CHAPTER 1

Introduction and Literature Review

1.1 Dry Dipterocarp Forest

The dry dipterocarp forest (DDF) is a deciduous forest distributed naturally on mainland of Southeast Asia; Burma, Laos, Vietnam, Thailand and India. This forest is scattered in the area of monsoon climate with a marked dry period more than 4 months a year and total rainfall ranges of 900-1,200 mm. per year (Nalampun *et al*., 1969). Four dominant xeric dipterocarp tree species are indicator of DDF; *Shorea obtusa*, *S. siamensis*, *Dipterocarpus obtusifolius* and *D. tuberculatus* (Smitinand, 1977; Kutintara, 1975). Many ecologists believe that fire is a limiting factor in DDF, and, thus, it is identified as the fire climax ecosystem. If no fire, the DDF might be changed to another forest type (Kuchler and Sawyer, 1967; Cooling, 1968). The forest fire usually occurs during December to April. The species composition and regeneration in the DDF is influenced by forest fire.

In Thailand, DDF occurs along the western mountain ranges from Petchaburi province up to the north, Chiang Rai province. The DDF covered extensively in northeastern region with alternative to Mixed Deciduous Forest (MDF). It is found in arid zone; drought, poor soil, heavy sand, gravels and rocks on top soil, between 50-1,000 m altitude (Bunyavejchewin, 1979). Natural regeneration and tree growth depend on soil properties and soil moisture. The good forest is usually found on sandy clay loam with slightly acid soil. Species diversity and primary production in the forest are lower than other forest types. Mostly plant production are obtained during rainy season and stopped in dry season. The good DDF was remained at Huai Kha Khaeng Wildlife Sanctuary in Uthai Thani province (Maksirisombat, 1997).

Charuphat (1998) reported that the DDF area in 1980 was 147,000 sq.km (47% of forest area), and decreased to 26,800 sq.km. (20%) in 1998. It was decreased approximately 6,677 sq.km. (1.5%) per year. Dhanmanonda (1994), found that the destroyed DDF needs about 60 years of gap-phase recovery, 62 years for building phase and 122 years more for development to climax forest.

The dry dipterocarp forests tend to be airy, with relatively clean under-storey and semi-open canopies. Species belonging to the Dipterocarpaceae comprise the predominant trees found in these forests.

1.2 Research Works on Dry Dipterocarp Forest

Many researches have been taken for the dry dipterocarp forest including forest structure, subtype community, soil characteristics, nutrient cycling and so on. However, more research are still needs according the variation with locations of this forest.

The DDF in Intakin Silvicultural Research Station, Chiang Mai Province, is a secondary forest recovered from logging in the past. The four dominant Dipterocarps; *S. obtusa*, *S. siamensis*, *D. obtusifolius* and *D. tuberculatus*. The forest gives benefits to local people as non-wood products particularly edible mushrooms, vegetables, edible insects, etc. Most forest areas are medium and deep soil with sandy loam texture, and has forest fire every year. Fortunately, an area of about 8 hectares has no fire for about ten years. Ecological changes are thought to be occurred in the non-fire forest including plant species diversity, soil properties, carbon sinks and nutrient accumulations, and so on.

Sukwong (1974) stated that the DDF usually has three vertical structure including upper, middle and lower canopy layers. The stem basal area of middle tree layer is normally higher than the upper and lower tree layers. In undisturbed forest, crown cover is about 70%, and light intensity at the forest floor is about 60-80% of full sun light. Stem size and height are varied with locations. The trees in this forest usually have good ability of sprouting from stump. Ground fire is common in this forest.

Sukwong and Dhammanitayakul (1977) and Smitinand (1977) described that deciduous forests in Thailand were abundant and their physical structures were generally classified into 3-4 strata depending on the locality of study area and soil fertility as well as climatic conditions. Sahunalu *et al.* (1979) and Boontawee *et al.* (1995) indicated that species diversity of MDF was higher than DDF.

Pamprasit (1994) study on relationship between plant associations and soil characteristics in DDF at 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 2.94-3.67

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

Ratree and Thammathaworn (2004) studied on ecology, diversity, survival, taxonomic identification and reproduction in Nong Rawiang DDF. Soil analysis data revealed that the soil was very poor. There were ten dominant tree species. Shannon-Wiener index of species diversity ranged from 1.25 to 2.12. It consisted of 35 species in 22 families.

Murray (1997) studied on plant species diversity of DDF at Chiang Mai Plantation Trial Station. He found that *D. obtusifolius* was the most dominance. The lower dominant tree was *S. obtusa*. Importance value index of these dominant trees were 21.6 and 17.9, respectively. It was the forest of low species diversity.

Kiratiprayoon *et al*. (1999) found that species richness in DDF at Doi Suthep was 102 species for trees of dbh above 4.5 cm. The ten common species included *S. obtusa, Aporosa villosa, D. tuberculatus, Gluta usitata, Quercus kerrii, D. obtusifolius, Tristaniopsis burmanica, Wendlandia tinctoria* and *S. siamensis.*

1.3 Effects of Fire on Dry Dipterocarp Forest

Forest fire is critical in mountainous areas. Most fire is caused by human. It gives a major contribution of air pollution during dry season in the northern Thailand. It is common in DDF, MDF and pine forest. The local people burn the forest for many purposes such as stimulating mushrooms and sprouting of wild vegetable, wildlife hunting, etc.

Annual forest fires are commonly experienced in the deciduous forest due to the dry conditions. Under these conditions, soil moisture during the dry season is reduced to around 50 percent of wet season levels. The yearly forest fires wreak havoc on both climax and pioneer tree species. If there are no forest fires for 10 years, regeneration will occur, but the original forest status will change. The number of new tree species per hectare is as much as nine times more than in the original forest (Sukwong, 1977).

Forest fire usually affects on tree growth. The wounds caused by fire will lead to disease and insect damage to wood. Annually fire makes the drought condition. This leads to decrease in tree growth, yield and wood quality (Kaitpraneet, *et al*., 1988).

Maksirisombat (1997) studied on effects of forest fire on plant species composition in the good DDF at Huay Kha Kaeng, Uthai Thani province. The forest consisted of dominant trees as *S. obtusa, S. siamensis, T. mucronata, Buchanania lanzan* and *T. alata*.

The deciduous forest has an inherent capability to recover from human disturbance. Roots of the deciduous forest remain viable after clear-cutting or fire. Within one year, these roots will produce new coppice growth. An average of 281 stumps per hectare will emerge. Within three years, up to 2,956 new stumps per hectare can be observed, comprising more than 47 species. This demonstrates the ability of the original plants in the deciduous forest to regenerate without having to rely on the seed-based reproductive systems of the trees (Sukwong, 1978).

1.4 Forest Biomass and Carbon Accumulation

Sahunalu *et al*. (1993) used the allometric equation of Tsutsumi *et al.* (1983) for biomass study in dry evergreen forest, and the equation of Ogino *et al.* (1967) in DDF. They found that the amount of soil organic matter 18.9 t/rai.

Carbon accumulations in the forest were depended upon annual biomass increment (Creedy and Wurzbacher, 2001). The rate of accumulation was decreased in the mature forest as the net primary production was declined. (Murty *et al*., 1996) Increase in wood litter had negative relation with amount and cycling of nitrogen which was further affected on growth and biomass increment (Zimmerman *et al.*, 1995) Clark *et al.* (2001) gathered the data on net primary production in tropical forests. They found that NPP had logarithmic relationship with amounts of litterfall and annual biomass increment.

Nuan-urai (2005) studied on carbon sequestration potential in aboveground biomass of DDF, MDF, DEF and moist evergreen forest (MEF) at Kaeng Krachan National Park. It was found that MEF had the highest above-ground carbon sequestration as 168.04$\pm$107.88 t/ha, where as those in DEF, MDF and DDF were 103.85$\pm$61.32, 34.26$\pm$24.18 and 29.31$\pm$9.17, respectively.

Carbon sequestration potential in above-ground biomass of dry dipterocarp forest, mixed deciduous forest, dry evergreen forest and moist evergreen forest at Kaeng Krachan National Park was estimated from above-ground biomass by forest inventory, tree diameter at breast height (DBH) more than 4.5 cm. Above-ground carbon sequestration was calculated by multiplying conversion factor as 0.5 of biomass. The results revealed that the highest above-ground carbon sequestration was accounted in moist evergreen forest as 168.04±107.88 tonne C/ha. While above-ground carbon sequestration in dry evergreen forest, mixed deciduous forest are 103.85±61.32 tonne C/ha, 34.26±24.18 tonne C/ha. and dry dipterocarp forest and 29.31±9.17 tonne C/ha, respectively.

Sunyaarch (1989) study on fire effected, the result showed that, the mortality after burning of undergrowths which include herbs, forbs, small shrubs and grasses was 100%. The average mortality of seedlings and saplings which the diameters at basal stem ranged from 0.5-4.0 cm, was 58.06%. The diameter at basal stem of the survived seedlings was 2.45±0.67 cm. The density of seedlings was increased after burning. Two year after burning, the densities of seedlings in single burn and double burn plots were increased at 800% and 348% respectively, but the seedling density of urban plot was decreased at 17.39%.The rate of height growth of the seedlings in urban plot was increased at 12.35 cm/yr (increased 23.57%), but the rates of height growth of seedlings in single burn and in double burn plot were decreased at 3.2 cm/yr (decreased 5.61%), and at 7.4 cm/yr (decreased 14.20%) respectively. The density of grasses in double burn plot was higher than those in single burn and urban plots. The density of herbaceous plant was shown an increasing trend in unburn plot. Species composition of undergrowth was highest in rainy season which was about 28 species and was lower in dry season which was about 10 species.

Himmapan and Kaitpraneet (2008) found that the forest fire had a little effect on growth and mortality of trees, but it affected to both growth and mortality of seedlings and saplings. The average height and stem diameter of sapling which immediately killing by fire were 4.20 m and 5.14 cm, respectively. The seedlings with diameter at ground level less than 0.50 cm were over 50% killed. The mortality dramatically increased one month after burning and most of the survival seedlings could recover through sprouting in the rainy season.

The losses of carbon and nitrogen by the forest fire were measured in a dry dipterocarp forest (DDF), northeast Thailand. The above-ground biomass of grass was increased from March to July during the rainy season and reached the peak of 5.8 Mg.ha^{-1} in July. Then, the biomass gradually decreased to 2.5-2.6 Mg.ha^{-1} at the end of rainy season. The nitrogen concentration in grass biomass decreased gradually from 1.7% at the beginning of rainy season to about 1% at the end of rainy season, and dropped markedly to 0.4% at the burning time in January. So about 60% of the peak nitrogen mass (45 kg.ha^{-1}) were lost or retranslocated from the above-ground biomass to below-ground. Carbon and nitrogen lost by the forest fire were 2.3 Mg.ha^{-1} and 28 kg.ha^{-1}, respectively. The occurrence of forest fire synchronized with the senescent period of grasses, resulting in the minor loss of nitrogen in the forest ecosystem (Toda *et al*., 2007)

1.5 Soils in Dry Dipterocarp Forest

Soils can be enormously complex systems of organic and inorganic components. Soil texture refers to the relative proportion of sand, silt and clay size particles in a sample of soil. Soil texture effects many other properties like structure, chemistry, and most notably, soil porosity, and permeability. Bulk density of a soil is the mass per unit volume including the pore space. Bulk density increases with clay content and is considered a measure of the compactness of the soil. The greater the bulk density due to the more compact the soil.

As dead plant material and decays it adds organic matter in the form of humus to the soil. Humus improves soil moisture retention while affecting soil chemistry. Cations such as calcium, magnesium, sodium, and potassium are attracted and held to humus. These cations are rather weakly held to the humus and can be replaced by metallic ions like iron and aluminum, releasing them into the soil for plants to use. Soils with the ability to absorb and retain exchangeable cations have a high cation exchange capacity. Soils with a high cation exchange capacity are more fertile than those with a low cation exchange capacity.

Parent material composition has a direct impact on soil chemistry and fertility. Parent materials rich in soluble ions-calcium, magnesium, potassium, and sodium, are easily dissolved in water and made available to plants.

Paowongsa (1976) found that the amount of litterfall in DDF at Sakaerat, Nakhon Ratchasima province was 4.66 t/ha/yr whereas that at Doi Saket district, Chiang Mai was 4.34 t/ha/yr (Hongthong, 1994).

Kafle (1996) compared two sites of DDF-oaks in Doi Suthep-Pui national park. One site had no fire for 28 years and another one had fire every year for investigating effects of forest fire protection on plant diversity, tree phenology, and soil nutrients. He found that species richness was higher in non-fire forest, but no statistic significance was observed between two sites. The amounts of phosphorus as well as soil temperature were higher in the fire forest. Other soil properties had no significant differences. However, mean soil moisture content in non-fire forest was higher.

Winichsorn (1997) studied the changes of vegetation and soil after control fire for seven years in Dry Dipterocarp Forest at Sakaerat in Nakhon Ratchasima province. The result showed that the number and the density of sapling species were increased but the densities of seedlings, shrubs, herbs and grasses were decreased; whereas, soil moisture content, cation exchange capacity, organic matter, calcium, magnesium, sodium, and sulphur were increased.

Charoenpol (2002) compared soil properties in the forests at Sakaerat. He reported that physical properties including soil porosity and moisture were the highest in DEF. Amounts of gravel and bulk density were the highest in the forest ecotone with DDF. Cation exchange capacity and base saturation were the highest in DEF soil whereas extractable phosphorus was the highest in DDF soil.

Effects of fire frequencies on soil properties in Dry Dipterocarp Forest were conducted at Tam Bon Sakaerat, Amphur Pak-Thong-Chai, Changwat Nakhon Ratchasima. After immediately burning soil moisture decreased by 53.57 percent while the bulk density, particle density, soil porosity, sand, silt and clay particles were relatively constant. Cation exchange capacity (CEC) and soil organic matter were increased by 31.00 and 9.52%, respectively. Soil pH was slightly increased after immediate burn. The plant nutrient increased after immediate burning, potassium was the maximum increased by 54.98%, and magnesium, calcium, phosphorus and sodium were increased by 47.76, 33.47, 7.82 and 1.05%, respectively. Sulphur content has 0.83 ppm after immediate burning while there was not sulphur before burning (Chansuk, 1990).

After five years study, soil moisture maximum increased by 44.57% in annual burn plot, and maximum decreased by 13.9% in quadrennial burn plot. The soil moisture was relatively constant in biennial burn, triennial burn and pentrennial burn plots. The bulk density in every plot did not change. The particle density in pentrennial burn changed the most proportion by 31.44% and the quadrennial burn changed the least proportion by 10.6%, the annual , biennial, triennial burn did not change. Soil porosity in the pentrennial burn changed the most proportion by 20.96%, the quadrennial burn changed the least proportion by 14.72% and the annual, biennial and triennial burn did not change. The sand particle in annual burn changed the most proportion by 14.77%. The remaining plot did not change. The silt particle in annual burn changed the least proportion by 62.59%, in quadrennial, pentrennial, triennial and biennial burn decreased 40.77, 32.15, 29.02 and 11.13%, respectively. The clay particle in triennial burn increased the most proportion by 35.65%, the pentrennial and annual burn plot increased 32.52 and 17.57%, but biennial, quadrennial burn plot did not change (Chansuk, 1990).

For soil chemical property, soil pH in every plot did not change. For organic matter in annual burn increased the most proportion by 19.41% and the quadrennial burn decreased the most proportion by 59.12%, the pentrennial, triennial burn decreased by 40.46 and 38.72%, respectively. The biennial burn did not change. For CEC, in annual burn increased the most proportion 20.01%, the quadrennial burn decreased the most proportion by 45.11%, the pentrennial and triennial burn decreased 24.64 and 20.45%, respectively. The biennial burn did not change. For phosphorus, in annual burn increased the most proportion by 53.85%, in biennial burn decreased the most proportion by 15.38% and the triennial, quadrennial and pentrennial burn plot did not change. For potassium, in annual burn increased the most proportion by 41.57%, in triennial and biennial burn increased by 31.57 and 11.57% and the quadrennial, pentrennial burn did not change. For calcium, in annual burn increased the most proportion by 120%, the triennial burn increased 55.27 and 35.92%, respectively. The biennial burn decreased by 13.39%, the quadrennial burn did not change. For magnesium, in every plot, the annual burn increased the most proportion by 128.12%, the triennial, biennial and quadrennial burn decreased by 13.46, 12.76 and 12.76% respectively. The pentrennial burn did not change. For sulphur, before burning, no sulphur in every plot, but after 5 years burn, sulphur was found in the biennial, triennial burn by 2 ppm, but the annual, quadrennial, and pentrennial burn, sulphur was not found. The result of five years study revealed that the annual burn has increased the plant nutrient the most proportion than other plots and the next most is the triennial burn (Chansuk, 1990).

1.6 Research Objectives

The objectives of this research are to investigate effects of forest fire on plant diversity, carbon sinks and nutrient accumulations in dry dipterocarp forest with and without fire at the Intakin Silvicultural Research Station, Mae Tang district, Chiang Mai province