FARSYMABI PROJECT

"A farming system approach to mainstream biodiversity in the agriculture and planning sectors: bridging between the national and local levels"

RESEARCH REPORT
ASSESSMENT OF TREE SPECIES COMPOSITION AND DIVERSITY ACROSS DISTURBANCE GRADIENTS IN MOUNT NAMULI

Natasha Ribeiro e Victorino Buramuge

MAY 2024

PARTNERS: OMR Observatório do Meio Rural; Instituto Superior de Agronomia Universidade de Lisboa; Universidade Eduardo Mondlane; Universidade Lúrio

SPONSORS: AFD Agence Française de Développement

CONTENT

LIST FIGURES

LIST OF TABLES

ACKNOWLEDGEMENT

We would like to acknowledge the contribution of Nitidae, FARSYMABI's local partner, who provided support at all stages of the project, in particular in fieldwork, which was essential for the development and performance of the project activities, including the biodiversity inventory. Nitidae's support was fundamental in the preparation and execution of the expedition, providing support in liaising with the local/traditional authorities, the guides and field assistants, and providing their camp located in Murrabué, including materials and equipment (e.g., generator, cooking and kitchen utensils, and other materials). Their support was also relevant for insight and guidance regarding the organization and hierarchy at the community level, which contributed to following the cultural and traditional customs, promoting proper interaction with traditional leaders and community members. Nitidae's team were always available to support the FARSYMABI team in emergency and unforeseen situations. Therefore, we would like to deeply thank the entire Nitidae team, and a special thanks to the team based in Gurué.

We would also like to thank all those involved in the Namuli vegetation inventory, including the guides, field assistants and the inventory assistants, especially Jone Fernando, Ernesto Boane, Aidão Munome and Mateus Mapossa, whose efforts were essential to understanding the region's biodiversity. We greatly appreciate the time and energy you've committed to the FARSYMABI project.

1. BACKGROUND

The tropical forests represent important habitats for up to two-thirds of terrestrial animal and plant species (FAO, 2018), provide multiple ecosystem services and contribute to global climate regulation and the hydrological cycle.

In Africa, tropical forests play an important role by providing income for rural population and economic development (Ribeiro et al., 2020). However, they are being depleted at a faster rate, experiencing unprecedented losses, as a consequence of deforestation and degradation (Geist and Lambin 2002). Rapid population growth, agricultural land expansion, and intensive forest harvesting for firewood and timber, are the main drivers of deforestation and forest degradation. Agriculture practice is considered the major direct driver of deforestation (Curtis et al., 2018).

Shifting agriculture has been considered one of the main causes of deforestation and forest degradation (Ceagre, 2016). When soil fertility is depleted, new sites are identified, and the vegetation is cut down and burned. Abandoned areas are left as fallow to regain soil fertility and resumed later, after about 8-10 years. This practice has been recognized as being one of the main threats to biodiversity and therefore requiring the adoption of actions to make agricultural systems more sustainable. Human population continues to grow and the demand for agricultural resources (including land) is increasing. In this context, it is required that production systems are reassessed, integrating a fundamental aspect - the biodiversity.

The sustainable agricultural systems are those that ensure sustained food production and at the same time are intrinsically linked to the role of biodiversity. Biodiversity maintain critical ecological processes such as pollination, soil fertilization and adaptation to climate change. Thus, biodiversity-rich ecosystems are resilient and more sustainable.

The present study assess the ecological condition of the vegetation component in different habitats of Mount Namuli, Gurue District, related to the existing farming systems. The information obtained is critical to understanding the ecological processes and dynamics induced by human interventions in the Mount Namuli, a hotspot of biodiversity. The results of this assessment are crucial to incorporate biodiversity aspects into agricultural policies.

2. METHODOLOGY

2.1 Sampling strategy

This study was conducted in Mount Namuli, Gurue district, Zambézia Province, central Mozambique. Data were collected in three habitats, namely Forest, Fallow and Cropland, which were considered as our study strata (Table 1). Forest and cropland strata were further divided into mountain and lowland habitats and the fallow strata into young (1-2 years old after abandonment) and old (> 3 years old) in mountain and lowland areas.

The strata were established based on land cover cartography and satellite images. Validation of habitats and strata was carried out in 2023 through ground observations. The age of the fallows was established based on field observations and information from local communities. For data collection,

stratified sampling was established and the corresponding number of plots per strata was defined based on the size of the habitat (Table 1).

Our sampling plots were 50 x 20 m in size, where we collected the following vegetation parameters: number of adult (diameter at breast height, dbh > 5cm) and regenerating (dbh <=5 cm) tree individuals and their scientific names (when possible) and, herbaceous and grass species. The scientific names of the trees and herbaceous species were identified by a botanists from Eduardo Mondlane University, and the species with ambiguous identification were confirmed in the Herbarium of the Faculty of Sciences, Eduardo Mondlane University and other relevant sources. Species were categorized according to their level of endemism, invasiveness, and indicators of soil degradation.

Table 1. Description of the habitat areas and the respective strata

Habitat	Strata	Description	Nº plots
Forest	01_Mont_Forest	Montane forest (> 1 600 m asl)	28
	05_Low_Forest	Low-elevation forest (< 1 500 m asl); includes riparian, lowland and mid-altitude forest	14
Fallow	02_Mont_Fallow_3_4	Old montane fallows - age: 3 or more years (> 1 600 m asl)	10
	03_Mont_Fallow_1_2	Young montane fallows - age: 1-2 years (> 1 600 m asl)	5
	06_Low_Fallow_3_4	Old low-elevation fallows - age: 3 or more years (< 1 500 m asl)	10
	07_Low_Fallow_1_2	Young low-elevation fallows - age: 1-2 years (< 1 500 m asl)	11
Cropland	04_Mont_Crop	Montane cropland (> 1 600 m asl)	9
	08_Low_Crop	Low-elevation cropland (< 1 500 m asl)	28

2.2. Data analysis

The following parameters were calculated per strata at the species level:

1) Frequency (absolute and relative): the number of plots where a particular species occur
2) Abundance (absolute and relative): number of individuals per hectare

We conducted multivariate analyses to determine species diversity and composition differences among the different strata. We generated rarefaction curves for each strata to evaluate the representativeness of the sampling effort and to compare specie richness and diversity among the strata. The rarefaction curves were constructed using the iNEXT package (Chao et al., 2014).

Biodiversity indices (Shannon-Weiner's H′ and Pielou's J′ evenness) were calculated for the tree strata. The Kruskal–Wallis test (for non-normally distributed data), followed by Dunn's test at the 5% significance level, were used to assess Shannon index diversity differences between strata.

A non-metric multidimensional scaling (NMDS) analysis was used to determine the similarity of species composition for each stratum, using the Bray-Curtis similarity indexes. The similarity test

(ANOSIM, 9999 permutations) was used to assess differences in the species composition of the strata. To evaluate the differences between the groups in ANOSIM, the R-value was used:
$0.75 < R < 1$: Highly different

$0.5 < R < 0.75$: Different

$0.25 < R < 0.5$: Different with some overlap

$0.1 < R < 0.25$: Similar with some differences (or high overlap)

$R < 0.1$: Similar

Additionally, Similarity analysis (SIMPER) was employed to determine the species contribution to the overall dissimilarity. The SIMPER multivariate analysis attempts to find the species that contribute the most to the differentiation of sample groups (Clarke, 1993).

The statistical analyzes were performed using the R statistical software (R Core Team, 2021) and Paleontological Statistics Software Package for Education and Data Analysis (Hammer et al., 2001).

3. RESULTS

3.1. Rarefaction curves

3.1.1 Forest habitat: mountain vs lowland forests

As indicated in Figure 1, there are no significant differences in species diversity between mountain and lowland forest at adult level (Figure 1A) but for young cohort, species diversity was significantly higher in the mountain forest (Figure 1B).

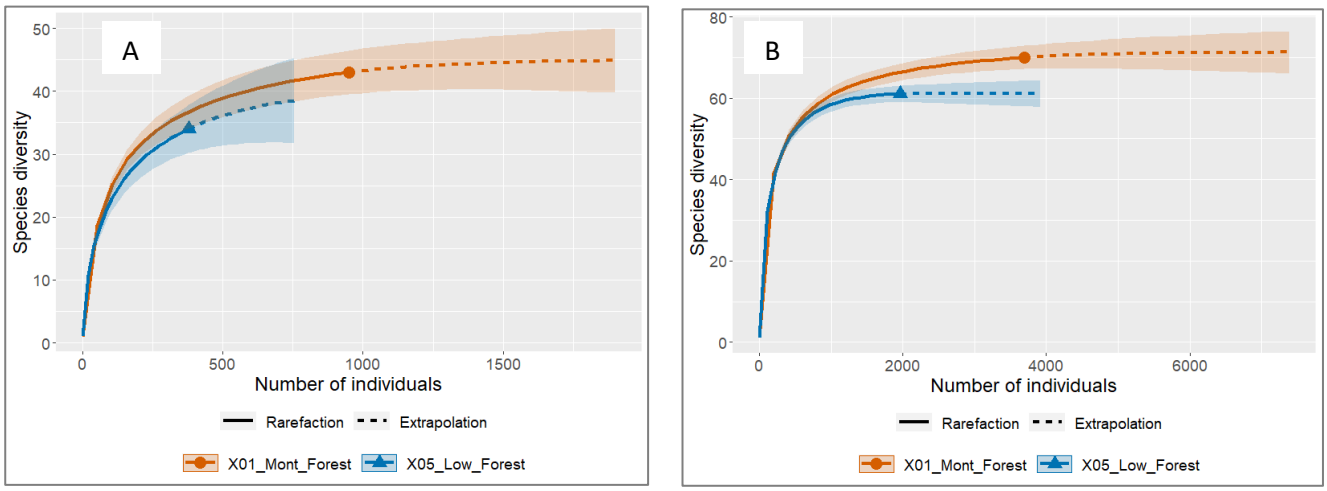


Figure 1. Rarefaction curves for forest areas (A) Adult trees and B) Regeneration trees B). (95% confidence intervals)

Forest areas located in mountain areas, tended to present high H' values, both for mature trees and r egeneration, according to the Kruskal-walls test (chi-squared = 8.4134, df = 3, p-value = 0.0382). N atural regeneration had higher abundance and species richness, but mature individuals, have the low est abundance and species richness in lowland forest areas (Table 2). Tree distribution including ma ture and regeneration, had balanced distribution according to J´ observed.

Table 2. Diversity indices (adult trees and regeneration) for forest habitat. Values that do not share a letter are significantly different (Kruskal–Wallis test; α = 5%).

	Adult trees		**Regeneration**	
	Mount. forest	Lowl. forest	Mount. Forest	Lowl. Forest
Richness (S)	43	34	70	61
Abundance (N/ha)	1584	315	1945	1635
Total Shannon (H')	2.83^{a}	2.71^{bc}	3.39^{ab}	3.29^{c}
Equitability (J')	0.75	0.77	0.80	0.80

3.1.2. Croplands: mountain vs lowland

Rarefaction curves for this habitat were only performed for the regenerating trees since the adults abundances were insufficient to perform the analysis. As indicated in Figure 2, lowland farms had significantly higher species diversity at the regeneration level.

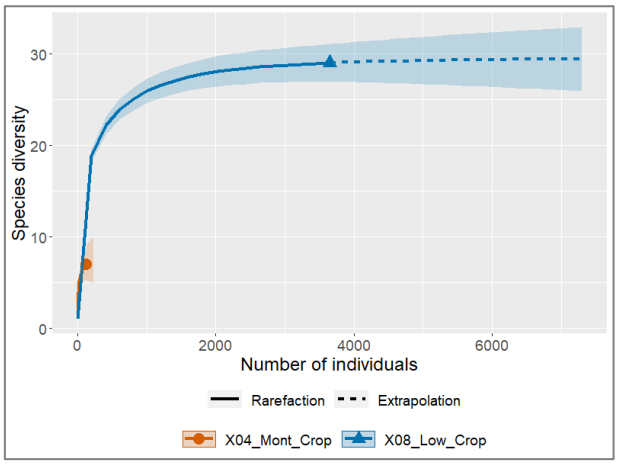


Figure 2. Rarefaction curves for regenerating trees in Mountain (X04_Mont_Crop) and lowland (X08_Low_crop) (95% confidence intervals).

The Shannon species diversity were compared both for Mountain Cropland and Lowland Cropland, for the regeneration, according to nonparametric Wilcoxon Signed Rank test (W = 171, Z = 3.70, Exact Prob>|W| = 7.62939E-6, p-value = 0.00). Significant differences on Shannon diversity index were found, between the two strata (p-value = 0.00), Therefore, lowland cropland areas, maintain high species richness (Table 3). The distribution of the individuals tended to be balanced.

Table 3. Diversity indices of regenerating trees in cropland habitat (there was not enough information to generate diversity indices for adults trees in this habitat).

	Regeneration	
	Mountain cropland	Lowland cropland
Richness (S)	7	29
Abundance (N/ha)	166	1522
Shannon (H')	1.22[b]	2.35[a]
Equitability (J')	0.62	0.71

3.1.3. Fallow areas: Mountain vs lowland/ young (1-2 years old) vs old (> 3 years old)

As indicated in Figure 3, old fallows had the higher species diversity with the lowland fallows presenting significantly higher diversity than the mountain fallows, (Figure 3A). The two young fallows had the lowest species diversity, as observed in the Figure 3B. The natural regeneration showed the same tendency, where high species diversity occurs under old lowland areas when compared to old mountain lands (Figure 3B).

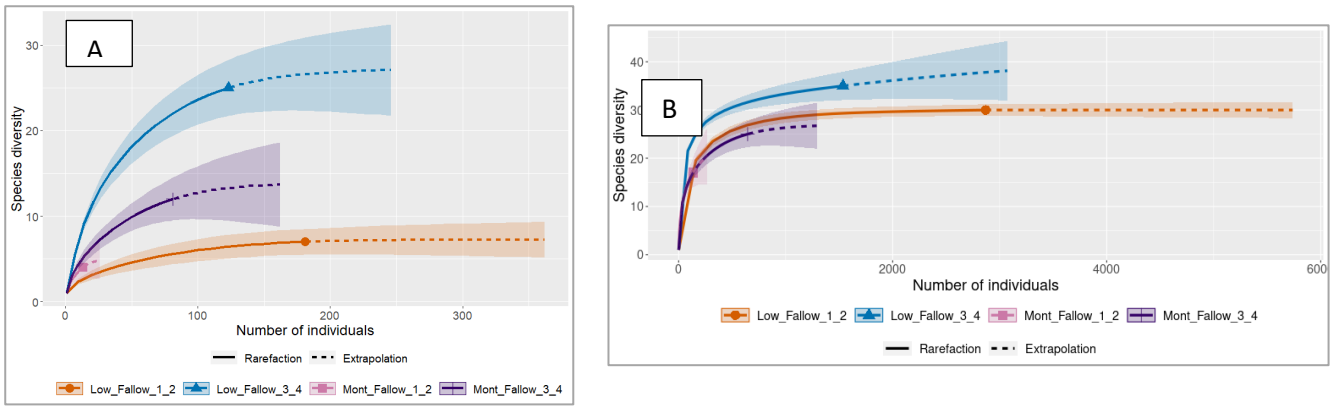


Figure 3. Rarefaction curves for fallow areas (A) Adult trees and B) Regeneration trees B). (95% confidence intervals)

According to the Kruskal-Walls test, there are significant differences in the Shannon diversity index of adult trees between fallow strata (chi-squared = 7.8871, df = 3, p-value = 0.0484). Older fallows from both lowland and mountain areas seem to show high signs of recovery. When comparing the young fallows, mountain areas was likely to recover better (Table 4). Younger lowland fallows have lower Shannon diversity index, and the distribution of individuals is more homogenous (J' = 0.37).

Table 4. Species diversity index for fallow (adult trees). Values that do not share a letter are significantly different (Kruskal–Wallis test; α = 5%).

	Mountain Fallow (3-4y)	**Mountain Fallow (1-2y)**	**Lowland Fallow (3- 4y)**	**Lowland Fallow (1-2y)**
Richness (S)	12	4	25	7
Abundance (N/ha)	81	13	123	181
Shannon (H')	1.65^{b}	1.03^{abc}	2.74^{a}	0.72^{c}
Equitability (J')	0.66	0.74	0.85	0.37

Species diversity for regeneration was high in old lowland fallows. The results showed significant differences in Shannon diversity index for fallow regeneration areas (Kruskal-Wallis chi-squared = 20.535, df = 3, p-value = 0.0001315). The H´ showed that older fallows tended to recovery better, although higher recovery levels tend to occur in lowland fallows. Fallows in mountain areas are similar in terms of H'. In all strata, regenerating trees had a more heterogeneous distribution, showing an balanced distribution of species (Table 4).

Table 5. Species diversity indices for fallow (regeneration). Values that do not share a letter are significantly different (Kruskal–Wallis test; α = 5%).

	Mountain Fallow (3-4y)	**Mountain Fallow (1-2y)**	**Lowland Fallow (3- 4y)**	**Lowland Fallow (1-2y)**
Richness (S)	25	17	35	30
Abundance (N/ha)	806.25	270	1536	717.25
Shannon (H')	3.22^{c}	2.84^{d}	$3.56d^{ab}$	3.38^{bc}
Equitability (J')	0.71	0.79	0.83	0.63

3.2. Species composition

3.2.1. Forest habitat

3.2.1.1. Adult species composition

The Non-metric multidimensional scaling (NMDS) revealed that, at the adult level, the mountain a nd lowland forests are separated in terms of species composition (Figure 4), but some level of overl ap is observed between the 2 habitats, i.e., some species occur in both (Stress = 0.122; ANOSIM: R = 0.3679; P = 0.000; permutations = 9999).

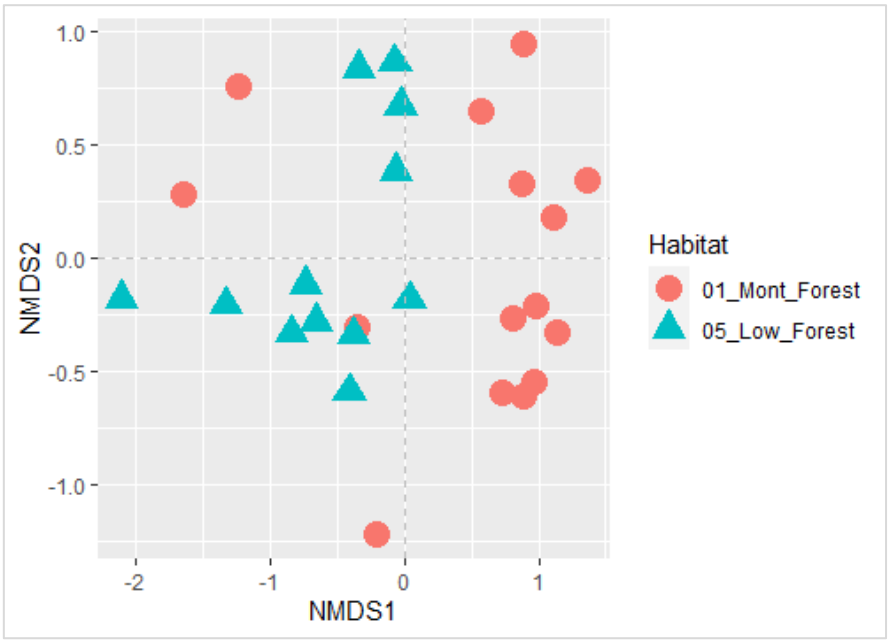


Figure 4. Non-metric multidimensional scaling (NMDS) based on species composition for adult trees in forest areas, using the Bray–Curtis index

Table 6 lists the nine species that contributed the most to the separation between mountain and lowland forests according to the SIMPER analysis (overall average dissimilarity = 94%). *Cassipourea malosana* had a largest contribution and was found only in Mountain Forest. *Pavetta gurueensis* was also limited to the latter stratum, while *Oxyanthus speciosus* was restricted to lowland forests.

Table 6. Percentage (%) contribution of species to separate mountain and lowland forests. Only species with a contribution to average dissimilarity of >3% are included (Overall average dissimilarity: 93.91).

Taxon	Contrib. %	Mountain Forest	Lowland Forest
Cassipourea malosana	11.5	13.3	0
Parinari excelsa	10.2	0.6	7.3
Pavetta gurueensis	8.5	9.27	0
Rawsonia lucida	8.2	9.2	0.3
Englerophytum magalismontanum	6.4	3.73	3.4
Oxyanthus speciosus	5.2	0	4.0
Newtonia buchananii	4.9	0.9	2.9
Chionanthus foveolatus subsp. Major	3.5	1.5	1.2
Syzygium cordatum	3.3	0.3	1.6

3.2.1.2. Regeneration species composition

The NMDS ordination of species composition for regeneration in forest habitat, showed a distinct separation of strata with some overlap (Stress = 0.16446; ANOSIM: R = 0.3098; P = 0.000; permutations = 9999; Figure 5).

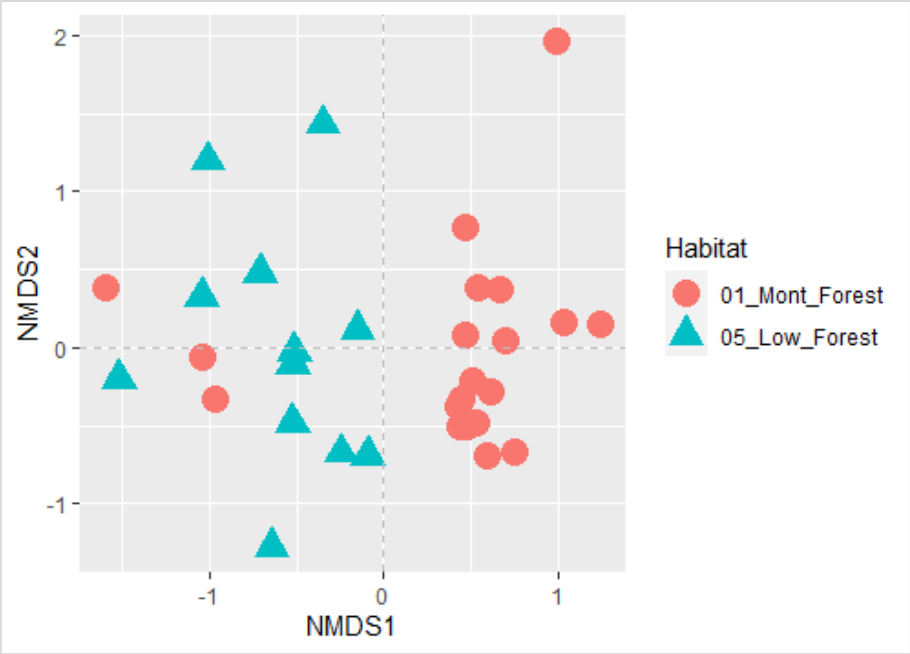


Figure 5. Non-metric multidimensional scaling (NMDS) based on species composition for regeneration trees in forest areas, using the Bray–Curtis index.

The simper analysis showed that *Harungana madagascariensis* contributed significantly to the strata's dissimilarity (overall average dissimilarity = 90.25; Table 7). In general, all species were found in all strata, except for *Psychotria ursomontana*, which only occurred in mountain forests.

Table 7. Percentage (%) contribution of species to dissimilarities for regeneration between mountain and lowland forests. Only species with a contribution to average dissimilarity of >3% are included. (Overall average dissimilarity: 90.0).

Taxon	Contrib. %	Mountain forest	Lowland Forest
Harungana madagascariensis	6.4	10.8	19.7
Lasianthus kilimandscharicus	6.3	18.5	1.9
Newtonia buchananii	5.7	1.6	15.2
Rawsonia lucida	5.1	17.6	0.2
Psychotria zombamontana	5.0	17.7	0.0
Canthium oligocarpum	4.3	5.3	11.2
Tarenna pavettoides	4.2	12.2	1.8
Parinari excelsa	4.1	0.6	12.5
Englerophytum magalismontanum	3.9	11.4	3.7
Syzygium cordatum	3.6	1.7	20.0
Dombeya lastii	3.2	6.7	4.5
Dodonaea viscosa	3.0	10.3	3.1

3.2.2. Cropland habitats

Figure 6 shows the NMDS ordination of species composition for cropland regeneration, showing a significant difference in species composition, with distinct groups (Stress = 0.086; ANOSIM: R = 0.86; P = 0.000; permutations = 9999). For the adult trees, there were insufficient data to perform the NMDS.

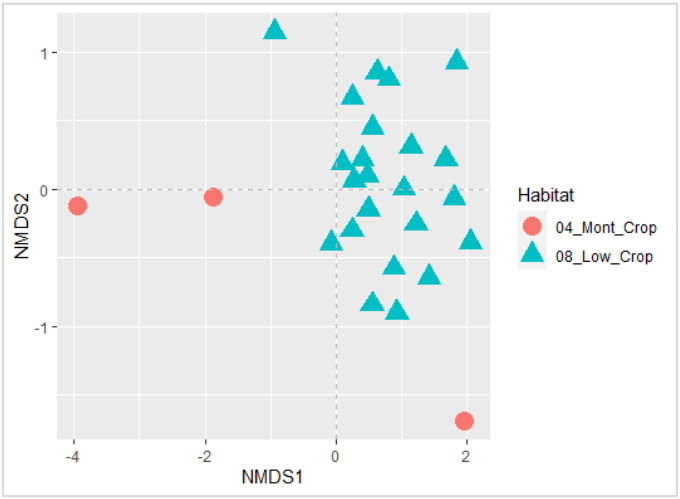


Figure 6. Non-metric multidimensional scaling (NMDS) based on species composition for adult trees in cropland areas, using the Bray–Curtis index.

The SIMPER analysis revealed that for regeneration, eight species had higher participation in the formation of groups, in the croplands (overall average dissimilarity: 99.78; Table 8). The table indicates that only one species occurred in mountain croplands - *Tetradenia riparia* while all the others occurred exclusively in lowland croplands.

Table 8. Percentage (%) contribution of species to dissimilarities for regeneration between Mountain and Lowlands croplands. Only species with a contribution to average dissimilarity of >3% are included. (Overall average dissimilarity: 99.66).

Taxon	Contrib. %	Mountain Cropland	Lowland Cropland
Syzygium cordatum	15.7	0	32.8
Tetradenia riparia	14.7	10.9	0
Harungana madagascariensis	13.8	0	26.2
Albizia adianthifolia	10.9	0	18.6
Parinari excelsa	8.0	0	8.67
Parinari curatellifolia	6.5	0	23.6
Tecomaria capensis	4.6	0	9.5
Tetradenia galpinii	3.8	0	10.9

3.2.3. Fallow habitats

3.2.3.1. Adult trees composition

NMDS revealed species composition differences among fallow strata, but there was some overlap (R = 0.3678). In general de lowland fallows are more similar while the mountain fallows form 2 different clusters (Stress = 0.083; ANOSIM: R = 0.3678; P = 0.000; permutations = 9999; Figure 7).

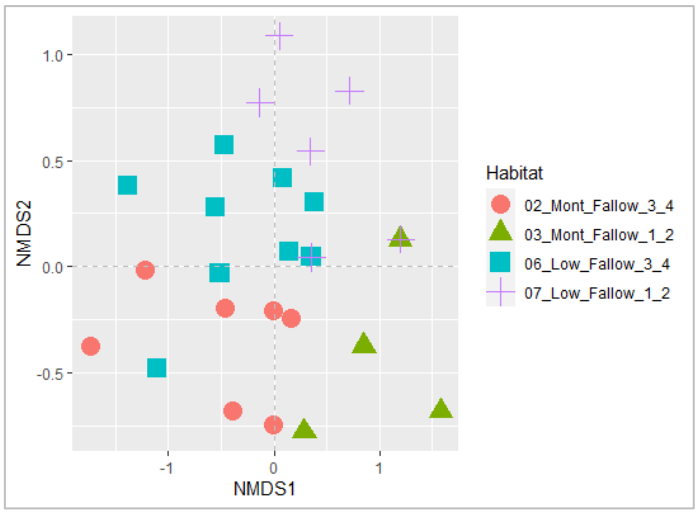


Figure 7. Non-metric multidimensional scaling (NMDS) based on species composition for adult trees for fallows, using the Bray–Curtis index.

Eight species substantially contributed to the species composition in the fallow strata (overall average dissimilarity: 90.24; Table 9). *Syzygium chordatum* was the most significant contributor, but it was absent in young mountain fallows. In this stratum two sepecies, Tetradenia riparia and Cassipourea malosan expressed highest contribution and *Cassipourea malosana* was restricted to it. *Tetradenia riparia* was exclusive to mountain fallows, and *Harungana madagascariensis* and *Albizia*

adianthifolia were restricted to Lowland fallows. *Englerophytum magalismontanum* was exclusive to older mountain and lowland fallows. *Pavetta gurueensis* only occurred old mountain fallows.

Table 9. Percentage (%) contribution of species to dissimilarities for adult species trees in fallow. Only species with a contribution to average dissimilarity of >3% are included. (Overall average dissimilarity: 92.86).

Taxon	Contrib. %	Mountain Fallow (3- 4 y)	Mountain Fallow (1-2 y)	Lowland Fallow (3-4 y)	Lowland Fallow (1-2 y)
Syzygium cordatum	21.12	5.14	0	5.33	7.67
Tetradenia riparia	18.53	11.1	3.2	0	0
Harungana madagascariensis	13.64	0	0	0.22	48.7
Englerophytum magalismontanum	4.97	1.14	0	4.22	0
Pavetta gurueensis	4.78	2.29	0	0	0
Albizia adianthifolia	4.57	0	0	1.56	1.33
Bridelia micrantha	3.39	0	0	0.44	0.67
Cassipourea malosana	3.24	0	1.2	0	0

3.2.3.2. Regeneration species composition in fallow habitats

Regeneration in fallow areas showed an overlap in species composition between lowland old and young fallows and between both ages mountain fallows (Figure 8). Species composition showed significant variation between strata, but with some overlap (Stress = 0.128; ANOSIM: R = 0.4467; P = 0.000; permutations = 9999).

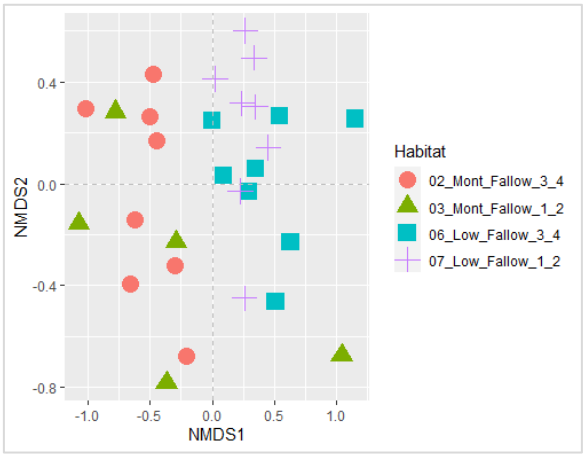


Figure 8*. Non-metric multidimensional scaling (NMDS) based on species composition for regeneration in fallow areas, using the Bray–Curtis index*

The SIMPER analysis revealed that for fallow, five regenerating species had high contribution to the formation of groups (overall average dissimilarity: 82.93), with *Harungana madagascariensis* being the one that occurred in the three strata, but absent in old mountain fallows (Table 10). *Albizia adianthifolia* and *Parinari curatellifolia* had an exclusive occurrence in old mountain and young lowland fallows, while *Tetradenia riparian* had an exclusive occurrence in old and young mountain fallows. The species *Syzygium chordatum* was only absent in young mountain fallow.

Table 10. Percentage (%) contribution of species to dissimilarities for regeneration in fallow. Only species with a contribution to average dissimilarity of >3% are included (Overall average dissimilarity: 82.93).

Taxon	Contrib. %	Mountain Fallow (3- 4 y)	Mountain Fallow (1-2 y)	Lowland Fallow (3-4 y)	Lowland Fallow (1-2 y)
Harungana madagascariensis	18.2	0	0.8	41.3	159.0
Syzygium cordatum	8.7	5.13	0	35.0	38.0
Tetradenia riparia	8.2	26.9	6.2	0	0
Albizia adianthifolia	6.2	0	0	10.5	41.5
Parinari curatellifolia	4.3	0	0	21.4	31.0

4. DISCUSSION NOTES

This study investigated species diversity, richness and abundance in three different habitats (forests, fallows and croplands) in the Namuli Mountain, aiming to investigate the impacts of agriculture in tree biodiversity in support of improving smallholder farming systems. In these notes we discuss the results of the different habitats separated by cohort and topographic location.

At the adult level our analysis indicated that mountain forest ecosystems had higher richness (43 species), abundance (1584 trees/ha), H' (2.83) and were more equitable (0.75). Croplands lowland had high species diversity for the regeneration (29 species), and abundance (1522 trees/species). In terms of species distribution, all strata was more balanced. Not enough adult individuals were found in croplands and thus not discussed here. These results indicate that in general, croplands reduce the tree species diversity but after a few years (3-4) into the succession the diversity is partially recovered in both mountain and lowland environments.
From our species composition analysis (Appendix 2) there is some overlap between old growth forests and old fallows in lowland habitats but in mountain locations the species in the fallow areas are different from the old growth forests. The young lowland fallows presented two exotic fruit trees (*Psidium guayaba* and *Mangifera indica*) in the first 10 most abundant individuals. These results indicate that some species after crop abandonment, there is a relatively fast (3-4 years) recovery of the ecosystems, but a longer-term assessment would be needed in order to observe if tree composition is restored to the original levels.

Comparing mountain and lowland forests, it is worth mentioning the slightly higher diversity indicators in the former (Table 2). But in the fallow areas, the old habitats have high diversity indicators than the corresponding mountain areas. The young fallows show a lot of variability in the diversity indicators which is probably related to the early stages of restoration. Faster recovery of the lowland fallows might be associated with better environmental conditions including water and nutrient conditions, but these were not assessed in the study.

At the regeneration level the mountain forests again showed higher levels of diversity (S = 70; N/ha = 1945), H'= 3.39; J'= 0.80) compared to croplands (S = 7; N/ha= 166; H'=1.22; J' = 0.62) and to young fallows (S = 17; N/ha = 23; H'= 2.84; J'= 0.79) and old fallows (S=25; N/ha = 47; H'=3.22;

J'= 0.71) fallow areas. Similarly, lowlands forests regeneration are in better diversity condition (S = 61; N/ha = 1635; H'= 3.29; J'= 0.80) compared to croplands (S = 29; N/ha = 1522; H'= 2.36; J'= 0.70). It worth mentioning the high abundance of regeneration tree in croplands, which indicates an initial fast recovery which is then leveled off likely due to competition. Comparing the mountain and lowland habitats the figures are similar to adult trees, with lowland areas regenerating faster than the mountain habitats.

The species composition varied according to the habitat type as the NMDS ordination generated consistent findings in separating lowland and mountain habitats across the gradient. For the fallows, communities' aggregation was more influenced by spatial position more than the fallow age. The analysis of species composition enabled the identification of species that are more crucial to the formation of the studied communities, as well as areas in which habitat do species occur exclusively. *Tetradenia riparia* was found to be among the most prevalent and abundant adult tree species in mountain fallow areas and *Albizia adianthifolia* in lowland fallow areas.

When subjected to fire, the dense herbaceous layer typically regenerates naturally, probably maintaining species diversity, regardless fire disturbance as observed in the current study. Understanding the effect of fire on this vegetation component, on the other hand, requires a more in-depth and systematic approach that considers historical data on fire events in the study area.

In terms of the species conservation status, the study found three endemic species, namely, *Faurea racemosa*, *Pavetta gurueensis* and *Protea madiensis Oliv. subsp. madiensis* in forests, in lowland and mountain areas, respectively. Only five invasive species were found, and a high number of individuals occurred in lowland croplands (165 N/ha) and younger fallow (122 N/ha) areas. In the forest areas the high density occurred in the lowland areas (19 N/ha) and. *Lantana camara* was the most common invasive specie occurred in the lowland areas, while *Vernonia adoensis* occurred in all areas, except in lowland forest areas. The occurrence of *Lantana camara* is concerning, since this species has the ability to colonize areas very quickly, making their management extremely difficult. The specie also interferes highly with the natural regeneration of native plants.

Six weed species were found, and the highest number of individuals occurred in the lowland croplands (187 N/ha). *Commelina benghalensis* were found in all fallow areas, except in the lowland old fallows.

The study revealed that the fire impacted the vegetation, especially in older fallow areas located in the lowland areas *Tecomaria capensis* was the most impacted species by fire and 407 N/ha was killed. The old mont fallow were also affected by fires (63 N/ha killed)

Soil disturbances were revealed by the presence of seven species, which act as indicators of soil condition, such as nutrient depletion. The occurrence of these species was observed in fallow lands and croplands in the lowlands. Only one species occurred in the lowland forest (*Dichrostachys cinerea)*. The largest number of these species occurred in croplands.

Thirty species have been found to have important socio-economic value, as they are used as food, medicine, house construction and coffin manufacturing. Other species play an important ecological role by acting as pollinators and providing food for birds.

REFERENCES

CEAGRE & Winrock-International (2016). Agentes e Causas de Desmatamento e Degradação Florestal em Moçambique; CEAGRE-UEM and Winrock International: Maputo, Moçambique; pp. 1–36.

Chao, A.; Gotelli, N.J.; Hsieh, T.C.; Sander, E.L.; Ma, K.H.; Colwell, R.K.; Ellison, A.M (2014). Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. Ecol. Monogr. 84, 45–67

Clarke, K.R., (1993). Non-parametric multivariate analyses of changes in community structure. Austral Ecol 18, 1993, 117–143. https://doi.org/10.1111/j.1442-9993.1993.tb00438.x

Curtis, Philip G., Christy M. Slay, Nancy L. Harris, Alexandra Tyukavina, and Matthew C. Hansen (2018): Classifying Drivers of Global Forest Loss. Science 361 (6407): 1108–11. https://doi.org/10.1126/science.aau3445.

FAO, ed. (2018): Forests Pathways to Sustainable Development. State of the World's Forests 2018. Rome: FAO.

Geist, H.J., Lambin, E.F., (2002b). Proximate Causes and Underlying Driving Forces of Tropical Defor-estation. BioScience 52, 143. https://doi.org/10.1641/0006-3568(2002)052[0143:PCAUDF]2.0.CO;2

Hammer, Ø., Harper, D. A. T., & Ryan, P. D. (2001). PAST: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica, 4, 9 p. http://palaeo-electronica.org/2001_1/past/issue1_01.htm

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ribeiro, N. S., Katerere, Y., Chirwa, P. W., & Grundy, I. M. (Eds.). (2020): Miombo Woodlands in a Changing Environment: Securing the Resilience and Sustainability of People and Woodlands. doi:10.1007/978-3-030-50104-4

APPENDICES

1. Kruskal-Wallis Pairwise comparisons of Shannon diversity index (H')

Table 1. Dunn's test for Shannon diversity index (H'): Forest trees species (adult and regeneration)

	Comparison		Z	P.unadj	P.adj
1	Ad_01_Mont_Forest	- Ad_05_Low_Forest	-1.1299154	0.258511881	1.00000000
2	Ad_01_Mont_Forest	- Rg_01_Mont_Forest	1.6629418	0.096324090	0.57794454
3	Ad_05_Low_Forest	- Rg_01_Mont_Forest	2.7841227	0.005367272	0.03220363
4	Ad_01_Mont_Forest	- Rg_05_Low_Forest	0.7404306	0.459038779	1.00000000
5	Ad_05_Low_Forest	- Rg_05_Low_Forest	1.9036855	0.056951152	0.34170691
6	Rg_01_Mont_Forest	- Rg_05_Low_Forest	-1.0033225	0.315705279	1.00000000

Ad = adult trees
Rg = Regeneration trees

Table 2. Dunn's test for Shannon diversity index (H'): Fallow Adult trees species

	Comparison		Z	P.unadj	P.adj
1	02_Mont_Fallow_3_4	- 03_Mont_Fallow_1_2	-1.7766828	0.075620444	0.45372266
2	02_Mont_Fallow_3_4	- 06_Low_Fallow_3_4	1.1200246	0.262703290	1.00000000
3	03_Mont_Fallow_1_2	- 06_Low_Fallow_3_4	2.6194712	0.008806622	0.05283973
4	02_Mont_Fallow_3_4	- 07_Low_Fallow_1_2	1.0123807	0.311356050	1.00000000
5	03_Mont_Fallow_1_2	- 07_Low_Fallow_1_2	2.4047413	0.016183919	0.09710351
6	06_Low_Fallow_3_4	- 07_Low_Fallow_1_2	0.1651078	0.868859126	1.00000000

Table 3. Dunn's test for Shannon diversity index (H'): Fallow regeneration trees species

	Comparison	Z	P.unadj	P.adj
1	Mont_Fallow_1_2 - Mont_Fallow_3_4	-3.9453	4.78E-04	1.00000
2	Mont_Fallow_1_2 - Low_Fallow_1_2	-5.7686	4.80E-08	1.00000
3	Mont_Fallow_1_2 - Low_Fallow_3_4	-10.144	2.12E-23	1.00000
4	Mont_Fallow_3_4 - Low_Fallow_1_2	-2.5751	0.06012	000000
5	Mont_Fallow_3_4 - Low_Fallow_3_4	-6.1982	3.43E-09	1.00000
6	Low_Fallow_1_2 - Low_Fallow_3_4	-2.4418	0.08768	000000

2. The most 10 frequent and abundant species

Forest
Adult trees

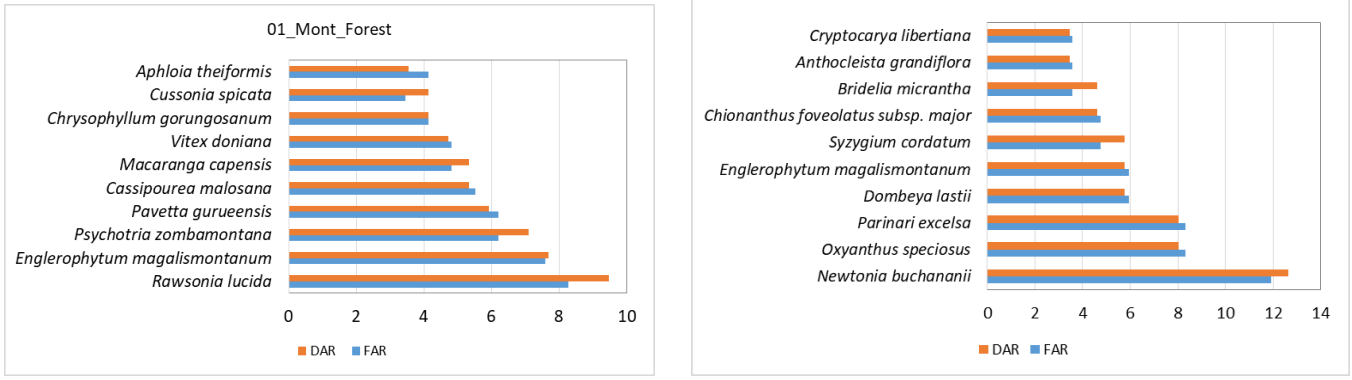


Figure 1. Specific species composition for adult trees in 01_Mont_Forest and 05_Low_Forest (DAR = Relative absolute density; FAR = Relative absolute frequency)

Regeneration trees

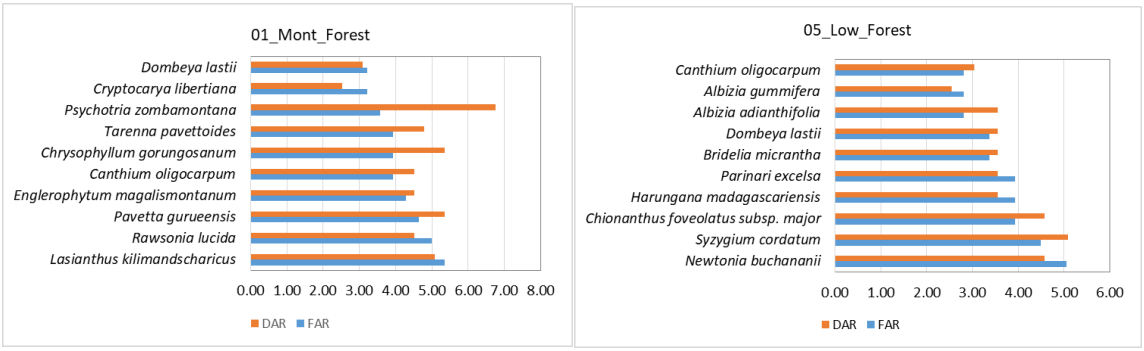
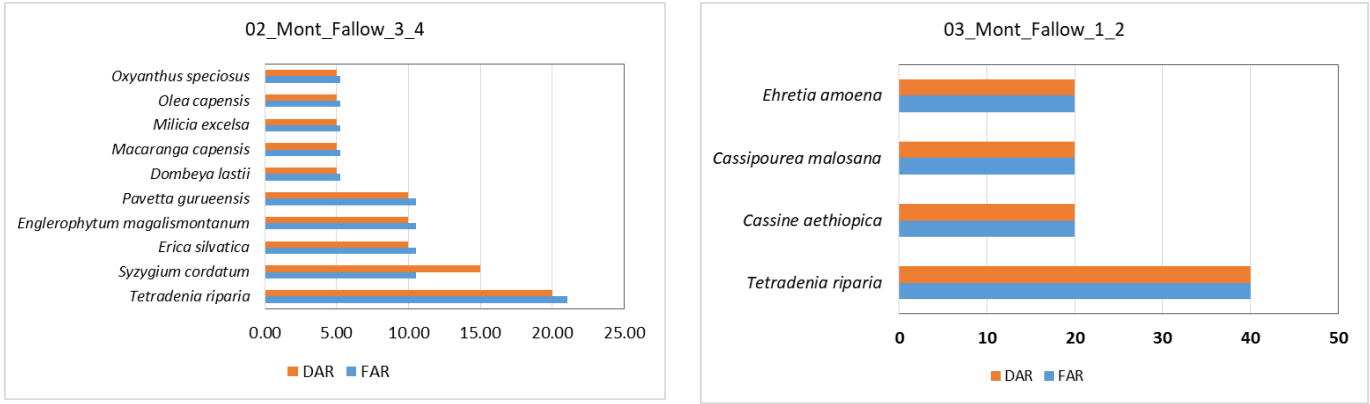
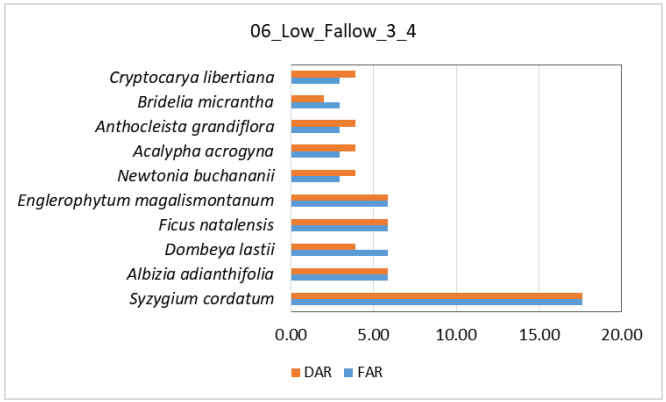


Figure 2. Specific species composition for regeneration in 01_Mont_Forest and 05_Low_Forest (DAR = Relative absolute density; FAR = Relative absolute frequency)

Fallow
Adult trees





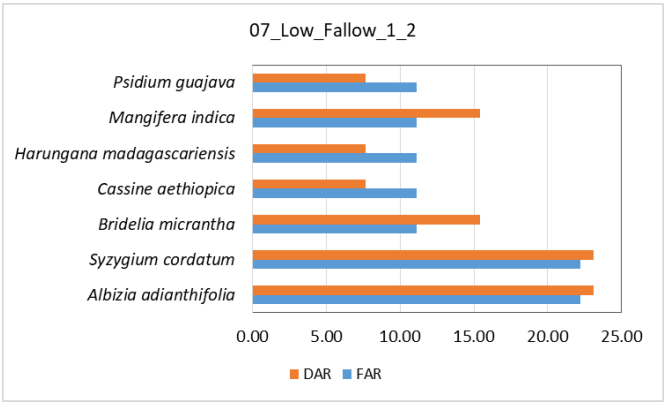
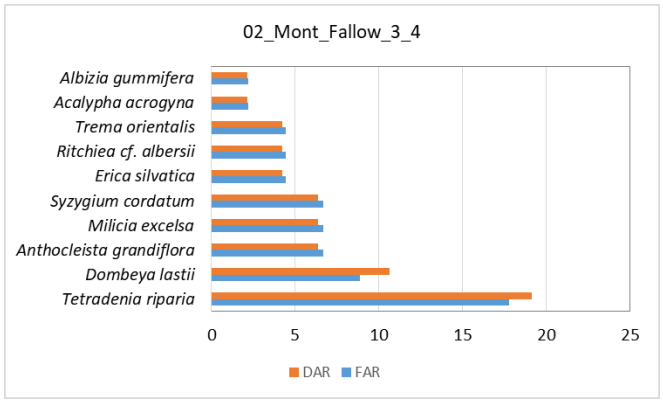
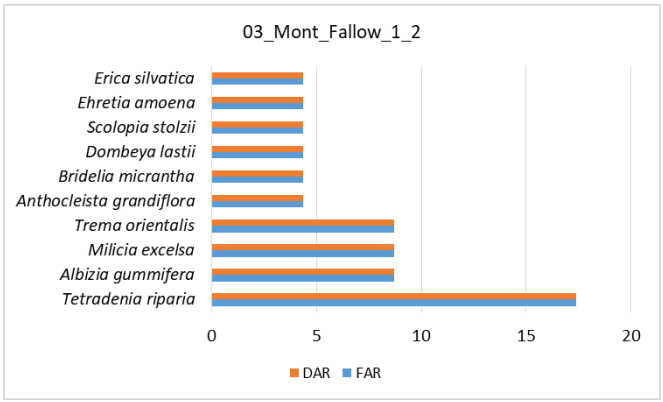
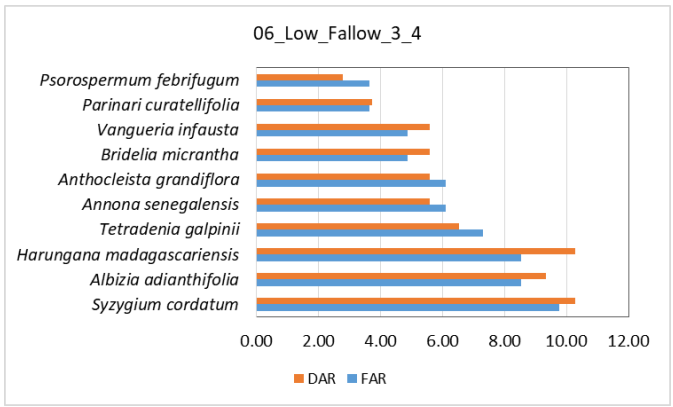


Figure 3. Specific species composition for adult tree species in fallow (DAR = Relative absolute density; FAR = Relative absolute frequency)

Regeneration







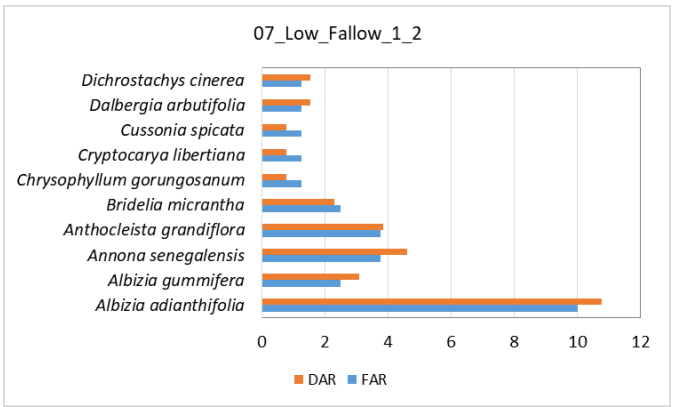


Figure 4. Specific species composition for regeneration species in fallow (DAR = Relative absolute density; FAR = Relative absolute frequency)

Cropland
Adult trees

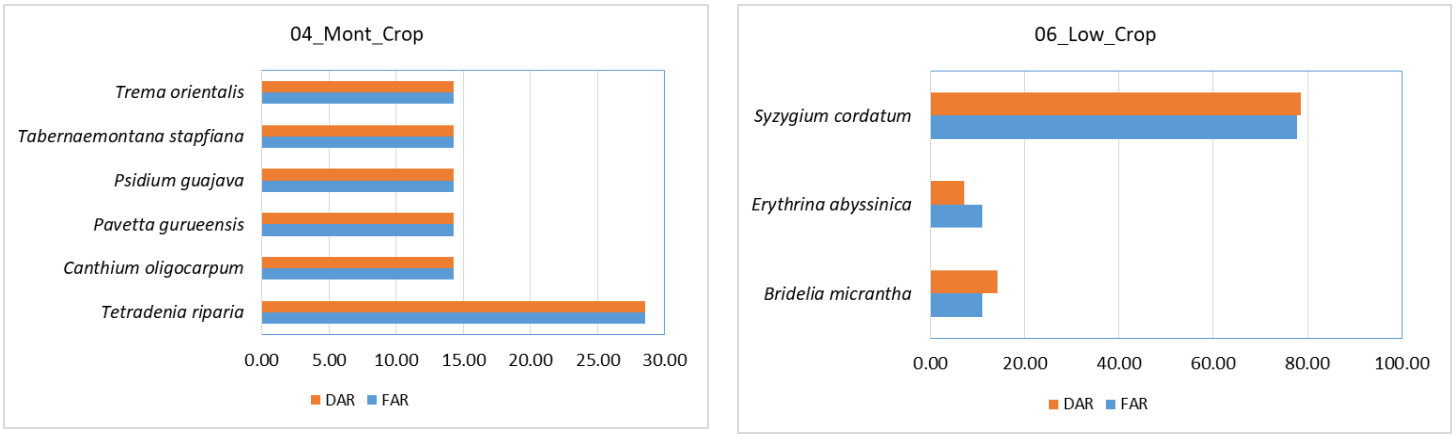


Figure 5. Specific species composition for adult trees in 04_Mont_Crop and 06_Low_Crop (DAR = Relative absolute density; FAR = Relative absolute frequency)

Regeneration trees

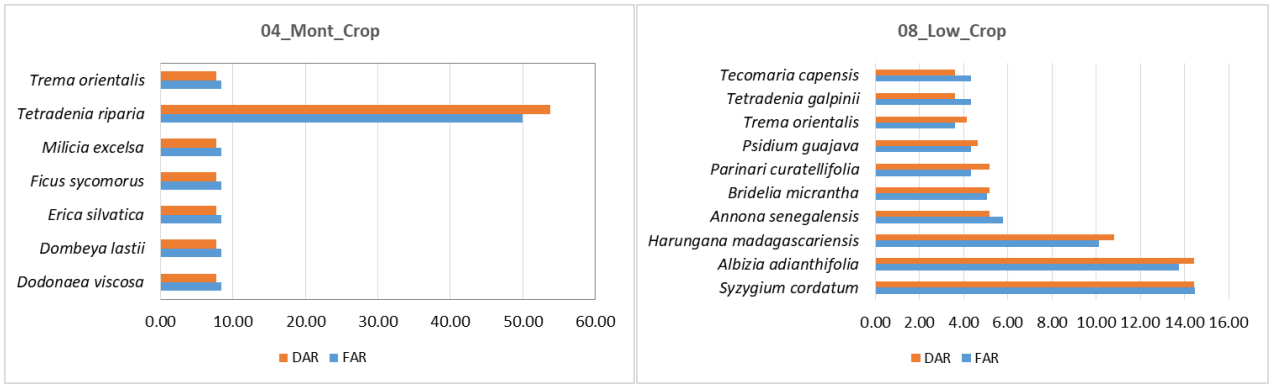


Figure 6. Specific species composition for regeneration in 04_Mont_Crop and 06_Low_Crop (DAR = Relative absolute density; FAR = Relative absolute frequency)

3. Endemic species

Strata	Especie	Familia
05_Low_Forest	*Faurea racemosa*	Proteaceae
01_Mont_Forest	*Protea madiensis Oliv. subsp. madiensis*	Proteaceae
01_Mont_Forest	*Pavetta gurueensis*	Rubiaceae

4. Invasive species

Species	Family	01_Mont _Forest	02_Mont _Fallow_3_4	03_Mont _Fallow_1_2	04_Mont _Crop	05_Low_ Forest	06_Low_ Fallow_3_4	07_Low_ Fallow_1_2	08_Low _Crop
Centella asiatica	Apiaceae	0	0	0	0	0	1	0	0
Indigofera astragalina	Fabaceae	0	18	0	0	5	0	36	15
Lantana camara	Verbenaceae	0	0	0	0	21	54	88	76
Lippia javanica	Verbenaceae	0	0	0	0	0	5	0	8
Vernonia adoensis	Asteraceae	1	67	21	44	0	3	10	362
TOTAL (N/ha)		**1**	**85**	**42**	**49**	**19**	**63**	**122**	**165**

5. Weed species

Species	Family	02_Mont_ Fallow_3_ 4	03_Mont_ Fallow_1_ 2	07_Low_ Fallow_1_ 2	08_Low _ Crop
Ageratum conyzoides	*Asteraceae*	0	5	0	17
Bidens pilosa	*Asteraceae*	0	8	0	215
Centella asiatica	*Apiaceae*	3	0	0	204
Commelina benghalensis	*Commelinaceae*	13	13	5	10
Cyperus longus	*Cyperaceae*	0	0	0	52
Polygonum salicifolium	Polygalaceae	0	0	0	25
TOTAL (N/ha)		**2**	**52**	**5**	**187**

Table 7. Species killed by fire by strata

Species		01_Mo nt _Forest	02_Mont _ Fallow_3 _4	03_Mont _ Fallow_1 _2	04_Mon t_ Crop	05_Lo w_ Forest	06_Low_ Fallow_3 _4	07_Low_ Fallow_1 _2	08_Lo w_ Crop
Albizia adianthifolia	Fabaceae	0	0	0	0	0	2	0	1
Annona senegalensis	Annonaceae	0	0	0	0	0	0	2	0
Anthocleista grandiflora	Gentianaceae	0	2	0	0	0	0	0	0
Dombya lastii	Malvaceae	0	60	0	0	0	0	0	0
Harrungana madagascariensis	Clusiaceae	0	0	0	0	0	6	0	0
Milicia excelsa	Moraceae	0	0	12	0	0	0	0	0
Pteridium aquilinum	Dennstaedtiaceae	1	0	0	0	1	0	2	19
Sesbania sesban	Fabaceae	0	0	0	15	0	1	0	0
Steganotaenia araliacea	Apiaceae	0	0	0	0	0	0	2	0
Syzygium cordatum	Myrtaceae	0	0	0	0	0	0	0	1

Species		01_Mont_Forest	02_Mont_Fallow_3_4	03_Mont_Fallow_1_2	04_Mont_Crop	05_Low_Forest	06_Low_Fallow_3_4	07_Low_Fallow_1_2	08_Low_Crop
Tecomaria capensis	Bignoniaceae	0	0	0	0	0	390	2	0
Tetradenia riparia	Lamiaceae	0	1	7	0	0	0	0	0
Vangueria infausta	Rubiaceae	0	0	0	0	0	0	4	0
Vernonia adoensis	Asteraceae	1	0	0	17	0	0	0	17
Vernonia sp	Asteraceae	0	0	0	0	0	8	0	0
Total (N/ha)		**1**	**63**	**38**	**36**	**1**	**407**	**11**	**14**

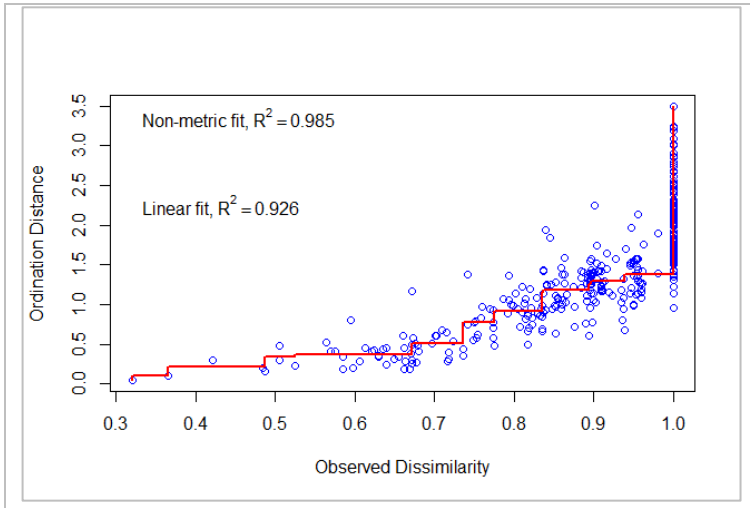
Table 8. Soil-condition indicator species

Species	Family	05_Low_Forest	06_Low_Fallow_3_4	07_Low_Fallow_1_2	08_Low_Crop	Description
Commelina benghalensis	Commelinaceae					Disturbed soil indicator
Crotalaria sp	Fabaceae					Nutrient poor soils indicator
Dichrostachys cinerea	Fabaceae					Nutrient poor soils indicator / disturbed
Lantana camara	Verbenaceae					Nutrient poor soils indicator
Melinis repens	Poaceae					Disturbed soil indicator
Pteridium aquilinum	Dennstaedtiaceae					Disturbed soil indicator
Senecio sp	Asteraceae					Nutrient poor soils indicator

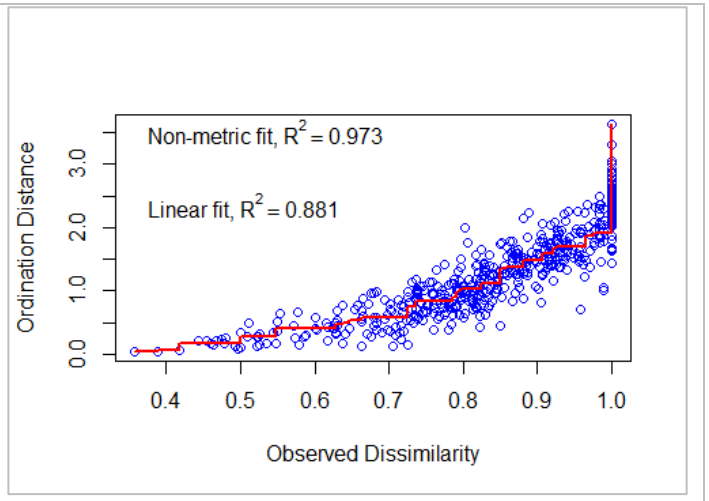
Table 9. List of species with local use

Species	01_Mont _Forest	02_Mont _Fallow_3_4	03_Mont _Fallow_1_2	04_Low _Forest	05_Low _Forest	06_Low _Fallow_3_4	07_Low _Fallow_1_2	08_Low _Crop	Uses
Amaranthus hybridus								■	Edible leaf
Anacardiaceae	■								Used for firewood
Asplenium preussii						■			Cough medicine
Barleria natalensis				■					Medicine for headaches
Bombax rhodognaphalon	■								edible fruit
Brassica oleracea								■	Food
Cassine aethiopica			■						Used for firewood
Cleome gynandra						■		■	Edible leaf
Crotalaria sp		■					■	■	Used for fishing
Cussonia spicata	■								Wood for making coffins
Dombya lastii	■				■				Used as a rope
Drypetes gerrardii					■		■		asthma medicine
Laurenaceae							■		Medication for knee pain
Mangifera indica								■	edible fruit
Manihot esculenta								■	Food
Musa alba								■	edible fruit
Parinari curatellifolia						■			edible fruit
Pavetta gurueensis	■								Used to make mortar
Pavonia columella						■			Used to make ropes
Psidium guajava						■	■	■	edible fruit
Psychotria capensis								■	Wood for making coffins

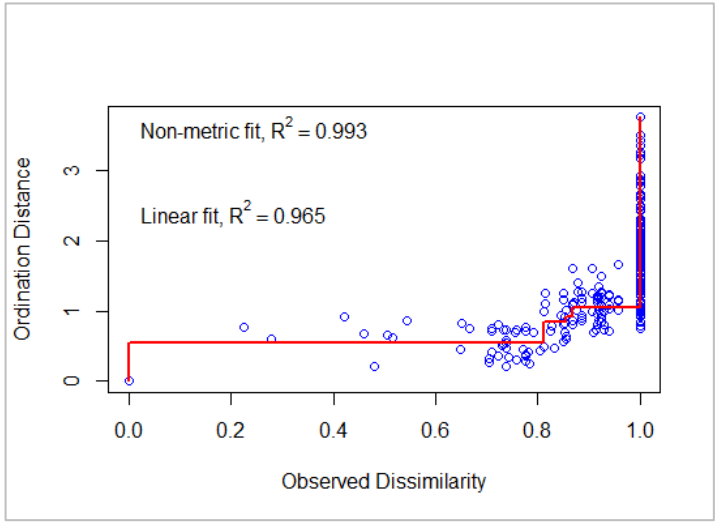
Species	01_Mont _Forest	02_Mont _Fallow_3_4	03_Mont _Fallow_1_2	04_Low _Forest	05_Low _Forest	06_Low _Fallow_3_4	07_Low _Fallow_1_2	08_Low _Crop	Uses
Psychotria zombamontana								1	Wood for making coffins
Rawsonia lucida					2				Edible fruit/firewood/Piles for building houses
Sesbania sesban						1			Medicine for headaches through "bafu"
Solanum lycopersicum									Food
Solanum melongena									Food
Syzygium cordatum									edible fruit
Tecomaria capensis									Flower for feeding birds
Tetradenia riparia									Bee pollination/used as glue
Vernonia sp									Bee pollination



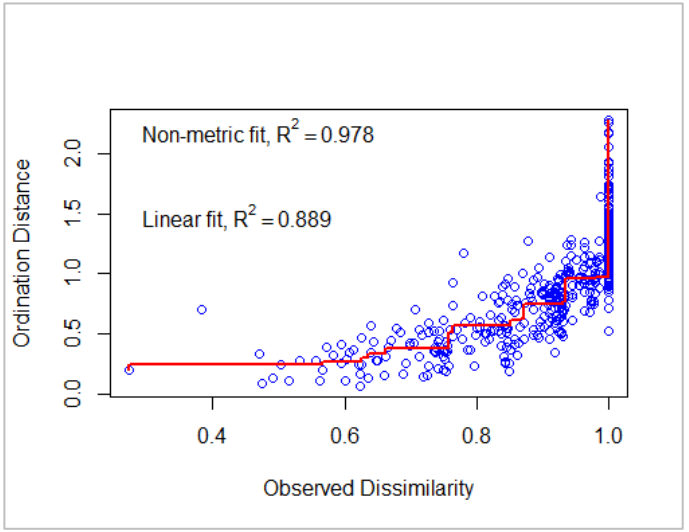
Forest adult



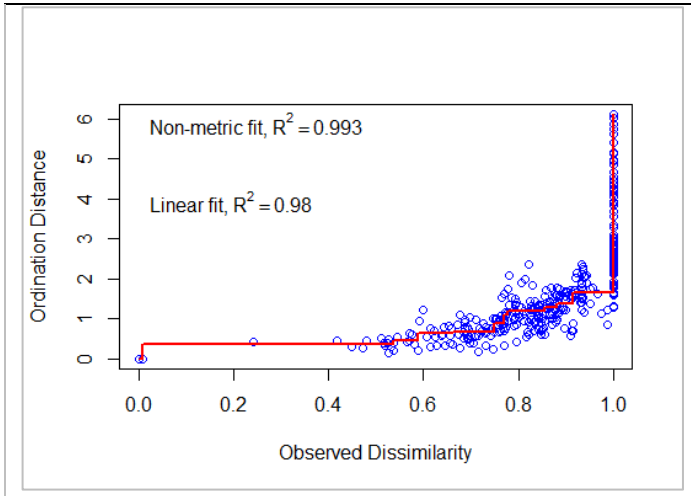
Forest regeneration



Fallow adult



Fallow regeneration



Cropland regeneration

Figure 7. NMDS Stressplots for the strata

6. List of species (FAR = Relative absolute frequency; DAR =Relative absolute density)

6.1.Forest

Adult trees

01_Mont_Forest

Species	FA	FAR	DA	DAR
Newtonia buchananii	0.11	1.38	1.05	1.18
Acalypha acrogyna	0.05	0.69	1.05	1.18
Albizia gummifera	0.05	0.69	0.53	0.59
Anthocleista grandiflora	0.05	0.69	0.53	0.59
Aphloia theiformis	0.32	4.14	3.16	3.55
Canthium oligocarpum	0.21	2.76	2.63	2.96
Canthium vulgare	0.16	2.07	1.58	1.78
Cassine aethiopica	0.05	0.69	0.53	0.59
Cassinopsis tinifolia	0.11	1.38	1.05	1.18
Cassipourea malosana	0.42	5.52	4.74	5.33
Catunaregam sp	0.11	1.38	1.58	1.78
Chionanthus foveolatus subsp. major	0.11	1.38	1.05	1.18
Chrysophyllum gorungosanum	0.32	4.14	3.68	4.14
Cussonia spicata	0.26	3.45	3.68	4.14
Dombeya lastii	0.16	2.07	2.11	2.37
Scolopia stolzii	0.16	2.07	1.58	1.78
Drypetes gerrardii	0.32	4.14	3.16	3.55
Erica silvatica	0.05	0.69	0.53	0.59
Ficus natalensis	0.05	0.69	0.53	0.59
Halleria lucida	0.05	0.69	0.53	0.59
Englerophytum magalismontanum	0.58	7.59	6.84	7.69
Lasianthus kilimandscharicus	0.21	2.76	2.63	2.96
Macaranga capensis	0.37	4.83	4.74	5.33
Milicia excelsa	0.11	1.38	1.58	1.78
Monotes engleri	0.05	0.69	0.53	0.59
Mostuea brunonis	0.05	0.69	0.53	0.59
Myrianthus holstii	0.05	0.69	0.53	0.59
Ochna holstii	0.16	2.07	1.58	1.77
Olea capensis	0.05	0.69	0.53	0.77
Parinari excelsa	0.11	1.38	1.05	1.18
Pavetta gurueensis	0.47	6.21	5.26	5.92
Protea madiensis Oliv. subsp. madiensis	0.05	0.69	1.05	1.18
Psychotria zombamontana	0.47	6.21	6.32	7.10
Rawsonia lucida	0.63	8.28	8.42	9.47

Rutidea orientalis	0.11	1.38	1.05	1.18
Strychnos sp	0.05	0.69	0.53	0.59
Syzygium cordatum	0.11	1.38	1.05	1.18
Tabernaemontana stapfiana	0.11	1.38	1.05	1.18
Tarenna pavettoides	0.21	2.76	2.11	2.37
Tricalysia sp	0.16	2.07	1.58	1.78
Vepris nobilis	0.05	0.69	0.53	0.59
Vitex doniana	0.37	4.83	4.21	4.73

05_Low_Forest

Species	**FA**	**FAR**	**DA**	**DAR**
Newtonia buchananii	0.83	11.90	9.17	12.64
Albizia adianthifolia	0.08	1.19	0.83	1.15
Albizia gummifera	0.08	1.19	0.83	1.15
Anthocleista grandiflora	0.25	3.57	2.50	3.45
Bridelia micrantha	0.25	3.57	3.33	4.60
Canthium oligocarpum	0.08	1.19	0.83	1.15
Cassinopsis tinifolia	0.17	2.38	1.67	2.30
Chionanthus foveolatus subsp. major	0.33	4.76	3.33	4.60
Cryptocarya libertiana	0.25	3.57	2.50	3.45
Cussonia spicata	0.08	1.19	0.83	1.15
Dombeya lastii	0.42	5.95	4.17	5.75
Scolopia stolzii	0.08	1.19	0.83	1.15
Ficus sycomorus	0.08	1.19	0.83	1.15
Halleria lucida	0.25	3.57	2.50	3.45
Harungana madagascariensis	0.08	1.19	0.83	1.15
Englerophytum magalismontanum	0.42	5.95	4.17	5.75
Milicia excelsa	0.08	1.19	0.83	1.15
Mostuea brunonis	0.08	1.19	0.83	1.15
Myrianthus holstii	0.25	3.57	2.50	3.45
Ochna holstii	0.08	1.19	0.83	1.15
Oxyanthus speciosus	0.58	8.33	5.83	8.05
Parinari excelsa	0.58	8.33	5.83	8.05
Phoenix reclinata	0.08	1.19	0.83	1.15
Phyllanthus sp	0.08	1.19	0.83	1.15
Polyscias fulva	0.25	3.57	2.50	3.45
Rawsonia lucida	0.08	1.19	0.83	1.15
Rinorea elliptica	0.08	1.19	0.83	1.15
Steganotaenia araliacea	0.08	1.19	0.83	1.15
Syzygium cordatum	0.33	4.76	4.17	5.75

Tabernaemontana stapfiana	0.08	1.19	0.83	1.15
Synsepalum brevipes	0.08	1.19	0.83	1.15
Trema orientalis	0.17	2.38	1.67	2.30
Trichocladus ellipticus	0.08	1.19	0.83	1.15
Vepris nobilis	0.17	2.38	1.67	2.30

Regeneration trees

01_Mont_Forest

Species	FA	FAR	DA	DAR
Lasianthus kilimandscharicus	0.79	5.36	9.47	5.07
Rawsonia lucida	0.74	5.00	8.42	4.51
Pavetta gurueensis	0.68	4.64	10.00	5.35
Englerophytum magalismontanum	0.63	4.29	8.42	4.51
Canthium oligocarpum	0.58	3.93	8.42	4.51
Chrysophyllum gorungosanum	0.58	3.93	10.00	5.35
Tarenna pavettoides	0.58	3.93	8.95	4.79
Psychotria zombamontana	0.53	3.57	12.63	6.76
Cryptocarya libertiana	0.47	3.21	4.74	2.54
Dombeya lastii	0.47	3.21	5.79	3.10
Scolopia stolzii	0.47	3.21	5.79	3.10
Vepris nobilis	0.47	3.21	5.26	2.82
Chionanthus foveolatus subsp. major	0.42	2.86	4.74	2.54
Tabernaemontana stapfiana	0.42	2.86	6.32	3.38
Cassipourea malosana	0.37	2.50	4.21	2.25
Anthocleista grandiflora	0.32	2.14	3.68	1.97
Euphorbia sp	0.32	2.14	3.68	1.97
Protea welwitschii	0.32	2.14	4.21	2.25
Aphloia theiformis	0.26	1.79	2.63	1.41
Cussonia spicata	0.26	1.79	2.63	1.41
Mostuea brunonis	0.26	1.79	3.16	1.69
Ochna holstii	0.26	1.79	3.16	1.69
Tetradenia riparia	0.26	1.79	3.16	1.69
Trema orientalis	0.26	1.79	2.63	1.41
Tricalysia sp	0.26	1.79	3.16	1.69
Catunaregam sp	0.21	1.43	2.11	1.13
Newtonia buchananii	0.16	1.07	1.58	0.85
Acalypha sp	0.16	1.07	2.11	1.13
Albizia adianthifolia	0.16	1.07	1.58	0.85
Albizia gummifera	0.16	1.07	2.11	1.13
Harungana madagascariensis	0.16	1.07	1.58	0.85
Podocarpus latifolius	0.16	1.07	1.58	0.85

Syzygium cordatum	0.16	1.07	2.11	1.13
Cussonia spicata	0.11	0.71	1.58	0.85
Dalbergia arbutifolia	0.11	0.71	1.05	0.56
Diospyros sp	0.11	0.71	1.05	0.56
Dodonaea viscosa	0.11	0.71	1.05	0.56
Halleria lucida	0.11	0.71	1.05	0.56
Tetradenia galpinii	0.11	0.71	1.58	0.85
Myrianthus holstii	0.11	0.71	1.05	0.56
Parinari excelsa	0.11	0.71	1.05	0.56
Polyscias fulva	0.11	0.71	1.05	0.56
Strychnos sp	0.11	0.71	1.05	0.56
Tecomaria capensis	0.11	0.71	1.05	0.56
Canthium vulgare	0.05	0.36	0.53	0.28
Cassinopsis tinifolia	0.05	0.36	0.53	0.28
Chassalia cf. pavifolia	0.05	0.36	0.53	0.28
Ficus sycomorus	0.05	0.36	0.53	0.28
Gardenia sp	0.05	0.36	0.53	0.28
Lannea schweinfurthii	0.05	0.36	0.53	0.28
Macaranga capensis	0.05	0.36	0.53	0.28
Margaritaria discoidea	0.05	0.36	0.53	0.28
Markhamia obtusifolia	0.05	0.36	0.53	0.28
Milicia excelsa	0.05	0.36	0.53	0.28
Monotes engleri	0.05	0.36	0.53	0.28
Ochna holstii	0.05	0.36	0.53	0.28
Olea capensis	0.05	0.36	0.53	0.28
Polysphaeria lanceolata	0.05	0.36	1.05	0.56
Ritchiea cf. albersii	0.05	0.36	0.53	0.28
Rothmannia urcelliformis	0.05	0.36	0.53	0.28
Rutidea orientalis	0.05	0.36	0.53	0.28
Shirakiopsis elliptica	0.05	0.36	0.53	0.28
Steganotaenia araliacea	0.05	0.36	1.05	0.56
Trichocladus ellipticus	0.05	0.36	0.53	0.28
Trycalysia sp	0.05	0.36	0.53	0.28
Vitex doniana	0.05	0.36	0.53	0.28
Xymalos monospora	0.05	0.36	1.05	0.56
Zanha africana	0.05	0.36	0.53	0.28

05_Low_Forest

Species	**FA**	**FAR**	**DA**	**DAR**
Newtonia buchananii	0.75	5.06	7.50	4.57
Syzygium cordatum	0.67	4.49	8.33	5.08

Chionanthus foveolatus subsp. major	0.58	3.93	7.50	4.57
Harungana madagascariensis	0.58	3.93	5.83	3.55
Parinari excelsa	0.58	3.93	5.83	3.55
Bridelia micrantha	0.50	3.37	5.83	3.55
Dombeya lastii	0.50	3.37	5.83	3.55
Albizia adianthifolia	0.42	2.81	5.83	3.55
Albizia gummifera	0.42	2.81	4.17	2.54
Canthium oligocarpum	0.42	2.81	5.00	3.05
Cussonia spicata	0.42	2.81	4.17	2.54
Halleria lucida	0.42	2.81	4.17	2.54
Tetradenia galpinii	0.42	2.81	5.00	3.05
Tarenna pavettoides	0.42	2.81	4.17	2.54
Anthocleista grandiflora	0.33	2.25	4.17	2.54
Dalbergia arbutifolia	0.33	2.25	3.33	2.03
Dodonaea viscosa	0.33	2.25	3.33	2.03
Scolopia stolzii	0.33	2.25	3.33	2.03
Englerophytum magalismontanum	0.33	2.25	3.33	2.03
Trema orientalis	0.33	2.25	4.17	2.54
Antidesma venosum	0.25	1.69	2.50	1.52
Chrysophyllum gorungosanum	0.25	1.69	2.50	1.52
Polyscias fulva	0.25	1.69	2.50	1.52
Tricalysia sp	0.25	1.69	3.33	2.03
Allophylus africanus	0.17	1.12	1.67	1.02
Annona senegalensis	0.17	1.12	1.67	1.02
Cassinopsis tinifolia	0.17	1.12	1.67	1.02
Cryptocarya libertiana	0.17	1.12	2.50	1.52
Cussonia spicata	0.17	1.12	1.67	1.02
Elaeodendron matabelicum	0.17	1.12	1.67	1.02
Euphorbia sp	0.17	1.12	1.67	1.02
Ficus sycomorus	0.34	2.24	3.34	2.04
Gardenia sp	0.17	1.12	1.67	1.02
Lasianthus kilimandscharicus	0.17	1.12	1.67	1.02
Myrianthus holstii	0.17	1.12	1.67	1.02
Ochna holstii	0.17	1.12	1.67	1.02
Pavetta gurueensis	0.17	1.12	2.50	1.52
Psidium guajava	0.17	1.12	1.67	1.02
Rawsonia lucida	0.17	1.12	1.67	1.02

Rothmannia urcelliformis	0.17	1.12	1.67	1.02
Tecomaria capensis	0.17	1.12	2.50	1.52
Synsepalum brevipes	0.17	1.12	1.67	1.02
Vangueria infausta	0.17	1.12	2.50	1.52
Zanha africana	0.17	1.12	1.67	1.02
Cassine aethiopica	0.08	0.56	0.83	0.51
Faurea racemosa	0.08	0.56	0.83	0.51
Grewio sp	0.08	0.56	0.83	0.51
Mostuea brunonis	0.08	0.56	0.83	0.51
Oxyanthus speciosus	0.08	0.56	0.83	0.51
Parinari curatellifolia	0.08	0.56	1.67	1.02
Phoenix reclinata	0.08	0.56	0.83	0.51
Phyllanthus sp	0.08	0.56	0.83	0.51
Protea madiensis Oliv. subsp. madiensis	0.08	0.56	0.83	0.51
Psorospermum febrifugum	0.08	0.56	0.83	0.51
Rinorea elliptica	0.08	0.56	0.83	0.51
Rourea orientalis	0.08	0.56	0.83	0.51
Strophanthus courmontii	0.08	0.56	0.83	0.51
Uvaria lucida	0.08	0.56	1.67	1.02
Vepris nobilis	0.08	0.56	0.83	0.51

1.1.Fallow

Adults

02_Mont_Fallow_3_4

Species	FA	FAR	DA	DAR
Dombeya lastii	0.17	5.26	1.67	5.00
Erica silvatica	0.33	10.53	3.33	10.00
Englerophytum magalismontanum	0.33	10.53	3.33	10.00
Macaranga capensis	0.17	5.26	1.67	5.00
Milicia excelsa	0.17	5.26	1.67	5.00
Olea capensis	0.17	5.26	1.67	5.00
Oxyanthus speciosus	0.17	5.26	1.67	5.00
Pavetta gurueensis	0.33	10.53	3.33	10.00
Ritchiea cf. albersii	0.17	5.26	1.67	5.00
Syzygium cordatum	0.33	10.53	5.00	15.00
Tetradenia riparia	0.67	21.05	6.67	20.00
Trema orientalis	0.17	5.26	1.67	5.00

03_Mont_Fallow_1_2

Species	FA	FAR	DA	DAR
Cassine aethiopica	0.25	20	2.5	20
Cassipourea malosana	0.25	20	2.5	20
Ehretia amoena	0.25	20	2.5	20
Tetradenia riparia	0.5	40	5	40

06_Low_Fallow_3_4

Species	FA	FAR	DA	DAR
Newtonia buchananii	0.11	2.94	2.22	3.92
Acalypha acrogyna	0.11	2.94	2.22	3.92
Albizia adianthifolia	0.22	5.88	3.33	5.88
Anthocleista grandiflora	0.11	2.94	2.22	3.92
Bridelia micrantha	0.11	2.94	1.11	1.96
Cryptocarya libertiana	0.11	2.94	2.22	3.92
Cussonia spicata	0.11	2.94	1.11	1.96
Dichrostachys cinerea	0.11	2.94	2.22	3.92
Dombeya lastii	0.22	5.88	2.22	3.92
Ficus natalensis	0.22	5.88	3.33	5.88
Ficus sycomorus	0.11	2.94	1.11	1.96
Halleria lucida	0.11	2.94	2.22	3.92
Harungana madagascariensis	0.11	2.94	1.11	1.96
Englerophytum magalismontanum	0.22	5.88	3.33	5.88
Tetradenia galpinii	0.11	2.94	1.11	1.96
Milicia excelsa	0.11	2.94	1.11	1.96
Oxyanthus speciosus	0.11	2.94	2.22	3.92
Parinari curatellifolia	0.11	2.94	1.11	1.96
Parinari excelsa	0.11	2.94	2.22	3.92
Phoenix reclinata	0.11	2.94	1.11	1.96
Phyllanthus sp	0.11	2.94	2.22	3.92
Rawsonia lucida	0.11	2.94	2.22	3.92
Rutidea orientalis	0.11	2.94	1.11	1.96
Syzygium cordatum	0.67	17.65	10.00	17.65
Tricalysia sp	0.11	2.94	2.22	3.92

07_Low_Fallow_1_2

Species	FA	FAR	DA	DAR
Albizia adianthifolia	0.40	22.22	6.00	23.08
Bridelia micrantha	0.20	11.11	4.00	15.38
Cassine aethiopica	0.20	11.11	2.00	7.69
Harungana madagascariensis	0.20	11.11	2.00	7.69
Mangifera indica	0.20	11.11	4.00	15.38
Psidium guajava	0.20	11.11	2.00	7.69
Syzygium cordatum	0.40	22.22	6.00	23.08

Regeneration

02_Mont_Fallow_3_4

Species	FA	FAR	DA	DAR
Acalypha sp	0.13	2.22	1.25	2.13
Albizia gummifera	0.13	2.22	1.25	2.13
Anthocleista grandiflora	0.38	6.67	3.75	6.38
Cassine aethiopica	0.13	2.22	1.25	2.13
Chionanthus foveolatus subsp. major	0.13	2.22	1.25	2.13
Cussonia spicata	0.13	2.22	1.25	2.13
Dombeya lastii	0.5	8.89	6.25	10.6
Scolopia stolzii	0.13	2.22	1.25	2.13
Erica silvatica	0.25	4.44	2.5	4.26
Ficus sycomorus	0.13	2.22	1.25	2.13
Gardenia sp	0.13	2.22	1.25	2.13
Englerophytum magalismontanum	0.13	2.22	1.25	2.13
Lasianthus kilimandscharicus	0.13	2.22	1.25	2.13
Markhamia obtusifolia	0.13	2.22	1.25	2.13
Milicia excelsa	0.38	6.67	3.75	6.38
Ochna holstii	0.26	1.44	2.50	4.26
Protea welwitschii	0.13	2.22	1.25	2.13
Rawsonia lucida	0.13	2.22	1.25	2.13
Ritchiea cf. albersii	0.25	4.44	2.5	4.26
Syzygium cordatum	0.38	6.67	3.75	6.38
Tarenna pavettoides	0.13	2.22	1.25	2.13
Tecomaria capensis	0.13	2.22	1.25	2.13
Tetradenia riparia	1	17.8	11.3	19.1

Trema orientalis	0.25	4.44	2.5	4.26
Vernonia sp	0.13	2.22	1.25	2.13

03_Mont_Fallow_1_2

Species	FA	FAR	DA	DAR
Albizia gummifera	0.4	8.7	4	8.7
Anthocleista grandiflora	0.2	4.35	2	4.35
Bridelia micrantha	0.2	4.35	2	4.35
Dombeya lastii	0.2	4.35	2	4.35
Scolopia stolzii	0.2	4.35	2	4.35
Ehretia amoena	0.2	4.35	2	4.35
Erica silvatica	0.2	4.35	2	4.35
Euphorbia sp	0.2	4.35	2	4.35
Gardenia sp	0.2	4.35	2	4.35
Harungana madagascariensis	0.2	4.35	2	4.35
Lasianthus kilimandscharicus	0.2	4.35	2	4.35
Milicia excelsa	0.4	8.7	4	8.7
Olea capensis	0.2	4.35	2	4.35
Tarenna pavettoides	0.2	4.35	2	4.35
Tetradenia riparia	0.8	17.4	8	17.4
Trema orientalis	0.4	8.7	4	8.7
Vitex doniana	0.2	4.35	2	4.35

06_Low_Fallow_3_4

Species	FA	FAR	DA	DAR
Syzygium cordatum	0.73	9.76	10.00	10.28
Albizia adianthifolia	0.64	8.54	9.09	9.35
Harungana madagascariensis	0.64	8.54	10.00	10.28
Tetradenia galpinii	0.55	7.32	6.36	6.54
Annona senegalensis	0.45	6.10	5.45	5.61
Anthocleista grandiflora	0.45	6.10	5.45	5.61
Bridelia micrantha	0.36	4.88	5.45	5.61
Vangueria infausta	0.36	4.88	5.45	5.61
Parinari curatellifolia	0.27	3.66	3.64	3.74
Psorospermum febrifugum	0.27	3.66	2.73	2.80
Canthium oligocarpum	0.18	2.44	2.73	2.80
Dodonaea viscosa	0.18	2.44	1.82	1.87

Dombeya lastii	0.18	2.44	1.82	1.87
Rourea orientalis	0.18	2.44	3.64	3.74
Tarenna pavettoides	0.18	2.44	2.73	2.80
Tecomaria capensis	0.18	2.44	1.82	1.87
Trema orientalis	0.18	2.44	1.82	1.87
Vernonia sp	0.18	2.44	2.73	2.80
Acalypha sp	0.09	1.22	0.91	0.93
Albizia gummifera	0.09	1.22	0.91	0.93
Dalbergia arbutifolia	0.09	1.22	0.91	0.93
Ficus sycomorus	0.09	1.22	0.91	0.93
Milicia excelsa	0.09	1.22	0.91	0.93
Phyllanthus sp	0.09	1.22	0.91	0.93
Protea madiensis Oliv. subsp. madiensis	0.09	1.22	0.91	0.93
Rawsonia lucida	0.09	1.22	0.91	0.93
Ritchiea cf. albersii	0.09	1.22	0.91	0.93
Rothmannia urcelliformis	0.09	1.22	1.82	1.87
Sesbania sesban	0.09	1.22	0.91	0.93
Steganotaenia araliacea	0.09	1.22	0.91	0.93
Tetradenia riparia	0.09	1.22	1.82	1.87
Zanha africana	0.09	1.22	0.91	0.93

07_Low_Fallow_1_2

Species	FA	FAR	DA	DAR
Albizia adianthifolia	0.73	10	12.7	10.8
Albizia gummifera	0.18	2.5	3.64	3.08
Annona senegalensis	0.27	3.75	5.45	4.62
Anthocleista grandiflora	0.27	3.75	4.55	3.85
Bridelia micrantha	0.18	2.5	2.73	2.31
Chrysophyllum gorungosanum	0.09	1.25	0.91	0.77
Cryptocarya libertiana	0.09	1.25	0.91	0.77
Cussonia spicata	0.09	1.25	0.91	0.77
Dalbergia arbutifolia	0.09	1.25	1.82	1.54
Dichrostachys cinerea	0.09	1.25	1.82	1.54
Dodonaea viscosa	0.36	5	5.45	4.62
Scolopia stolzii	0.09	1.25	1.82	1.54
Eucalyptus sp	0.09	1.25	1.82	1.54
Euphorbia sp	0.09	1.25	0.91	0.77
Ficus natalensis	0.09	1.25	0.91	0.77
Halleria lucida	0.09	1.25	0.91	0.77

Harungana madagascariensis	0.82	11.3	13.6	11.5
Tetradenia galpinii	0.36	5	5.45	4.62
Mangifera indica	0.09	1.25	0.91	0.77
Mangifera indica	0.09	1.25	0.91	0.77
Mostuea brunonis	0.18	2.5	1.82	1.54
Parinari curatellifolia	0.18	2.5	3.64	3.08
Parinari excelsa	0.27	3.75	5.45	4.62
Pavetta gurueensis	0.18	2.5	3.64	3.08
Phyllanthus sp	0.09	1.25	1.82	1.54
Psidium guajava	0.45	6.25	6.36	5.38
Psorospermum febrifugum	0.09	1.25	1.82	1.54
Steganotaenia araliacea	0.09	1.25	1.82	1.54
Strophanthus courmontii	0.09	1.25	0.91	0.77
Syzygium cordatum	0.82	11.3	14.5	12.3
Tecomaria capensis	0.27	3.75	3.64	3.08
Trema orientalis	0.18	2.5	2.73	2.31
Tricalysia sp	0.09	1.25	1.82	1.54

1.2.Cropland

Adult trees

04_Mont_Crop

Specie	FA	FAR	DA	DAR
Canthium oligocarpum	0.2	14.29	2.00	14.29
Pavetta gurueensis	0.2	14.29	2.00	14.29
Psidium guajava	0.2	14.29	2.00	14.29
Tabernaemontana stapfiana	0.2	14.29	2.00	14.29
Tetradenia riparia	0.4	28.57	4.00	28.57
Trema orientalis	0.2	14.29	2.00	14.29

06_Low_Crop

Specie	FA	FAR	DA	DAR
Bridelia micrantha	0.14	11.11	0.57	14.29
Erythrina abyssinica	0.14	11.11	0.29	7.14
Syzygium cordatum	1.00	77.78	3.14	78.57

Regeneration

04_Mont_Crop

Specie	FA	FAR	DA	DAR
Dodonaea viscosa	0.14	8.33	1.43	7.69
Dombeya lastii	0.14	8.33	1.43	7.69
Erica silvatica	0.14	8.33	1.43	7.69
Ficus sycomorus	0.14	8.33	1.43	7.69
Milicia excelsa	0.14	8.33	1.43	7.69
Tetradenia riparia	0.86	50.00	10.00	53.85
Trema orientalis	0.14	8.33	1.43	7.69

08_Low_Crop

Species	FA	FAR	DA	DAR
Syzygium cordatum	0.83	14.49	11.67	14.43
Albizia adianthifolia	0.79	13.77	11.67	14.43
Harungana madagascariensis	0.58	10.14	8.75	10.82
Annona senegalensis	0.33	5.80	4.17	5.15
Bridelia micrantha	0.29	5.07	4.17	5.15
Parinari curatellifolia	0.25	4.35	4.17	5.15
Psidium guajava	0.25	4.35	3.75	4.64
Trema orientalis	0.21	3.62	3.33	4.12
Tetradenia galpinii	0.25	4.35	2.92	3.61
Tecomaria capensis	0.25	4.35	2.92	3.61
Parinari excelsa	0.13	2.17	2.92	3.61
Dodonaea viscosa	0.13	2.17	2.50	3.09
Ficus sycomorus	0.21	3.62	2.08	2.58
Canthium oligocarpum	0.13	2.17	1.67	2.06
Ficus sycomorus	0.13	2.17	1.67	2.06
Pavetta gurueensis	0.13	2.17	1.67	2.06
Vangueria infausta	0.13	2.17	1.67	2.06
Anthocleista grandiflora	0.08	1.45	1.67	2.06
Dalbergia arbutifolia	0.13	2.17	1.25	1.55
Cussonia spicata	0.08	1.45	1.25	1.55
Erythrina abyssinica	0.08	1.45	0.83	1.03

Psorospermum febrifugum	0.08	1.45	0.83	1.03
Rourea orientalis	0.08	1.45	0.83	1.03
Eucalyptus sp	0.04	0.72	0.83	1.03
Halleria lucida	0.04	0.72	0.42	0.52
Mostuea brunonis	0.04	0.72	0.42	0.52
Prunus persica	0.04	0.72	0.42	0.52
Rawsonia lucida	0.04	0.72	0.42	0.52