Extended abstract No. 261

BARRIERS TO SEEDLING REGENERATION IN FIRE-DAMAGED TROPICAL PEATLAND OF BRUNEI DARUSSALAM

Dr. Hjh Dulima Jali
Department of Geography and Environmental Studies, Faculty of Arts and Social Science
Universiti Brunei Darussalam, Tungku Road, BSB, Brunei Darussalam
Tel: +6738925000; dulimah.jali@ubd.edu.bn

SUMMARY

Identifying the barriers to seedling establishment is essential as such knowledge would be useful to assess and interpret the spatio-temporal variability in vegetation post-disturbance performance and to design effective rehabilitation strategies. In this study the growth of five planted timber species *Shorea spp, Dryobalanops rappa*, and *Agathis alba* and other naturally established peatland saplings were monitored for three years. The results show that several interacting factors impose barriers to the growth and survival of these seedlings and arrest their natural succession, namely, competition from ferns and grasses, lack of seed dispersal mechanisms and habitat physical conditions, particularly the hydrological regime. It also highlights the need for management intervention in restoring floristic diversity. Application of Assisted Natural Regeneration (ANR) offers a potential approach that can accelerate natural successional processes by removing or reducing barriers such as competition with weedy species, manipulation of tree stands and addressing the recurrence of fire.

KEY WORDS: Degraded tropical peatland, barriers, seedlings establishment, assisted natural regeneration.

INTRODUCTION

The potential barriers to natural forest regeneration are numerous and have been discussed in many publications, but reports on the succession and regeneration in tropical peatland ecosystems are few. Many studies throughout the neotropics of tropical forests have shown that a number of interacting factors may impede tropical forest natural regeneration. These include seed dispersal limitations, competition from grasses, fire, drought and low soil nutrient availability (Uhl et al.,1988; Holl *et al*. 1999; Wijdeven & Kuzee 2000; Zimmerman et al., 2000; Hooper et al., 2005). For effective and realistic management planning, it is essential to understand the regeneration and succession mechanisms and the ecological dynamics of an ecosystem. Knowledge of the interactions ecological factors is essential for the interpretation of the high spatial-temporal variability found in post-fire species performance and such knowledge is necessary to assess the potential of different regeneration mechanisms to cope with ongoing land-use and climate change. The goal of this project is to develop a better understanding of the underlying ecological processes in regeneration of fire affected peat swamp forest of Batas, Brunei Darussalam with the primary aim to investigate what are the barriers to the colonization and natural regeneration of the plant communities in burnt areas that have been invaded by ferns and sedges. It is hypothesized that the site hydrological regime and competition from ferns, grasses, sedges and other weeds are the main barriers to seedling establishment and halt natural forest regeneration. It is hoped that

the findings will add to the pool of knowledge on peat forest regeneration and aid management and rehabilitation of damaged peatland ecosystems.

STUDY SITE

This study was conducted in the Belait - Badas Peat Swamp, in Brunei Darussalam (4°15'-4°39'N, 114°05'-l14°29'E) an area of state land statute under the jurisdiction of the Forestry Department of Brunei. This peatland, covering about 950 km^2 in area, situated between a large loop of the River Belait and the littoral fringe along the coast, with peat depths ranging frequently from 10 to 15 metres. The greater portion of forested peatland in Brunei is preserved and spared from exploitation, therefore relatively pristine, although some 10 – 30 per cent of the area has been burned and converted to other uses such as infrastructure, housing, logging and oil exploration/production.

Brunei has an Equatorial Oceanic Climate which is characterised by uniform temperature, but a somewhat more marked fluctuation in rainfall, humidity and wind velocities. The mean annual rainfall is 2800 mm. At any time of the year heavy rainfall may occur anywhere. Equally, there may be dry spells, although these are not regular or long. The effect of topography on the rainfall distribution is marked. The highland areas of the interior receive the highest rain, averaging about 4000 mm annually, while near to the coast average annual rainfall is 2600 mm.

MATERIAL AND METHODS

Two study sites of 0.5 ha each that represent different hydrological condition were selected. One site is located on the edge of the peatland dome with the water table near the surface (<20 cm below the surface) during dry period. The second site is located on the much drier central part of the peat dome.

In each site five transects 100m long were constructed for experimentation. Each transect was about 10m apart. Along each transect, three quadrats (5 x 5 m) were set up at midpoints about 10, 50, and 100m from the forest edge. In each quadrat seedlings of several timber (*Shorea pachyphylla, Shorea teysmanniana, Shorea platycarpa, Dryobalanops rappa* and *Agathis alba)* and non-timber tree species (*Podocarpus spp, Dyera lowii, and Combretocarpus rotundatus*) were planted. Each plot was prepared for the three treatments: cutting the fern and grasses once before planting, cutting every month and control (no cutting). Treatments were implemented by hand-cutting the grasses and fern. All plots were subdivided into 4 sub-subplots with a 0.5m trail between them to facilitate measurement of tree seedlings and cutting the grasses and fern without damaging the tree and shrub regeneration. The growth of planted seedlings and naturally established tree saplings within these plots were monitored at monthly intervals for three years. Seedlings and saplings encountered was identified to species where possible and marked.

RESULTS AND DISCUSSION

There are marked differences in the composition and density of regenerating woody species between the two sites. The plant community's successional direction is clearly dictated by the hydrological conditions of the site, particularly the depth of the water-table. In the wet sites, several species dominated, for example, *Tetractomia beccari, Eugenia spp, Litsea spp,*

Horsfieldia crassifolia, that regenerate naturally. It is apparent that the wet condition hampers the vigorous growth of ferns (*Pteridium aquilinum, Dicranopteris curranii and Nephrolepis biserrata*) and sedges and grasses (e.g. *Scleria purpurescens and Mnesithea sp.*). Most regenerating tree saplings and seedlings such as *Melastoma malabathricum,* and *Barringtonia cemosa* died during prolonged flooding. This indicates that the hydrological regime in normal years is suitable for establishment of these species, but exceptionally deep and prolonged floods, occurring once every few years, can significantly slow down the regeneration process.

In the drier site, early post fire colonizers *Stenochlaena palustris, Pteridium aquilinum and Blechnum indicum* grow vigorously and cover almost the entire surface with their strangling stems or dense leaves, which significantly hamper the establishment and growth of seedlings. At least five species of plants - *Teminius, Horsfieldia, Syzygium, Ficus and Uncaria spp* have the capacities to germinate directly within the less dense stand of ferns and grasses, indicating these species have high competitive ability and adaptability to a wide range of abiotic circumstances.

Although environmental conditions greatly influence vegetation regeneration, competition with ferns and grasses are equally critical. If seedlings manage to establish among the ferns their growth rates are significantly reduced as the seedlings are overgrown and remain covered and hidden between the ferns, resulting in deformed stems. This condition is clearly demonstrated by the planted seedlings, especially *Agathis*. Seedling growth is boosted as soon as ferns are removed. Controlling the growth of ferns and grasses caused significant changes in the species composition as more seedlings appear particularly *Teminius* spp and several species of *Ficus, Eugenia, Calophyllum* and *Uncaria*.

Ferns and sedges have inhibitory effects on the regeneration of woody vegetation by forming thick impenetrable thickets. They have several characteristics that make them strong competitors such as by their ability to produce large amounts of spores that are easily dispersed by wind. Many pioneer fern species have high ecological amplitude and high growth rates, characteristics that enable them to rapidly colonize fire-degraded areas, and they can often recover quickly from burning and flooding damage. These attributes make the establishment of other species very difficult. For example, *Stenochlaena palustris* prevented the establishment of very young seedlings by their dense growth as well as their ability to compete for light and space with higher trees by climbing up to a height of five metres. Similarly, *Dicranopteris curanii* and *Pteridium aquilinum* can grow up to 3 m high casting dense shade. During favourable condition, such as occurrence of rain after a period of rainless days fronds of these ferns grow up to 40 cm per week.

Lack of seed is another vital factor that hampers natural colonization of forest species. This is indicated by the increasing number of regenerating forest species nearer to undisturbed forest. The number of species and the populations were higher nearer (< 50 m) the forest edge compared to the plot further (>100 m) down. The seed bank is likely to be exhausted by fire because the organic nature of the substrate produces intense heat that destroys any available seeds. The rapid growth of early colonizer of fern and sedge communities limits dispersal activities because grasses and ferns offer few resources that attract seed dispersers, particularly birds and small mammals. Seeds dispersal therefore appears critical in determining the diversity, density, and location of natural regeneration.

The existence of surviving timber trees also showed some influence on the regeneration processes. These survivors appear to facilitate recolonization as indicated by the appearance

of several different seedlings that established around the surviving trees. They appear to perform a probable mode of dispersal by acting as perch to birds that play a significant role in the dispersal of small seeds. In addition, these surviving trees cast shade that reduces the growth of ferns and grasses that otherwise would limit the germination of tree saplings. However, there is no indication that the surviving trees act as seed sources as those seedlings are of totally different species.

As clearing eliminates ferns while enhancing the performance of most tree seedlings this suggests that planting trees to overcome dispersal limitations and produce a shade cover is the best way to eliminate the ferns. Once trees are established, they may act as regeneration nuclei by attracting seed dispersers and providing favourable growing conditions, thereby accelerating natural regeneration. So application of assisted natural regeneration (ANR) offers an efficient, low-cost forest restoration method that can effectively promote vegetation Regeneration. This approach aims to accelerate, rather than replace, natural successional processes by removing or reducing barriers to natural forest regeneration such as soil degradation, competition with weedy species and recurring disturbances (e.g. fire, grazing and wood harvesting).

CONCLUSION

There are a several interacting factors that impose barriers for the growth and survival of these seedlings and arrest the natural succession. The results of the study emphasize the predominant effect of competition, effective seed dispersal (a combination of dispersal and survival) and hydrological regime in affecting species composition and seedling growth. It also highlights the need for management intervention in restoring peatland floristic diversity. Application of Assisted Natural Regeneration (ANR) offers a potential approach to overcoming the barriers to, and accelerate natural successional processes by, removing or reducing competition with weedy species, manipulation of tree stands and addressing the recurrence of fire.

REFERENCES

Holl, K.D. (1999) Factors limiting Tropical Rain Forest Regeneration in Abandoned Pasture: Seed Rain, Seed Germination, Micro Climate and soil. Biotropica **31**(2): 229-242.

Hooper, E., Legendre, P. and Condit, R. (**2005**) Barriers to forest regeneration of deforested and abandoned land in Panama. Journal of Applied Ecology **42** (6): 1165–1174.

Uhl, C., Buschbacher, R. and Serrao, E.A.S. (1988). Abandoned pastures in eastern Amazonia, I: Patterns of plant succession. Journal of Ecology **76**:663-681

Wijdeven, S.M.J. and Kuzee, M.E. (2000). Seed availability as a limiting factor in forest recovery processes in Costa Rica. Restoration Ecology **8** (4): 414-424.

Zimmerman, J., J. Pascarella, and M. Aide (2000). Barriers to forest regeneration in an abandoned pasture in Puerto Rico. Restoration Ecology **8**: 328 – 338.