CHAPTER 1

Introduction

1.1 Principles, Theory, Rationale and/ or Hypotheses

Climate change is now recognized as one of the most serious challenges to the people, the environment and its economies of the world (EC, 2008). Most scientists agree that the anthropogenic cause of increment of green house gas (GHGs) in the atmosphere is the main cause of the - climate change incidences experienced (Robledo and Forner, 2005). The emissions of the GHGs that result from human activities, in particular land use changes such as deforestation in developing countries, and the burning of fossil fuels specifically from developed countries, are major causes. Emission of greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs) have grown since the industrial times, with an increase of 70% between 1970s and 2004 (IPCC, 2007). The rapid increase of atmospheric CO_2 in the recent decades is well documented and changes in the earth climate, due to the "enhanced greenhouse effect", are of growing concern. Therefore, mitigating the increase in atmospheric concentrations of CO_2 necessitates identification of options including: (i) reduce emissions by using low-carbon or no-carbon fuel sources, (ii) enhance energy use efficiency by minimizing losses, and (iii) sequester atmospheric CO_2 into solid carbon reservoirs with secure storage and long residence time (Lal, 2008).

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There is also evidence that with current climate change mitigation policies and related sustainable development practices, global GHGs emissions will continue to grow over the next few decades. The industrial lifestyles of rich countries accounts for the majority of majority fossil fuels burnt, contributing approximately 80% of total GHGs emissions into the atmosphere. In contrast people of poor countries contribute only about 20% of total emissions through the land use change and deforestation (Robledo and Forner, 2005; UNFCCC, 2007).

Forest degradation and deforestation are major contributors to global climate change accounting for at least 15% of total anthropogenic CO_2 emissions (Boucher, 2008). Tropical forests store about 17% of the total carbon contained in all of Earth's terrestrial vegetation. The pan-tropical average works out at about 240 tonnes of carbon stored per hectare, split more or less equally between the trees and soils (IPCC, 2000).

At the end of 2007, the parties to the United Nations Framework Convention on Climate Change (UNFCCC) confirmed their commitment to address the global climate challenge through the Bali Action Plan 6 and the Bali Road Map 7 for an agreement were completed at the Conference of the Parties (COP) to the UNFCCC in Copenhagen at the end of 2009. Their agreement includes reference to **emissions from deforestation and forest degradation - known as REDD**). Those discussions began with RED (i.e., limited to deforestation only) and expanded to REDD with consideration of forest degradation, then broadened to further consider forest conservation, sustainable forest management, and enhancement of forest carbon stocks (REDD+). Mitigation activities potentially included under REDD are changing in forest area (hectare) by reducing deforestation and enhancing afforestation and reforestation (Angelsen and Wertz-Kanounnikoff, 2008).

Whilst forest degradation and deforestation increase atmospheric carbon dioxide, forest restoration can absorb it and increase not only the current terrestrial carbon pool, but also the capacity for future carbon absorption. Forests play an important role in global carbon cycle. Carbon sequestration of by forests varies in different vegetation types and with forest age or successional status. Carbon storage in forest ecosystems includes both biomass and soil carbon. The soil carbon pool is twice as large as that of the atmosphere and is climate-dependent (IPCC, 2001). Forest soils play an important role in the global C cycle (Jobbagy and Jackson, 2000).

Inputs of carbon into the soil pool through litterfall is closely related to tree species composition, age structure, growth rate and productivity (Scherer- Lorenzen *et al.*, 2007). Litterfall increases rapidly in the first years of succession (Ewel, 1976); once the canopy is closed, however, there is no obvious trend in litterfall production with increasing stand age

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(Ostertag *et al*., 2008), species richness (Scherer-Lorenzen *et al*., 2007), or diversity (Wardle *et al*., 1997). Litter input to forest soil can be derived from forest biomass with biomass turnover rates (e.g. Starr *et al*., 2005; Liski *et al*., 2006).

Although much research has been done on carbon sequestration in mature forests (Chidthaisong and Lichaikul, 2005; Janmahasatian *et al*., 2005; Pibumrung *et al*., 2008; Timpan, 2008; Khamyong, 2009; Phonchaluen, 2009; Satienpirakul *et al*., 2013; Chaiwong *et al*., 2013) and in plantations (Poolsiri, 2005; Chidthaisong and Lichaikul, 2005; Pumijumnong, 2007; Tangsinmankong, *et al*., 2007; Pibumrung *et al*., 2008; Meungpong *et al*., 2010) particularly with regard to above ground carbon, little attention has been paid to the potential for forest restoration to sequester carbon, particularly in the soils. Furthermore, soil organic matter is a major contribution to the soil nutrient pool required for maintaining soil fertility, plant growth and ultimately the capacity for forest regeneration. Therefore, increased understanding of the dynamics of litterfall and accumulation of soil organic matter can ultimately lead to better forest restoration strategies.

Therefore, my research was focused on below-ground accumulation of carbon in litter and soil in forest restoration plots, established by the framework species method, making use of a system of plots of known ages and species composition established by Chiang Mai University's Forest Restoration Research Unit annually since 1997.

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Since 1994, the Forest Restoration Research Unit (FORRU) of Chiang Mai University has been assessing the suitability of the framework species approach for restoring seasonal evergreen forest (*sensu* Maxwell and Elliott, 2001) on degraded land in the highland of northern Thailand (FORRU, 1998, 2000). The framework species method involves planting a mixture of 20–30 pioneer and climax native tree species (Elliott *et al*., 2003). Furthermore, framework species should be easily propagated in nurseries, with features such as reliable seed availability, rapid and synchronous germination and growth of seedlings to a plantable size (50–60 cm) in less than 1 year (FORRU, 1998, 2006, 2008).

Best-performing framework tree species have been identified (Elliott *et al*., 2003) and optimal silvicultural treatments determined, to maximize survival and growth rates after planting (Elliott *et al*., 2000; FORRU, 2006). Essential characteristics of framework species are: (i) high survival and growth rates in open degraded site; (ii) spreading and dense crowns that shade out herbaceous weeds and (iii) providing fruits, nectar and nesting sites that attract seed-dispersing wildlife at an early age (Goosem and Tucker, 1995).

1.2 Objectives

The objectives of this research were to evaluate litter accumulation and determine soil carbon stock in forest restoration plots in different ages compared with both natural forest and non-restored sites. The objectives also included developing predictions of soil carbon stocks through forest restoration using the FullCAM model.

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