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Understanding High Altitude Reforestation in Mt. Apo, Philippines

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Abstract

Comparing the difference in forest community structure between a reforested area and a nearby old growth forest is one way to evaluate the ability of a disturbed forest to recover. Here, we show how a high altitude reforested area in Mt. Apo, Philippines is recovering relative to a nearby old growth forest. The species richness of understory vegetation in the old growth forest did not differ significantly from the 11 year-old reforested area, suggesting fast recovery in this aspect. However, the tree assemblage and sizes (i.e., Diameter at Breast Height) in the old growth forest had significantly higher tree diversity as well as larger trees than the reforested area, suggesting slower recovery in this aspect. In addition, the dominant species in terms of understory vegetation cover, tree abundance, and sizes differed significantly between the old growth forest and the 11 year-old reforested area. In general, the composition and structure of vegetation communities (understory and trees) in the old growth forest and the 11 year-old reforested area were about 13-29% similar. This means that, without management interventions (e.g., assisted recovery), it would probably take much longer time (than 11 years) for the reforested area to get to same condition as the nearby old growth forest. More importantly, results showed which aspects of the reforested area could be adjusted to potentially hasten its recovery towards the old growth forest status.

Key words: Forest Management, Forest Recovery and Resiliency, Philippines Forest, Reforestation, Restoration, Tropical Diversity

Introduction

Understanding the ability of a deforested area to recover to a state similar to its original condition or the condition of a nearby undisturbed (old-growth forest) and reforested areas is important for effective forest restoration (Halpern 1988). Knowing the rates by which a reforested area can return to a similar state as an old growth forest can help measure the effectiveness of reforestation or forest restoration efforts. In addition, understanding the ability of reforested areas to recover can help clarify the productivity and dynamics of exploited forests, and potentially increase their capacity to support the increasing human demands for forest products and services (Benayas *et al*. 2009; Chazdon 2008).

Old growth tropical forests (e.g., in SE Asia) are extensively being lost (Koh 2007) due to rapid increase in forest use and conversion by expanding human population and anthropogenic disturbances, which also contribute to the great loss of forests-associated biodiversity in SE Asia (Webb *et al*. 2010). In the Philippines, while over 50% of the primary forests were lost in the last 100 years, there is very limited quantitative data about the status of the remaining intact forests and the pre-deforestation and current conditions of deforested areas (Lasco *et al*. 2001), making forest conservation very challenging.

Biodiversity on earth is greatly concentrated in tropical Asia (Lane 2010). The Philippines is one of the megadiversity countries, but unfortunately, also a biodiversity hotspot (Carpenter and Springer 2005; Roberts *et al*. 2002; Sodhi *et al*. 2010b). This means that the loss of vast areas of tropical forests in the Philippines equates to great losses of biodiversity functions, services, and values (Sodhi *et al*. 2010a). To reverse this trend, reforestation or forest restoration efforts are undertaken. In general, there is often a lack of clarity in the targets of many reforestation projects (Sayer *et al*. 2004). Furthermore, varied ways of measuring success of forest restoration are used (Ruiz-Jaen and Mitchell Aide 2005). Thus, there is a great need for systematic ways of testing the effectiveness of reforestation efforts in recovering forest biodiversity (Chazdon 2008).

A common means to measure effectiveness of restoration projects is by testing the changes in conventional diversity metrics (e.g., species richness, evenness, and other diversity indices). However, this approach clearly cannot capture some aspects of biodiversity composition, structure (i.e., relative species abundance, sizes, DBH, etc.), and function (Lewis 2009). To address this problem, the Society of Ecological Restoration recommended a systematic and minimum set of measures for evaluating reforestation success (Ruiz-Jaen and Mitchell Aide 2005).

The study used a combination of conventional diversity measures and measures of community composition and structure using well-accepted and

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widely-used non-parametric multivariate statistical approaches to evaluate the ability of a high altitude reforested area in Mt. Apo, Philippines to recover in comparison to a nearby old growth forest (Clarke and Warwick 2001; Letcher and Chazdon 2009). The similarity in species composition, relative abundance, percentage cover, and sizes of trees (DBH), and understory vegetation cover (i.e., non-tree species) in an 11 year-old reforested area and a nearby old growth high altitude forest in Mount Apo, Mindanao, Philippines were also tested.

Materials and Methods

The reforested area (i.e., actively planted with native tree species such as *Leptospermum flavescens*, *Cinnamomum mercadoi* and *Dacrycarpus imbricatus*) and a nearby old growth forest study sites were located in Mount Apo, Mindanao, Philippines - a high altitude forest area with a peak of 2954 meters above sea level (m asl) (Paje *et al*. 2010) (Fig. 1). The reforested area and the old growth forest are so close to each other and share similar elevation, weather patterns, slope, and bedrock conditions (personal observations), although detailed geological study of the two study sites is still needed to confirm our initial impressions. The reforestation process and degraded condition of the reforested sites, including the low survival of *C. mercadoi* and *D. imbricatus*, were described in a separate paper (Paje *et al*. 2010), but below are the essential details about the sites. Except for the remaining patches of old growth forests, Mount Apo had been subjected to various anthropogenic disturbances (e.g., forest clearing, burning for subsistence agriculture, and logging), but had been actively reforested by planting several native species since the 1990s (Paje *et al*. 2010). The reforested areas were originally dominated by grasses – a typical end result of deforestation and slashed-burn agriculture in SE Asia (Hooper *et al*. 2002). However, the nearby old-growth forest that was used as a reference site was never subjected to any disturbance for as long as the local people in the area can remember. The elevation of the study sites ranged from 2400-2500 m asl.

To test the effectiveness of reforestation in a high altitude forest in Mount Apo, 12 randomly-laid belt transects (4 m width x 50 m length) in the two study sites were sampled: (1) an 11-year old reforested site, and (2) a nearby old growth forest (Fig. 1). Here, our main interest is to test the differences in forest community structure between a reforested area and a nearby old growth forest – thus, replications of random and non-overlapping transects (our sampling units) within the compared sites are necessary, appropriate, and are not pseudo-replications at this scale. All trees within each transect were identified, counted and their DBH (≥ cm DBH) measured. In addition, within a 1 x 1m quadrat along five sections of each transect (i.e., at points 0, 10, 20, 30, and 40 m), the percentage cover of understory vegetation (i.e., non-tree species) encountered were identified and estimated using the Braun-Blanquet vegetation survey approach (Wikum and Shanholtzer 1978), with the GPS coordinates of all transects recorded. The percentage cover of non-tree species within each quadrat were visually assessed (i.e., at ± 10% precision).

Non-parametric multivariate statistical approaches in testing spatial (or temporal) variations in ecological communities – such as testing the differences in species composition and relative abundance (or the sizes (DBH)) of species found in the reforested and old growth forests study sites (Clarke and Warwick 2001) - were used in the analysis. The non-parametric statistical methods that we used have been carefully explained in detail in papers published by the developers of the software PRIMER (Clarke 1993) and are widely accepted or applied in community ecology research

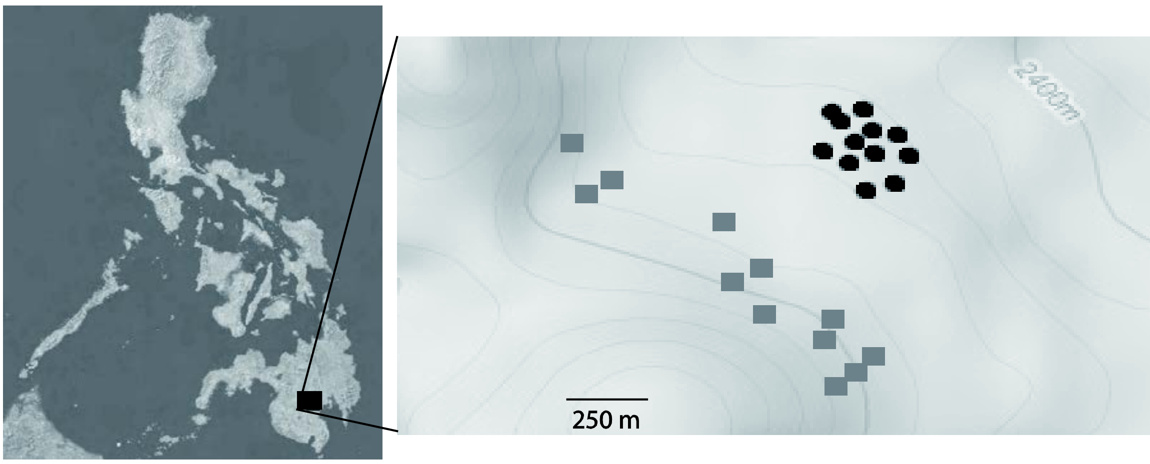

Fig. 1. Map of the study site, indicating the locations of sampled transects in the old growth (black circles) and reforested area (grey squares). Contour interval = 20 m.

(Anderson 2001; Anticamara *et al*. 2010; Letcher and Chazdon 2009). Initially, the species accumulation curves for both tree and understory data (using permutation approaches or randomization of sample addition in generating the species accumulation curves) were plotted. This yielded an estimate of total tree and understory vegetation species found in the reforested and old growth forests with every addition of transect sample. Afterwards, the Bray-Curtis Similarity value (a non-parametric equivalent of Euclidean distance for measuring similarity of species and relative abundance or size matrices (Clarke and Warwick 1994; Clarke 1993) was calculated for (1) the composition and relative abundance (or mean tree DBH) of species found in every transect sampled in the two study sites; and (2) the species composition and percentage cover of the understory species, found in each transect sampled in the two study sites.

Using the Bray-Curtis Similarity values of tree or understory composition and relative abundance (or DBH or percentage cover), the Non-metric Multi-dimensional Scaling Plots (NMDS) and Cluster Dendograms of transects sampled from the two forests types were generated (the details of these methods are described in original papers by the developers and others papers which adopted these methods) (Anticamara 2009; Clarke 1993; Letcher and Chazdon 2009). One-way Analysis of Similarity (ANOSIM) was applied to test the significance of any differences in tree and understory vegetation communities in the reforested and old growth forests based on the sampled transects. A Similarity of Percentage (SIMPER) Contribution analysis was undertaken to evaluate which species contributed most to the dissimilarities of the transects sampled in the two forest types, and to test how much the two areas differ in community composition and structure, using both the tree and understory vegetation data (Clarke and Warwick 2001; Colón and Lugo 2006; Gray *et al*. 1988; Gwali *et al*. 2010).

One-way ANOVA was used to test the differences in values of conventional univariate diversity indices (i.e., species richness, Shannon-Wiener’s H’, Margalef’s d, and Pielou’s J) calculated for tree and understory communities found in each transect in the two forest types.

Results and Discussion

Community Composition and Structure

The tree composition and structure (i.e., species’ relative abundance and size) were significantly different between the old growth forest and the 11 year-old reforested area (Figs. 2a-b and 3a-b). NMDS and Cluster plots showed distinct groupings of transect sampled from the old-growth and reforested areas in terms of relative abundance (Fig. 2a-b) and sizes of tree species (Fig. 3a-b) (note that NMDS are non-metric, therefore the NMDS plots have no scale; also note that the Cluster plots give a measure of the transect similarity values within and between the reforested and old growth forests). Using ANOSIM, these differences were statistically significant (Global R=0.9; P=0.001) (Figs. 2a-b and 3a-b). Analyses using SIMPER of various tree species indicated that in terms of (1) tree species abundance, the old growth forest was dominated by *Tasmannia piperita* (Table 1), while the reforested area was dominated by *Leptospermum flavescens*; however, in terms of (2) tree size, the old growth forest was dominated by *Leptospermum flavescens* (the species planted in the reforested area) and *Myrica javanica* (Table 2; Appendix Figures 2A and 2B).The average similarity in the composition and relative abundance of tree species between the old growth forest and reforested area was 15.5% (Table 1). The average similarity in the composition and sizes of tree species found in the old growth and reforested areas was 13.6% (Table 2).

These results indicate that more than 11 years is needed for the reforested area to fully approach the same state as the old growth forest (i.e., in terms of tree species composition and structure or the relative tree species abundance, size or DBH, and understory cover). This is probably due to the slow growth rates of *Leptospermum flavescens* as well as the absence of *Myrica javanica* in the reforested areas. Augmenting the recovery of these two species (e.g., adopting assisted recovery methods (Shono *et al*. 2007)) might hasten the recovery of the reforested study site. The understory vegetation in the old growth forest also differed from the reforested area – except for few transect samples where the two sites appeared similar (Fig.4a-b). NMDS and Cluster plots showed distinct groupings of transects from the old growth and reforested areas in term of percentage cover of understory species (Fig. 4a-b). ANOSIM indicated that these differences were significant (Global R=0.3; P=0.001) (Fig. 4a-b). SIMPER analysis indicated that although the understory of the old growth forest and the reforested areas were both dominated by *Saccharum spontaneum*, the mean percentage cover of this understory vegetation was lower in the old growth than the reforested area (Table 3). In addition, other understory vegetations that are dominant in the reforested site (e.g., *Dennstaedtia* sp. and *Graminae* sp.) did not show high percentage cover in the old growth forest compared to the reforested area (Table 3).

The overall similarity in the composition and percentage cover of understory vegetation between the two forest types was 28.7% (Table 3). Controlling the growth and cover (via shading and brushing) of *Saccharum spontaneum* and other understory vegetations in the reforested areas that are not present in the old growth forest might hasten the recovery of the reforested area towards an understory community that might approach that of the old growth forest (Hooper *et al*. 2002).

Diversity

Twelve tree species were found across the study sites (ten and eight species in the old growth forest and in the reforested area, respectively, Appendix Fig. A1a-b). One-way ANOVA detected a significantly higher tree diversity in the old growth forest than in the 11 year-old reforested area (Fig. 5a).

In contrast, 48 understory vegetation species were found across the study sites (23 species in the old growth and 25 species in the reforested area, Appendix Fig. A2a-b). No significant differences in the diversity of understory vegetation cover in the two forest types were detected using One-way ANOVA (Fig. 5b).

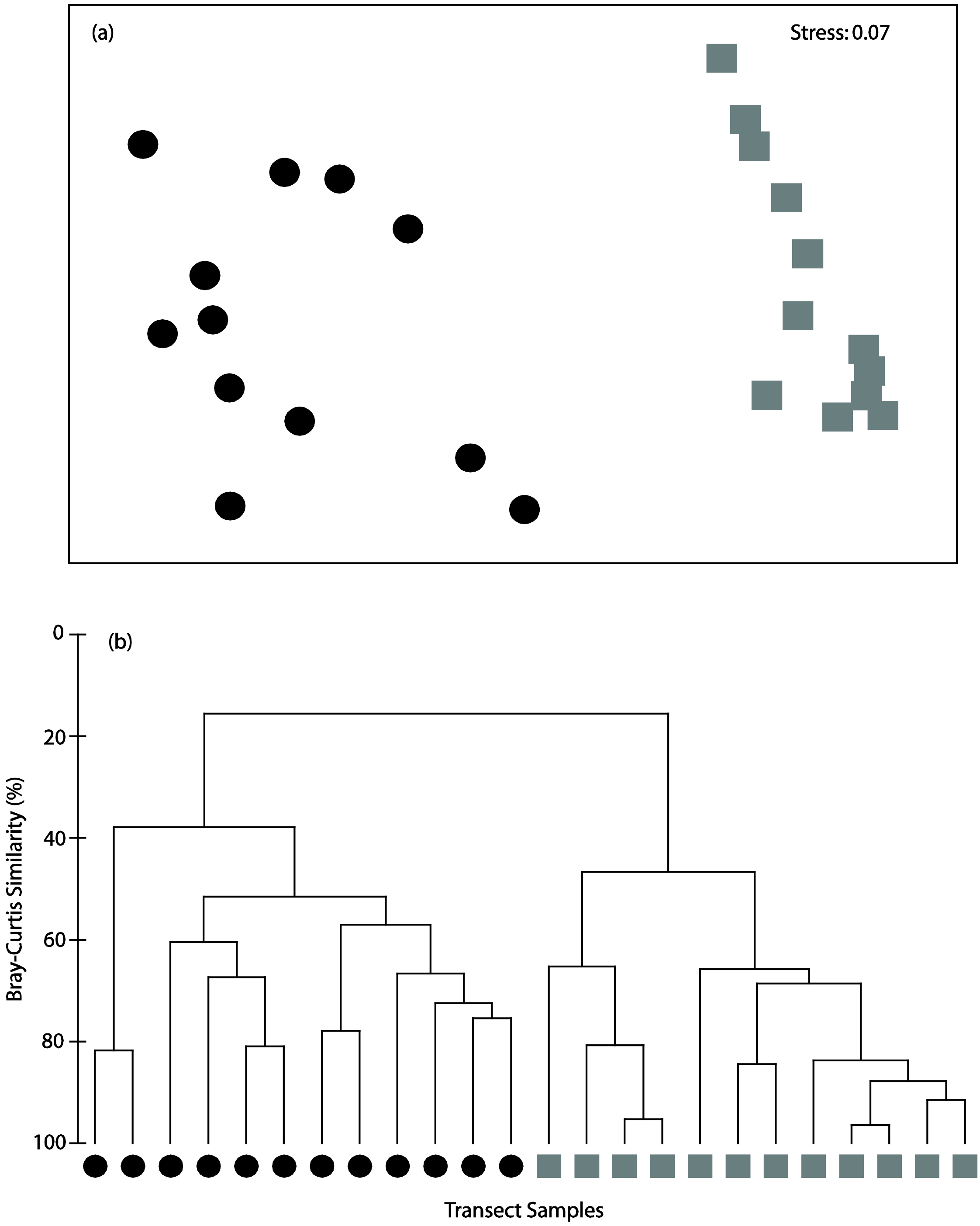

Fig. 2. Non-metric Multidimensional Scaling (NMDS) (a) and Cluster (b) plots showing the Bray-Curtis Similarities of transects sampled across the old growth (black circles) and reforested area (grey squares), in terms of tree composition and relative abundance. Transects that are close to each other on NMDS space indicate highly similar species composition and relative abundance of those species, and transects farther from each other indicate otherwise.

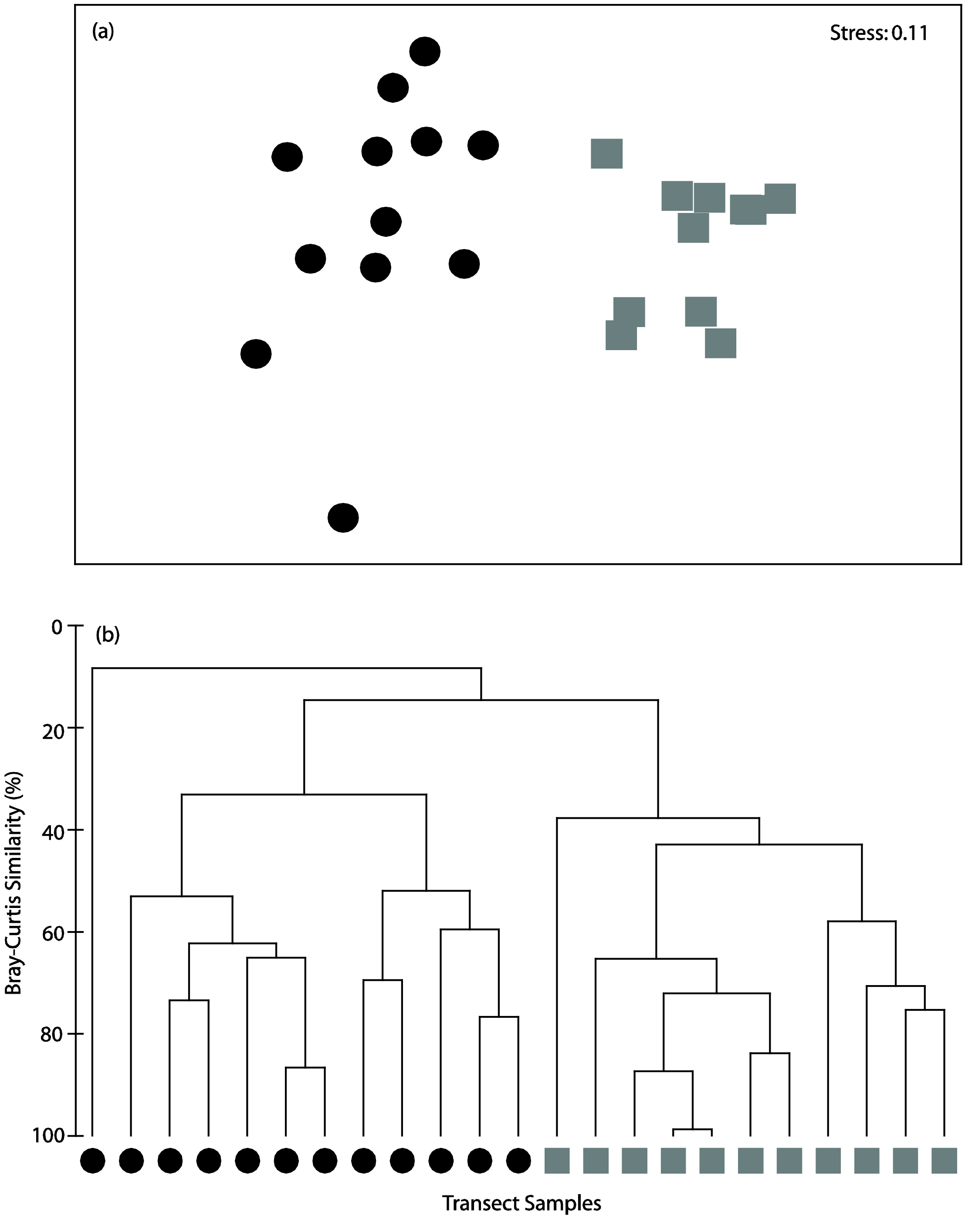

Fig. 3. Non-metric Multidimensional Scaling (NMDS) (a) and Cluster (b) plots showing the Bray-Curtis Similarities of transects sampled across the old growth (black circles) and reforested area (grey squares), in terms of tree composition and relative size (i.e., Diameter at Breast Height DBH in cm).

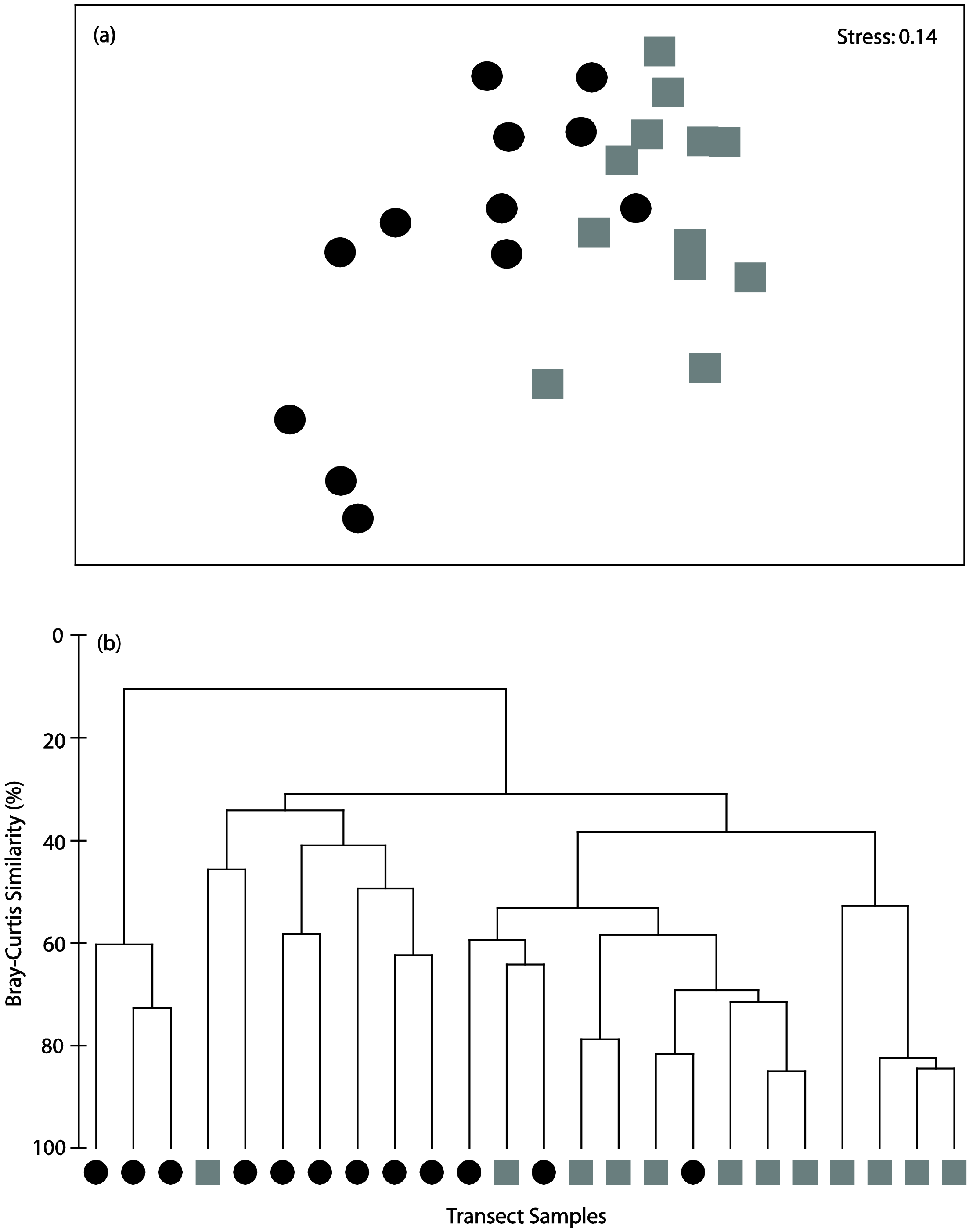

Fig. 4. Non-metric Multidimensional Scaling (NMDS) (a) and Cluster (b) plots showing the Bray-Curtis Similarities of transects sampled across the old growth (black circles) and reforested area (grey squares), in terms of understory vegetation composition and percentage cover.

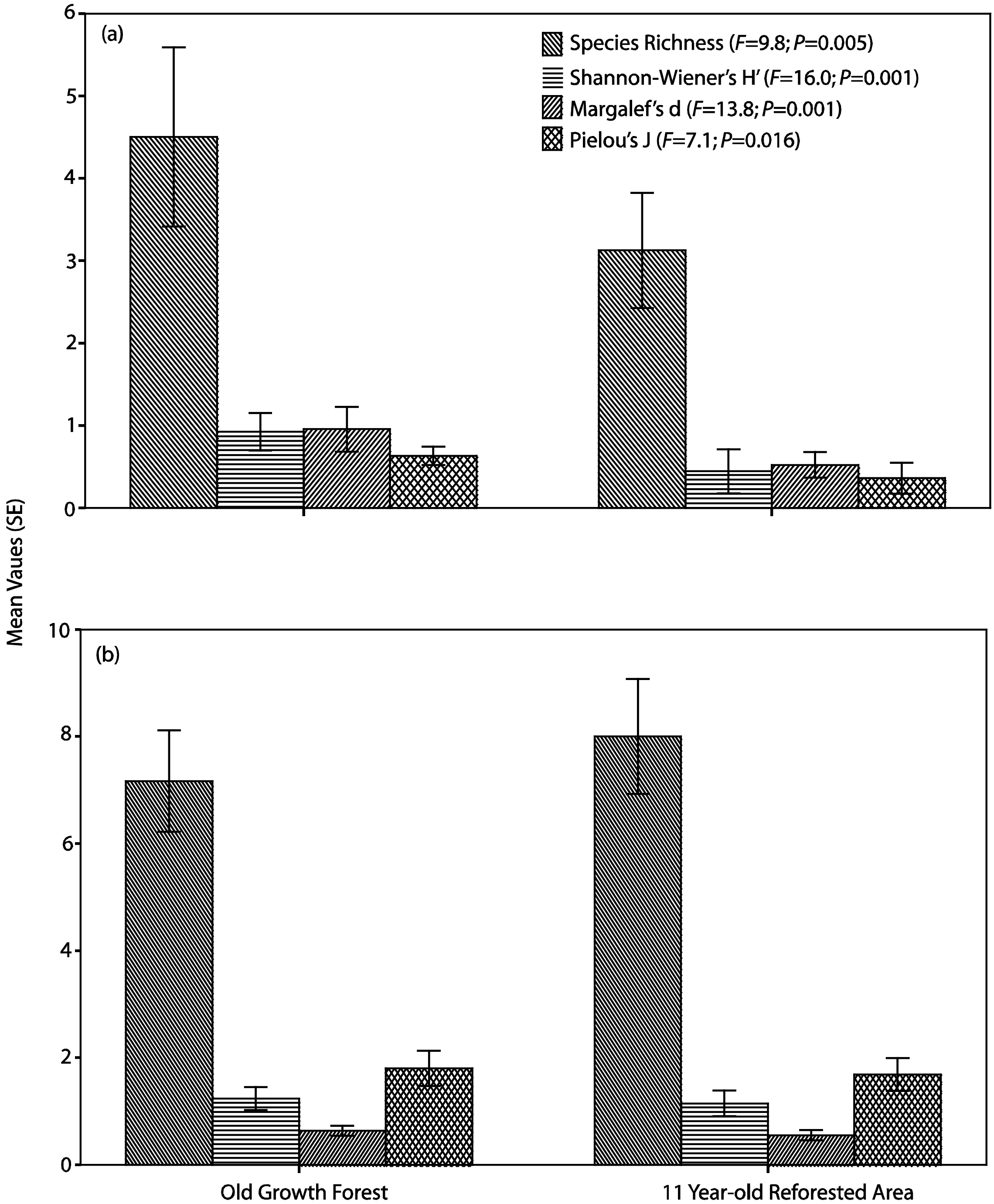

Fig. 5. Barplots showing the mean values (standard errors SE) of the four measures of diversity of trees (a) and understory vegetations (b) across all the transects sampled in the old growth and reforested study sites. Also presented are the outputs of the One-way ANOVA testing the differences in the four diversity indices between the old growth and reforested sites (F and P values were presented for significant results).

Table 1. Outputs from the Similarity of Percentage (SIMPER) Contribution analysis detailing the contributions of the dominant tree species in average dissimilarities of the species composition and relative abundance between transects sampled from the old growth and reforested areas (Average Dissimilarity = 84.45%; or Average Similarity = 15.55%)

Species	Average Abundance (Old Growth)	Average Abundance (Reforested)	Average Dissimilarity	% Contribution
Leptospermum flavescens	8.5	50.8	43.9	52.0
Tasmannia piperita	29.5	0.5	27.7	32.8
Pipturus cf asper		3.3	3.1	3.7
Myrsine cf apoensis	2.9	0.2	2.7	3.2

Table 2. Outputs from the Similarity of Percentage (SIMPER) Contribution analysis detailing the contributions of the dominant tree species in average dissimilarities of the species composition and relative size (DBH in cm) between transects sampled from the old growth and reforested areas (Average Dissimilarity = 86.36%; or Average Similarity = 13.64%)

Species	Average DBH (Old Growth)	Average DBH (Reforested)	Average Dissimilarity	% Contribution
Leptospermum flavescens	29.6	4.9	31.8	36.8
Myrica javanica	25.0		20.7	23.9
Eurya sp.	6.6	0.2	10.3	11.9
Cyathea sp.	6.8		7.4	8.5
Tasmannia piperita	4.0	0.6	4.7	5.4
Myrsine cf apoensis	3.2	0.5	3.8	4.4

Current Findings versus Published Literature

These results are consistent with similar studies indicating that forests can quickly recover terms of diversity indices (i.e., species richness), but the composition and structure (e.g., dominance patterns in terms of species' relative abundance, size or DBH, or percentage cover of understory vegetation) may take some time to restore in disturbed forests, even for relatively low diversity high altitude tropical forests (Berry *et al*. 2010). The inadequacy of conventional diversity metrics capturing recovery in reforested areas or the impacts of anthropogenic disturbances was also noted (Lewis 2009). Quantifying a more comprehensive aspect and measure of forest recovery (i.e., species richness, diversity, and dominance patterns in terms of relative abundance and size) will provide concrete guide for enhancing the effectiveness of forest restoration (i.e., by knowing exactly which forest diversity aspects to control for or enhance). In this study, controlling *Saccharum spontaneum* cover and augmenting the growth rates of *Leptospermum flavescens*, seemed likely parameters to explore. Other studies also indicated that assisted recovery is needed to increase the speed of recovery in reforested areas (Shono *et al*. 2007; Zanne and Chapman 2001). In other tropical reforestation projects, shading of *Saccharum spontaneum* was done to enhance the recovery of tree species (Hooper *et al*. 2002). It is strongly suggested that a comprehensive analyses of community composition and structure should be applied to reforestation projects in highly deforested tropics, such as the Philippines. This will allow for insights to be gained on how to exactly restore such deforested areas to conditions similar to nearby old growth forests.

Table 3. Outputs from the Similarity of Percentage (SIMPER) Contribution analysis detailing the contributions of the dominant understory species in average dissimilarities of the species composition and relative percentage cover between transects sampled from the old growth and reforested areas (Average Dissimilarity = 71.21%; or Average Similarity = 28.79%)

Species	Average % Cover (Old Growth)	Average % Cover (Reforested)	Average Dissimilarity	% Contribution
Saccharum spontaneum	19.0	35.2	25.2	35.3
Dennstaedtia sp.	1.0	16.8	16.3	22.9
Graminae sp.		5.6	5.1	7.1
Acrophorus nodosus	3.8	2.5	4.6	6.5
Dimorphanthera apoana	2.9	0.5	2.8	3.9
Elatostema sp.	1.0	1.2	2.4	3.3
Sarcandra glabra	2.3	0.0	2.3	3.2
Juncus effusus		1.5	1.8	2.5
Selaginella sp.	1.6		1.4	2.0
Rubus cf fraxinifolius	0.2	0.8	1.0	1.5
Belvisia sp.	0.9	0.0	1.0	1.4

Future Research Directions

Ways for evaluating recovery in reforested areas in high altitude tropical forests in the Philippines were demonstrated. More importantly, factors and processes (e.g., effects of biological and environmental seed dispersers, or community interactions between trees, understory vegetation, and associated fauna) should be further explored to gain fuller insights of recovery in reforested tropical forests. A more comprehensive database of reforestation projects in the Philippines should be developed, in order to gain comparative analyses of the variations in the recovery of reforested areas across the Philippines in relations to forest types, elevation, and geographical locations – to further test the effects of scale and site replications on the recovery patterns that we observed.

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References

Anderson MJ (2001) A new method for non-parametric multivariate analysis of variance. Austral Ecology 26:32–46.

Anticamara JA (2009) Ecology of recovering degraded reef communities within no-take marine reserves. University of British Columbia (https://circle.ubc.ca/handle/2429/21384).

Anticamara JA, Zeller D, Vincent ACJ (2010) Spatial and temporal variation of abundance, biomass and diversity within marine reserves in the Philippines. Diversity and Distributions 16:529–536.

Benayas JMR, Newton AC, Diaz A, Bullock JM (2009) Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. Science 325:1121.

Berry NJ, Phillips OL, Lewis SL, Hill JK, Edwards DP, Tawatao NB, Ahmad N, Magintan D, Khen CV, Maryati M (2010) The high value of logged tropical forests: lessons from northern Borneo. Biodiversity and conservation 19:985–997.

Carpenter KE, Springer VG (2005) The center of the center of marine shore fish biodiversity: the Philippine Islands. Environmental biology of fishes 72:467–480.

Chazdon RL (2008) Beyond deforestation: restoring forests and ecosystem services on degraded lands. Science 320:1458.

Clarke K, Warwick R (1994) Similarity-based testing for community pattern: the two-way layout with no replication. Marine Biology 118:167–176.

Clarke KR (1993) Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18:117–143.

Clarke KR, Warwick RM (2001) Change in marine communities: an approach to statistical analysis and interpretation. Primer-E Ltd, Plymouth, UK.

Colón SM, Lugo AE (2006) Recovery of a Subtropical Dry Forest After Abandonment of Different Land Uses. Biotropica 38:354–364.

Gray J, Aschan M, Carr M, Clarke K, Green R, Pearson T, Rosenberg R, Warwick R (1988) Analysis of community attributes of the benthic macrofauna of Frierfjord/Langesundfjord and in a mesocosm experiment. Marine Ecology Progress Series 46:151–165.

Gwali S, Okullo P, Hafashimana D, Byabashaijaa DM (2010) Taxonomic diversity, distinctness, and abundance of tree and shrub species in Kasagala forest reserve in Uganda: implications for management and conservation policy decisions. Tropical Conservation Science 3:319–333.

Halpern CB (1988) Early successional pathways and the resistance and resilience of forest communities. Ecology 69:1703–1715.

Hooper E, Condit R, Legendre P (2002) Responses of 20 native tree species to reforestation strategies for abandoned farmland in Panama. Ecological Applications 12:1626–1641.

Koh LP (2007) Impending disaster or sliver of hope for Southeast Asian forests? The devil may lie in the details. Biodiversity and Conservation 16:3935–3938.

Lane DJW (2010) Tropical islands biodiversity crisis. Biodiversity and Conservation 19:313–316.

Lasco R, Visco R, Pulhin J (2001) Secondary forests in the Philippines: Formation and transformation in the 20th century. Journal of Tropical Forest Science 13:652–670.

Letcher SG, Chazdon RL (2009) Rapid recovery of biomass, species richness, and species composition in a forest chronosequence in northeastern Costa Rica. Biotropica 41:608–617.

Lewis OT (2009) Biodiversity change and ecosystem function in tropical forests. Basic and Applied Ecology 10:97–102.

Paje MJ, Alvares JAS, Guangco RS, del Rosario EP (2010) EDC's Reforestation Initiatives in Mt. Apo World Geothermal Congress 2010, Bali, Indonesia, pp 1–5.

Roberts CM, McClean CJ, Veron JEN, Hawkins JP, Allen GR, McAllister DE, Mittermeier CG, Schueler FW, Spalding M, Wells F (2002) Marine biodiversity hotspots and conservation priorities for tropical reefs. Science 295:1280.

Ruiz-Jaen MC, Mitchell Aide T (2005) Restoration success: How is it being measured? Restoration Ecology 13:569–577.

Sayer J, Chokkalingam U, Poulsen J (2004) The restoration of forest biodiversity and ecological values. Forest ecology and management 201:3–11.

Shono K, Cadaweng EA, Durst PB (2007) Application of assisted natural regeneration to restore degraded tropical forestlands. Restoration Ecology 15:620–626.

Sodhi NS, Lee TM, Sekercioglu CH, Webb EL, Prawiradilaga DM, Lohman DJ, Pierce NE, Diesmos AC, Rao M, Ehrlich PR (2010a) Local people value environmental services provided by forested parks. Biodiversity and Conservation 19:1175–1188.

Sodhi NS, Posa MRC, Lee TM, Bickford D, Koh LP, Brook BW (2010b) The state and conservation of Southeast Asian biodiversity. Biodiversity and Conservation 19:317–328.

Webb CO, Slik JWF, Triono T (2010) Biodiversity inventory and informatics in Southeast Asia. Biodiversity and Conservation 19:955–972.

Wikum DA, Shanholtzer GF (1978) Application of the Braun-Blanquet cover-abundance scale for vegetation analysis in land development studies. Environmental Management 2:323–329.

Zanne AE, Chapman CA (2001) Expediting reforestation in tropical grasslands: distance and isolation from seed sources in plantations. Ecological Applications 11:1610–1621.

Appendix

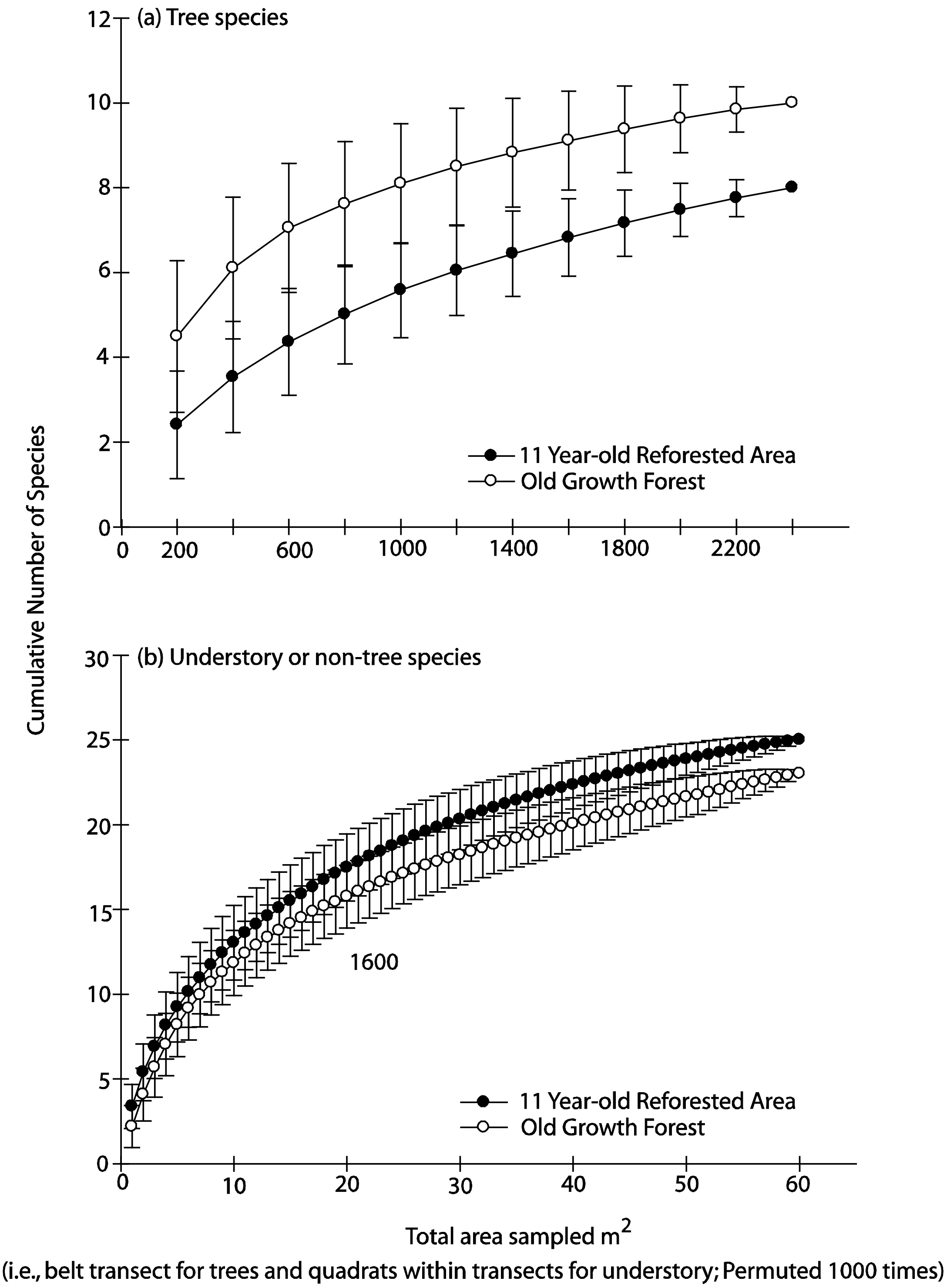

Fig. 1. Cumulative number of tree species found in every additional sample transects in Old growth forests and 11-year old reforested area, based on 1000x permutations of transect ordering (a); Cumulative number of understory vegetation found in every additional sample transects in old growth forests and 11-year old reforested area, based on 1000x permutations of quadrats ordering (b). Sampling unit (i.e., transect and quadrat are presented as area surveyed). Error bars are standard deviations.

Figure 2A

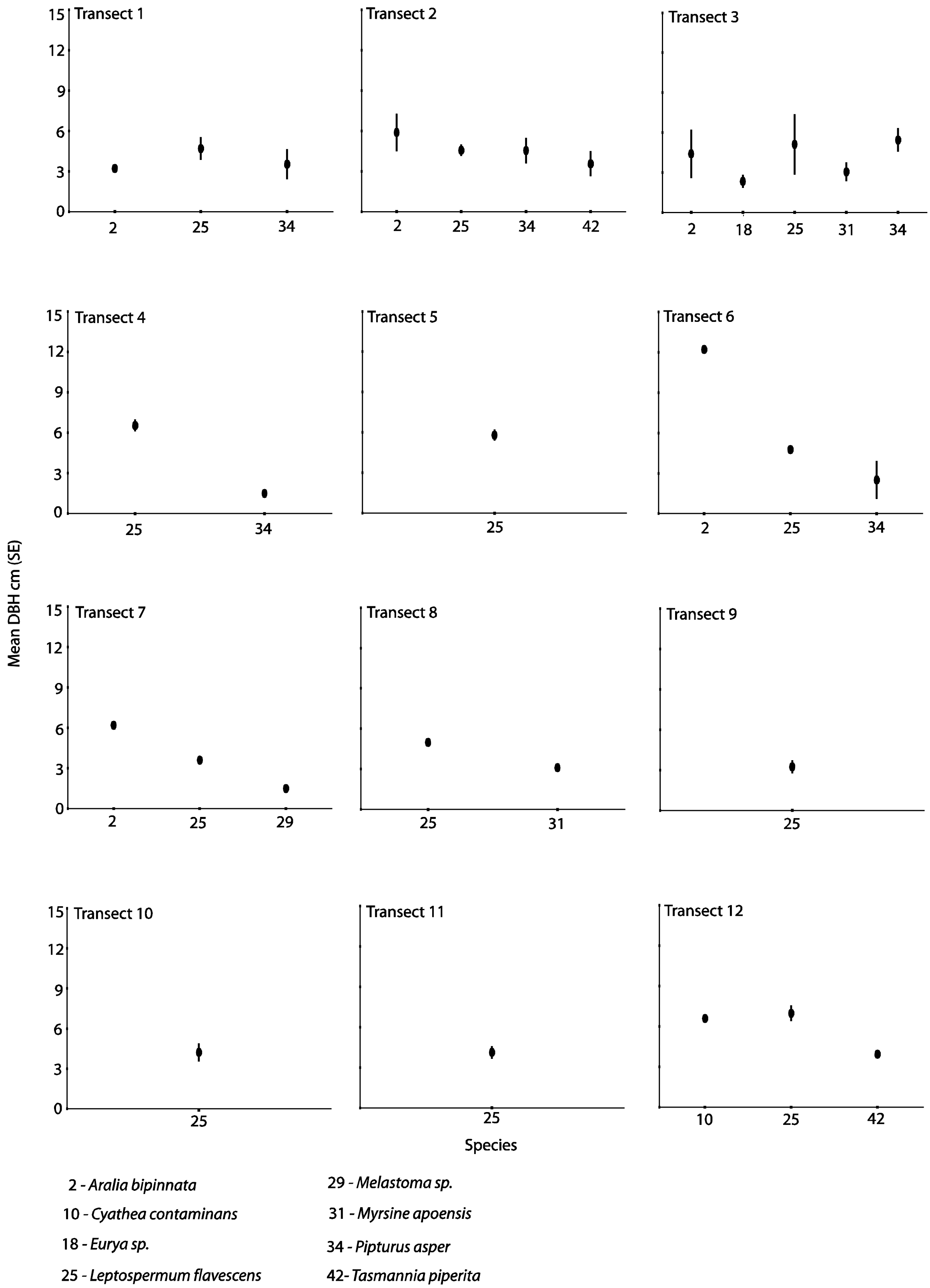
Mean DBH cm (SE)
Transect 1
Transect 2
Transect 3
Transect 4
Transect 5
Transect 6
Transect 7
Transect 8
Transect 9
Transect 10
Transect 11
Transect 12
Species
2 - Aralia bipinnata
10 - Cyathea contaminans
18 - Eurya sp.
25 - Leptospermum flavescens
29 - Melastoma sp.
31 - Myrsine apoensis
34 - Pipturus asper
42- Tasmannia piperita

Figure 2B

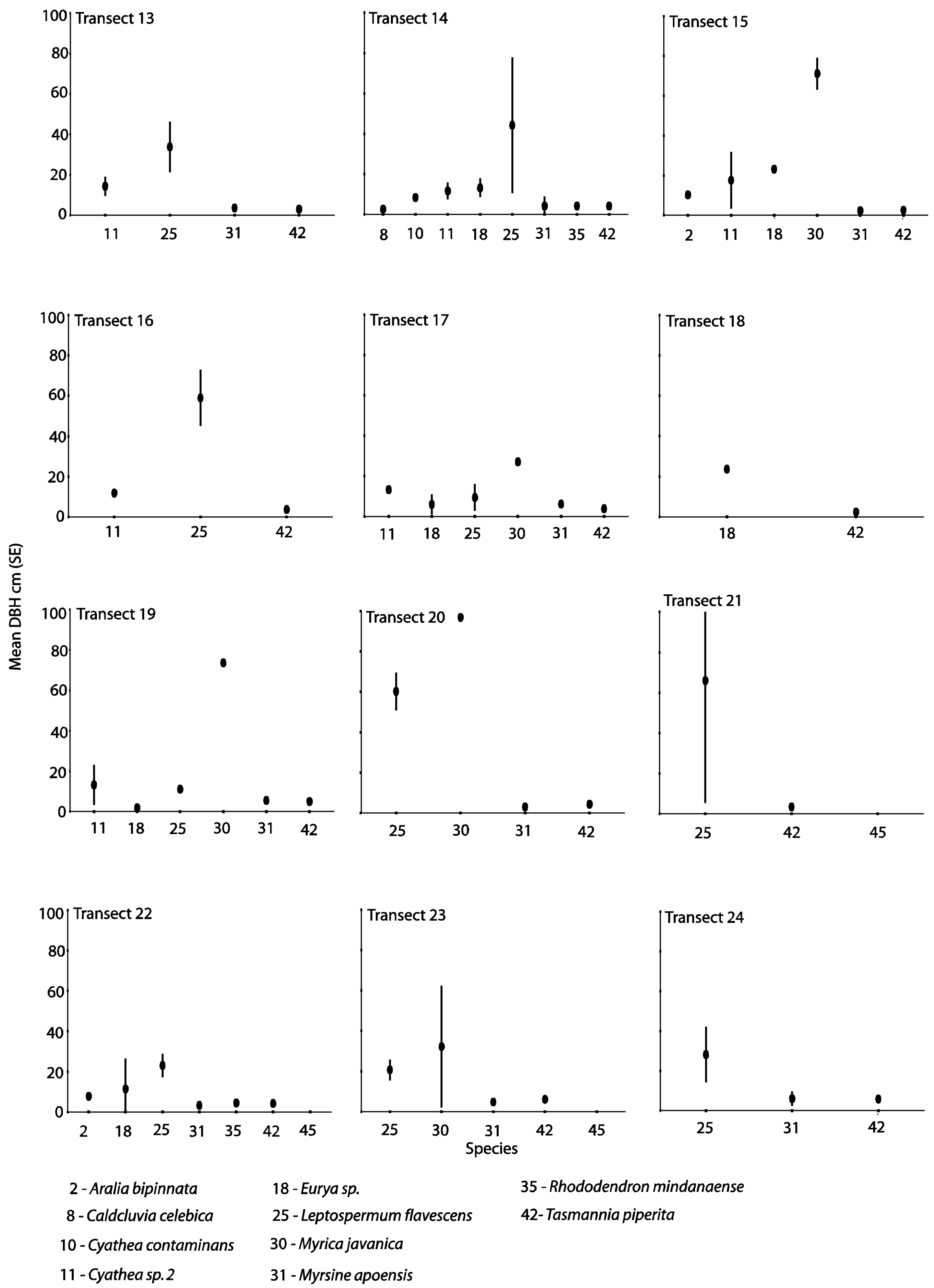

Fig. 2. Size structure (i.e. mean DBH ± SE) of tree species found in sampled transects within the 11-year old reforested site (A) and the old growth forest (B). Note the difference in y-axis scales between Figures 2A and 2B.