ASSESSMENT OF THE RECOVERY OF A SECONDARY TROPICAL DRY FOREST AFTER HUMAN DISTURBANCE IN CENTRAL MYANMAR

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Received September 2015

SANN B, KANZAKI M, AUNG M & HTAY KM. 2016. Assessment of the recovery of a secondary tropical dry forest after human disturbance in central Myanmar. We examined the recovery of a secondary tropical dry forest using 30 quadrats (20 m × 20 m). The objectives of this study were to describe the species composition and stand structure of a secondary tropical dry forest after human disturbance and to assess its recovery. In total, 30 species from 16 families were observed in the quadrats. In the 24-year period, the tropical dry forest had recovered to 706 (± 99 standard error) individuals ha^{-1} with an average total height of 4.3 ± 1.5 m and basal area of 2.92 ± 0.51 m^2 ha^{-1}. To assess the recovery of the tropical dry forest, its diversity measures and structural attributes were compared with the values of an old-growth forest of over 70 years old. Species richness, exponential of Shannon's index and Fisher's α recovered by 43, 40 and 34% respectively. Stem density, average total height and basal area recovered by 57, 48 and 14% respectively. The species diversity of the secondary tropical dry forest had potential to increase but might not attain the level of the old-growth forest. However, the structure of the secondary tropical dry forest was on the way to the status of the old-growth forest. Long-term conservation or silvicultural interventions would be required for the forest to reach its full recovery.

Keywords*:* Old-growth forest, rarefaction, species diversity, stand structure, succession

INTRODUCTION

Tropical dry forests are the most threatened of terrestrial ecosystems because of a considerable pressure of exploitation (Janzen 1988). They have lesser floristic and structural complexity and smaller stature compared with wet forests, but the geographic extent of dry forests is important as they can provide a wide range of ecosystem services (Bullock et al. 1995, Chidumayo & Gumbo 2010). Moreover, they once represented 42% of tropical forest vegetation (Murphy & Lugo 1986). They are among the most disturbed due to anthropogenic and economic pressures (Janzen 1988, Bullock et al. 1995). However, academic research is still insufficient to sustain tropical dry forests due to the lack of interest in these ecosystems.

During recent decades, studies in tropical dry forests have increased mainly due to increased awareness that they are being destroyed or converted at an alarming rate. These studies mainly focused on structure and composition (Murphy & Lugo 1986, Gillespie et al. 2000), natural regeneration (Gerhardt & Hytteborn 1992, Fredericksen & Mostacedo 2000) and vegetation–soil relationships (Jha & Singh 1990, Gonzalez & Zak 1996). Only a few studies have been conducted on assessing the recovery of dry forest vegetation. Although these few studies offer some reasonable insight into the recovery of tropical dry forests, no research has assessed the recovery of Myanmar dry forests, especially in the central dry zone where their conservation is given priority to maintain environmental integrity of the region.

In Myanmar, dry forests cover over 3 million ha and are spatially fragmented in the central dry zone (Forest Department 2010). Most of these dry forests are degraded forests due to human disturbances such as cattle grazing, firewood cutting, agricultural expansion and extensive woodcutting. Despite past disturbances and current threats to Myanmar dry forests, sensible attempts towards conservation began three decades ago. To design the necessary management interventions, assessments of the recovery of the conserved dry forests are urgently required. Recovery is assessed by comparing recovering plots with control plots of undisturbed vegetation in the same location or mature forest stands (Kennard 2002, Lebrija-Trejos et al. 2008, Lévesque et al. 2011) in the same region. In this study, we examined a secondary tropical dry forest conserved for 24 years in the central dry zone. Due to the fragmented landscape of dry forests and severe disturbances in the zone, no mature forest stands existed in the proximity of the secondary tropical dry forest. Therefore, for the comparative assessment, we used an old-growth forest aged over 70 years old of similar type located in the same region. The objectives of this study were to examine the current status of species composition and stand structure of the secondary tropical dry forest and to assess its recovery compared with the old-growth forest. Findings of this study will provide guidance for conservation management and planning of the secondary tropical dry forest.

MATERIALS AND METHODS

Description of study site

The study was carried out at the Taungphila reserved forest (21° 18' N, 95° 37' E; 15 km^2) located in central Myanmar (Figure 1), which contains a mosaic of permanent agriculture, human settlement and remnant forest vegetation. The region experiences three seasons annually, namely, hot (February–April), rainy (May–October) and cold (November–January) seasons. The area receives an annual rainfall of less than 700 mm, and the average monthly temperature is 27 °C. The study area in the semiarid region is characterised by lowland hills of undulating topography, with lowest and highest altitudes of 209 and 292 m above sea level respectively. The mesic savanna study area is predominated by Luvisols in many sites and by Vertisols in a few sites (DZGD 2010).

Establishment of sample quadrats and data collection

Twenty-five quadrats (20 m × 20 m) were placed systematically at 800-m intervals across the

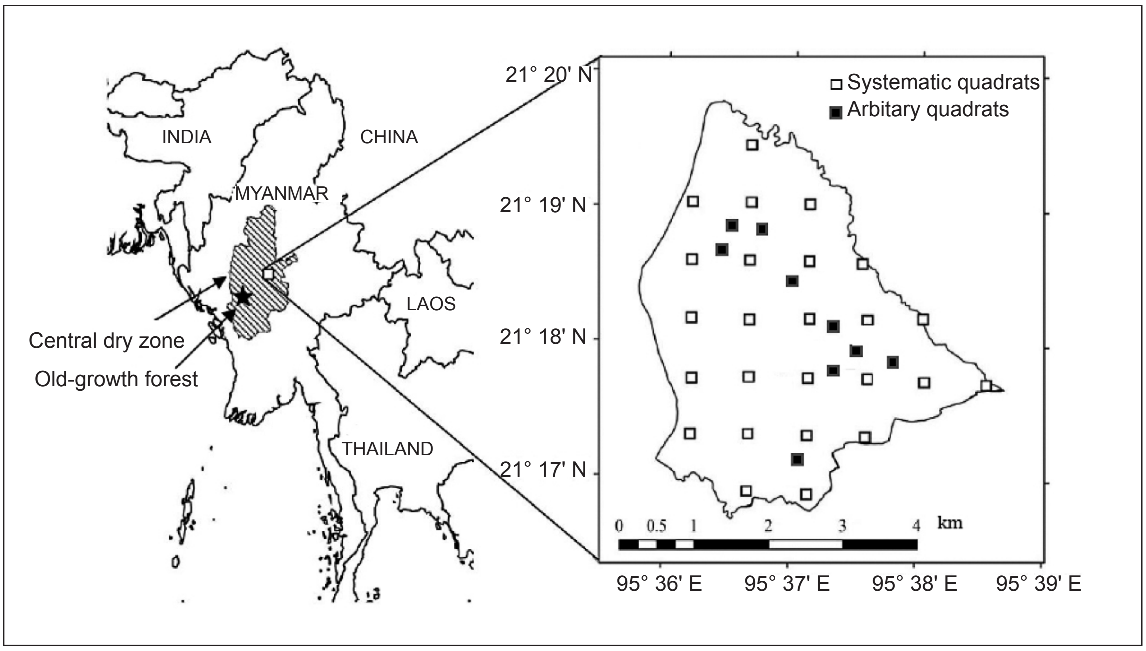

Figure 1 Locations and layout of the systematic and arbitrary quadrats (20 m × 20 m) at the Taungphila reserved forest in the central dry zone of Myanmar

secondary tropical dry forest using a handheld navigator, Garman GPSMAP 62s. We used a species–area curve to evaluate the adequacy of the sample size. Although the systematic quadrats were evenly distributed spatially, the species–area curve suggested that they did not encompass the entire spatial variation of species composition in the forest. Thus, an additional nine quadrats (totalling 34) (Figure 1) of the same size were arbitrarily assigned to ensure that the species–area curve approached an asymptote so as to cover the remaining variation in species composition. Girth at breast height (gbh = diameter at breast height (dbh) × π) and total height for all individuals (≥ 10 cm gbh) were measured and recorded for all species in each quadrat. In addition, tree and shrub species outside the quadrats were recorded through visual observation (Appendix). Plant specimens were identified to species level with the assistance of staff of the the Forest Research Institute of Myanmar. Vegetation survey was conducted in November–December 2012 in only 30 of the 34 quadrats as the remaining four quadrats had no individuals with gbh ≥ 10 cm.

Disturbance history

The study area is bounded by permanent agricultural fields and 23 long-settled villages (about 5300 households) located within 3 to 5 km from the forest. As early as 1940, the study area had been a natural remnant forest continuously threatened by lopping, overgrazing and minor cutting of trees . The area was officially designated as a reserved forest in 1985 to protect the threatened natural vegetation. However, in 1988, Myanmar was faced with nationwide democracy movements that lasted nearly one year. During this period, local people intensively cut the forest for firewood, agricultural implements and household poles and posts, leaving the whole area over-exploited. Since then, the Forest Department had strengthened the protection of the forest by means of staffing in permanent base camps, frequent patrol and fire protection. Secondary succession in the forest has begun since 1989 although slight disturbances of lopping and cattle grazing continue to this date.

Selection of an old-growth forest for comparison

Quantitative structure and composition of the Taungphila reserved forest in pre-disturbance state were unavailable due to the lack of documentation. Therefore, an old-growth dry forest was selected to perform comparative assessments on the recovery of the secondary tropical dry forest. The old-growth forest (21° 10' N, 94° 53' E, area about 338 km^2) comprised three contiguous reserved forests, namely, Shwesettaw, Kywedaga and Kyauk-oo. This forest was the only old-growth forest in the region and it had similar species composition, geological substrate, topography and climate as the secondary tropical dry forest (Khaing 2013). Structure of the old-growth forest was also comparable with that of the tropical dry forests at maturity, i.e. over 1000 individuals ha^{-1}, maximum total height 7–12 m and dbh 20–40 cm (Lebrija-Trejos et al. 2008). The area was primarily a flat plain with low hills less than 300 m above sea level, and the dominant soil types were Luvisols and Vertisols (Khaing 2013). Average annual rainfall was about 700 mm and the monthly mean temperature was 28 °C. The old-growth forest has never been extensively cut and has been officially conserved for over 70 years. The vegetation of the old-growth forest was studied by Htay (2014).

Data analysis

Dominant and subordinate species were identified on the basis of importance value (IV) (McCune & Grace 2002):

$$\%IV = \text{Average } (\%\text{relative density} + \%\text{relative dominance} + \%\text{relative frequency})$$

Species with higher IVs were defined as dominant, and those with lower IVs, subordinate (Appendix). Vegetation similarity between the secondary tropical dry forest and the old-growth forest was indicated by Sørensen's coefficient of similarity (McCune & Grace 2002):

$$\text{Sørensen's coefficient of similarity} = 2w/(n_A + n_B)$$

where w = number of common species between forests A and B, n_A = number of species in the forest A and n_B = number of species in the forest B. Species diversity was measured in terms of estimated species richness (S_{est}) (Colwell et al. 2012) and exponential of Shannon's index ($e^{H'}$) (Hill 1973):

$$e^{H'} = \exp\ (- n_i/N\ \Sigma \ln\ n_i/N)$$

where n_i = number of individuals of species i and N = total number of individuals for all species. Fisher's α was calculated as (Fisher et al. 1943):

$$S = \alpha \ln\ (1 + N/\alpha)$$

where S = number of species and N = number of individuals. We computed the diversity measures for the old-growth and secondary tropical dry forests based on density abundances of species from each pooled data set. The old-growth forest (3374 individuals per 2.72 ha equivalent to 1240 individuals ha^{-1}) and the secondary tropical dry forest (848 individuals per 1.2 ha or 706 individuals ha^{-1}) differed in numbers of individuals due to differing sampling efforts. The former was rarefied to 848 individuals to obtain a common number of individuals for meaningful comparison of species diversity (Gotelli & Colwell 2001). Species diversity values based on rarefaction to 848 individuals were computed in EstimateS version 9.1.0. Stand structure was expressed using stem density (individuals ha^{-1}), average total height (m) and basal area (m^2 ha^{-1}) for the two forests. Recovery of species diversity and structure was measured as per cent of the diversity and structural parameter values of old-growth forest represented by each respective value of the secondary tropical dry forest.

RESULTS

Recovery of species composition and stand structure in secondary tropical dry forest

There were 30 species belonging to 16 families inside the 30 quadrats across the secondary tropical dry forest (Appendix). All the species were native tree and shrub species, except for *Prosopis juliflora*. Among the families, Mimosaceae had the greatest number of species, i.e. 4 species while Combretaceae, Capparaceae, and Rubiaceae each had 3 species. Seven species, namely, *Dalbergia paniculata, Terminalia oliveri, Acacia catechu, Acacia inopinata, Millettia multiflora, Terminalia tomentosa* and *Grewia tiliifolia* were the dominant species, with IVs between 8 and 14 (Appendix) and 58–117 individuals ha^{-1} (data not shown). The remaining 23 species were subordinate species (i.e. IV ≤ 2%, Appendix), 21 of which were represented by less than 10 individuals ha^{-1}.

In the 24 years of conservation, the secondary tropical dry forest recovered to 706 (± 99 standard error) individuals ha^{-1} (range 250–1850 individuals ha^{-1}) and 82% of stems were < 9 cm dbh. The forest attained an average total height of 4.3 ± 1.5 m. *Lannea coromandelica* had the largest (dbh 27.2 cm) and tallest (10.5 m) stem while *D. paniculata* and *T. oliveri* had dbh and height values of about 15 cm and 9 m respectively. Mean basal area was 2.92 ± 0.51 m^2 ha^{-1}, ranging from 1.17–11.62 m^2 ha^{-1}. The overall trend in diameter distribution exhibited a reverse j-shaped distribution, and the dominant species were much higher in abundance than the subordinate species in each size class (Figure 2). Therefore, structural recovery was mainly led by the dominant species in the secondary tropical dry forest.

Comparative assessments of the recovery of the secondary tropical dry forest

Based on the presence/absence of species, a modest similarity was displayed between the secondary tropical dry forest and the old-growth forest, with 43 overlapping species and Sørensen's similarity coefficient of 0.57 (Appendix). In addition, the dominance–diversity curves indicated high dominance in both forests, with similar species dominance patterns (Figure 3). The steep slopes of the curves suggested that both forests were dominated by a few species; 23 and 13% of the species occupied 78 and 65 of the total IVs in the secondary tropical dry forest and the old-growth forest respectively. However, a comparison of size class distribution (Figure 4) indicated that the secondary tropical dry forest had fewer large-size individuals (> 60 cm gbh or > 19.1 cm dbh) than the old-growth forest.

Species diversity in the secondary tropical dry forest was consistently lower than in the old-growth forest (Figures 5a–c). During the 24-year conservation of the secondary tropical dry forest, species richness, exponential value of Shannon's index and Fisher's α achieved 43, 40 and 34% respectively of the old-growth forest values (Table 1). However, percentages of recovery of the structural attributes varied greatly. Stem density, average total height and basal area recovered by 57, 48 and 14% respectively (Table 2). Among the structural attributes, stem density had the fastest recovery and basal area had the slowest recovery during the 24-year conservation period.

DISCUSSION

Recovery of species composition and stand structure in the secondary tropical dry forest

There were 30 species inside the quadrats, although we encountered a total of 62 species across the secondary tropical dry forest (Appendix), due primarily to the rareness of species, i.e. many spatially-rare species occurred across the latter. Nonetheless, the number of species in the secondary tropical dry forest was comparable with the global range of 30–90 species in tropical dry forests (Bullock et al. 1995). The importance values indicated that the secondary

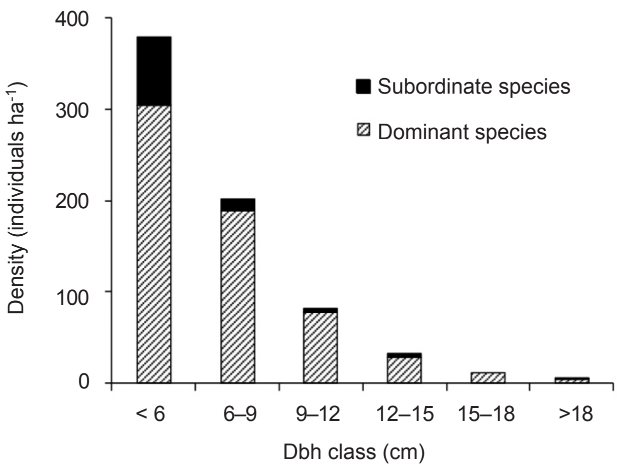

Figure 2 Size class distribution of dominant and subordinate species in the secondary tropical dry forest

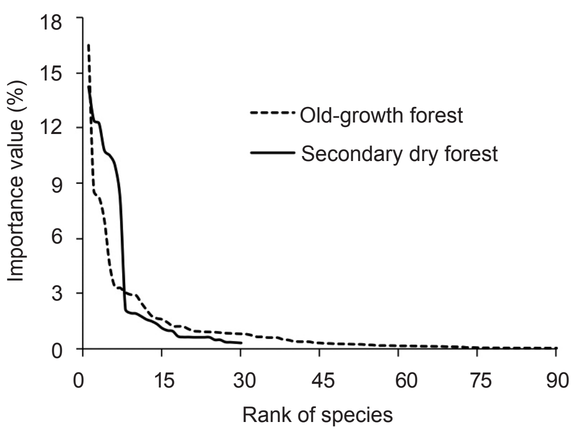

Figure 3 Dominance–diversity curves of the secondary tropical dry forest and the old-growth forest based on importance values of the species

tropical dry forest was dominated by relatively few species. In fact, the top seven species accounted for 78% of the total importance values (Appendix). Dominance by a few species seemed to be a compositional characteristic of tropical dry forests as 12, 11 and 13 species out of 90, 70 and 75 species comprised 65, 68 and 67% of the total importance values respectively in three other Myanmar dry forests (Aung et al. 2009, Htay 2014). Similar dominance patterns were observed by Gonzalez and Zak (1996), Murphy and Lugo (1986) and Kennard (2002) in tropical dry forests around the world.

Average total height (range 2.9–6.0 m, Table 2) of individuals in the secondary tropical dry forest fell within the usual range (< 10 m) of tropical dry forests (Gonzalez & Zak 1996, Lebrija-Trejos et al. 2008, Lévesque et al. 2011). The former had lower density of individuals (range 250–1850 individuals ha^{-1}, Table 2) than neotropical dry forests (1070–12,170 individuals ha^{-1}, Bullock et al. 1995). However, the density range was comparable with that of other Myanmar dry forests (395–1800 individuals ha^{-1}, Khaing 2013). In the secondary tropical dry forest, we observed large spatial variation in basal area (range 1.17–11.62 m^2 ha^{-1}, Table 2), with an average of 2.92 m^2 ha^{-1}. Basal area value of the secondary tropical dry forest was substantially lower than the usual range for tropical dry forests, i.e. 17–40 m^2 ha^{-1} (Bullock et al. 1995) and was also lower than the range (9–21 m^2 ha^{-1}) in other Myanmar dry forests (Khaing 2013). The lower basal area in the secondary tropical dry forest could be explained by the lack of large stems (> 18 cm dbh, Figure 2). Even though the forest was conserved for 24 years, the majority of individual stems were small in diameter, probably because of the slow growth rate related to the harsh environment in the dry forest. Silvicultural interventions (e.g. pruning branchy trees, restoration plantations) may accelerate natural regeneration in the secondary tropical dry forest.

Comparative assessments of the recovery of the secondary tropical dry forest

Mature or old-growth forest stands are often used as reference forests for the purpose of assessing the recovery of secondary forests with the expectation that the structure and composition of secondary forests will become similar to those in the reference forest in the future. In this study, 43 species in the old-growth forest were also observed in the secondary forest (Appendix). Dominant species in the secondary tropical dry forest such as *D. paniculata*, *T. oliveri*, *T. tomentosa*, *A. catechu* and *M. multiflora* were commonly found in the old-growth forest. However, some

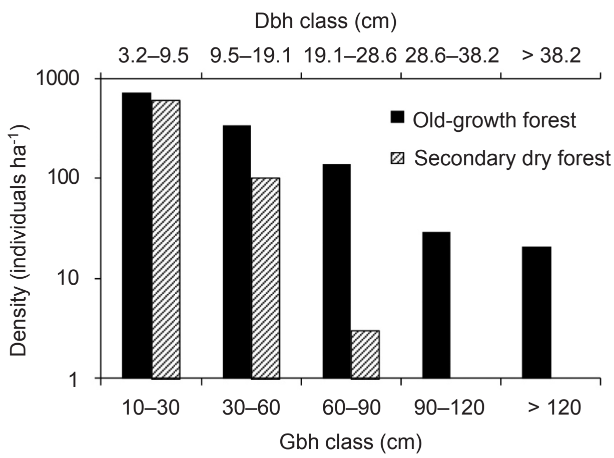

Figure 4 Comparison of size class distribution between the secondary tropical dry forest and the old-growth forest; as the original data for the old-growth forest (Htay 2014) were reported with gbh (girth at breast height) classes, the size class distribution of the secondary dry forest was prepared with gbh classes, the secondary x-axis corresponds to a conversion of gbh to dbh (diameter at breast height) for each class interval

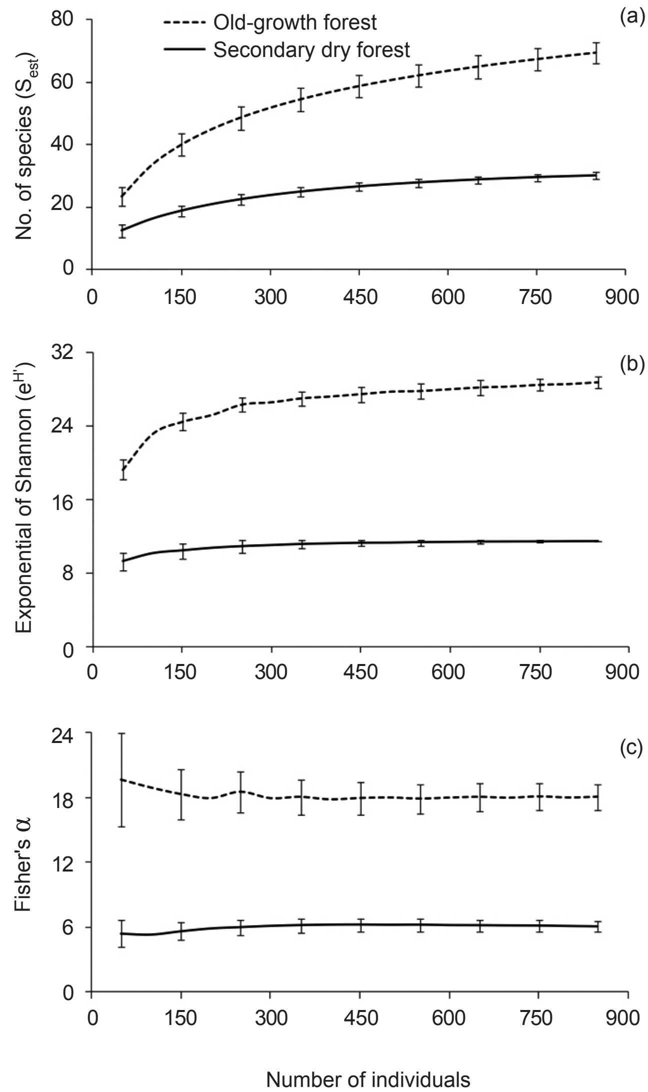

Figure 5 Species diversity measures of the secondary tropical dry forest and the old-growth forest: (a) species richness, (b) exponential of Shannon's index and (c) Fisher's α; error bars represent standard deviations (± 1)

species that usually occur in relatively moist forests were found only in the old-growth forest; these were *Shorea siamensis*, *Morinda tinctoria*, *Xylia xylocarpa* and *Millettia ovalifolia*. In contrast, some species, namely, *A. inopinata*, *A. nilotica*, *Capparis sepiaria*, *C. glauca* and *Ziziphus jujuba* that are usually found in open dry forests were observed only in the secondary tropical dry forest. Differences in species composition between the two forests could be partially related to the location of the old-growth forest at the edge of the central dry zone which was closer to the moist deciduous forests of the Rakhine mountain ranges.

There were some similarities between the secondary tropical dry forest and the old-growth forest. This included species composition as indicated by the Sørensen's similarity coefficient of 0.57, dominance patterns of species represented by the importance values (Figure 3), Vertisols and Luvisols soil types and undulating topographies. However, there were differences, e.g history of disturbance. The secondary tropical dry forest was extensively cut,

Table 1 Recovery of species composition in the secondary tropical dry forest in 24 years

Diversity measure	Secondary tropical dry forest (A)	Old-growth forest (B)	Recovery (%) (= 100 (A/B))
Species richness (S_{est})	30	69	43
Exponential of Shannon's index ($e^{H'}$)	11.44	28.68	40
Fisher's α	6.06	18.06	34

Table 2 Recovery of vegetation structure in the secondary tropical dry forest in 24 years

Vegetation structure	Secondary tropical dry forest		Old-growth forest (C)	% recovery	
	Average (A)	Range (B)		Average (= 100 (A/C))	Range (= 100 (B/C))
Density (individuals ha^{-1})	706	250–1850	1240	57	20–149
Average total height (m)	4.3	2.9–6.0	9.0	48	32–67
Basal area (m^2 ha^{-1})	2.92	1.17–11.62	21.61	14	5–54

while the old-growth forest never experienced human disturbance. Their sizes also varied whereby the former was 15 km^2 while the latter, 338 km^2. Annual rainfalls of the two forests were also different, i.e. 600 and 700 mm $year^{-1}$. Some dryer forest species were only confined to the secondary tropical dry forest, while some moister forest species were found only in the old-growth forest.

The secondary tropical dry forest had recovered to certain levels (43, 40 and 34% in species richness, exponential of Shannon's index and Fishers's α respectively, Table 1) of the old-growth forest, but it may not reach a full recovery due to differences between the two forests. However, its species diversity had potential to increase because the abundance of the spatially-rare species (Appendix) was likely to increase. Due to the fragmented landscape of dry forests, no adjacent forest existed to faciliatate natural regeneration in the secondary tropical dry forest. However, resprouting seemed to be a noticeable regeneration mechanism after the disturbance in the secondary tropical dry forest, like in other dry forests (Vieira & Scariot 2006). In this study, there were individuals reaching up to 149% recovery in stem density compared with the old-growth forest (Table 2) and most of these individuals had multiple stems due to resprouting (personal observation). Recovery of average total height (32–67%) could probably proceed to full recovery since the common dominant species (e.g. *D. paniculata*, *T. oliveri*) had total height of about 9 m in the secondary tropical dry forest. However, basal area in the secondary tropical dry forest had slow recovery (average 14%, range 5–54%) in most sites, and thus, would require a longer time or silvicultural treatments to reach that of the old-growth forest (21.61 m^2 ha^{-1}).

In conclusion, recovery in the secondary tropical dry forest in the 24-year study varied with vegetation parameters. Species diversity of the secondary tropical dry forest had potential to increase but may not attain the level of the old-growth forest. However, structure of the secondary tropical dry forest was on the way to the status of the old-growth forest. Therefore, the dry forest could recover from human disturbance by means of natural regeneration although the overall results reflected slow recovery especially for basal area. Long-term conservation or silvicultural interventions would be required for the secondary tropical dry forest to reach its full recovery.

ACKNOWLEDGEMENTS

This research was funded by the Japanese Government (Monbukagakusho: MEXT) Scholarship Program and JSPS Grants-in-Aid for Scientific Research (KAKENHI Numbers

22251004 and 23248055). We highly appreciate the Forest Department and the Dry Zone Greening Department of Myanmar for their kind collaboration. We also would like to acknowledge N Htun, TM Htun, P Oo and O Kyaing for fieldwork assistance.

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Appendix Importance values (IVs) of species in the secondary dry forest and the old-growth forest

Species	IV (%)		Species	IV (%)	
	Secondary dry forest	Old-growth forest		Secondary dry forest	Old-growth forest
Dalbergia paniculata	14.24	8.59	*Vitex limonifolia*	○	0.05
Terminalia oliveri	12.42	8.24	*Azadirachta indica*	○	×
Acacia catechu	12.24	3.38	*Bombax ceiba*	○	×
Acacia inopinata	10.78	×	*Delonix regia*	○	×
Millettia multiflora	10.51	1.44	*Desmodium diffusam*	○	×
Terminalia tomentosa	9.98	2.95	*Premna tomentosa*	○	×
Grewia tiliifolia	8.14	×	*Randia laetevirens*	○	×
Lannea coromandelica	2.15	7.00	*Shorea siamensis*	×	4.60
Ehretia laevis	1.93	×	*Morinda tinctoria*	×	3.07
Acacia nilotica	1.90	×	*Xylia xylocarpa*	×	2.14
Sideroxylon burmanica	1.75	0.15	*Phyllanthus albizzioides*	×	1.22
Flacourtia indica	1.58	0.66	*Harrisonia perforata*	×	0.98
Carissa carandas	1.48	×	*Terminalia chebula*	×	0.96
Randia dumetorum	1.33	0.49	*Ziziphus oenoplia*	×	0.93
Hiptage benghalensis	1.10	1.24	*Shorea obtusa*	×	0.93
Gardenia turgida	0.98	0.26	*Melanorrhoea usitata*	×	0.91
Anogeissus acuminata	0.94	0.40	*Dipterocarpus tuberculatus*	×	0.89
Wendlandia ligustrina	0.66	×	*Heterophragma sulfureum*	×	0.85
Capparis sepiaria	0.62	×	*Lagerstroemia venusta*	×	0.84
Rhus paniculata	0.62	×	*Gomphostemma lucidum*	×	0.80
Diospyros montana	0.61	0.18	*Argyreia barbigera*	×	0.74
Bauhinia racemosa	0.62	0.34	*Dalbergia cultrata*	×	0.62
Diospyros burmanica	0.61	1.66	*Millettia eriocalyx*	×	0.62
Boscia variabilis	0.61	1.09	*Ziziphus rugosa*	×	0.61
Prosopis juliflora	0.47	×	*Gardenia sootepensis*	×	0.52
Cappris glauca	0.47	×	*Gentiana kurroo*	×	0.42
Bridelia retusa	0.35	0.86	*Artocarpus chaplasha*	×	0.33
Ziziphus jujuba	0.34	×	*Adina cordifolia*	×	0.31
Cassia grandis	0.32	×	*Pterocarpus macrocarpus*	×	0.27
Croton oblongifolius	0.30	×	*Capparis grandis*	×	0.26
Tectona hamiltoniana	○	16.48	*Cordia grandes*	×	0.25
Albizia chinensis	○	3.32	*Chukrasia tabularis*	×	0.19
Croton joufra	○	2.92	*Phyllanthus columnaris*	×	0.19
Millettia ovalifolia	○	2.52	*Lophopetalum wallitchii*	×	0.17
Gardenia sessiliflora	○	1.80	*Polyalthia crassa*	×	0.17
Emblica officinalis	○	1.61	*Strychnos potatorum*	×	0.17
Buchanania lanzan	○	1.23	*Engelhardtia spicata*	×	0.17
Bombax insigne	○	0.82	*Holarrhena pubescens*	×	0.15
Grewia eriocarpa	○	0.66	*Wrightia arborea*	×	0.14
Acacia leucophloea	○	0.40	*Congea tomentosa*	×	0.13
Stereospernum colais	○	0.39	*Olax scandens*	×	0.12
Miliusa velutina	○	0.30	*Hymenodictyon orixense*	×	0.11
Bauhinia diphylla	○	0.28	*Butea monosperma*	×	0.09

(continued)

(Appendix continued)

Species	IV (%)		Species	IV (%)	
	Secondary dry forest	Old-growth forest		Secondary dry forest	Old-growth forest
Terminalia pyrifolia	○	0.28	*Millettia glaucescens*	×	0.07
Cissus repanda	○	0.23	*Dillenia indica*	×	0.06
Acacia pennata	○	0.22	*Mitragyna parvifolia*	×	0.06
Abrus precatorius	○	0.19	*Schleichera oleosa*	×	0.06
Osyris arborea	○	0.15	*Spondias pinnata*	×	0.06
Albizia lebbekoides	○	0.14	*Syzygium fruticosum*	×	0.06
Balanites aegyptiaca	○	0.13	*Antidesma ghesaembilla*	×	0.05
Sterculia foetida	○	0.09	*Sebastiana chamaclea*	×	0.05
Garuga pinnata	○	0.06	*Syzygium kurzii*	×	0.05
Homalium longifolium	○	0.05	*Dalbergia oliveri*	×	0.05
Dolichandrone spathacea	○	0.05	*Vitex canescens*	×	0.05
Tamarindus indica	○	0.05			

Circle (○) represents spatially rare species observed outside the sample quadrats and cross (×) represents the absence of species