CHAPTER 2

Research Areas and Methods

2.1 Research Areas

2.1.1 Nong Khai and Bueng Kan Provinces

The research areas were located in Phon Phisai district, Nong Khai province, and Rattanawapi district, Bueng Kan province. An altitude range of the areas was between 161 and 200 m m.s.l., with 1-7 % slope gradient. The parent rocks in the areas are shale, siltstone and sandstone.

Nong Khai province is situated in the northeastern Thailand, between 17^{o} 52’ N latitude and 102^{o} 44’ E longitude. It covers the total area of 7,332,280 km^{2} (733,228 ha). The total population is about 907,250. Most areas of this province are close to the Mekong river, and the opposite side is Laos People's Democratic Republic. The northern part of the province is close to the Mekong river. The eastern part is close to Ban Phaeng district, Nakon Phanom province. The western part is close to Pak Chom and Chiang Khan districts, Loei province. The southern part is close to Wanon Niwat district, Sakon Nakhon province, and Ban Dung, Pen and Ban Phue districts, Udon Thani province. On March 23, 2010 Nong Khai province was split into 2 provinces, Nong Khai and Bueng Kan.

Figure 2-1 Locations of Nong Khai and Bueng Kan provinces

2.1.2 Study Sites

The study sites included 1, 5, 10, 15 and 20-year-old rubber plantations (RRIM600 clone), and two natural forests on Phon Phisai and Chakkarat soil series. A total of 12 sites were selected for this research.

For Phon Phisai soil series, there were five sites of a series of rubber plantations, and one site of a dry dipterocarp forest. For Chakkarat soil series, the natural forest was a dry evergreen forest. Fortunately, these two natural forests were located inside the Nong Khai Rubber Research Center, Rubber Research Institute, Department of Agriculture. The original forests were very poor. After establishment of this station about twenty years ago, the forests are protected from tree cutting, and thus the forests are recovered nearly the same to the oldest rubber plantations in Nong Khai province. Therefore, these forests were used to compare the influence of rubber plantations on carbon storages.

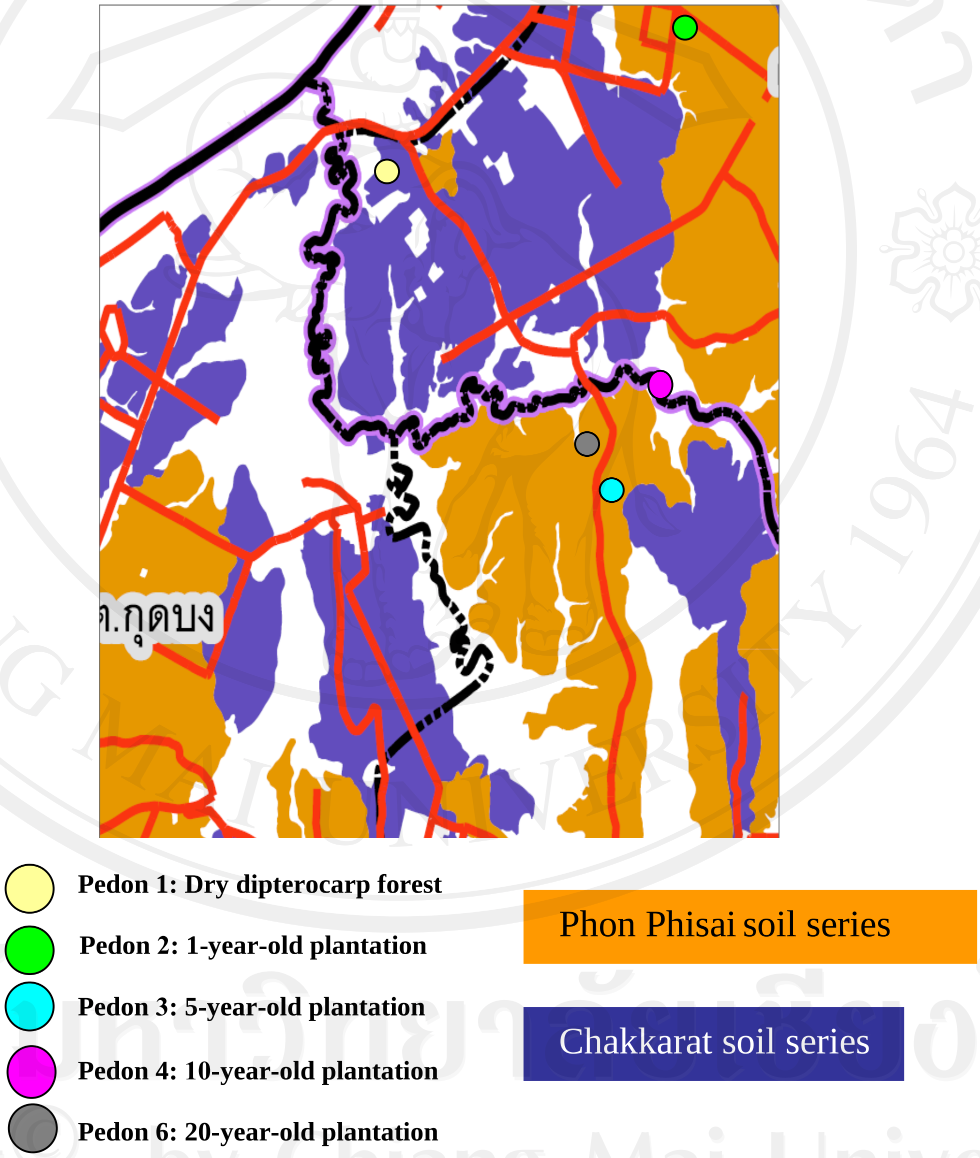

Figure 2-2 Locations of soil pedon 1-6 in Rattanwapi district, Bueng Kan province

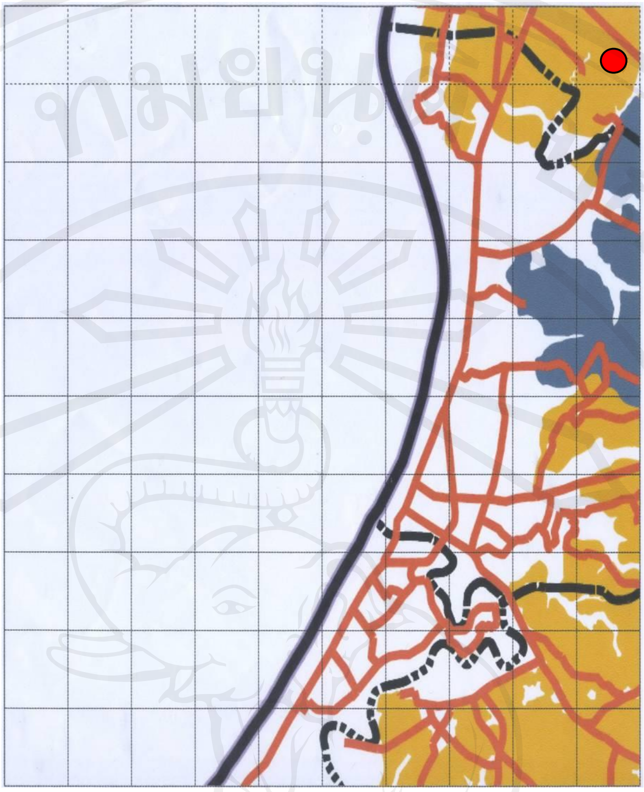

Figure 2-3 Location of soil pedon 5 in Phon Phisai district, Nong Khai province

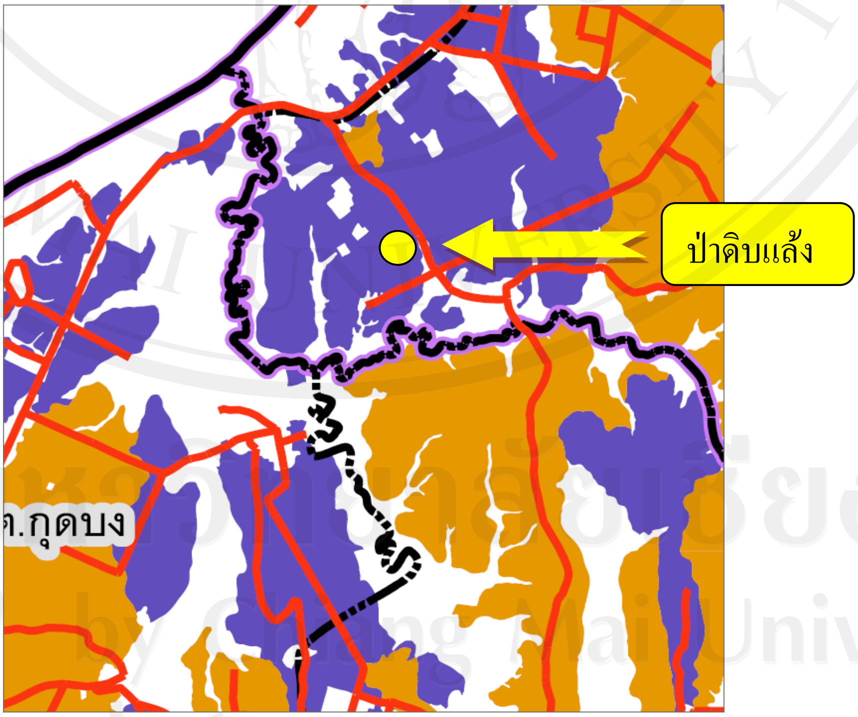

Figure 2-4 Location of soil pedon 7 in Rattanawapi district, Bueng Kan province

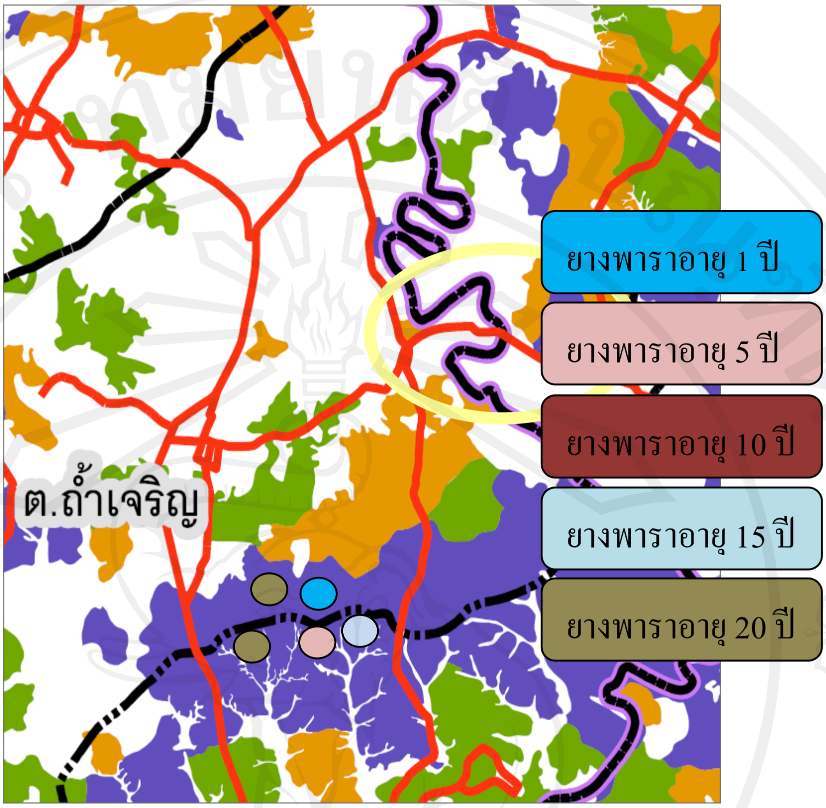

Figure 2-5 Locations of soil pedon 8-12 in Soopisai district, Nong Khai province

2.2 Research Methods

This research was divided into four parts; (1) the site selection of rubber plantations, (2) growth and biomass production of the rubber trees, (3) soil characteristics, and (4) carbon storages in the rubber plantations.

2.2.1 Site selection of rubber plantations

(1) Explore the para rubber plantations, the age between 1-20 years, and the natural forests in areas of Phon Phisai and Chakkarat soil series in Nong Khai and Bueng Kan provinces.

(2) Para rubber plantations, the age between 1-20 years in areas of Phon Phisai and Chakkarat soil series were selected as 1, 5, 10, 15 and 20 years old plantations, and two adjacent natural forests.

2.2.2 Growth and biomass production in rubber plantations and adjacent natural forests

2.2.2.1 Growth study

A. Rubber Plantations

(1) A total of 30 plots, 40×40 m^2 in size, were used for investigation of growth and biomass production of 1-20 years old rubber plantations in

Phon Phisai and Chakkarat soil series (3 replications for each of five age-class plantations with a total of 15 plots for each soil series). Five different age plantations including 1, 5, 10, 15 and 20 years old for each of soil series were selected for soil study.

(2) In each plot, all rubber trees were measured for stem girth at breast height (1.30 m above ground, gbh), tree height and crown width.

B. Adjacent Natural Forests

Two natural forests on Phon Phisai and Chakkarat soil series were used as reference natural ecosystems. In each forest, a 40×40 m^2 plot divided into 16, 10 x 10 m^2 subplots were made and located in a topographic map using GPS. Sampling of forest vegetation was based on a method of plant community analysis (Krebs, 1985). In each plot, stem girth at 1.3 m above ground and height of all trees with >1.5 m height were measured.

(a) Quantitative characteristics

The collected data were calculated for the following ecological parameters.

(1) Plant Density

$$\text{Plant Density} = \frac{\text{Number of individuals of species x.}}{\text{Total number of plots}} \quad \text{(individuals/plot)}$$

$$\text{Relative Plant Density} = \frac{\text{Number of individuals of species x.}}{\text{Total number of trees of all species}} \times 100$$

(2) Plant Dominance

The relative dominance value of tree species was calculated from the stem basal area.

$$\text{Relative Plant Dominance} = \frac{\text{Sum of stem basal area of species x.}}{\text{Sum of stem basal area of all species}} \times 100$$

(3) Important Value Index (IVI)

The ecological importance value index (IVI) is the sum of relative density and relative dominance. It is an integrated influence of a tree species in the forest. It can be expressed in term of relative IVI. In this study, only one plot was used. Therefore, the relative frequency was omitted. The IVI value varies between 0 and 200.

$$\text{IVI (200)} = \text{Relative density} + \text{Relative dominance}$$

$$\text{Relative IVI} = \frac{\text{IVI of species x.}}{\text{Sum of IVI of all species}} \times 100$$

(b) Qualitative Characteristics

All plant species in the sampling plots were listed for their scientific names. The trees were identified as common species, intermediate and rare species based on their ecological parameters.

2.2.2.1 Biomass and stored carbon studies

(1) Standing biomass of rubber trees in different age plantations

In each age-class rubber plantation, one individual of rubber tree which had the growth nearly the same to mean value in the plantation was cut for analysis of biomass. It was separated into stem, branch, leaf and root components using a stratified clip technique. The samples of stem wood, branch, leaf and root were later analyzed for carbon and nutrients.

The allometric equations were made from the sample cutting rubber trees in 1, 5, 10, 15 and 20 years old plantations on both soil series.

(2) Standing biomass of tree species in natural forests

For the dry evergreen forest, allometric equations of Tsutsumi *et al.* (1983) were used for biomass estimation.

W_S (stem) $= 0.0509\ (D^2H)^{0.919}$
W_B (branch) $= 0.00893\ (D^2H)^{0.977}$
W_L (leaf) $= 0.0140\ (D^2H)^{0.669}$
W_R (root) $= 0.0313\ (D^2H)^{0.805}$

when W = biomass (kg/ha)
D = diameter at 1.3 m above ground (cm.)
H = tree height (m)

For the deciduous forest, tree biomass was calculated by the equations of Ogino *et al.* (1967).

W_S (stem) $= 189\ (D^2H)^{0.902}$ (kg/tree)
W_B (branch) $= 0.125\ Ws^{1.204}$ (kg/tree) : $D^2H = m^3$
W_L (leaf) $= 1/(11.4/Ws^{0.90} + 0.172)$ (kg/tree)

Root biomass was calculated by equation of Ogawa *et al.* (1965).

$W_R = 0.026\ (D^2H)^{0.775}$: $D^2H = (cm^2.m)$

2.2.3 Soil properties and stored carbon in two series of rubber plantations

(1) **Soil characterization**: The two soil series, Phon Phisai and Chakkarat, under 1, 5, 10, 15 and 20 years old rubber plantations and two natural forests were characterized on the soil series map of Land Development Department using scale 1:100,000.

(2) **Soil sampling**: Three soil pits, 1.5×2×2 m in size, were made for each selected plantation, and soil samples were collected along the profiles based on a composite sampling method from the depth of 0-5, 5-10, 10-

20, 20-30, 30-40, 40-60, 60-80, 80-100, 100-120, 120-140, 140-160, 160-180 and 180-200 cm. One soil pit was used for soil development and taxonomy study according to Soil Survey Division Staff (1993); Land Classification Division and FAO Project Staff (1973) and Soil Survey Staff (1980).

(3) **Soil analysis:** The soil samples were analyzed in the Laboratories of Department of Agriculture and Faculty of Agriculture, Chiang Mai University.

(4) **Carbon-nutrient accumulations:** Amounts of nutrients per unit area including total C and N, extractable P, K, Ca, Mg and Na were calculated from their contents or concentrations and the amount of soil mass

A. Physical properties:

(1) Bulk density using a core method
(2) Soil texture and particle size distribution using a pipette method

B. Chemical properties:

(1) Soil reaction by using a pH meter; pH (H_2O) (soil:water = 1:1) (Mclean, 1982)
(2) Total N by using Micro Kjedahl method (Bremner and Mulvaney, 1982)
(3) Organic matter and carbon contents were analyzed by the wet oxidation method (Nelson and Sommers, 1982)
(4) Extractable phosphorus by using Bray II and Colorimetric method and read by Spectophotometer (Olsen and Sommers, 1982)
(5) Extractable potassium and sodium extracted by ammonium acetate solution 1N, pH 7.0 and read by a flame photometer (Knudsen and Peterson, 1982)
(6) Extractable calcium and magnesium extracted by ammonium acetate solution 1 N, pH 7.0 and read by an atomic absorption spectophotometer (Lanyon and Heald, 1982)
(7) Cation exchange capacity (CEC) extracted by ammonium acetate solution 1 N, pH 7.0 (Rhoades, 1982)
(8) Extractable acidity (EA) was extracted by using barium chloride-triethanolamine, pH 8.2 (Thomas, 1982)
(9) Base saturation percentage (BS%) is the amount of basic cations that occupy the cation exchange sites, divided by the total cation exchange capacity (CEC) (Soil Survey Staff, 1972)