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PERFORM SITE-BASED FOREST INVENTORY REPORT

A TECHNICAL REPORT ON LIWONDE,
NTCHISI AND PEREKEZI FOREST RESERVES



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FEBRUARY 2017

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ACRONYMS AND ABBREVIATIONS

AGB	Above Ground Biomass
BGB	Below Ground Biomass
DBH	Diameter at Breast Height
EF	Emission Factor
GoM	Government of Malawi
GIS	Geographic Information System
GPS	Global Positioning System
MRV	Monitoring, Reporting and Verification
MSU	Michigan State University
PERFORM	Protecting Ecosystems and Restoring Forests in Malawi
SOP	Standard Operating Procedures
tC	Tonnes of Carbon or Carbon Stock
USAID	United States Agency for International Development

1.0 INTRODUCTION

PERFORM’s forest inventory in the Liwonde, Ntchisi, and Perekezi Forest Reserves serves several objectives:

1. Improvement of the co-management plans and governance arrangements for the forest management blocks in each reserve by providing information on the stocks and the growth rate of those stocks
2. Inform the design of a National Forest Inventory for Malawi, providing best practices, a methodology, measurement protocol, and pilot data
3. Provide the necessary data to estimate carbon stocks in the forest reserves, and estimate emissions reductions due to PERFORM’s activities with higher precision

As noted in the PERFORM FY ’16 Work Plan: “site-based demonstrations of forest carbon field plot inventories to support the production of Emission Factors in a National Forest Inventory “pillar” of a Malawi National Forest Monitoring System. The activity will focus on: 1) design of forest inventories for each pilot site, 2) development of handbooks and guidance for standard operating procedures (SOP) for field plot data collection of carbon stocks, 3) design of the plot sample frame and plot allocations, 4) training and management of inventory crews, and 5) analysis of the plot inventory data.”

The field inventory work was completed by five teams with support from PERFORM staff and with MSU Technical backstopping in the first week of data collection. Table #1 below provides details on field teams and data collection dates.

Table 1. Field Inventory General Information

	Liwonde	Ntchisi	Perekezi
Field team leaders	Mike Chirwa, Henry Utila, Dan Ndalowa	Henry Kadzuwa	Bennet Mataya
Start date	9 June 2016	14 June 2016	14 June 2016
Finish date	29 June 2016	29 June 2016	1 July 2016
PERFORM supervisors	Alinafe Chibwana, Clifford Mkanthama	Alinafe Chibwana, Clifford Mkanthama	Alinafe Chibwana, Clifford Mkanthama
MSU technical support	Dr. David L. Skole, Jay H. Samek	Dr. David L. Skole, Jay H. Samek	Dr. David L. Skole, Jay H. Samek

Teams consisted of six to eight members who carried out specific technical tasks during the data collection period. Team members included staff from DOF (inclusive of headquarters, FRIM, MCFW and District Forestry Offices), National Herbarium and Botanical Garden (NHBG), Department of Surveys (DOS), and local communities.

The field inventory data collected followed Standard Operating Procedures (SOP) detailed in two volumes.

- Standard Operating Procedures: Forest Carbon Inventory, Data Collection and Reporting—
Volume 1: Establishing the Inventory and Sample Plots
- Standard Operating Procedures: Forest Carbon Inventory, Data Collection and Reporting—
Volume 2: Field Measurements at Sample Plots

Data collection data sheet were developed with input from team leaders and PERFORM staff. These data collection sheets were printed on write-in-rain parchment paper and distributed to each team leader. Training in establishing plots and in data collection (use of measurement tools) were completed in April 2016 with the team leaders, and again on the first two days of the site-based forest inventories in June 2016, with all team members from each forest reserve.

A cartographic map book was published in large format for each forest reserve. These map books were laminated and made field ready. They consisted of an overview map of the reserve with plot locations overlaid on hi-resolution satellite data. This overview map was followed by 1:10,500 scale detailed maps. These map books were used to support the field data collection effort, in particular, in route-finding from access roads and trails to plot locations in order to minimize time and effort.

Data inventory tracking was supported by a google web application developed by PERFORM and used to collect a daily log for status reporting by the team leaders in all three forest reserves. Hard copy data sheets were collected, collated and scanned as PDF files at the PERFORM Office in Lilongwe. An Excel file database was used to track the data sheets collection and processing which included uploading the PDF files and plot photos to Dropbox.

The MSU team acquired the scanned PDF field data sheets from PERFORM and completed data entry to the MRV Toolbox data management and reporting system through upload of Excel data sheets for each plot. MSU also used the field-recorded GPS information (UTM Northing and Easting values) to create an ESRI GIS shapefile. These data have been made available to team leaders and the PERFORM office.

2.0 DATA COLLECTION SUMMARY INFORMATION

The initial target for field data collection, in terms of the number of cluster plots, based upon a sample design using 95 % confidence and 10 % error, was:

- Liwonde = 47
- Ntchisi = 13 (though we targeted 18 to ensure a minimum of one plot per block)
- Perekezi = 21

The cluster plot design of three individual plots located in a “T” shape meant that the total number of individual plots for each forest reserve would be:

- Liwonde = 141
- Ntchisi = 54
- Perekezi = 63

The summary table #2 shows the number of clusters and plots with data collected, number of clusters rejected, number of plots moved as well as the number of plots where data were collected for specific carbon pools (downed deadwood, regeneration) and the number of plots that included tree heights (refer to the SOP VOLUME 2).

Table 1. Summary Information for Field Inventory

	Liwonde	Ntchisi	Perekezi	Total
Expected number of clusters (plots)	47 (141)	18 (54)	21 (63)	86 (258)
Actual number of clusters (plots)	48 (140)	17 (50)	20 (60)	85 (250)
Number of clusters rejected	8	0	0	8
Number of plots moved	30	15	26	71
Number of clusters from oversample pool	10	5	0	15
Number of days to complete data collection	21	16	18	55
Number of plots with regeneration data	126	49	56	231
Number of plots with tree height measurement	70	20	27	120
Number of trees with DBH and height measurement	608	247	265	1120

3.0 AGB AND BGB CARBON STOCKS AND EMISSION FACTORS

Plot inventory data were input into the MRV Toolbox (mrv.carbon2markets.org) for all three forest reserves. Two assessments of the plot inventory data were completed using the MRV Toolbox for estimating the AGB and BGB carbon stocks (tC) and the emission factors (tCha⁻¹). In these two assessments standing deadwood and down deadwood were not included.

3.1 MRV TOOLBOX ASSESSMENT: KACHAMBA ET AL. ALLOMETRIC EQUATION – DBH

The first assessment used all 250 plot data sheets (Perkezi n=60; Ntchisi n=50; Liwonde n=140) with all live trees measured in the 20m and 12m sub-plots. A root-to-shoot ratio of 0.28¹ was used to compute the BGB. The first assessment uses the allometric equation published by Kachamba et al. (2016) for computing biomass in miombo woodlands that requires only one tree mensuration variable, DBH or diameter at breast height (cm) (See Eq 1).

$$AGB = 0.21691 * dbh^{2.318391} \quad \text{Eq. 1}$$

Where:

AGB = above-ground biomass; kilograms of dry matter (kg d.m.)

dbh = diameter at breast height in centimeters (cm)

The MRV Toolbox computes the mean AGB and BGB in terms of tCha⁻¹ for all plots associated with a specific forest reserve. The carbon fraction of 0.47 is used to calculate carbon (C) from kilograms of dry matter (kg d.m.). The total carbon stock is a computation of the area of the forest reserve times the mean AGB and BGB values derived from the plot level field inventory data. Figure 1 below shows the MRV Toolbox report of the total carbon by Forest Reserve and the carbon density values or emission factor (EF) for the AGB and BGB pools for each forest reserve.

Figure 1. MRV Toolbox Report of Total Carbon Stock and Forest Carbon Emission Factors (EFs) for Three Forest Reserves

Tier 3 - Carbon Stocks by Parcel ×

Parcel Descriptors		Carbon Density				Carbon Stocks						
Values below in ha		Values below in tC/ha				Values below in tC						
ID	Area	AGB	BGB	SOC	Litter	Deadwood	AGB	BGB	Soil	Litter	Deadwood	Total
LIWONDE	26,889.18	35.01	9.80	0.00	0.00	0.00	941,290.70	263,561.40	0.00	0.00	0.00	1,204,852.09
NTCHISI	9,410.52	45.00	12.60	0.00	0.00	0.00	423,466.03	118,570.49	0.00	0.00	0.00	542,036.52
PEREKEZI	15,600.14	42.49	11.90	0.00	0.00	0.00	662,844.02	185,596.33	0.00	0.00	0.00	848,440.34
Project Totals							2,027,600.75	567,728.21	0.00	0.00	0.00	2,595,328.96

Yellow rows indicate Parcels containing Plots with rejected data. Calculations may be erroneous due to faulty plot data.

The emission factors for each forest reserve in the first assessment that only uses AGB and BGB pools of carbon are shown in table 3. They range from a low of 44.81 tCha⁻¹ in Liwonde to a high of 57.60 tCha⁻¹ in Ntchisi. Total carbon stocks based on the AGB + BGB EFs and reserve areas are also reported in table 3 for each of the three forest reserves.

¹ IPCC mean default root to shoot ratio for Subtropical dry AGB >20 td.m./ha. IPCC 2006.

Table 3. Forest Reserve Emission Factors and Total Carbon Stock from the First Assessment

Forest Reserve	Mean AGB (tC/ha)	Mean BGB (tC/ha)	Emission Factor – AGB+BGB (tC/ha)	Carbon Stock (tC) Area * EF
Liwonde	35.01	9.80	44.81	1,204,852.09
Ntchisi	45.00	12.60	57.60	542,036.52
Perekezi	42.49	11.90	54.39	848,440.34

The mean and variation of AGB and BGB based on the number of plots for each forest reserve is reported in table 4. BGB mean though is simply of function of the root-to-shoot ratio used to compute BGB values.

Table 4. Mean and Standard Deviation of AGB and BGB Values for Each Forest Reserve from the First Assessment

Forest Reserve	Mean AGB (tC/ha)	AGB Standard Deviation	Mean BGB (tC/ha)	BGB Standard Deviation	Number of Plots N=
Liwonde	35.01	20.42	9.80	5.72	140
Ntchisi	45.00	19.04	12.60	5.33	50
Perekezi	42.49	16.13	11.90	4.52	60

3.2 MRV TOOLBOX ASSESSMENT: COMPARISON OF FOUR ALLOMETRIC EQUATIONS – LIWONDE FOREST RESERVE

A second analysis was completed comparing four allometric equations, two from Kachamba et al. (2016) and two from Brown (1997) for Liwonde Forest Reserve (See equations 2 – 5).

$$\text{Kachamba 1: } AGB = 0.21691 * dbh^{2.318391} \quad \text{Eq. 2}$$

$$\text{Kachamba 2: } AGB = 0.103685 * dbh^{1.921719} * ht^{0.844561} \quad \text{Eq. 3}$$

$$\text{Brown Tropical Dry: } AGB = \exp(-1.996 + 2.23 * \ln(dbh)) \quad \text{Eq. 4}$$

$$\text{Brown Tropical Moist: } AGB = 42.69 - 12.8 (dbh) + 1.242 (dbh) \quad \text{Eq. 5}$$

Where:

AGB = above-ground biomass; kilograms of dry matter (kg d.m.)

dbh = diameter at breast height in centimeters (cm)

ht = total tree height in meters (m)

The data sheets for Liwonde where tree heights were recorded were subset from the main set of data sheets and the small trees (plot radius = 6 m) whose tree height was not recorded were removed. This subset of data sheets (n = 70) could then be used in the MRV Toolbox with the Kachamba 2 equation that requires height as a tree measurement variable. To compare the four equations the same 70 data sheets were uploaded to the MRV toolbox four times each time computing the carbon values using one of the four allometric equation models. Again, only AGB and BGB values were computed and BGB values were computed using the root-to-shoot ratio of 0.28.

Figure 2 shows the MRV Toolbox report of the AGB and BGB mean values from the 70 plots uploaded computed using the four different allometric equation models.

Figure 2. Comparison of Four Allometric Equations

Tier 3 - Carbon Stocks by Parcel x

Parcel Descriptors		Carbon Density					Carbon Stocks					
Values below in ha		Values below in tC/ha					Values below in tC					
ID	Area	AGB	BGB	SOC	Litter	Deadwood	AGB	BGB	Soil	Litter	Deadwood	Total
Kachamba1	0.00	28.62	8.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kachamba2	0.00	33.71	9.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LIWONDE Brown Tropical Dry	0.00	13.22	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LIWONDE Brown Tropical Moist	0.00	37.69	10.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Project Totals							0.00	0.00	0.00	0.00	0.00	0.00

Yellow rows indicate Parcels containing Plots with rejected data. Calculations may be erroneous due to faulty plot data.

The comparison of the emission factors of the four allometric equation models are shown in table 5. The results vary from a low of 16.92 tCha⁻¹ using the Brown Tropical Dry equation to a high of 48.25 tCha⁻¹ using the Brown Tropical Moist equation. The two Kachamba models result in a difference of 6.5 tCha⁻¹. In comparison to the results from the full data set (n = 140) for Liwonde using the Kachamba 1 equation (44.81 tCha⁻¹) the results from the second assessment are conservative which is to be expected after omitting the trees measured in the 6-m radius sub-plot.

Table 5. Comparison of Emission Factors from Four Allometric Equation Models

Allometric Equation Model	Mean AGB (tC/ha)	Mean BGB (tC/ha)	Emission Factor –AGB+BGB (tC/ha)
Kachamba 1	28.62	8.01	36.63
Kachamba 2	33.71	9.44	43.14
Brown Tropical Dry	13.22	10.55	16.92
Brown Tropical Moist	37.69	10.55	48.25

The mean and variation of AGB and BGB based on the 70 plots used by each allometric equation model is reported in table 6. BGB mean though is simply of function of the root-to-shoot ratio used to compute BGB values.

Table 6. Mean and Standard Deviation of AGB and BGB Values for Each Allometric Model from 70 Plots in Liwonde Forest Reserve

Allometric Equation Model	Mean AGB (tC/ha)	AGB Standard Deviation	Mean BGB (tC/ha)	BGB Standard Deviation	Number of Plots N=
Kachamba 1	28.62	18.14	8.01	5.08	70
Kachamba 2	33.71	23.75	9.44	6.65	70
Brown Tropical Dry	13.22	8.32	3.70	2.33	70

Brown Tropical Moist	37.69	24.07	10.55	6.74	70
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4.0 AGB, BGB AND DEADWOOD CARBON STOCKS AND EMISSION FACTORS

A third assessment of the inventory data for all three forest reserves was completed adding in the deadwood pool of carbon. The deadwood pool includes both standing and down deadwood. These data were collected by field crews as per the SOP VOLUME 2: Field Measurements at Sample Plots. All standing deadwood data were subset from the data sheets and compiled by plot ID. Standing deadwood biomass were computed for each plot using the Kachamba 1 equation when tree height was not recorded and the Kachamba 2 equation when tree height was recorded. Carbon was calculated using the carbon fraction of 0.47 and converted to tCha⁻¹ based on the subplot size. Table 7 shows the number of plots in each forest reserve where standing deadwood was recorded in the field, the total number of standing deadwood trees, and the amount of carbon (tC).

Table 7. Standing Deadwood by Forest Reserve

Forest Reserve	Number of Plots with Standing Deadwood	Total Number of Trees	Total tC
Liwonde	45	75	528.29
Ntchisi	1	1	0.29
Perekezi	13	23	15.13

Down deadwood data were also subset by plot ID and biomass (carbon) computed. Using the field measurements of each down piece of wood, the volume was computed and kilograms of dry biomass estimated using a wood density value of .66g/cm³ (Malimbwi et al. 1994). The carbon fraction of 0.47 was used to compute carbon from biomass. The field crews estimated a percent decay which was used to compute a final carbon value. Table 8 shows the number of plots in each forest reserve where down deadwood was recorded in the field, the total number of down deadwood pieces, and the amount of carbon (tC).

Table 8. Down Deadwood by Forest Reserve

Forest Reserve	Number of Plots with Down Deadwood	Total Number of Trees	Total tC
Liwonde	38	91	91.94
Ntchisi	12	20	0.0001
Perekezi	16	31	8.29

4.1 MRV TOOLBOX ASSESSMENT: RESULTS FROM ADDING THE DEADWOOD POOL OF CARBON

The deadwood pool of carbon is a sum of the standing and down deadwood. The sum of the standing and down deadwood carbon values in term of tCha⁻¹ were added to the initial MRV Toolbox assessment (computing AGB and BGB using the Kachamba 1 equation) for those plots where deadwood was present. The MRV Toolbox report of the total carbon by Forest Reserve and

the carbon density values or emission factor (EF) for the AGB, BGB and Deadwood pools for each forest reserve are shown in figure 3.

Deadwood is a rather small portion of the carbon pool in each of the three reserves. In Ntchisi it is negligible. In Perekezi it accounts for less than 1% of the total EF. In Liwonde it accounts for 8.4% of the total EF. The emission factors for each forest reserve for AGB, BGB and deadwood pools of carbon along with the total EF value and carbon stocks are shown in Table 9.

Table 9. Forest Reserve Emission Factors and Total Carbon Stock from Third Assessment

Forest Reserve	Mean AGB (tC/ha)	Mean BGB (tC/ha)	Mean Deadwood (tC/ha)	EFs: AGB+BGB+DW (tC/ha)	Carbon Stock (tC) Area * EF
Liwonde	35.01	9.80	4.29	49.09	1,320,108.74
Ntchisi	45.00	12.60	0.01	57.61	542,124.98
Perekezi	42.49	11.90	0.40	54.78	854,638.26

The mean and variation of deadwood pool based on the number of plots for each forest reserve is reported in table 10. Note that variance is quite high in Liwonde. The mean is computed from all plots and should be noted that only some plots included deadwood.

Table 10. Mean and Standard Deviation of Deadwood Values for Each Forest Reserve

Forest Reserve	Mean Deadwood (tC/ha)	Deadwood Standard Deviation	Number of Plots N=
Liwonde	4.29	10.99	140
Ntchisi	0.01	0.04	50
Perekezi	0.40	0.82	60

Figure 3. MRV Toolbox Report of Total Carbon Stock and Forest Carbon Emission Factors (EFs) Including Deadwood for Three Forest Reserves

Tier 3 - Carbon Stocks by Parcel

Parcel Descriptors		Carbon Density					Carbon Stocks					
ID	Area	AGB	BGB	SOC	Litter	Deadwood	AGB	BGB	Soil	Litter	Deadwood	Total
LIWONDE	26,889.18	35.01	9.80	0.00	0.00	4.29	941,290.70	263,561.40	0.00	0.00	115,256.64	1,320,108.74
NTCHISI	9,410.52	45.00	12.60	0.00	0.00	0.01	423,466.03	118,570.49	0.00	0.00	88.46	542,124.98
PEREKEZI	15,600.14	42.49	11.90	0.00	0.00	0.40	662,844.02	185,596.33	0.00	0.00	6,197.91	854,638.26
Project Totals							2,027,600.75	567,728.21	0.00	0.00	121,543.01	2,716,871.97

Yellow rows indicate Parcels containing Plots with rejected data. Calculations may be erroneous due to faulty plot data.

5.0 PLOT INVENTORY TREE CROWN ANALYSES

Tree crown measurements were recorded by the field crews as per SOP VOLUME 2: Field Measurements at Sample Plots. Tree crown areas were computed using an ellipsoid formula for each tree with the two crown measurements. Assuming no overlap in tree crowns, an assessment of percent crown area was computed for each reserve and each plot that had tree crown measurements.

Summary statistics are reported for each reserve in table 11. Note that percent canopy coverage could be more than 100% as we assume no overlap between tree crowns. Tree crown area were computed for the 12-m and 20-m subplots and then summed. Canopy areas above 100% are assumed to be multi-story canopies with tree crown overlaps.

Table 11. Summary Statistics for Canopy Cover from Tree Crown Measurements (Figures in % Canopy Cover)

Forest Reserve	Minimum	Maximum	Mean	Standard Deviation
Liwonde	2	350	114	94
Ntchisi	15	370	135	101
Perekezi	16	210	88	60

A frequency distribution of the number of plots by percent canopy for each forest reserve shows the range of canopy densities (Table 12). Perekezi includes more areas with lower canopy densities than Liwonde or Ntchisi, both of which have close to 50% or more, respectively, of plots with greater than 100% canopy (with multi-story and/or tree crown overlap).

Table 12. Frequency Distribution of Plots by % Canopy for Three Forest Reserves

Liwonde			Ntchisi			Perekezi		
% Canopy	Frequency	% of Total	% Canopy	Frequency	% of Total	% Canopy	Frequency	% of Total
0-25	8	17	0-25	1	6	0-25	3	15
26-50	5	11	26-50	2	13	26-50	4	20
51-75	8	17	51-75	1	6	51-75	3	15
76-100	5	11	76-100	3	19	76-100	3	15
>100	20	43	>100	9	56	>100	7	35

6.0 FOREST RESERVE AND BLOCK MANAGEMENT INFORMATION

The information before this section in this Forest Inventory Technical Report has centered on forest carbon: AGB, BGB and Deadwood pools, carbon stocks and emission factors and forest canopy derived from the tree crown measurement data. This section reports the non-carbon information from the inventory data; Species diversity and composition and forest density, sometime called stem density. Data are reported at the reserve and the block management levels².

Species count and a list of the five most dominant species by count are noted in table 13 by forest reserve. *Brachystegia* genus dominate in all three forest reserves. Both Ntchisi and Perekezi however include *Julbernardia* as one of the top five dominant genera. See appendix for complete list of species and counts by forest reserve.

Table 13. Species Counts and Dominant Species by Forest Reserve

Forest Reserve	Total Number of Species Identified	Five Most Dominant Species	Species Count
Liwonde	78 ³	<i>Brachystegia bussei</i>	235
		<i>Brachystegia manga</i>	94
		<i>Brachystegia longifolia</i>	86
		<i>Brachystegia utilis</i>	69
		<i>Brachystegia boehmii</i>	67
Ntchisi	55	<i>Brachystegia bussei</i>	89
		<i>Brachystegia boehmii</i>	82
		<i>Brachystegia manga</i>	78
		<i>Brachystegia spiciformis</i>	57
		<i>Julbernardia globiflora</i>	30
Perekezi	47 ⁴	<i>Brachystegia utilis</i>	88
		<i>Julbernardia paniculate</i>	79
		<i>Brachystegia boehmii</i>	75
		<i>Brachystegia microphylla</i>	50
		<i>Uapaca kirkiana</i>	48

² Block management information was provided by the PERFORM office as ESRI shapefiles. In the case of Perekezi, not all block names are listed in the ESRI shapefile attribute table (provided to MSU by PERFORM) so reference is given by noting the block directly East, South, or North of the block without a name.

³ Five individual trees were not identified by code.

⁴ Three individual trees were not identified by code.

The plot sample design ensured that at least one cluster plot fell inside a management block area, though a block may not have any plot if the plot was rejected or moved in the field. Tables 14 - 16 below show the Block Name, the Plot IDs located within each block, the number of species present and the three most dominant species by count within each block. There is one table for each forest reserve.

Table 14. Block Level Species Count and Dominance Liwonde Forest Reserve

Block Name and List of Cluster Plot IDs	Number of Cluster Plots	Total Number of Species Identified	Three Most Dominant Species	Species Count
Chamatwa Tokomana	2	12	<i>Brachystegia bussei</i>	48
			<i>Brachystegia utilis</i>	8
			<i>Pericopsis angolensis</i> & <i>Pterocarpus angolensis</i>	3
Chikwakwata Mangaka Nyama	4	23	<i>Brachystegia bussei</i>	29
			<i>Brachystegia manga</i>	10
			<i>Burkea africana</i>	5
Chindenga Chamba	2	10	<i>Brachystegia bussei</i>	24
			<i>Pericopsis angolensis</i>	4
			<i>Sepium ellipticum</i>	4
Chindenga Nsanama Mangulu	6	27	<i>Brachystegia bussei</i>	39
			<i>Brachystegia boehmii</i>	22
			<i>Brachystegia microphylla</i>	17
Chipamba	2	12	<i>Brachystegia bussei</i>	19
			<i>Brachystegia longifolia</i>	10
			<i>Brachystegia spiciformis</i>	10
Chipojola	2	13	<i>Brachystegia manga</i>	5
			<i>Brachystegia boehmii</i> , <i>Brachystegia longifolia</i> , <i>Burkea africana</i> & <i>Combretum molle</i>	4
Kwilasya	3	20	<i>Julbernardia globiflora</i>	22

			<i>Brachystegia utilis</i>	16
			<i>Brachystegia longifolia</i>	14
Lipongo	1	5	<i>Brachystegia spiciformis</i>	13
			<i>Uapaca kirkiana</i>	4
			<i>Uapaca nitida</i>	3
Liundi Mposa Chipole	2	15	<i>Uapaca kirkiana</i>	14
			<i>Brachystegia boehmii</i>	9
			<i>Brachystegia utilis</i>	9
Liundi Muhala Malajira	3	12	<i>Brachystegia bussei</i>	27
			<i>Brachystegia manga</i>	25
			<i>Brachystegia boehmii</i>	6
Lulanga Chiwanga Mphonde	2	19	<i>Diplorhynchus condylocarpon</i>	8
			<i>Pseudolachnostylis maprouneifolia</i>	4
			<i>Zanha africana</i>	4
Makaluka Magadi	1	13	<i>Brachystegia manga</i>	9
			<i>Brachystegia boehmii</i>	7
			<i>Brachystegia bussei, Dalbergia nitidula & Parinari curatellifolia</i>	4
Malopa Swaibu Mahete Mbawe	1	15	<i>Brachystegia bussei</i>	9
			<i>Brachystegia microphylla</i>	9
			<i>Pericopsis angolensis</i>	5
Matandika 2	3	16	<i>Brachystegia bussei</i>	17
			<i>Brachystegia manga</i>	10
			<i>Brachystegia utilis</i>	5
Mikunga Mtambalika	2	17	<i>Ozoroa insignis</i>	5
			<i>Brachystegia spiciformis</i>	4

			<i>Diplorhynchus condylocarpon</i>	4
Mitawa	4	18	<i>Uapaca kirkiana</i>	13
			<i>Brachystegia bussei</i>	9
			<i>Parinari curatellifolia</i>	9
Mliwo Nsemba	2	12	<i>Diplorhynchus condylocarpon</i>	4
			<i>Brachystegia boehmii</i>	3
			<i>Brachystegia longifolia</i>	2
Mpango	2	13	<i>Brachystegia longifolia</i>	27
			<i>Brachystegia manga</i>	13
			<i>Brachystegia utilis</i>	13
Mtawira Mpunga Sela Mlomba Kapu	1	2	<i>Commiphora caerulea</i>	1
			<i>Kirkia acuminata</i>	1
Naungu	3	11	<i>Brachystegia longifolia</i>	24
			<i>Brachystegia utilis</i>	13
			<i>Pericopsis angolensis</i>	9

Table 15. Block Level Species Count and Dominance Ntchisi Forest Reserve

Block Name and List of Cluster Plot IDs	Number of Cluster Plots	Total Number of Species Identified	Three Most Dominant Species	Species Count
Chanika	1	7	<i>Brachystegia manga</i>	37
			<i>Monotes africanus</i>	2
			<i>Olax dissitiflora</i>	2
Chazama	1	5	<i>Brachystegia spiciformis</i>	13
			<i>Julbernardia paniculata</i>	9
			<i>Uapaca kirkiana</i>	3

Chenche	1	12	<i>Brachystegia boehmii</i>	16
			<i>Julbernardia globiflora</i>	8
			<i>Acacia galpinii</i>	4
Chifwelekete	1	11	<i>Brachystegia bussei</i>	29
			<i>Julbernardia globiflora</i>	9
			<i>Brachystegia boehmii</i> & <i>Monotes africanus</i>	5
Kajaliza	1	7	<i>Combretum collinum</i>	13
			<i>Markhamia obtusifolia</i>	10
			<i>Acacia polyacantha</i>	6
Kasakula	1	10	<i>Brachystegia utilis</i>	12
			<i>Brachystegia boehmii</i>	10
			<i>Julbernardia globiflora</i>	5
Mandwe	1	7	<i>Brachystegia manga</i>	6
			<i>Julbernardia paniculata</i>	6
			<i>Brachystegia boehmii</i>	3
Mkomba	1	11	<i>Brachystegia manga</i>	7
			<i>Brachystegia manga</i>	6
			<i>Pseudolachnostylis maprouneifolia</i>	6
Mndinda	1	12	<i>Acacia polyacantha</i>	3
			<i>Combretum collinum</i>	3
			<i>Bauhinia petersiana</i> , <i>Monodora junodii</i> & <i>Stereospermum kunthianum</i>	2
Mnguluwe	1	9	<i>Brachystegia manga</i>	9

			<i>Julbernardia paniculata</i>	5
			<i>Diplorhynchus condylocarpon</i>	4
Mpamila	1	4	<i>Brachystegia boehmii</i>	6
			<i>Brachystegia spiciformis</i>	4
			<i>Brachystegia utilis</i>	2
Mponda	1	3	<i>Brachystegia bussei</i>	25
			<i>Brachystegia spiciformis</i>	8
			<i>Uapaca kirkiana</i>	1
Msankhire	1	11	<i>Bauhinia petersiana</i>	5
			<i>Bridelia micrantha</i>	5
			<i>Markhamia obtusifolia</i>	5
Nyanga	1	5	<i>Uapaca kirkiana</i>	4
			<i>Brachystegia spiciformis</i>	3
			<i>Brachystegia manga, Brachystegia microphylla & Parinari curatellifolia</i>	1
Nyanja	1	10	<i>Brachystegia boehmii</i>	17
			<i>Brachystegia spiciformis</i>	10
			<i>Brachystegia utilis</i>	10
Samabakusi	1	5	<i>Brachystegia spiciformis</i>	18
			<i>Brachystegia boehmii</i>	4
			<i>Uapaca kirkiana</i>	3
Undi	1	9	<i>Brachystegia bussei</i>	32
			<i>Brachystegia boehmii</i>	14
			<i>Brachystegia manga</i>	14

Table 16. Block Level Species Count and Dominance Perekezi Forest Reserve

Block Name and List of Cluster Plot IDs	Number of Cluster Plots	Total Number of Species Identified	Three Most Dominant Species	Species Count
Chiling'oma	1	7	<i>Brachystegia manga</i>	9
			<i>Parinari curatellifolia</i>	3
			<i>Julbernadia paniculata</i>	2
Chipungu	1	4	<i>Julbernadia paniculata</i>	7
			<i>Uapaca kirkiana</i>	6
			<i>Isoberlinia angolensis</i>	3
Duwu	2	17	<i>Uapaca kirkiana</i>	23
			<i>Brachystegia longifolia</i>	16
			<i>Brachystegia taxifolia</i> & <i>Syzigium cordatum</i>	11
East of Gudugudu	3	19	<i>Brachystegia floribunda</i>	19
			<i>Julbernadia paniculata</i>	18
			<i>Brachystegia utilis</i>	17
Gudugudu	3	28	<i>Julbernadia paniculata</i>	20
			<i>Brachystegia floribunda</i>	19
			<i>Brachystegia utilis</i>	18
Lwasozi	1	7	<i>Brachystegia boehmii</i>	16
			<i>Brachystegia utilis</i>	14
			<i>Brachystegia manga</i>	13
Mnyukuzi	3	15	<i>Brachystegia utilis</i>	35
			<i>Brachystegia boehmii</i>	28
			<i>Brachystegia manga</i>	22
	2	20	<i>Uapaca kirkiana</i>	15

North of Chipungu			<i>Brachystegia longifolia</i>	12
			<i>Syzigium cordatum</i>	10
South of Duwu	2	8	<i>Brachystegia microphylla</i>	34
			<i>Brachystegia taxifolia</i>	23
			<i>Brachystegia spiciformis</i>	4
Zawo	2	17	<i>Brachystegia utilis</i>	13
			<i>Brachystegia boehmii</i>	12
			<i>Brachystegia spiciformis</i>	10

An estimate of tree density and total tree stock was computed from the inventory data. Estimates of tree (or stem) density in per hectare units based on number of trees by subplot and mean density values for blocks that contained more than one set of plot clusters were calculation. Tables 17 – 19 show the mean stem density by block, the number of cluster plots within a block, the GIS attribute reported area of the block and the estimated standing stock of the trees for each of the three forest reserves.

Table 17. Liwonde Forest Reserve: Tree Density by Management Block

Block Name	Number of Cluster Plots	Block Area (ha)	Stem Density (per ha)	Estimate of Total Stock (Number of Trees)
Chamatwa/Tokomana	2	1,428.66	165	236,010
Chikwakwata/Mangaka/Nyama	4	1,612.58	108	174,071
Chindenga Chamba	2	2,725.78	99	271,138
Chindenga Nsanama/Mangulu	6	952.76	133	126,691
Chipamba	2	818.96	141	115,859
Chipojola	2	998.51	75	75,339
Kwilasya	3	1,038.78	170	177,063
Lipongo	1	1,804.50	296	534,502

Liundi Mposa/Chipole	2	966.16	137	132,412
Liundi/Muhala/Malajira	3	1,144.30	130	148,620
Lulanga/Chiwanga/Mphonde	2	1,263.74	100	126,638
Makaluka/Magadi	1	1,028.21	615	632,760
Malopa/Swaibu/Mahete/Mbawe	1	1,365.40	571	779,902
Matandika 2	3	1,008.13	100	100,825
Mikunga/Mtambalika	2	951.03	102	96,983
Mitawa	4	1,353.52	88	118,481
Mliwo/Nsemba	2	1,347.79	50	67,133
Mpango	2	1,527.27	229	349,079
Mtawira/Mpunga/Sela/Mlomba/Kapu	1	717.88	30	21,581
Naungu	3	1,229.83	97	118,769

Table 18. Ntchisi Forest Reserve: Tree Density by Management Block

Block Name	Number of Cluster Plots	Block Area (ha)	Stem Density (per ha)	Estimate of Total Stock (Number of Trees)
Chanika	1	819.12	223	182,755
Chazama	1	655.78	152	99,539
Chenche	1	804.4	218	175,204
Chifwelekete	1	420.54	358	150,719
Kajaliza	1	207.26	221	45,753
Kasakula	1	848.62	155	131,811
Mandwe	1	373.81	117	43,739
Mkomba	1	472.75	190	90,010

Mndinda	1	439.34	79	34,573
Mnguluwe	1	262.01	139	36,449
Mpamila	1	252.92	86	21,841
Mponda	1	524.61	189	99,265
Msankhire	1	689.67	181	124,603
Nyanga	1	125.77	55	6,895
Nyanja	1	763.17	347	265,193
Samabakusi	1	361.04	185	66,719
Undi	1	525.23	413	217,032

Table 19. Perekezi Forest Reserve: Tree Density by Management Block

Block Name	Number of Cluster Plots	Block Area (ha)	Stem Density (per ha)	Estimate of Total Stock (Number of Trees)
Chiling'oma	1	895	398	356,109
Chipungu	1	1,697	362	613,695
Duwu	2	1,745	214	372,615
East of Gudugudu	3	2,501	227	568,076
Gudugudu	3	2,188	257	561,469
Lwasozi	1	980	1066	1,045,011
Mnyukuzi	3	2,192	270	592,429
North of Chipungu	2	1,270	239	303,377
South of Duwu	2	817	236	192,516
Zawo	2	1,417	250	354,780

7.0 INVENTORY SUMMARY SHEET

Table 20. Forest Inventory Assessment

	Liwonde	Ntchisi	Perekezi
No of Clusters (plots)	48 (140)	17 (50)	20 (60)
Stem Density ⁵ (trees/ha)	120	195	237
12m subplot mean +/- var	91 +/- 58	159 +/- 89	223 +/- 64
20m subplot mean +/- var	29 +/- 20	36 +/- 23	15 +/- 11
Estimate of Total Stock ⁶ (no of trees)	3,234,095	1,831,702	3,703,109
Emission Factor ⁷ (tC/ha) +/- var	49.09 +/- 29.27	57.61 +/- 24.37	54.78 +/- 20.60
Estimate of Total Carbon Stock ⁸ (tC)	1,320,109	542,125	854,638
Mean Biomass ⁹ (t.d.m./ha)	104	122	116
Estimate of total Biomass ¹⁰ (t.d.m.)	2,808,489	1,153,489	1,818,246
No of Species	78	55	47
Dominant Species	<i>Brachystegia bussei</i>	<i>Brachystegia bussei</i>	<i>Brachystegia utilis</i>

Table 21. Summary Statistics for Tree Density at the Block Level

	Liwonde	Ntchisi	Perekezi
No of Blocks (w/plots)	20	17	10
Min stem density (trees/ha)	30	55	214
Max stem density (trees/ha)	615	413	1066
Mean stem density (trees/ha)	172	195	352
Standard Deviation stem density	156	99	258

⁵ Sum of all subplots stems divided by the number of clusters

⁶ Sum of stem density multiplied by the area of the reserve (GIS computed)

⁷ Mean of all plots within a reserve for AGB + BGB + Deadwood Pools of Carbon

⁸ Sum of the EFs multiplied by the area of the reserve (GIS computed)

⁹ Computed using a carbon fraction of 0.47

¹⁰ Sum of the Mean Biomass multiplied by the area of the reserve (GIS computed)

Table 22. Carbon Uncertainty Assessment

	90% C and 10% Error	95% C and 10% Error	Actual Number of Plots
Liwonde	97	137	140
Ntchisi	49	69	50
Perekezi	39	55	60

Carbon estimates for Liwonde and Perekezi are significant at 95% confidence and 10% error level.
Carbon estimates for Ntchisi are significant at 90% confidence and 10 % error level.

8.0 LESSONS LEARNED

There are several important lessons learned from the implementation of the field campaign. Here we highlight a few key points in specific thematic areas.

PRE-FIELD CAMPAIGN

- The addition of terrain information (slope) for the random plot allocation data is extremely useful. This is easily done using ArcGIS and ASTER DEM data (freely available)
- Over-sample plots are required
- Training should also include navigation to plots and the use of maps with GPS
- Equipment logistics require more lead time (e.g. lack of boots for the field crews)
- Improvements to the field data sheets can be made (e.g. densiometer field; comments space, marked tree/plot locator fields, etc.)
- Vetting of field teams is required to ensure stamina levels are sufficient to participate in the strenuous work associated with field data collection in sometime very difficult terrain

DATA COLLECTION IN THE FIELD

- All data should be clearly recorded on the field sheets
- Rejected plots should include a metadata sheet and complete details for the rejection status
- Navigation to field plots would benefit from using maps or digital hi-res data on a laptop in combination with GPS

POST-FIELD CAMPAIGN

- Defining a clear protocol for post field collection data processing and management will be helpful
- Both hardcopy and digital data in back-up form is needed

9.0 REFERENCES

- Brown, S. (1997). Estimating biomass and biomass change of tropical forests: a primer (Vol. 134). Food & Agriculture Org.
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- Kachamba, D. J., Eid, T., & Gobakken, T. (2016). Above-and belowground biomass models for trees in the miombo woodlands of Malawi. *Forests*, 7(2), 38.
- Malimbwi, R. E., Solberg, B., & Luoga, E. (1994). Estimation of biomass and volume in miombo woodland at Kitulangalo Forest Reserve, Tanzania. *Journal of Tropical Forest Science*, 230-242.

10.0 APPENDICES

10.1 SAMPLE DATA SHEET FOR UPLOAD TO THE MRV TOOLBOX

PLOT METADATA		* The fields in blue are mandatory	
Parameter	Data	Optional Carbon Pools	Data
Date:	13/06/2016	Litter (tC/ha):	
Start Time:	08:13	Deadwood (tC/ha):	
End Time:		Additional Non-Tree AGB (tC/ha):	
Crew:	Dan Chidani	Additional Non-Tree BGB (tC/ha):	
Project Name:	PERFORM1	Optional Nested Sub-Plots	Data
Parcel Name:	LIWONDE	Sub-Plot #1 Name:	0002-01-12
Plot Name:	1LIW-0002-01-20	Sub-Plot #1 Area (m ²):	452.38934
Plot Description:		Sub-Plot #1 Shape:	circular
Plot Area (m ²):	1256.637061	Sub-Plot #1 Dimensions (rect):	
Plot Shape:	circular	Sub-Plot #1 Radius (circle):	12
Plot Dimensions (rect):		Lower Bound #1, DBH >	14.9
Plot Radius (circle):	20	Upper Bound #1, DBH <=	29.9
GPS Latitude:		Sub-Plot #2 Name:	0002-01-06
GPS Longitude:		Sub-Plot #2 Area (m ²):	113.09734
Elevation:		Sub-Plot #2 Shape:	circular
Slope Condition:		Sub-Plot #2 Dimensions (rect):	
Hemispherical Photo Center:		Sub-Plot #2 Radius (circle):	6
Hemispherical Photo North:		Lower Bound #2, DBH >	4.9
Hemispherical Photo East:		Upper Bound #2, DBH <=	14.9
Hemispherical Photo South:		Sub-Plot #3 Name:	
Hemispherical Photo West:		Sub-Plot #3 Area (m ²):	0
Horizontal Photo North:	DSC00041	Sub-Plot #3 Shape:	
Horizontal Photo East:	DSC00042	Sub-Plot #3 Dimensions (rect):	
Horizontal Photo South:	DSC00043	Sub-Plot #3 Radius (circle):	
Horizontal Photo West:	DSC00044	Lower Bound #3, DBH >	
Weather:		Upper Bound #3, DBH <=	
Comments:	TAGGED AT 90E (3.3M FROM CENTER) AND AT 215N (5.0M FROM CENTER)		

TREE INVENTORY DATA									
* The fields in green are mandatory									
* Any trees which do not sort into an optional sub-plot are sorted into the whole plot									
Tree ID	Genus	species	DBH (cm)	Plot or Sub-plot	Total Ht (m)	Wood Specific Gravity	Crown D max (m)	Crown D right angle (m)	Comments
1			53	7.5 0002-01-06					
2			168	5.3 0002-01-06					
3			53	7.0 0002-01-06					
4			39	20.5 0002-01-12	14.0		10.5	6.1	
5			39	27.3 0002-01-12	23.0		9.9	5.9	
6			39	38.5 Whole Plot	18.3		10.3	7.8	
7			43	22.1 0002-01-12	18.7		9.3	5.6	
8			39	21.0 0002-01-12	18.9		3.9	3.8	
9			43	29.3 0002-01-12	18.9		8.4	7.4	
10			39	32.3 Whole Plot	23.5		10.5	6.1	
11			39	30.8 Whole Plot	19.8		11.9	10.6	
12			39	31.2 Whole Plot	19.2		11.4	8.9	
13				Whole Plot					
14				Whole Plot					
15				Whole Plot					
16				Whole Plot					
17				Whole Plot					
18				Whole Plot					
19				Whole Plot					
20				Whole Plot					
21				Whole Plot					
22				Whole Plot					
23				Whole Plot					
24				Whole Plot					
25				Whole Plot					
26				Whole Plot					
27				Whole Plot					
28				Whole Plot					
29				Whole Plot					
30				Whole Plot					

10.2 SPECIES LIST AND FREQUENCY BY FOREST RESERVE

LIWONDE FOREST RESERVE	
Species	Frequency
<i>Brachystegia bussei</i>	235

<i>Brachystegia manga</i>	94
<i>Brachystegia longifolia</i>	86
<i>Brachystegia utilis</i>	69
<i>Brachystegia boehmii</i>	67
<i>Julbernardia globiflora</i>	60
<i>Pericopsis angolensis</i>	48
<i>Brachystegia spiciformis</i>	46
<i>Brachystegia microphylla</i>	42
<i>Diplorhynchus condylocarpon</i>	42
<i>Uapaca kirkiana</i>	42
<i>Parinari curatellifolia</i>	27
<i>Pseudolachnostylis maprouneifolia</i>	24
<i>Pterocarpus angolensis</i>	21
<i>Burkea africana</i>	17
<i>Lannea discolor</i>	16
<i>Uapaca nitida</i>	15
<i>Brachystegia floribunda</i>	11
<i>Dalbergia nitidula</i>	11
<i>Combretum molle</i>	10
<i>Ozoroa insignis</i>	10
<i>Cussonia arborea</i>	8
<i>Dalbergiella nyasae</i>	7
<i>Monotes africanus</i>	7
<i>Zanha africana</i>	7
<i>Sepium ellipticum</i>	6
999 = No Species Code	5
<i>Bauhinia petersiana</i>	5
<i>Strychnos innocua</i>	4
<i>Vitex payos</i>	4
<i>Bridelia cathartica</i>	3
<i>Diospyros kirkii</i>	3
<i>Erythrina abyssinica</i>	3

<i>Ficus sycomorus</i>	3
<i>Terminalia stenostachya</i>	3
<i>Vitex doniana</i>	3
<i>Annona senegalensis</i>	2
<i>Apodytes dimidiata</i>	2
<i>Breonardia salicina</i>	2
<i>Bridelia micrantha</i>	2
<i>Combretum adenogonium</i>	2
<i>Combretum zeyheri</i>	2
<i>Crossopteryx febrifuga</i>	2
<i>Dalbergia boehmii</i>	2
<i>Dombeya rotundifolius</i>	2
<i>Erythrophleum suaveolens</i>	2
<i>Euclea crapes</i>	2
<i>Ficus capensis</i>	2
<i>Ochna schweinfurthiana</i>	2
<i>Olax dissitiflora</i>	2
<i>Pleurostyliia africana</i>	2
<i>Pteleopsis myrtifolia</i>	2
<i>Syzigium cordatum</i>	2
<i>Uapaca sansibarica</i>	2
<i>Acacia nilotica</i>	1
<i>Albizia versicolor</i>	1
<i>Allophylus africana</i>	1
<i>Brachystegia glaucescens</i>	1
<i>Commiphora caerulea</i>	1
<i>Commiphora mossambicensis</i>	1
<i>Croton megalobotrys</i>	1
<i>Cussonia spicata</i>	1
<i>Diospyros mesipiliformis</i>	1
<i>Faidherbia albida</i>	1
<i>Faurea rochetiana</i>	1

<i>Ficus ingens</i>	1
<i>Gardenia jovis-stonantos</i>	1
<i>Holarrhena pubescens</i>	1
<i>Kirkia acuminata</i>	1
<i>Olax obtusifolia</i>	1
<i>Paullinia pinnata</i>	1
<i>Rothmania engleriana</i>	1
<i>Sterculia quinqueloba</i>	1
<i>Strychnos madagascariensis</i>	1
<i>Strychnos spinosa</i>	1
<i>Tapiphyllum africana</i>	1
<i>Vangueria infausta</i>	1
<i>Xeroderris stuhlmannii</i>	1
<i>Ximenia americana</i>	1

NTCHISI FOREST RESERVE

Species	Frequency
<i>Brachystegia bussei</i>	89
<i>Brachystegia boehmii</i>	82
<i>Brachystegia manga</i>	78
<i>Brachystegia spiciformis</i>	57
<i>Julbernardia globiflora</i>	30
<i>Brachystegia utilis</i>	27
<i>Julbernardia paniculata</i>	26
<i>Diplorhynchus condylocarpon</i>	23
<i>Combretum collinum</i>	20
<i>Pseudolachnostylis maprouneifolia</i>	20
<i>Markhamia obtusifolia</i>	16
<i>Uapaca kirkiana</i>	16
<i>Bauhinia petersiana</i>	12
<i>Acacia polyacantha</i>	9
<i>Monotes africanus</i>	9

<i>Acacia galpinii</i>	7
<i>Lannea discolor</i>	7
<i>Stereospermum kunthianum</i>	6
<i>Bridelia micrantha</i>	5
<i>Faurea rochetiana</i>	4
<i>Terminalia stenostachya</i>	4
<i>Brachystegia longifolia</i>	3
<i>Combretum apiculatum</i>	3
<i>Pterocarpus angolensis</i>	3
<i>Acacia sieberiana</i>	2
<i>Byrsocarpus orientalis</i>	2
<i>Combretum adenogonium</i>	2
<i>Dalbergia nitidula</i>	2
<i>Monodora junodii</i>	2
<i>Ochna schweinfurthiana</i>	2
<i>Olax dissitiflora</i>	2
<i>Uapaca nitida</i>	2
<i>Ziziphus mucronata</i>	2
<i>Acacia tortilis</i>	1
<i>Albizia anthelmintica</i>	1
<i>Albizia harveyi</i>	1
<i>Albizia versicolor</i>	1
<i>Brachystegia microphylla</i>	1
<i>Bridelia cathartica</i>	1
<i>Burkea africana</i>	1
<i>Combretum molle</i>	1
<i>Combretum zeyheri</i>	1
<i>Diospyros kirkii</i>	1
<i>Dombeya torrida</i>	1
<i>Faurea saligna</i>	1
<i>Lecaniodiscus fraxinifolius</i>	1
<i>Newtonia buchananii</i>	1

<i>Parinari curatellifolia</i>	1
<i>Pericopsis angolensis</i>	1
<i>Rauvolfia caffra</i>	1
<i>Syzigium guineense</i>	1
<i>Terminalia sericea</i>	1
<i>Ximenia caffra</i>	1
<i>Xylopia parviflora</i>	1
<i>Zanha africana</i>	1

PEREKEZI FOREST RESERVE

Species	Frequency
<i>Brachystegia utilis</i>	88
<i>Julbernardia paniculata</i>	79
<i>Brachystegia boehmii</i>	75
<i>Brachystegia microphylla</i>	50
<i>Uapaca kirkiana</i>	48
<i>Brachystegia spiciformis</i>	46
<i>Brachystegia taxifolia</i>	46
<i>Brachystegia manga</i>	45
<i>Brachystegia longifolia</i>	40
<i>Brachystegia floribunda</i>	35
<i>Syzigium cordatum</i>	24
<i>Isoberlinia angolensis</i>	23
<i>Parinari curatellifolia</i>	16
<i>Monotes africanus</i>	12
<i>Combretum molle</i>	11
<i>Lannea discolor</i>	9
<i>Faurea rochetiana</i>	7
<i>Syzigium guineense</i>	7
<i>Azanza garckeana</i>	6
<i>Diospyros quiloensis</i>	5
<i>Erythrina abyssinica</i>	5

999 = No Species Code	3
<i>Bridelia micrantha</i>	3
<i>Fagara charybeum</i>	3
<i>Uapaca sansibarica</i>	3
<i>Diospyros mesipiliformis</i>	2
<i>Lecaniodiscus fraxinifolius</i>	2
<i>Ozoroa reticulata</i>	2
<i>Vitex doniana</i>	2
<i>Albizia antunesiana</i>	1
<i>Boscia salicifolia</i>	1
<i>Cassine aethiopica</i>	1
<i>Commiphora africana</i>	1
<i>Croton macrostachys</i>	1
<i>Cussonia arborea</i>	1
<i>Dalbergia nitidula</i>	1
<i>Diplorhynchus condylocarpon</i>	1
<i>Ekebergia benguelensis</i>	1
<i>Faurea saligna</i>	1
<i>Ficus buckei</i>	1
<i>Hymenocordia acida</i>	1
<i>Ochna schweinfurthiana</i>	1
<i>Pseudolachnostylis maprouneifolia</i>	1
<i>Sclerocarya birrea</i>	1
<i>Steganotaenia araliacea</i>	1
<i>Strychnos madagascariensis</i>	1
<i>Strychnos pungens</i>	1
<i>Syzigium owariense</i>	1



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