

## CHAPTER 1

### Introduction and Literature Review

#### 1.1 Introduction

The forest in northern Thailand is usually classified into five types according to dominant tree species and species composition including two deciduous forests and three evergreen forests. The deciduous forests are dry dipterocarp (DDF) and mixed deciduous (MDF) forests. The evergreen forests are dry evergreen (DEF), pine (PF) and montane (MF) forests. These forests distribute in different areas along altitude gradient in the watershed. The DDF occupies the dry to extremely dry site on upper slope and along the ridges with altitude range of about 150-1,200 m m.s.l. The MDF is widely distributed below 800 m in valley and stream banks. The DEF is found in a limited area in the north, and normally covers the areas along perennial stream below 1,000 m m.s.l. The PF is subdivided into pine-dry dipterocarp (pine-DDF) and pine-lower montane (Pine-LMF) subtype forests. The pine-DDF is usually observed in the dry area between 500-1200 m (Santisuk, 1988), whereas the pine-LMF covers the moderate moist areas at altitude between 1,000-1,900 m. The MF is considered as the climax forest ecosystem on high mountains above 1,000 m. Its subtypes included the lower and upper montane forests. The latter subtype covers over the summit of Mt. Inthanon, the highest mountain of the country (Khamyong *et al.*, 2004).

The natural pine forests are found in dry areas on the highland. The pine-DDF covers on more dry site than the pine-LMF, where some important tree species are existed such as *Pinus merkushi*, *P. kesiya*, *Shorea obtusa*, *S. siamensis*, *Dipterocarpus obtusifolius*, *D. tuberculatus*, etc. The pine-LMF usually consists of *P. kesiya*, *Quercus brandisiana*, *Castanopsis divesifolia*, *C. acuminatissima*, *Schima wallichii*, *Styrax benzoides* and *Anneslea fragrans*, etc. *Pinus merkusii* and *P. kesiya* are the uppermost tree canopy as dominant trees, and other broad-leaf dominant tree species are the lower canopy as co-dominant trees. Most of ground-covered species are grass and seedlings.

The pine-DDF can be divided into subtype communities according to existence of different dipterocarp tree species including *D. tuberculatus*, *D. obtusifolius*, *S. obtusa* and *S. siamensis*. Their species composition may be also different among subtypes. The variations of physical environments especially soil characteristics, nutrient status, site temperature and moisture may be occurred as well as nutrient cycles particularly carbon.

It is importance to investigate the differences in plant species diversity, soil characteristics as well as carbon stocks in these subtype communities of the natural pine forest to provide basic information for forest and watershed management. The data are implied to the roles of the natural pine forest on atmospheric carbon dioxide.

#### 1.2 Literature Review

Three topics including plant species diversity, soil characteristics and carbon stocks in forest ecosystems are reviewed in this section.

### 1.2.1 Plant species diversity

The concepts of biodiversity can be applied at several ecological works, genetic, species, community and ecosystem diversities. Plant species diversity is the combination of species richness (number of species) and evenness (population heterogeneity) (Krebs, 1985).

Pamprasit (1994) studied on the relationship between plant associations and soil characteristics in the DDF at the Doi Inthanon national park. The four associations included dominant *S. obtusa*, *S. siamensis*, *D. obtusifolius* and *D. tuberculatus*. These dominant trees had relative important values between 35-39% of all species, and species diversity indexes by Shannon-Wiener Index (SWI) varied between 2.94 and 3.67.

Khamyong and Seramethakun (1995) examined the quantitative plant species diversity in the DDF at the Doi Suthep-Pui national park. The forest was dominated by *D. obtusifolius*, and consisted of 65 tree species. It was a secondary forest recovered from forest concession and illegal cutting in the past before establishing the national park.

Seanchanthong (2005) studied the plant species diversity and soil characteristics of forest communities in Pang Ma Pha district, Mae Hong Son province. The forests included six forest communities; dry dipterocarp, mixed deciduous, dry dipterocarp-mixed deciduous, pine-dry dipterocarp, pine-lower montane and lower montane forests. The total number of tree species in these forests were 269 species (179 genus and 71 families); DDF: 90, MDF: 108, DDF-MDF: 128, P-DDF: 63, P-LMF: 85 and LMF: 182.

Phonchaluen (2009) assessed plant species diversity in Ban Sai Thong community forest, Lamphun province, in two sites each of DDF and MDF including older conserved (site 1) and newly conserved (site 2) areas. Totally 181 species were found in two forests. The DDF of site 1 and site 2 consisted of 71 and 64 species whereas those of the MDF were 122 and 121, respectively.

Naimphulthong (2011) reported that by using 100, 40 x 40 m sampling plots in the DDF on sedimentary rock of mixed fragmented rocks, gravels and pebbles at the Petrified wood forest park, Tak province, the forest consisted of 107 tree species, in 81 genus, 41 families. At the same time, Wongin (2011) found that the DDF on granitic rock in this forest park composed of the lower species richness, 91 species (76 genus and 37 families).

Seeloy-ounkeaw (2011) investigated the species diversity in two pine-montane community forests at Nong Tao village, Mae Wang district, Chiang Mai province including conservation and utilization forests located on granitic rock by using 100, 40 x 40 m sampling plots. He found that there were 244 species (166 genus and 78 families) and 132 species (93 genus and 51 families) existed in conservation and utilization forests.

### 1.2.2 Soil characteristics

Some researches on soil characteristics in different forests have been conducted. This includes soil taxonomy, physical and chemical properties.

Pamprasit (1995) studied on the relationship between plant associations and soil characteristics in the DDF at the Doi Inthanon national park, Chiang Mai province. Soil in the *S. siamensis* association was young developed soil (Order

Entisols). It was less than 50 cm in depth. The soil under *S. obtusa* association was more developed soil with 50-80 cm depth (Order Inceptisols) whereas those under *D. obtusifolius* and *D. tuberculatus* associations were more developed, more than one meter in depth, and were classified in Order Ultisols.

Laorpansakul (2000) investigated on soil characteristics in various forest types of the Queen Sirikit botanic garden, Chiang Mai province. He found that soil chemical properties varied among forest types. Slightly differences in pH and CEC were observed. The soil reaction varied from moderate to very strong acid, and CEC was moderate to high. The amounts of soil organic matter and total nitrogen were higher in the LMF and MDF, intermediate in DEF and lower in DDF.

Parathai (2003) studied on soil properties of *P. kesiya* plantations and a natural pine forest at Doi Boa Luang, Chiang Mai. He concluded that bulk densities of top soil and texture in 7 to 37 year-old stands were slightly differences among plantations, varying 1.0-1.6 Mg m<sup>-3</sup>. The pH values varied from 4.9 to 6.1 (moderately to strongly acid). It was slightly decreased in the older stands. Organic matter was increased with stands age; varying 17.3-66.8 g kg<sup>-1</sup>. The amounts of organic matter in one-meter soil profile of the 7 to 37 year-old stands were 83.86-153.80 Mg ha<sup>-1</sup>, carbon: 48.64- 89.20 kg ha<sup>-1</sup>, and nitrogen: 3,243-5,947 kg ha<sup>-1</sup>. Concentrations and amounts of extractable P, Ca and Mg in soils were higher in the older stands, but K was adversely lower.

Seanchanthong (2005) found that soil characteristics in various forests in Pang Ma Pha district, Mae Hong Son province were different. Soil types in DDF, MDF, DDF-MDF were classified in Order Alfisols on limestone area, and some were Order Inceptisols on sand stone/granitic rocks. The soils under the pine-DDF, pine-LMF and LMF were Order Ultisols. Soil densities in most forests except LMF were high while the acidity was variable among different forests, neutral to strong acid. Organic matter was higher in the LMF soil and lower in other forests.

Phonchaluen (2009) also studied about soil characteristics in Ban Sai Thong community forest, Lamphun province, in two sites including each of DDF and MDF involving older conserved (site 1) and newly conserved (site 2) areas. The DDF covered on rocky area and shallow to moderately deep soil whereas the MDF soils were moderately to deep soils.

Naimphulthong (2011) reported that the DDF soil on sedimentary rock at the Petrified wood forest park, Tak province, contained mainly fragmented rocks, gravels and pebbles, with some soil particles between them. The soil order varied from Order Ultisols to Alfisols. The DDF soil on granitic rock varied from very shallow to deep soil, and classified into Order Inceptisols to Ultisols (Wongin, 2011).

Seeloy-ounkeaw (2011) also investigated the soil characteristics in two pine-montane community forests at Nong Tao village, Mae Wang district, Chiang Mai province including conservation and utilization forests located on granitic rock. He described that these forests had very deep soils, more than 2 meters, Order Ultisols and Suborder Humults. They were acid soils with the high organic matter.

### 1.2.3 Carbon stocks in forest ecosystems

Carbon can be accumulated in various compartments of the forest ecosystem particularly forest biomass, organic layers on forest floor and soil system. Some studies have been carried out.

Ladpala and Junmahasatein (2006) studied carbon contents in stems and leaves of trees in MDF at the Maeklong watershed research station, Kanchanaburi province during 2003-2005. The average contents in stem and leaf of dominant species were 49.01 and 48.81%, respectively. The above-ground carbon stock was calculated as 91.27 Mg ha<sup>-1</sup>: 87.07 Mg ha<sup>-1</sup> in living part and 4.20 Mg ha<sup>-1</sup> in dead part. Variations of carbon contents with different tree height of same species were not statistically significant but significant difference among tree species were observed. The carbon contents of most species were lower than 50% except for *Xylia xylocarpa* and *Vitex peduncularis* (50.17%).

Diloksumpun et al. (2006) studied on carbon cycling in the DEF at Sakaerat, Nakhon Ratchasima province and the MDF at Maeklong, Kanchanaburi province. In 2003, carbon accumulations in above-ground and below-ground biomass in DEF were 145.56 and 68.41 Mg ha<sup>-1</sup>, respectively, whereas the MDF were in the order of 84.24 and 39.59 Mg ha<sup>-1</sup>. They were higher in DEF than MDF. Junmahasatein et al. (2006) found that the mean carbon storages in one-meter soils were 210.89 Mg ha<sup>-1</sup> for the DEF and 223.91 Mg ha<sup>-1</sup> for the MDF.

Pibumrung et al. (2008) investigated the carbon stocks in forest, reforestation and agricultural land of northern Thailand. The results revealed that the amount of total carbon stock of forests (357.62 Mg ha<sup>-1</sup>) was greater than the reforestation (195.25 Mg ha<sup>-1</sup>) and agricultural land (95.09 Mg ha<sup>-1</sup>).

Phonchaluen (2009) concluded about the carbon storages in Ban Sai Thong community forest, Lamphun province, in two sites for each of DDF and MDF including older conserved (site 1) and newly conserved (site 2) areas. The DDF in site 1 and site 2 had biomass of 119.83 and 47.65 Mg ha<sup>-1</sup>, respectively, which were calculated to be 59.16 and 23.50 Mg ha<sup>-1</sup> of carbon. The MDF in site 1 and site 2 had biomass of 207.22 and 62.73 Mg ha<sup>-1</sup>, and the biomass carbon amounts of 102.37 and 30.94 Mg ha<sup>-1</sup>.

Naimphulthong (2011) reported that the total carbon amount stored in forest biomass and soil of DDF on sedimentary rock at the Petrified wood forest park, Tak province was 46.31 Mg ha<sup>-1</sup>, 27.27 Mg ha<sup>-1</sup> (58.19%) in biomass and 19.04 Mg ha<sup>-1</sup> (41.11%) in soil. The DDF on granitic rock had the total carbon amount of 55.00 Mg ha<sup>-1</sup>, 23.78 Mg ha<sup>-1</sup> (43.00%) in biomass and 31.22 Mg ha<sup>-1</sup> (57.00%) in soil (Wongin, 2011).

Seeloy-ounkeaw (2011) studied carbon stocks in two pine-montane community forests at Nong Tao village, Mae Wang district, Chiang Mai province including conservation and utilization forests located on the granitic rock. The total carbon storages in conservation and utilization forests were 475.39 (biomass: 124.68 Mg ha<sup>-1</sup>, soil: 332.71 Mg ha<sup>-1</sup>) and 153.28 Mg ha<sup>-1</sup> (biomass: 69.01 Mg ha<sup>-1</sup>, soil: 84.27 Mg ha<sup>-1</sup>), respectively.

### 1.3 Research Objectives

- (1) To study differences in plant species diversity, soil characteristics and carbon stocks among subtype communities of the natural pine forest in Kunlaya Ni Wattana district, Chiang Mai province
- (2) To evaluate the roles of plant species diversity and soil characteristics on carbon stocks in the pine forest ecosystems

#### 1.4 Usefulness of the Research

The data about differences in plant species diversity, soil characteristics and carbon stocks among subtype communities of the natural pine forest are useful for the conservation and management of this forest. After we know that which subtypes have the high carbon storages in the ecosystems whereas the others may have the lower amounts, restoration of the poor communities is therefore required including planting of existing fast growing species to increase their population and density, inducing natural regeneration, fire protection, soil erosion prevention, controlling illegal cutting and harvest of non-wood products, etc. Identification of tree species as common, intermediate and rare species will be useful to have the program of species selection for seedling production and planting. A large amount of carbon storage in forest biomass is usually very rapid by the fast growing tree species. The restoration project is important for watershed management of the Royal Forestry Department and Department of Natural Parks, Wildlife and Plant Conservation.