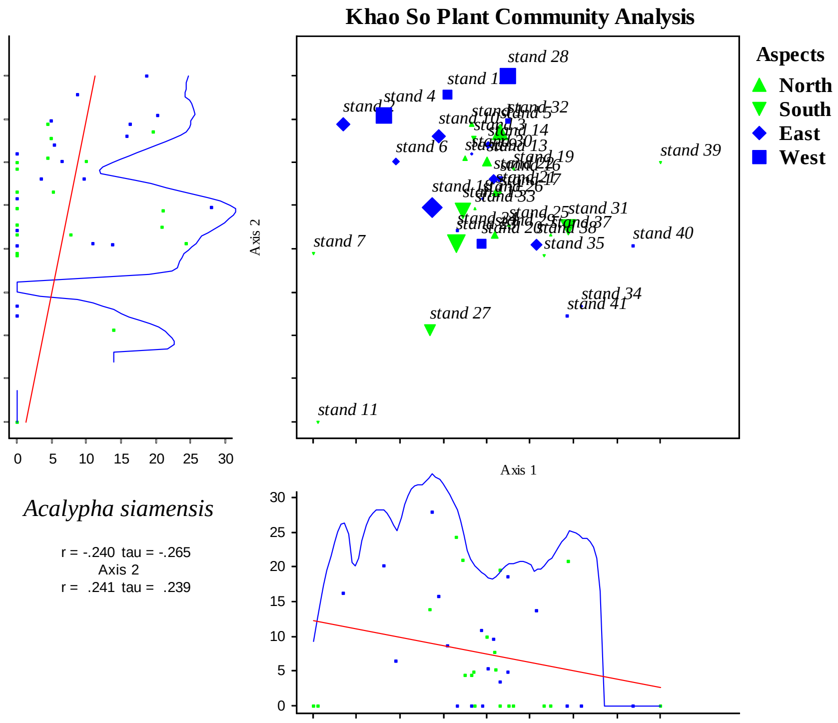


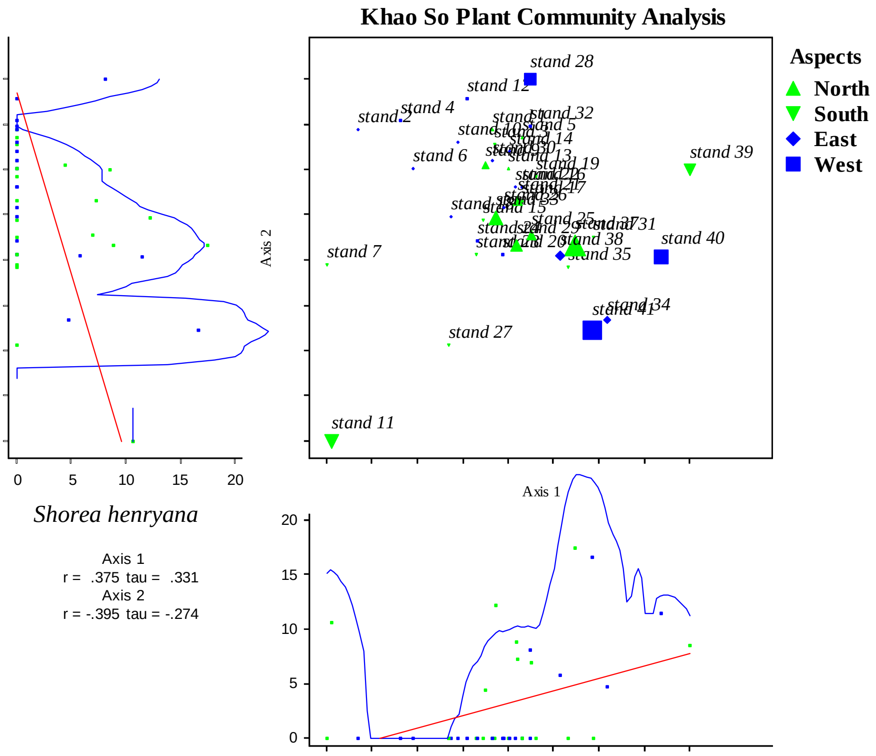
Appendix Figure 12. Scatterplot of primary seedling species in relationship along environmental gradients.



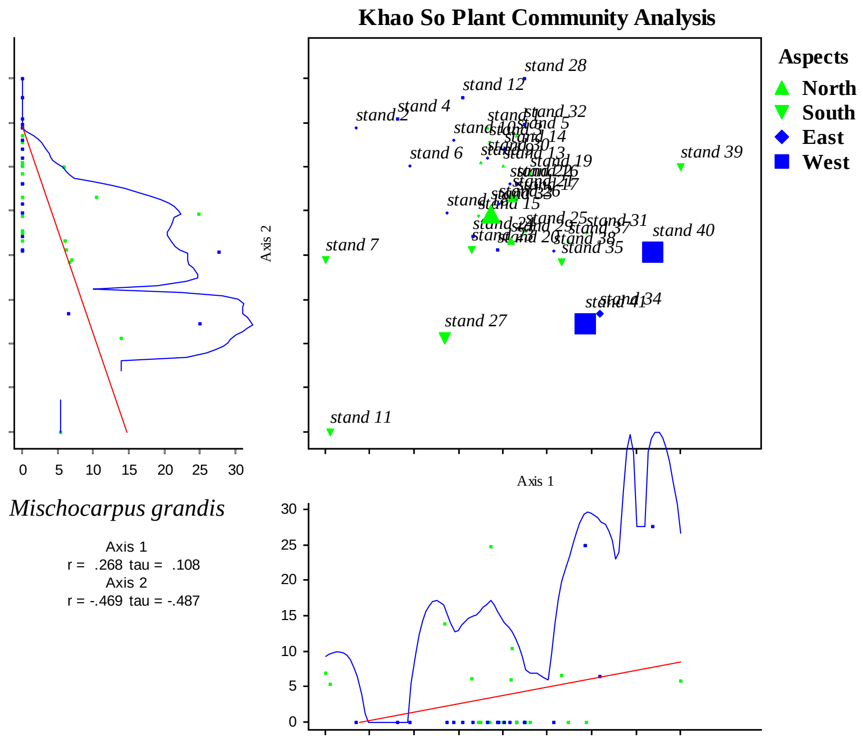


Appendix Figure 12. (Continued).

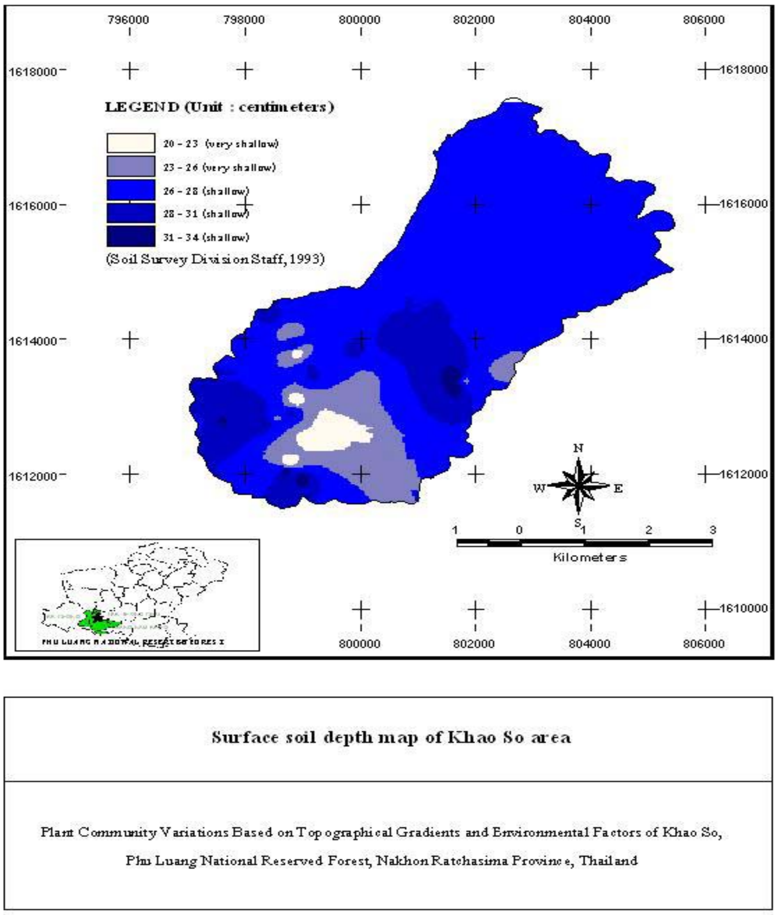




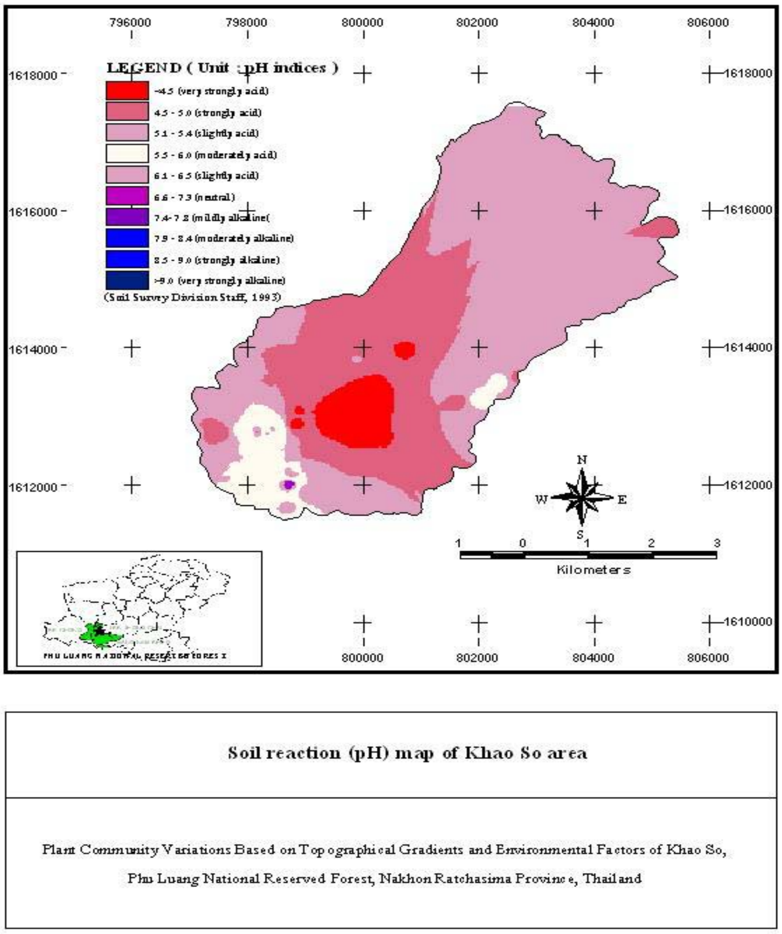
Appendix Figure 12. (Continued).



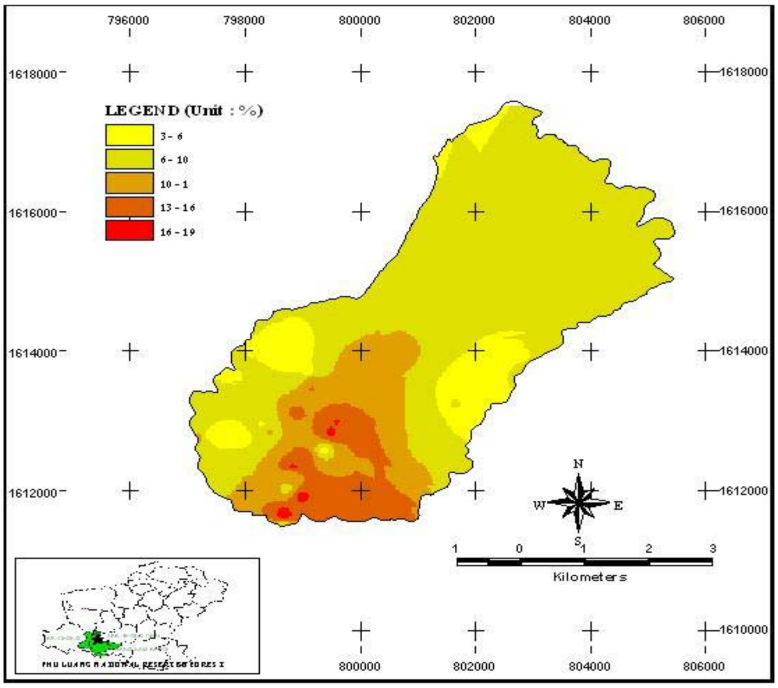
Appendix Figure 12. (Continued).



Appendix Figure 13. **Surface soil depth along altitudes and aspects of Khao So area.**



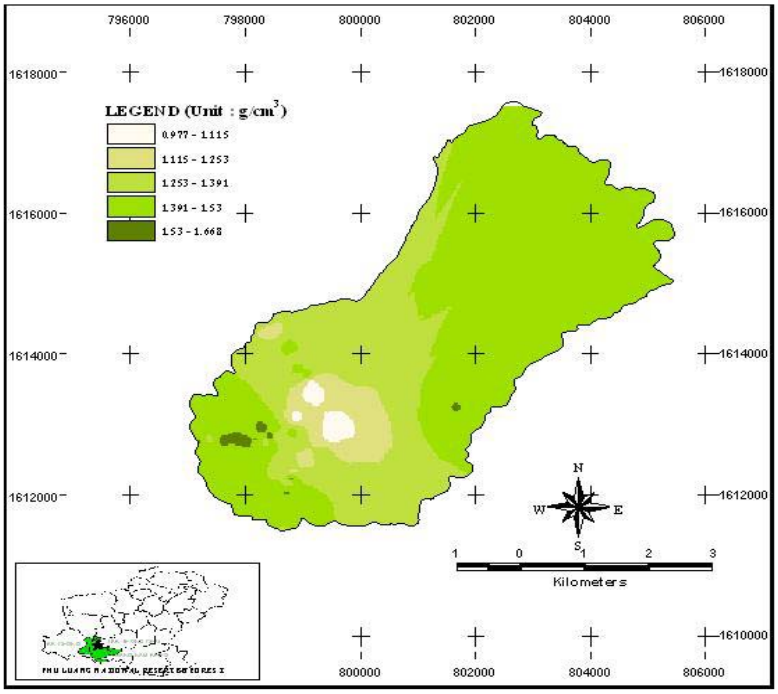
Appendix Figure 14. **Soil reaction (pH) along altitudes and aspects of Khao So area.**



Soil moisture content (Kc) map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So,
Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

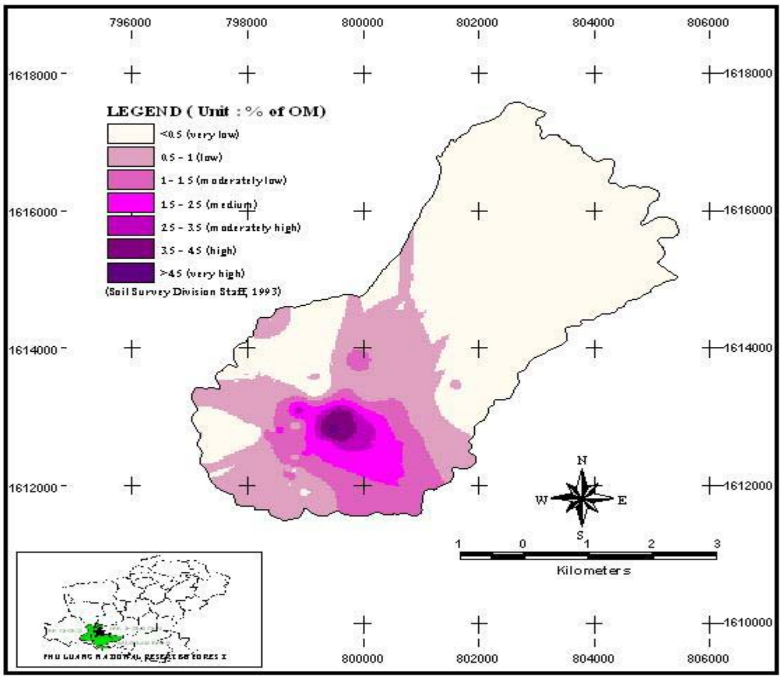
Appendix Figure 15. **Soil moisture content along altitudes and aspects of Khao So area.**



Bulk density (Db) map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

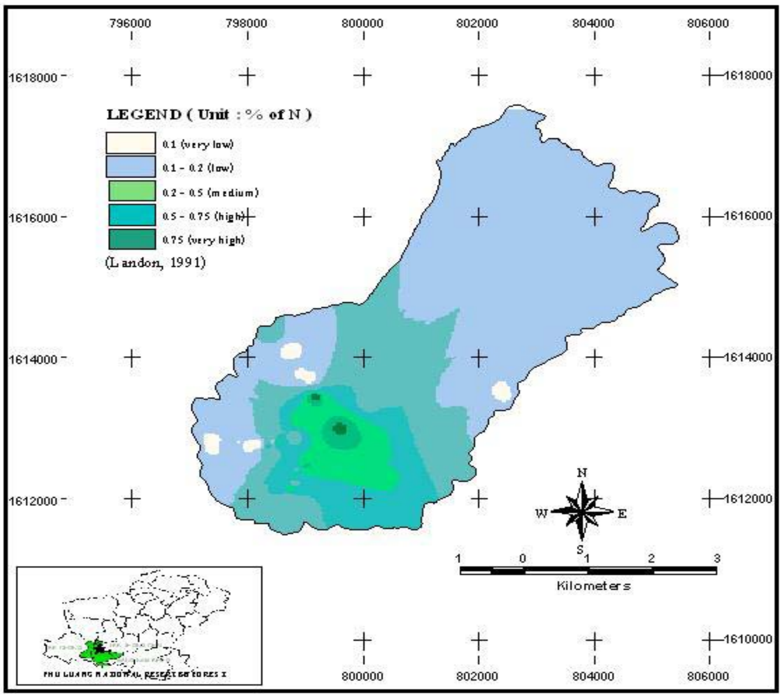
Appendix Figure 16. **Bulk density (Db) along altitudes and aspects of Khao So area.**



Organic matter (OM) map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

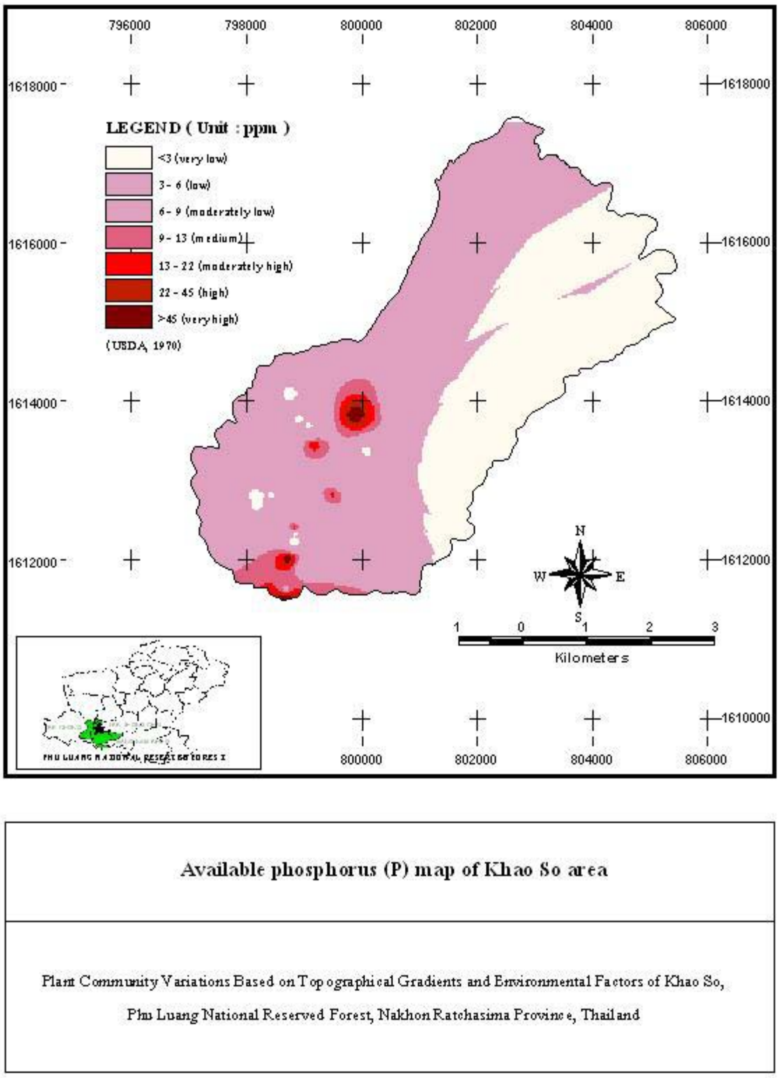
Appendix Figure 17. **Organic matter (OM) along altitudes and aspects of Khao So area.**



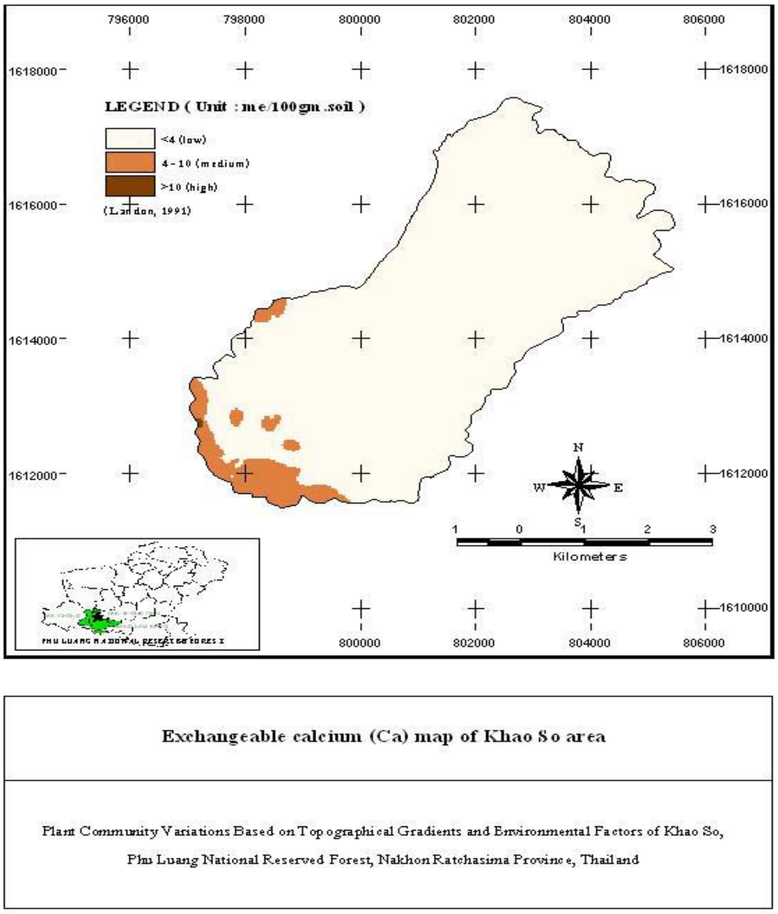
Total nitrogen (N) map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

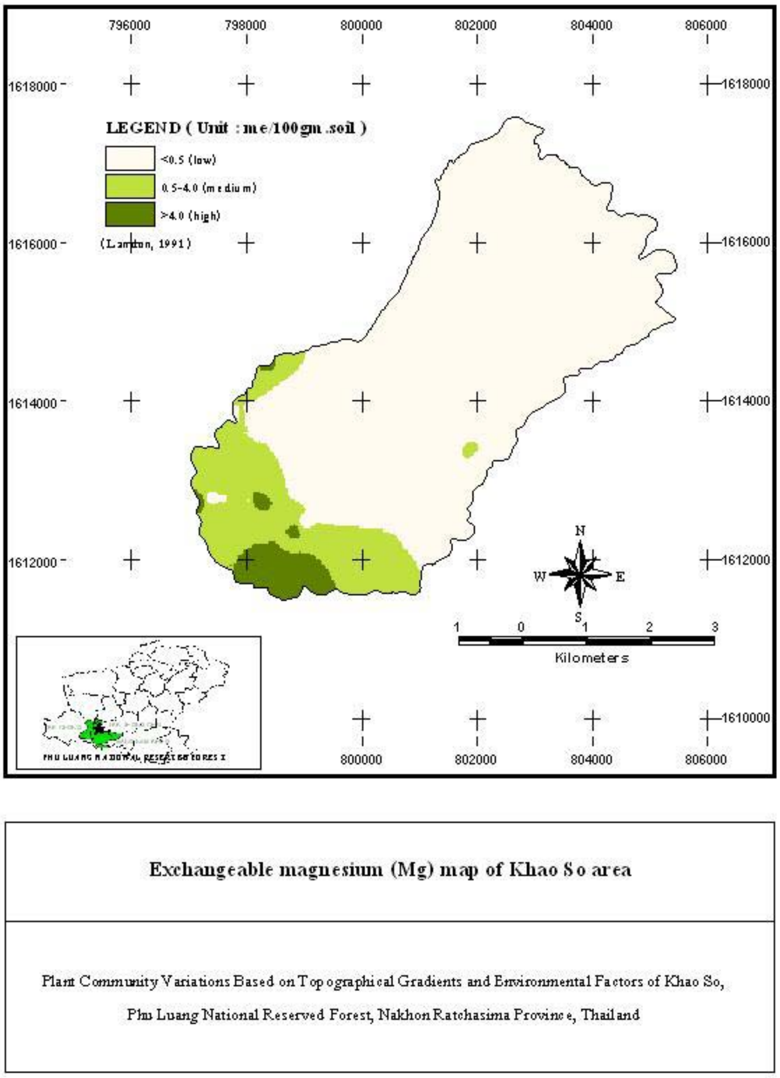
Appendix Figure 18. **Total nitrogen along altitudes and aspects of Khao So area.**



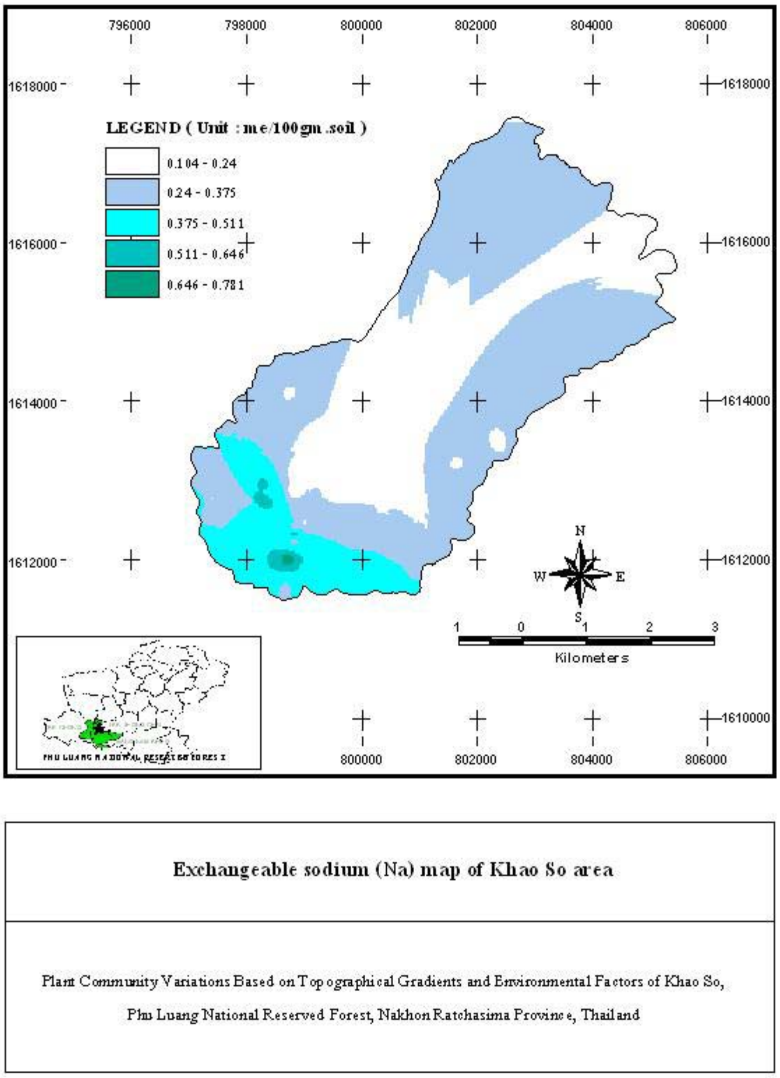
Appendix Figure 19. **Available phosphorus (P) along altitudes and aspects of Khao So area.**



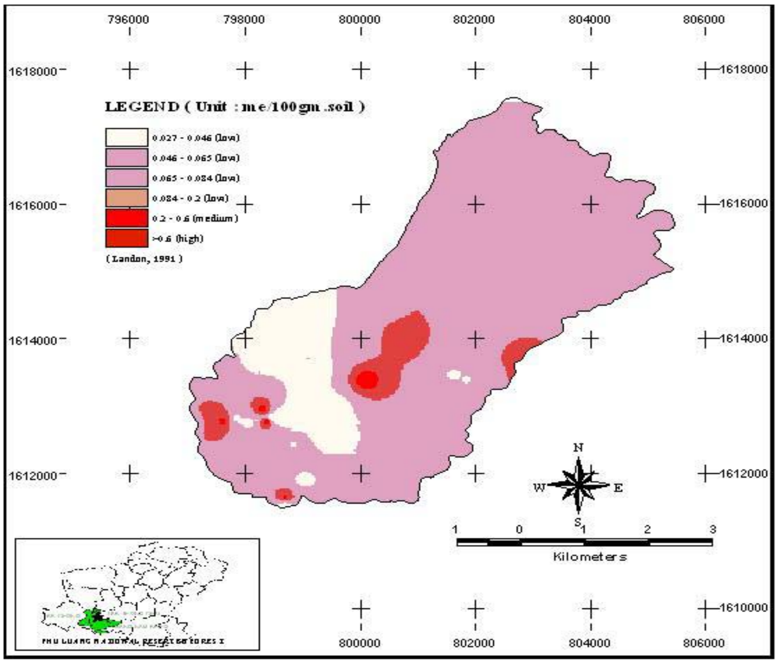
Appendix Figure 20. **Exchangeable calcium (Ca) along altitudes and aspects of Khao So area.**



Appendix Figure 21. Exchangeable magnesium (Mg) along altitudes and aspects of Khao So area.



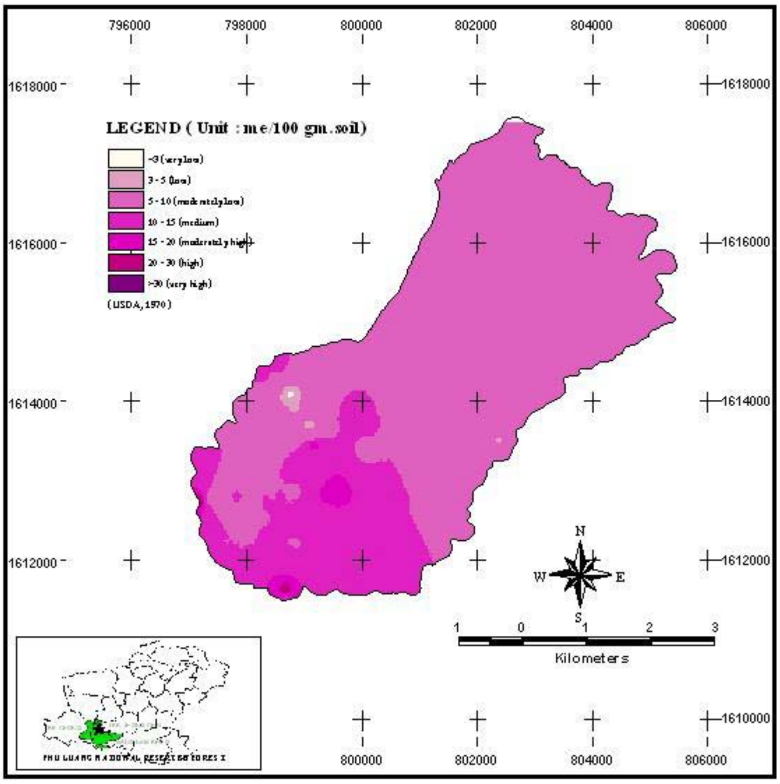
Appendix Figure 22. **Exchangeable sodium (Na) along altitudes and aspects of Khao So area.**



Exchangeable potassium (K) map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

Appendix Figure 23. **Exchangeable potassium (K) along altitudes and aspects of Khao So area.**



Cation exchange capacity (CEC) map of Khao So area

Plant Community Variations Based on Topographical Gradients and Environmental Factors of Khao So, Phu Luang National Reserved Forest, Nakhon Ratchasima Province, Thailand

Appendix Figure 24. **Cation exchange capacity (CEC) along altitudes and aspects of Khao So area.**

CURRICULUM VITAE

Miss Pradub Reanprayoon was born in July 23, 1972 in Chachoengsao province, Thailand. She received Bachelor's degree in General Management from Rajabhat Institute Chachoengsao in 1995 and Master's degree in Technology of Environmental Planning from Mahidol University in 1998 and she enrolled at Suranaree University of Technology in graduate program for Doctor of Philosophy in Environmental Biology in 1999.