CHAPTER 1

Introduction

1.1 Historical Background

Tropical forests have been severely degraded, mainly due to anthropogenic disturbances. This critical reduction in forest cover is a major driver of biodiversity loss and is having a substantial impact on the global climate. Therefore, degraded forest land should be restored back to forests, as quickly as possible, to bring back ecosystem services and functions (Lamb et al., 2005).

Forest restoration practices vary greatly, depending on the initial degree of degradation, the type of the target forest to be restored, climatic conditions and surrounding landscape factors. However, restoration is possible, even under the harshest of conditions, such as those on mine sites (e.g. Fields-Johnson et al., 2012). Techniques vary from relying on natural regeneration, assisting (or accelerating natural regeneration (ANR) to planting the maximum number of tree species (Miyawaki, 1993) or planting seedlings of a few (20-30 species) functionally significant native tree species to foster natural regeneration: the so-called “framework species method” of Goosem and Tucker (1995). The latter involves selecting species with high field performance, ability to shade out weeds and provision of resources to attract seed-dispersing animals at the early stage. The framework species method was originally conceived in Queensland, Australia, for lowland rain forests and has been successfully modified to restore seasonally dry tropical forest in northern Thailand by Forest Restoration Research Unit, Department of Biology, Chiang Mai University (FORRU-CMU) (Elliott et al., 2013). The method has been successful at attracting seed-dispersing birds into restored areas (Wydhayagarn et al., 2009), which promote rapid diversification of the understory.

Forest restoration mostly involves planting trees in degraded land. Propagating trees in nurseries is costly in terms of labour, time, equipment, irrigation systems etc. Hence, establishing forest from seeds should reduce costs and allow sites, without a nearby nursery, to be restored. Although, direct seeding could potentially improve the cost-effectiveness of forest restoration, it does not work for all desired species. Seed size plays a vital role in seedling establishment success, with larger seeds having higher establishment rates than smaller ones (Doust et al., 2006; Doust et al., 2008; Tunjai and Elliott, 2012). However, small seed-sized species can be established, if diseases are prevented at the establishment stage (Kuaraksa and Elliott, 2013).

Seed predation can prevent seedling establishment. Ants are a major cause of predation in abandoned agricultural land in northern Thailand (Woods and Elliott, 2004). Rodents are also major seed predators e.g. of *Quercus* species (Birkedal et al., 2009). Hence, burying seeds usually reduces seed losses due to predation (Woods and Elliott, 2004) and increases establishment rate (Doust et al., 2006; Doust et al., 2008). In field trials, which compared performance of direct seeded trees with nursery-raised ones, the former grew faster than the latter over one year after planting (Tunjai, 2005). However, so far, few framework trees species have been tested like this and further experiments are needed to identify a wider range of species that perform well from direct seeding.

In Thailand, direct seeding has only been carried out using species, that produce seeds just before the optimum direct seeding time (which is 4-6 weeks into the rainy season i.e. mid-June in northern Thailand, FORRU, 2006). Direct seeding could have wider applications if seeds, produced at other times of the year could be stored until the optimum direct seeding time, or if the method could be implemented at other times of the year with good results. Most studies have avoided or ignored the risk of seed storage on the overall outcome of direct seeding (Doust et al., 2006; Doust et al., 2008; Tunjai and Elliott, 2012). Only a few studies investigated the effects of different seed sowing times on seedling establishment (beginning and late rainy season of sowing) and no similar study has been performed in seasonally dry tropical forest ecosystems, where seasonal variation in weed growth is much more marked.

Most tropical forest seeds cannot be stored for long periods, without considerable loss of viability (Doust et al., 2006; Doust et al., 2008; Tunjai and Elliott, 2012). The seed storage behavior of framework species should be studied, since it could be applied to aerial seeding, storing seeds as genetic resources, or providing a seed supply when trees fail to fruit. Hence, it is important to know how long seeds can be stored and under which conditions.

1.2 Research Objectives

1. To determine optimal seed storage conditions of native tree species, from fruiting times to optimal direct seeding time.
2. To compare direct seeding success between seeds sown at the time of seed collection and those stored until the optimum direct seeding season.
3. To compare direct seeding with conventional tree planting.
4. To develop treatments to improve direct seeding success.

1.3 Usefulness of the Research

1. This study will help to develop novel and effective techniques to restore tropical forest ecosystems. It will help to meet the increasing demand for technical knowledge of forest restoration since REDD+ included "enhancement of carbon stock" as a valid mitigation mechanisms for global climate change.

2. The framework species approach meets the stipulation that forest restoration must include biodiversity recovery and meet the needs of local people for a diverse range of forest products, since the method places strong emphasis on diversity.

3. To improve direct seeding by enabling wider species choices and developing protocols that will make forest restoration more feasible over large areas and thus enable forest restoration to contribute significantly towards climate change mitigation.

4. Understanding seed storage can be applied to developing aerial seeding methods and maintaining genetic diversity, through access to stored seeds. It will also make forest restoration possible even where seeds are unavailable from nearby forests.