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THE ROLE OF ARTIFICIAL BIRD PERCHES FOR INCREASING SEED DISPERSAL IN DEGRADED TROPICAL PEAT SWAMP FOREST

Laura L. B. Graham[1,2], Salahuddin[2], Suwido Limin[2], Sue Page[1]

[1] University of Leicester, University Road, Leicester, UK, llbg1@le.ac.uk

[2] CIMTROP, UNPAR, Jl. Yos Sudarso, Palangka Raya 73111, Kalimantan Tengah, Indonesia

Abstract

Forest rehabilitation activities are being initiated across multiple degraded peatland areas in South East Asia. However, best rehabilitation techniques are still under development. In order to achieve rehabilitation efficiently and on the largest possible scale, cost-effective, transferable methods must be established. One potential method is to construct artificial bird perches outside the forest. This method, proved successful in temperate and neo-tropical ecosystems, provides resting perches for frugivorous bird, encouraging them to fly out of the forest, thus increasing seed-dispersal, and subsequent seedling-recruitment in the degraded area. This study trials this method for the first time in degraded tropical peatlands of Indonesia, SE Asia, considering the importance of distance from the forest edge and seasonal effects. The data show that artificial bird perches are used by frugivorous birds, leading to an increase in seed-dispersal and seedling recruitment beneath the bird perches. Distance and season are shown to be important factors to be taken into consideration. Furthermore, whilst ‘forest-adapted species’ are shown to be dispersed, only ‘degraded-area and edge adapted species’ are seen to make it to the seedling stage, indicating the severity of degradation after disturbance of tropical peatlands, and the need for a gradual approach to reforestation; regeneration cannot simply be kick started. The applicability and economic considerations for this restoration method are also discussed.

Keywords: Tropical peatlands, rehabilitation, degradation, seed dispersal, artificial bird perches

Introduction

Tropical peatlands make up approximately 12% (30-45Mha) of the total global peatlands (Immirizi and Maltby 1992), of which Indonesia supports the greatest area, 16-27Mha (Rieley et al. 1996). However, between 1985 and 2005, Indonesia lost over 30% of its tropical peat swamp forest (TPSF) through logging, fires, conversion of land for agriculture and plantations; the annual destruction continues at a rate of 1.7% (Hooijer et al. 2006). After forest clearance, peat becomes more susceptible to fires and flooding, resulting in a downward cycle of retro-succession, with floral diversity becoming dominated by shrubs, ferns and sedge (Page et al. in press a). When undisturbed, tropical peatlands act as carbon sinks (Page et al. 2002), support extremely high levels of floral and faunal biodiversity (Cheyne et al. 2007), maintain stable hydrological and nutrient cycling systems (Wösten et al. 2006) and provide means of livelihood for local communities (Smith 2003).

Given the array of environmental services this ecosystem provides, at the local, national and international level, interest is developing to initiate restoration and rehabilitation programs. For example, the rehabilitation program initiated at Lamandau Wildlife Reserve, the Master Plan, to rehabilitate the Ex-Mega Rice Project, and WWF-Indonesia's rehabilitation activities along the Sabangau River. However, peatland restoration is a very difficult process. Unlike mineral soil-based ecosystems, peatlands rapidly lose their ability to regenerate following disturbance (Page et al. in press b). Effective restoration methods should aim to target and alleviate one or more of the regeneration barriers that are acting as obstacles in the process of natural regeneration. Appropriate, efficient and cost-effective restoration methods remain speculative. In order to implement successful restoration programs, transferable methods need to be developed.

Subsequent to forest degradation, one of the most common regeneration barriers is limitations to seed dispersal. In the tropics, it is proposed that 50-90% of the trees rely on seed-dispersal by animals (Hull 1998) with birds being the most important seed dispersers (Howe and Smallwood 1982). In the forests of Indonesia, gibbons have been shown to be key dispersers, and orangutans play a unique role, facilitating the dispersal of seeds which other animals cannot deal with (Harrison, pers. comm.) Bats, birds, other primates, pigs and deer may also play a role (Corlett 1998), and the studies in the Neotropics and Australasia have also revealed rodents to be potentially important seed dispersers (Forget and Vander Wall 2001, D'Arcy and Graham 2005). After degradation, whilst some opportunistic or scavenger species may be able to quickly adapt and make use of the new habitat, most will remain within familiar forest territory, where there is food and protection. Terrestrial animals are unprotected in open spaces and choose to stay in remaining fragments which still offer vegetation cover. Arboreal animals depend on the trees for their mode of transport, their living environment and their food source, so remain within the forested zones. Flying animals choose places which provide shade and landing posts to rest on, which degraded areas rarely offer. As such, unless dispersed through water, wind or chance animal behaviours, many plant species routes for regeneration have become disrupted after degradation (Wang and Smith 2002).

One potential applicable method to overcome this barrier is that of artificial bird perches. This method targets the regeneration barrier of reduced seed dispersal in degraded forest zones, and has found to be successful in both temperate and tropical environments. Work in the neo-tropics has shown that birds no longer fly out into deforested zones as there is not sufficient perching material (Holl 1998, Zanini and Garade 2005). However, if artificial bird perches are constructed near to, but outside from the forest edge (ranging 25-250m) then, frugivorous birds will use the perches to rest on, defecate whilst there, and through this seed-dispersal can increase in the deforested zone, in some studies, up to 150 times the previous levels (Hooper 2005, Holl 1998). This method is yet to be trialed in South-East Asia, or TPSF, and this study will be the first to investigate if seed dispersal and subsequent seedling recruitment can be increased through the use of artificial bird perches for this ecosystem, and the season and distance at which this method is most effective.

Methods

Study Area

The field study took place at the Natural Laboratory of Peat Swamp Forest, a protected area of tropical peat swamp forest in the catchment of the Sabangau River, approximately 15km south of Palangka Raya, Central Kalimantan, Indonesia. This area, whilst mainly primary disturbed peat swamp forest, has a 1.5km wide area between the river and the forest that has been heavily degraded by logging and fires. Annual rainfall is 22000ml with the wet season from Nov-May. This study was carried out from July 2007-July 2008.

Construction of perches

Sixteen perches were constructed, eight 50m from the forest edge, and eight 200m from the forest edge, with 40m between each perch (20m between each perch and control point) (fig 1a). Each perch was constructed in situ, as described in figure 1.b), reaching approximately 8m in height, with perch area of 1.33x0.66m (fig 2.a). Trees overhanging the perch were recorded to account for any possible natural seed-rain that might occur.

Level of seed dispersal

After construction, beneath the perch, a seed-fall trap was erected, directly adjacent to the main pole (fig 1c). These traps were constructed from plastic piping creating a $1x1m^2$ square, raised approximately 60cm from the ground. The square was filled with sagging netting to catch all that fell from above. Netted walls (30cm in height) were attached to prevent loss of trap-content through wind (fig 2.b). Every fortnight for one year, the contents of the seed-traps were collected and sorted. Seeds were counted and classified by species, and seeds and bird-faeces were dried in a drying oven for 14 days at 40-50°C, and their dry weight recorded.

Level of recruitment

Beneath the perch, adjacent to the seed-fall trap, a $1x1m^2$ seedling plot was established, and all the seedlings present within the plot tagged (fig 1.c). Every month, for one year, the seedling plots were checked, seedling survival recorded, and new recruits tagged. Every three months the height of the seedlings was measured (fig. 2.c).

Bird observations

A bird observation post was constructed 125m from the forest edge, between the two rows of perches (fig. 2. d). During the first seven months, four days every month were spent observing bird presence, species and activity on the bird perches. A pilot study indicated that during hours of daylight (5.30am – 5.30 pm), peak times of bird activity were from 5.30am-9.30am and 3.30pm-5.30pm, thus these were the selected observation times. Only five perches could be watched at any given time, so five perches 50m from the forest edge would be observed for the first hour, and five perches 200m from the forest edge would be observed in the second hour, and so on. It was ensured that the perches watched for the first hour was alternated for subsequent watching days. For the final five months of study, the bird observation days were reduced to two days per month, as data indicated all the dominate species and activities were already established, so only seasonal variation needed to be accounted for.

Statistics

In order to discover if the levels of frugiviorous birds using the perches, the level of bird-faeces and seed-dispersal and the level of seedling recruitment differed significantly between perch and control positions, and across distances, ANOVA was used.

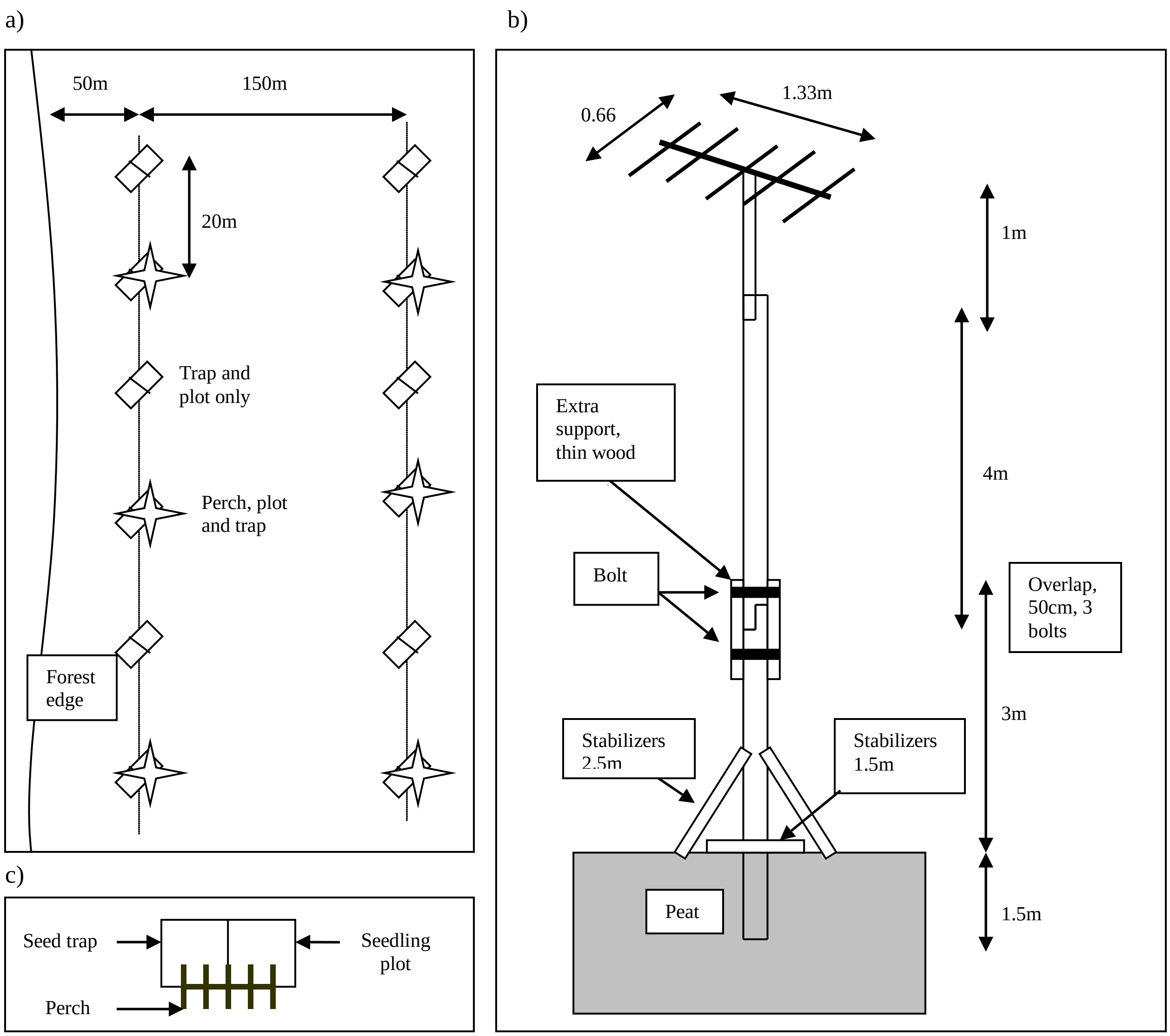

Figure 1: a) Placing of traps, plots and perches in relation to forest edge. Only three perches per distance shown, sixteen perches were made; eight at each distance, with each trap having an adjacent control position, b) Stylised drawing of artificial bird perch, c) Birds-eye view from above an artificial bird perch, showing the aerial perch, and beneath the placing of the seed trap and the seedling and sapling plot.

Figure 2: a) Constructed artificial bird perch, 200m from the forest edge, b) Research assistant, Salahuddin, collecting seeds and bird-faeces from seed-fall traps at perch position, 50m from forest edge, c) Control position at 200m from the forest edge; Salahuddin, measuring a seedling in the seedling plot, adjacent to the seed-trap, d) Bird observation position.

Results

Bird observations

During the one year of bird observations, both insectivorous and frugivorous birds were observed using the bird perches (Table 1). Whilst insectivorous birds were more abundant, both in number of observations and total time using the perches, Pacific swallows and Blue-throated fly-catchers being most dominant, frugivorous birds were also seen frequently. The most dominant frugivors were the Yellow-vented and Cream-vented bulbuls (Table 2). Furthermore, these birds were frequently observed flying in and out from the perches in the direction of the forest, suggesting a movement between the forest and the degraded area. Potentially, the next most dominant species were the flower peckers. However, flower peckers are very small birds (approx 10cm in length) and their colouring closely resembles that of the Olive-backed sunbirds, also observed using the perches. Given the distance from the observing site to the perches, it was often difficult to distinguish between these two groups, and as such, their results had to be combined. Unfortunately, as sunbirds are insectivorous, the total duration of the frugivorous group, flowerpeckers, is uncertain. In addition to the list given, though hornbills and parrots were observed flying over the 50m perches, they were never observed using the perches. There was no observed seasonality to the frequency of observations of frugivorous birds throughout the year of study. Bulbuls were seen to show a preference for the perches at 200m, with 128 of their sitings being on 200m perches, and just 50 on 50m perches. However, there was no such trend for the other frugivorous birds.

Level of seed dispersal

The average biomass accumulation per day was calculated for bird-faeces and seed biomass. A slight seasonal trend was visible regarding bird-faeces, with more biomass accumulating during the dry season than through the wet season. However, there were no seasonal trends observed regarding seed biomass, or from the bird observation data, and, as such, this trend was interpreted being due to the heavy rains washing the faeces away, rather than an indication of lower bird presence. Thus, the data was pooled across the eight control seed-traps and the eight perch seed-traps for each distance. These data show distinct differences between control and perch seed traps at both 50m and 200m for both bird-faeces and seed biomass, with perch seed-traps accumulating significantly more biomass in all cases (highest p value<0.0002) (fig. 3). However, there was no significant difference observed between the two distances of 50m and 200m for perch seed-traps, for both bird-faeces and seed biomass.

Seed biomass data from one control seed-trap was removed during the months of November 07, December 07 and January 08. This was because the seed-trap had an overhanging Tampohot tree, which was fruiting during these months, thus the observed high seed levels were assumed to be due to seed-rain rather than seed-dispersal.

A total of thirteen species were found in the seed traps (table 3), ten of which use animals as their means of dispersal. Of these ten, only three of the species were known to occur in the degraded zone. Unfortunately, given the frequent small seed size, and the alteration to colour and texture after passing through an animal gut, nearly 20% of the seeds could not be identified.

Table 1: Showing all bird species that were observed using the artificial bird perches during the one-year study, the frequency and total duration of their time spent on the perches, and their feeding preference, listed in order of longest duration.

All birds (family or species)	**Latin**	**No. of bird obs.**	**% of total obs.**	**Total duration on perches (mins)**	**% of total duration on perches**	**Food type**
Pacific swallow	*Hirundo tahitica* (Hirundinidae)	460	39.72	4784	57.63	Insectivorous
Blue-chested bee-eater	*Merops viridis* (Meropidae)	245	21.16	1731	20.85	Insectivorous
Yellow-vented and White-vented bulbul	*Pycnonotus simplex/goiavier* (Pycnonotidae)	216	18.65	850	10.24	Primarily frugivorous
White-breasted wood-swallow	*Artamus leucorhynchus* (Artamidae)	82	7.08	596	7.18	Insectivorous
Long-tailed shrike	*Lanius schach* (Laniidae)	34	2.94	118	1.42	Insects, small vertebrates
Flower pecker and Olive-backed sunbird	Dicaeidae and *Nectarinia jugularis* (Nectariniidia)	53	4.58	80	0.96	Small insects, fruits/ Nectar, insects, pollen
Stork-billed kingfisher	*Pelargopsis capensis* (Alcedinidae)	6	0.52	24	0.29	Insects, small vertebrates, fish
Woodpecker	Picidae	5	0.43	23	0.28	Insectivorous
Unknown		21	1.81	21	0.25	
Pied fantail	*Rhipidura javanica* (Muscicapidae)	9	0.78	20	0.24	Insectivorous
Yellow-bellied prinia	*Prinia flaviventris* (Sylviidae)	11	0.95	20	0.24	Insectivorous
Magpie robin	*Copsychus saularis* (Turdidae)	8	0.69	11	0.13	Berries and insects
Mangrove whistler	*Pachycephala grisola* (Pachycephalidae)	2	0.17	7	0.08	Insectivorous
Pigeon	*Treron sp.* (Columbidae)	1	0.09	5	0.06	Frugivourous
Spotted dove	*Streptopelia chinensis* (Columbidae)	1	0.09	5	0.06	Frugivourous
Bonaparte's nightjar	*Caprimulgus concretus* (Caprimulgidae)	2	0.17	4	0.05	Insectivorous
Barbet	Capitonidae	1	0.09	1	0.01	Frugivourous
Minivet	*Pericrocotus sp.* (Campephagidae)	1	0.09	1	0.01	Insects and fruit

Table 2: Showing only the frugivorous bird species observed using the bird perches, listed in order of longest duration.

Frugivorous birds (family or species)	**No. of bird obs.**	**% of total obs.**	**Total duration on perches (mins)**	**% of total duration on perches**
Yellow-vented and White-vented bulbul	216	76.87	850	89.19
Flower pecker and Olive-backed sunbird	53	18.86	80	8.39
Magpie robin	8	2.85	11	1.15
Pigeon	1	0.36	5	0.52
Spotted dove	1	0.36	5	0.52
Barbet	1	0.36	1	0.10
Minivet	1	0.36	1	0.10

a) b)

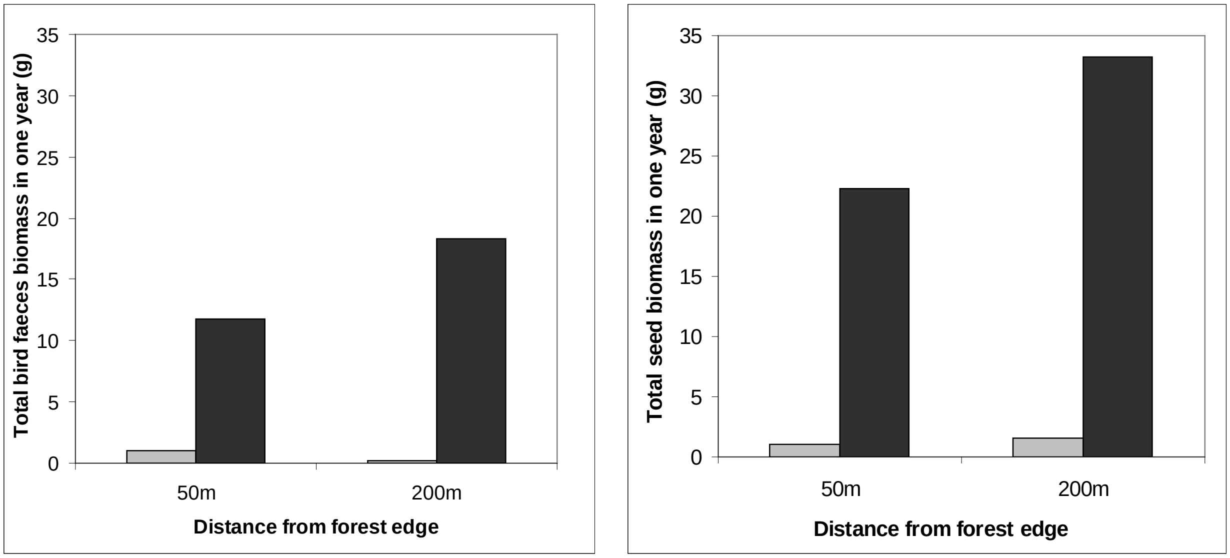

Figure 3. Total biomass of bird-faeces (a) and seeds (b), accumulated over one year and summed across eight seed-traps for each given variable, shown in respect to distance from the forest edge, and control seed-traps (light grey) and perch seed-traps (dark grey).

Table 3: Showing all seed species found in the seed-fall traps and their forest type preference, listed by means of dispersal then % of total seeds.

Local name	**Latin name**	**No. of seeds**	**%**	**Means of dispersal**	**Forest type**
Tumih	*Combretocarpus rotundatus* (Anisophyllaceae)	173	11.97	wind	edge and degraded
Asam-asam	*Ploiarium alternifolium* (Theaceae)	49	3.39	wind	edge and degraded
Bintan	*Licania splendens* (Chrysobalanaceae)	4	0.28	wind	edge and closed-canopy
Tampohot batang	*Syzygium sp.* (Myrtaceae)	536	37.09	animal	edge and degraded
Jambu	*Syzygium sp.* (Myrtaceae)	113	7.82	animal	edge and closed-canopy
Mahalilis	*Garcinia sp.* (Clusiaceae)	98	6.78	animal	edge
Mangkinang	*Elaeocarpus mastersii* (Elaeocarpaceae)	73	5.05	animal	closed-canopy
Kopi-kopi	*Canthium dydimum* (Rubiaceae)	40	2.77	animal	closed-canopy
Sedge	*Thoracostachyum bancanum* (Cyperaceae)	25	1.73	animal	degraded
Hampuak galeget	*Syzygium sp.* (Myrtaceae)	25	1.73	animal	edge
Teras nyating	*Campnosperma squamatum* (Anacardiacceae)	7	0.48	animal	closed-canopy
Pupuh palanduk	*Neoscortechinia kingii* (Euphorbiaceae)	17	1.18	animal	closed-canopy
Solam	Melastomataceae	2	0.14	animal	degraded
Unknown		283	19.58		
Total		**1445**			

Level of recruitment

The number of seedlings recruited during the one year of study (not including those which subsequently died), was considerably greater in the seedling plots beneath the perches than the control seedling plots. This was observed at both 50m and 200m (fig. 4). This trend however was not significant (p value = 0.14 at 50m and 0.35 at 200m). Equally, more seedlings were recruited under perches 200m from the forest edge, compared to the seedling plots at 50m, though again this trend was not significant (p value = 0.16). This lack of significance is likely due to the high degree of variance that was observed across seedling plots; whilst some plots beneath seedling perches had 10-15 new recruits, others had no recruits, resulting in a maintained degree of overlap between perch and control plots data and the perch plots at the different distances from the forest edge, despite the overall difference.

The seedling species found were nearly all Tampohot batang (78%). The three most dominant species, Tampohot batang, Patanak daun besar, and Tangkaranak, are all found to grow in the degraded area. There were other seedlings recruited, though fewer in number, that are only found within the forest or along the forest edge, such as Jambu, Mahalilis and Mangkinang. The period of recruitment was seen to be highest during the first few months of study (July-Dec 2007). There was little recruitment from Jan-May 08.

Discussion

In order to determine if artificial bird perches are an effective restoration method for degraded areas of TPSF, by increasing seed-dispersal and subsequent seedling recruitment outside the forest, all stages of this process must be assessed. Firstly, it must be determined that frugivorous birds species are actively using the bird perches, and thus bringing out seeds from the forest. This has been confirmed in this study, through bird observations ascertaining that of seven frugivorous species of birds used the perches, with two species using the perches regularly. Equally, the seeds found in the seed traps was often located within bird-faeces, again illustrating it was the birds bringing the seeds, and not through some other means. The next question is, although the birds are using the perches, does this act increase the seed-fall beneath the perches? Again, this study was able to confirm that seed-fall beneath the perches was significantly higher than seed-fall at the control positions. Not only that, but the seed species found in the traps were forest-edge and closed-canopy species, indicating that seeds were brought from within the forest, not just dispersed within the degraded zone. Finally, it must be determined that these dispersed seeds are then going onto germinate, leading to increased recruitment rates beneath the perches. This study was able to establish recruitment rates were increased in the seedling plots beneath the perches, as compared to seedling plots with no perches above them. Although these data were not significant, it must be taken into account ANOVA compares difference of *variance*. In degraded zones, some areas are entirely inhospitable to seedling growth, thus, even beneath the perches, some seedling plots were found to have no recruitment. Yet, in other perch seedling plots, where the environmental conditions were less severe, seedling recruitment was far higher than corresponding control seedlings plots. Given this, the variance of perch seedling plot data was wide, with a high degree of overlap to control seedling plot data (where recruitment rates were low). Instead, the total sum of recruited seedlings beneath the perch and control seedling plots should be compared, and here it is apparent of the increased rates of recruitment beneath perches.

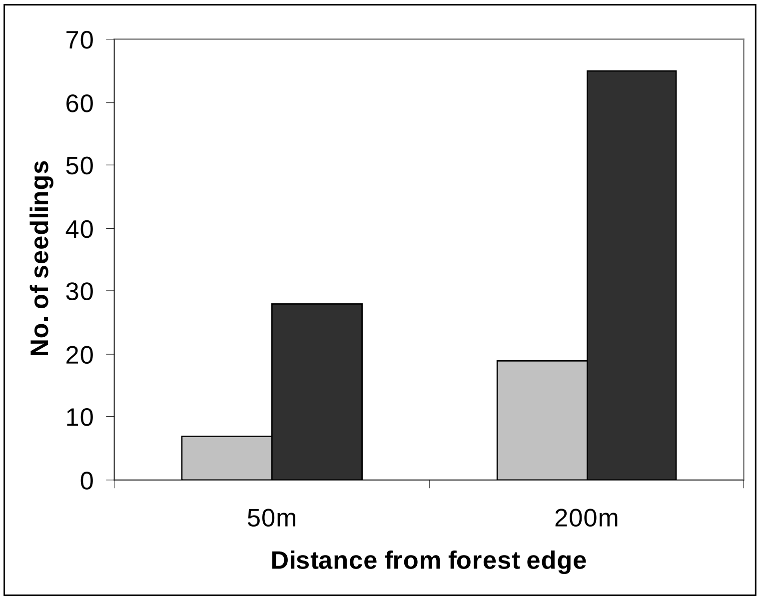

Figure 4. Showing total number of seedling recruits accumulated over one year, with respect to distance from the forest edge, and control seedling plots (pale grey) and perch seedling plots (dark grey)

Table 4: Showing the tree species of seedlings that were recruited in the seedling plots, listed by most abundant. Percentages of corresponding seeds found in the seed-fall traps also listed

Local name	**Latin name**	**No. of seedlings**	**%**	**% of no. of seeds**	**Forest type**
Tampohot batang	*Syzygium sp.* (Myrtaceae)	94	78.99	37.09	Edge and degraded
Patanak daun kecil	Rubiaceae	7	5.88	0	Degraded
Tangkaranak	Unknown	4	3.36	0	Degraded
Kambasira	*Ilex hypoglauca* (Aquifoliaceae)	3	2.52	0	Edge
Mahalilis	*Garcinia sp.* (Clusiaceae)	3	2.52	6.78	Edge
Tabati himba	*Syzygium sp.* (Myrtaceae)	3	2.52	0	Edge and degraded
Jambu	*Syzygium sp.* (Myrtaceae)	1	0.84	7.82	Edge and closed-canopy
Mahadingan	*Calophyllum sp.* (Clusiaceae)	1	0.84	0	Closed-canopy
Mangkinang	*Elaeocarpus mastersii* (Elaeocarpaceae)	1	0.84	5.05	Closed-canopy
Sulam	Melastomataceae	1	0.84	0.13	Degraded
Uey name	*Flagellaria sp.* (Palmae)	1	0.84	0	Edge and degraded
Total		119			

Distance and seasonality

Given that all the above stages are operating, indicating that artificial bird perches do increase regeneration rates out in a degraded area of TPSF, the next question to be addressed, is are there provisos to this method? Does it only apply at certain times of year, or is it specific to distance? Data suggested a slight reduction of bird-faeces during the wet season. But given this can be explained by the rains causing the faeces to disintegrate and wash through the trap netting, and given the bird observation and seed-rain did not display a corresponding trend, it seems the seed-dispersal occurs uniformly throughout the year. However, there was an observed trend in periods of seedling recruitment. Recruitment was highest during the dry season, where as at the onset of the wet season, recruitment levels tailed off. This can be explained by the levels of flooding that occur in the degraded area during the wet season, where depths of greater than 50cm are common. Thus, during the wet season, it is likely seeds were washed away before they could germinate. Furthermore, during the wet season, those seedlings which were recruited during the previous dry season were then submerged for over five months. Given that this study ran for a complete year, until the dry season 2008, it was possible to observe the survival rates of those submerged during this time, and the majority were able to tolerate the floods and did survive.

The environmental conditions at 50m and 200m from the forest edge are considerably different. The 'forest edge' was defined as where the canopy opened overhead. This meant that beyond the forest edge, there were still sporadic individual trees, which could reach as high as 8m, the height of the bird perches. However, these individual trees petered out with further distance from the forest, being nearly entirely absent after 100m distance. Given this, it was anticipated that the effectiveness of the artificial bird perches might be lower at 50m than 200m, as birds had the option of using natural perches at 50m, and not at 200m. There is a consistent, though not significant, trend to suggest bird activity and corresponding seed-dispersal was greater at the 200m transects, with higher number of bulbul sitings, and greater biomass of bird-faeces and seeds (though not significantly higher). This trend continues for seedling recruitment, with an overall greater number of seedlings at 200m than at 50m.

It should be noted that whilst bird activity and corresponding seed-dispersal was greater at 200m, it did not necessarily follow that seedling recruitment would also be higher. At 200m from the forest edge the surrounding environment is more severely degraded than at 50m. Light intensity is greater, flooding is more severe and nutrients are lower in availability (Page et al. in press a). Given this, seedlings might not have been able to tolerate these conditions, and it is possible that those species adapted to forest conditions could not survive these harsh conditions, hence the reduction in edge and closed-canopy species from the seed-trap stage to the seedling recruitment stage (8 species, Table 3, to 3 species, Table 4). This factor might account for the reason why, although more seedlings are recruited at 200m, the number is not significantly higher.

Overall application: success and economic viability

Overall, this study has shown that each stage necessary to indicate the success of artificial bird perches as a means of TPSF restoration is operating well; frugivorous birds have been observed using the perches, seed-fall is higher beneath the perches, as is seedling recruitment. Furthermore, the recruited seedlings are able to cope with the extreme conditions present in the degraded area, and remain present after the wet season floods.

However, there is one aspect to this success that must be addressed. There is a distinct shift of tree species when moving from the seed-trap to seedling recruitment stage, with fewer 'edge and closed-canopy' being present as seedlings than were found to be present in the seed-traps. This would indicate that whilst seeds were being brought from inside the forest and the forest edge out to the perches, these seeds were then poorly adapted at either germinating or surviving as seedlings in the degraded conditions. There are also 'edge-degraded species' species that newly occur at the seedling stage, that were not present at the seed-trap stage. Whilst this may indicate they arrived at the plots separately, it seems unlikely, as even if they are not dispersed by the birds, there is as much chance for them to arrive to a seed-trap as to a seedling plot, so one would expect presence in both. Instead, it is more likely these species make up part of the ‘unknown’ quotient of seeds.

Given this overall trend in shifting from ‘forest-adapted species’ to ‘degraded-adapted species’, does this then reduce the use of this restoration method? Whilst it certainly would be most advantageous to see forest species moving out and successfully regenerating in the degraded area through this method, it is perhaps an unrealistic hope. Forest-adapted species do not posses the correct genetic make-up, even allowing for phenotypic plasticity, to tolerate such harsh environments. Whilst forest species were observed regenerating in neo-tropical studies, this can perhaps be explained by the higher degree of degradation that occurs for tropical peatlands as opposed to mineral soil, after disturbance, and also the extremely high dependency of tropical peatland tree species to ‘good-quality’ peat. Instead, what is observed here *is* an increase of regeneration rates, but only by species that are already adapted to the degraded conditions. This does not mean the method is a failure, but instead shows the route to restoration for this ecosystem must be more gradual, with a greater number of smaller steps along the way: Regeneration of forest-species in degraded TPSF cannot be kick-started. Instead, this method provides a route to increasing natural regeneration of tree species which can tolerate these conditions, a stage which must obviously be achieved, before mid-successional species can be introduced. Indeed, the method perhaps highlights a route to creating a quickly-formed closed-canopy, so the next stage of restoration can begin.

Given that over 1MHa of tropical peatlands in Central Kalimantan alone are degraded, effective restoration methods must not only improve regeneration rates, but also be transferable and cost- and area-effective. The potential for transferring this method should be high, with bird species and behavioural patterns being homogenous through-out this region. However, for the present form of artificial bird perches employed, the related cost and area effectiveness is where this method is less successful. Construction of bird perches is both time-consuming and expensive; both in labour costs and cost of equipment and transport (a team of four was able to construct 5 perches in one day, with an extra day for transport, each perch costing approximately $60). Furthermore, only the area beneath the perch, approximately 4m^2 would receive assisted regeneration. Obviously for such a high costs, this area is very small. However, the perches have the advantage that once constructed they require very little extra effort, the birds doing the rest of work! Alternative solution have been suggested: use of bamboo rather than wood for perch construction; cheaper and lighter, with a possibility to ‘relocate’ perches regularly to increase area covered (Brend, pers. comm.), and use of rope or wire strung between perches, instantly increasing ground-area covered (Graham, pers. comm.) This study indicates this method has high potential for success; it operates autonomously after an initial outlay, all year round, with high survival rates of seedlings, leading to high regeneration rates. What remains is to trial potential cost-reducing and area-increasing methods, to make artificial bird perches a necessary tool in tropical peatland restoration.

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