

## CHAPTER 6

### Conclusions and Recommendations

#### 6.1 Conclusions

1. The intensity of seed removal varied greatly, depending on seed characteristics, particularly seed size and ability of animal to access the sowing seeds. Tree species with seed size ranging from 0.024 to 4.247 g had average seed removal of  $18.22 \pm 2.64$  percent. On the other hand, large seeded species, *H. glabra* suffered up to 100 percent seed removal, when the seeds were not protected from vertebrates.

2. Vertebrates played a major role in seed removal in comparison to insects. Camera trapping showed that rats (*Rattus* sp.) were the most abundant in the study site. The animal visits to study site peaked after seeds were sown. In addition to vertebrates, insect seed predators included ants (Order Hymenoptera) and insects in Order Coleoptera may also remove and/or damage seeds.

3. Seed germination varied among species and germinability was not affected by exposure to vertebrate and invertebrate species. In this study, *A. kurzii* and *P. cerasoides* had high percent germination in the field. All remaining seeds of *H. glabra* failed to germinate because of low viability before sowing. The variation in germination among species is influenced by seed characteristics that are associated with germination requirements.

4. In term of seedlings, average cotyledonous-seedling and leafy-seedling mortality across species were 4.62 and 21.40 percent, respectively. Caging seedlings significantly reduced percent mortality of cotyledonous-seedling. The finding indicated that vertebrates were the major cause of cotyledonous-seedling mortality. On the other hand, predator-exclusion did not reduce the mortality of leafy seedlings. The effects of herbivores on seedling mortality may differ among plant ontogenetic stages.

5. The study can be applied to species selection for direct seedling. The most excellent tree species was *P. cerasoides*, low seed predation, high percent germination, high seedling survival and relative growth rate. For two species, *A. kurzii*, *C. axillaris*, seed removal was low but they may require pretreatments to increase their ability to germinate and survive. Among studied species, *H. glabra* and *H. dulcis* were considered the least favorable for direct seeding. *H. glabra* had high seed predation and had recalcitrant seeds (See in Chapter 4, Table 4.5), while *H. dulcis* had low germination and low seedling establishment. The two species may be appropriate to germinate in the nursery and to use in the conventional tree planting method.

## 6.2 Recommendations

1. For direct seeding, site preparation should include surveying of potential seed predators before direct sowing. Different sites might have different types of natural enemies (Birkedal *et al.*, 2010). A better understanding of species and animal dynamics in the area will guide appropriate site preparation and management plans.

2. To reduce the probability of seed predation, techniques to accelerate germination rate should be applied. Seed pretreatments may include removing seed coat or testa, seed soaking in acid or water, etc. before sowing seeds in the area. Selecting pretreatment methods depends on species and characteristics of seeds (Mng'omba, *et al.*, 2007). Increasing of seed germination rate enhance plant survival and success rate on seedling establishment in the area (Tunjai and Elliott, 2012).

3. Protecting seeds from predators is necessary for large seeded species. Seed protection may be seed burial deeper in the soils (Doust *et al.*, 2006). In addition, seeds may be coated by clays or other materials and chemicals that help deter seed predators. An example could be urine of carnivores that prey on seed predators. The smell of carnivores may scare off seed predators. Selecting appropriate seed protection techniques for different species is an important topic for future research.

4. Direct seeding is appropriate for some tree species. For species that fail to establish by direct seeding method, conventional tree planting may be better for those species. Alternatively, a combination of direct seeding and conventional tree planting may be implemented.

5. The conservation carnivores will help to control populations of major seed predators, such as rats. For instance, the leopard cat is predator of small rodents.

6. For future research, the study of factors affecting seedling mortality will guide site management. Other natural enemies such as fungi and pathogen can be the cause of seed destroyed or seedling mortality. For conventional tree planting, seedlings were raised in tree nurseries and healthy seedlings are selected to plant in the target area. In comparison to conventional tree planting, small seedlings from direct seeded method may be more vulnerable to pathogens attack. If we have information about seedling losses due to different causes, we can estimate how many seeds need to be sown and whether additional treatments are necessary to prevent seedling mortality.



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