CHAPTER 1

Introduction

Worldwide, deforestation and forest degradation are occurring at alarming rates, affecting about 13 million ha per year estimated in 2005(FAO, 2010). The main cause is conversion of forestland to agriculture and for infrastructure development (FAO, 2010). On the other hand, worldwide forests cover is about 4 billion ha (FAO, 2010). In the 1990s, Asia was estimated to have an annual net loss of forest of 800,000 ha (FAO, 2007). Also in 1990 to 2005, forest cover in Southeast Asian declined from 245 to 203 million ha, (annual rate of deforestation estimated at 2.8 million ha from 2000 to 2005 (FAO, 2007).

The northern provinces of Thailand were once densely forested, but over the past 100 years, natural forest cover has declined significantly (Walker, 2002), due to swidden agriculture, unregulated logging and fires (Schmidt-Vogt, 2001). Despite a commercial logging ban since 1989, eight kinds of infrastructure developments have also been responsible for wiping out over 480,000 hectare of forest over the past four decades, or 10% of forest land loss in the past 40 years. Of particular relevance to this study - 77,128.96 ha of forest have been destroyed by mining. (http://www.bangkokpost.com/lifestyle/family/374915/clearing-the-way).

The primary driver of deforestation in this region is increasing population and the consequent need for agricultural land, while secondary drivers include national laws and policies related to socioeconomic development (Pinthong, 1992; Ganjanapan, 2000; Jamarik & Santasombat, 1993).

Extractive activities such as mining and the infrastructure development are also significant causes of deforestation (FAO, 2010). All levels of the mine excavations can result in changes to forest types, which in turn can impact on local biodiversity. Thailand is a significant producer of lignite, which is used almost exclusively for power generation. Around 1,354 million tons of coal is produced within 16 districts of Northern Thailand, which is mostly ranked as lignite or sub-bituminous coal. Total national lignite production is around 21 Mt/y. Mining has huge adverse effects on the surrounding environment, including removal of topsoil and overburden, and changes in topography, streams and vegetation. Therefore, land reclamation is required according to Thai Government rules (Sivavong and Limkitisupasin, 2005).

The study site for this project was Siam Cement Group (SCG) lignite mine in Mae Than village, Sop-Prap Sub-district, Mae Than District, Lampang Province. SCG initiated a reforestation project in 2008 (*c.* 2 ha) and in 2011 FORRU assisted with another planting (*c.*1.5 ha).

Research on forest rehabilitation has often focused on the role of tree plantations in accelerating secondary succession in altered areas (Parrota, 1992; Lugo, 1997), while the most ambitious goal of restoration is reestablishment of the original forest ecosystem (Lamb, Erskine, & Parrotta, 2005). Many countries have been undertaking reforestation for economic development and the provision of environmental services (FAO, 2010a). More commonly, reforestation has been carried out using large- or small-scale plantation monocultures. Most of these plantations consist of exotic species and most involve very few tree species. For example, a limited number of species from just four genera (*Acacia*, *Eucalyptus*, *Pinus* and, *Tectona*) account for the majority of tropical plantations (Lamb & Gilmour, 2003). Although many of these plantations have been productive and generated goods, such as pulpwood, few provide the variety of goods (e.g. timbers, medicines, and foods) once provided by the original forests to the people living in these areas (Lamb, *et al.*, 2005). In addition, their simple composition and structure rarely contribute significantly to biodiversity conservation (Lamb & Gilmour, 2003) and a steady flow of ecosystem services (Guariguata & Balvanera, 2009).

In recent years, new forms of reforestation may offer alternative ways of dealing with degraded tropical forest landscapes. Two broad approaches have been tested; one is to use a small number of fast-growing but short-lived tree species to create canopy cover, whilst additional native species reach the site by natural seed dispersal from nearby intact forest (Lamb, *et al*., 2005). This is the most successful strategy, since it simultaneously enhances seed dispersal, improves soil and microclimatic conditions and shades out aggressive herbaceous vegetation (Holl & Kappelle, 1999; Martinez-Garza, *et al*., 2005) but it only works where mature forest and seed dispersing animals still exist nearby. Another approach uses a much greater number of species, representative of more mature succession stages and bypasses the natural succession sequence (Lamb, *et al*., 2005). This approach requires sufficient ecological knowledge to be able to collect seeds and germinate large numbers of seedlings from a wide variety of species (FORRU, 2008a) and the key limitation is its high cost (Erskine, 2002).

Tree planting is a relatively high-cost technique to recover the ecosystem and biodiversity and it requires high labor inputs. Direct seeding is potentially of greatest use where establishment costs are more important than growth rates. It can significantly reduce the cost of planting seedlings, because labor and time for raising seedlings in nurseries are not required. If this technique is proved to be efficient, it may be particularly useful for steep slopes or otherwise inaccessible areas, where transportation of seedlings is difficult, as well as for rural montane communities with limited funding and other resources to establish and manage tree nurseries (Woods and Elliott, 2004).

Over the last 50 years, direct seeding has gained in importance, especially in North America and China, where large area have been direct seeded from helicopter or airplanes (Ochsner, 2001). Furthermore, it is widely used for broad-scale re-vegetation projects such as mine land rehabilitation (Dalton, 1993).It can be undertaken in many ways such as broadcasting (seeds are broadcasted by hand or by machine), drilling (using a seed drill), pitting and seeding (by hand or machine) and imprinting (by a large heavy drum) (Bainbridge, 2007). It can also be used in deserts and dry land (Bainbridge, 2007), abandoned agricultural lands (Engel and Parrotta, 2001; Woods and Elliott, 2004), in agro-forestry systems (Mandal and Nielsen, 2004) and for restoration of rainforest species (Doust *et al.*, 2006).

Direct Seeding is constrained by the need for adequate soil moisture and effective weed control. Whilst it is likely that creating optimum conditions for germination and early seedling growth around direct seeded seeds increase the efficiency of the technique, little field research has been done on the effectiveness of soil conditioning materials (biosolids, sewerage sludeg, compost etc). Consequently, this project tested the effectiveness of direct seeding of framework species in a lignite mine site, and determined whether soil conditioners could substantially improve success rate.

1.1 Hypotheses:

1) Direct seeding of framework species is an effective and cheap method of establishing trees on decommissioned lignite mines.

2) Soil conditioners increase the effectiveness of direct seeding on mine substrates.

1.2 Objectives:

To test the effectiveness of direct seeding and soil conditioners to establish framework tree species and restore forest ecosystems at a completely barren open-cast lignite mine in Lampang Province, Thailand.