SANGO
Nature Project

Sango Nature Project

Sango Carbon Inventory: Data management and analysis

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LIST OF ACRONYMS

AGB	Aboveground Biomass
BGB	Belowground Biomass
BSD	Basal Diameter
CD	Crown Diameter
CI	Confidence Interval
CIRC	Circumference
CWD	Coarse Woody Debris
DAMAF	Data Management and Analysis Framework
DBH	Diameter at Breast Height
DIC	distance from center point
DM	Dry Matter
EF	Expansion Factor
fpc	finite population correction
H	Total Height
IQR	Interquartile Range
NFI	National Forest Inventory
QC	Quality Control
SNP	Sango Nature Project
SG	Species Group
SOC	Soil Organic Carbon
SOP	Standard Operating Procedure
stDW	Standing Deadwood
VMC	Vegetation Management Classes
VTS	Vegetation Type Strata

1
Introduction to data management and analysis

1 INTRODUCTION TO DATA MANAGEMENT AND ANALYSIS

The administration of the Sango Wildlife Conservancy has set up the Sango Nature Project (SNP) with a vegetation carbon stock assessment being a major component. The assessment comprised, first, a terrestrial inventory of carbon stocks in four carbon pools, aboveground- and belowground biomass (AGB, BGB) in tree and shrub species groups, deadwood (DW) and Soil Organic Carbon (SOC) supported by a vegetation cover classification based on Sentinel 2 satellite data (see RSS 2024). Second, the spatially-explicit modelling of aboveground biomass has been conducted based on space-borne lidar data and ground-based data for calibration and validation.

The entire carbon stock assessment including terrestrial inventory, remote sensing work and analysis has been conducted from July 2023 to April 2024, with the ground-based data collection taking place from July to November 2023 and the data management and analysis presented hereafter from November 2023 to April 2024. A reconnaissance survey took place in June / July 2023 which provided clarity on the sampling design and has revealed the importance of AGB in trees and shrubs in terms of the contribution to the total carbon stock which was reason why particular focus was put on AGB.

The objective of the work package "Data management and analysis" has been to standardize data sets and preprocess all inputs as much as necessary to conduct the analysis of carbon stocks using a developed systematic and repeatable modular framework for the present and future carbon stock assessments.

The core of the data management are the centrally stored inventory data spreadsheets and files in common data exchange formats derived from digitized hardcopy tally sheets and serving as data base for any further data management and analysis in R programming language with a set of consecutive work packages developed by the author. The data base contains the data of the first inventory cycle 2023 in Sango Wildlife Conservancy (project area) as well as the associated meta data following the variables and data types collected in the forest inventory from July to November 2023.

Thus, the definition of data management referred to hereafter covers a subset of the comprehensive management of data that already starts with the 1) data collection in the field, 2) organizing and storing data, e.g. through the design of the tally sheets and results spreadsheets, 3) ensuring data quality, e.g. through plausibility checks and checks for missing or ambiguous data done in the field and at the end -of-the-day procedure when digitizing tally sheets. This already is a major part of data management for the purpose of data analysis but is already partly covered by the SOP for data collection and not repeated hereafter.

The use of hardcopy tally sheets is the classical approach to collect pertinent data in forest inventories. It has some advantages over direct data entry into PDA handhelds in the field among them the opportunity to store the paper copies for future reviews at the administration of the client. Furthermore, the ease of applicability, once thoroughly developed, helps field staff repeating the task in follow-up inventories in the future. One of the major drawbacks of this approach, double work and the risk of erroneous data transcription while digitizing where not ranked to severe, since careful checks of data quality and integrity have been taken while preprocessing the data sets.

The key element for the analysis is the extrapolation of the data from the ground-based sample data to the total population of the woody vegetation in the inventory area. The extrapolation procedure follows from the sampling design. The extrapolation results including intermediate graphs and ancillary results, e.g. descriptive statistics, will be outputted and systematically stored into results spreadsheet files.

2
Methodology

2. METHODOLOGY

2.1 Concept of data management and analysis

In line with the objective of the work package to standardize data sets, to preprocess all inputs as much as necessary and to conduct the analysis of carbon stocks using a developed systematic and repeatable modular framework for the present and future carbon stock assessments, a Data Management and Analysis Framework (DAMAF) has been developed in R programming language with an intermediate and final output linkage to Microsoft (MS) Excel as standard spreadsheet software.

The two tools, R and MS Excel, have been coupled by hard-coding, e.g. the modular scripts run in the R environment use inputs from MS Excel, e.g. the digitized tally sheets, species list, list of allometric equations etc. On the other hand, key results and intermediate numbers for plausibility checks are outputs from the R scripts and are displayed in MS Excel for the ease of readability without prior knowledge of R coding.

The framework is structured in a modular manner, containing a

- read-in module (Module 1 based on script 1) including first checks of data quality,
- preprocessing, data cleansing module (Module 2 based on script 2) that also generates descriptive statistics of preprocessed raw data, and a
- statistical analysis module (Module 3 based on script 3) that estimates the carbon stocks in different carbon pools and aggregates to estimated total population values in line with the inventory concept and sampling design.

The parametrization and inclusion or exclusion of modules is done via a main script, that steers the sourcing of libraries and the read in of a parametrization file.

The data storage is file-based in plain text-format (csv-format) and copied to a formatted spreadsheet format for the ease of reading without further processing. Due to the time constraint in setting up the framework and analyzing the data, the file-based "data base" is a pragmatic approach.

In order to increase user friendliness and transparency, not only the tally sheets, but also area-related inputs as well as species lists, allometric functions and matrices defining species groups across vegetation types are provided in spreadsheet format.

In each module, key output tables are generated in csv-format and used as input into the next module. This approach increased efficiency running and maintaining the framework.

In addition to key output tables, particular attention was given to the transparency and demonstrated plausibility in calculations for external staff such as personnel from the company in charge of the verification of the carbon inventory. Thus, a kind of traceability system of reading out relevant data from single stems to aggregated results has been implemented.

The DAMAF aims at managing data quality and calculating standard and special outputs needed for verification audits and quality control measures. The framework tests and manages data quality based on the criteria conformity, completeness, correctness, consistency, precision, timeliness, and uniqueness

(Chapters 2.2 to 2.4). The analysis of carbon stocks (Chapter 2.5) puts a particular focus on the accounting for uncertainty.

Uncertainty consists of two components:

- Bias or systematic error (lack of accuracy) occurs, e.g., due to flaws in the measurements or sampling methods or due to use of an Emission Factor (EF) that is not suitable
- Random error (lack of precision) is a random variation above or below a mean value. It cannot be fully avoided but can be reduced by, for example, increasing the sample size.

Precision is defined as the agreement among repeated measurements or estimates, while accuracy is the agreement between estimates and exact or true values.

Uncertainties that stem from random errors tend to cancel out each other at higher levels of aggregation. For example, estimates at Sango domain (e.g., total carbon stock across Vegetation Type Strata, VTS) are expected to have a lower impact from random errors than estimates at the level of VTS (subdomains). Due to the sampling design and proportionate to area allocation of sample plots, larger VTS have greater sample sizes which, in turn, lead to greater precision and less uncertainty.

The management and analysis of the ground-based data has systematically been done following the steps:

1. Preprocess tally sheets and read in main survey data from standard digitized tally sheets into standard data structures and data types and conduct a preliminary check of meta data completeness and conformity
2. Conduct main checks of data integrity and preprocess input data into statistically usable data sets
3. Preprocess anxiliary data like species list, species group, allometric equations, technical parameters
4. Estimate mean and total carbon stocks in four carbon pools in VTS across the project area

2.2 Step 1: Preprocessing tally sheets and ancillary data sets

Step 1) preprocesses the digitized tally sheets in spreadsheet format and additional data inputs needed for calculations.

Preprocessing tally sheets

Before reading in the data into the DAMAF, the digitized tally sheets have undergone a first check (preprocessing substep of managing data quality after tally sheets have been digitized) for very basic inconsistencies and faulty meta data. The preprocessing of 293 digitized tally sheets comprised

- the addition of values where required meta data was missing particularly concerning sample plot ID (SP_ID) and XY coordinates of center plot,
- the correction of faulty XY coordinates in 11 tally sheets, identified by obvious typos and very large deviations from the location of actual plot measurements (identified based on marked plot centers) by comparing plotted XY coordinates of actual locations versus those stated in tally sheets. The XY coordinates of tally sheets have been corrected and marked as being corrected in the respective tally sheet.

- the correction of the vegetation type stratum, in case there was doubt about the correct classification, the chief ecologist and colleagues in Sango repeated the visit for reclassification,
- obviously misclassified and wrongly coded trees and shrub species have been corrected in the tally sheets based on the final classification provided by Joubert (2024), empty sections in tally sheets, e.g. due to the absence of species in the species classes "trees" or "shrubs" have been rechecked by field personnel and reconfirmed, to exemplify:
- Plot 36: misclassified *Croton megalobotrys* has been reclassified under "trees", for simplicity the BSD (at 30 cm height measured) has been treated as proxy for DHB, which is valid, because of the small dimension (5-6 cm) and negligible tapering.

Summary of the sampling design, plot layout and derived discrete vegetation type areas

The main aim of the sampling design is that it is unbiased and statistically robust based on probabilistic sampling theory, to ensure a high quality and scientifically sound data collection during the terrestrial vegetation carbon stock inventory.

The terrestrial vegetation carbon stock inventory follows a stratified systematic sampling design (RSS 2024, Fehrmann et al. 2017). The selected systematic sampling design has been applied in forest inventories from management unit-level to national level worldwide and studies (Fehrmann et al. 2017, Koprivica 2017, Nesha et al. 2022, Köhl et al. 2011). The stratification of land cover types or woody vegetation types based on remotely sensed data to generate relatively homogenous strata with respect to the variance of a target variable per stratum, such as wood volume or dry matter biomass, is widely used (Wallner et al. 2017, Reams et al. 2005, Haywood et al. 2016, Köhl et al. 2011).

Stratification of the population can increase the efficiency of inventories especially in those cases where the variability inside the strata is low and the differences of means between the strata are large (Fehrmann et al. 2017). In this case a higher precision can be achieved with the same sample size. Beside statistical issues there are further practical arguments for stratification, like e.g. the organization of field work.

The stratification of vegetation types was based on available Sentinel-2 data between March and May 2023 and subdivided into a pre-stratification to help determine the tentative sample size per stratum and a final stratification. The spatial distribution of remote sensing- based vegetation types strata (VTS) matched well with six vegetation management classes (VMC) from an earlier ecological study (Joubert 2012), which was reason why VTS were used in classifying each sampling unit and the final stratification took place based on the actual VTS from the terrestrial survey. Non-response areas such as built-up land like air strips or permanent water bodies have been excluded.

The systematic sampling via a grid of systematically arranged sample plots is among the most frequently used designs in forest inventories and fulfils the requirements of a probabilistic sampling if correctly done (Fehrmann et al. 2017, Koprivica 2017). It has some advantages over random sampling such as a) the transparency to understand the sampling procedure, b) it yields more precise results than simple random sampling with the same sample size, and c) it is guaranteed that all parts of the population are covered (see Kleinn 2007). From a sample selection point of view, only one independent selection of a sample point takes place; after having selected the first point, all others are fixed, arranged in a grid. However, it is common to look at the systematic sample as a sample in which the sub-plots are considered the observation plots.

The SNP defined a 1 ha base grid (100x100 meters) which was established over the study area with a random starting point and a random rotation (see technical report, RSS 2024). The centroids of each 1 ha grid cell were buffered by a 500 m^2 circle and make up the population of sample plots. In total, 293 sample plots have systematically been drawn across all VTS, but independently and proportionally to area in each (pre-) stratum. Attention was given, that the starting point in each stratum was randomly selected to ensure independence of samples between strata.

Proportionate sampling is often applied because: 1) the sampling method is simple and it doesn't depend on the cost of sample plot allocation into strata; 2) even when stratification is improperly done, the standard error cannot be higher than the standard error of the simple random sample; 3) the use of more complex methods of allocation with the aim of increasing the level of estimate precision does not produce better results; 4) calculations used for parameter estimates and precision are simplified.

For the ease of measurement, the plot layout follows a circular shape with a size of 500 m^2 where all variables of interest were measured according to the SOP[1].

The circular systematically arranged sample plots are assumed to represent a distinct VTS per base grid cells. Due to the 10m resolution of earth observation data (based on space-borne radar from Sentinel 1, see RSS 2024) a 500 m^2 sample plot could cover several VTS, particularly where small patches of different VTS (close to the minimum of 100 m^2 resolution) agglomerated in the base grid cell. That is reason why a majority rule has been applied to assign a unique VTS to each sample plot. However, only minor deviations between the vegetation area and the area of the population of 1ha sample plots in the base grid occur, which ideally would have been identical (see Table 1).

Table 1: Area of vegetation type strata, total number of sample plots per stratum and sample size

No.	VTS	AREA (ha)	Population of sample plots (count)	Sample size (count)
1	ACA	20,023	19,999	46
2	COL	19,386	19,378	160
3	COM	10,740	10,748	64
4	DIO	2,025	2,048	10
5	KIR	2,970	2,984	4
6	XAN	1,763	1,773	9
Total		**56,908**	**56,930**	**293**

Compilation of species list

The species list as compiled by a key informant at Sango covers the Family, Genus, scientific and common name of the species, and wood density for two classes, trees and shrubs (See Joubert 2024, Appendix 1a and 1b). The distinction follows Joubert (2024), following common definitions in order to make allometric models applicable that commonly distinguish between trees and other vegetation in forest inventories. The list has been quality checked and extended throughout the ground data collection. For each woody species a unique code consisting of four to five digits has been assigned with the first to letters corresponding to the first two letters of the genus and the second two or three letters corresponding to the species' name.

1 This concerns tree / shrub heights, diameter at breast height (DBH), and basal diameter (BSD) for the AGB pool of each stem of each individuum per tree / shrub species. Standing deadwood (stDW) has been measured analogous to living trees / shrubs while downed coarse woody debris (CWD) above a minimum mid diameter was measured by diameter and length. The soil samples were generally taken at 0 °C azimuths at each sample plot. The stock of the Soil Organic Carbon (SOC) pool was derived from a single soil sample at 15 cm depth for 270 plots while a subsample of 30 observations at 30, 20 and 10 cm depths was collected at randomly selected plots to compare the changes of carbon percentage, bulk density and SOC across depths.

It has been used as a reference for verifying and correcting the data entries in tally sheets regarding misspellings, wrong attribution to the tree or shrub class etc.

Definition and entry of species groups

The mapping of woody species to 1) species groups (SG) which are vegetation type strata (VTS) - specific and 2) those SG to allometric models (species-specific and generalized models, see Joubert 2024) is a key preprocessing step that has been done as follows.

First, the definition of general SG has been based on Joubert (2024) following the approach of dominant species by means of the cumulative stem diameter and surrogate species that form distinct SG across all VTS (equal to VMC) in the project area. The dominance of species by cumulative stem diameter was calculated from the spreadsheet data base derived from digitized tally sheets. Those species not considered dominant by Joubert (2024) have been covered by the SG "SG_REST".

Second, preselected allometric models have been attributed to SG per VTS as defined in the first step. SG concerning dominant species and so-called surrogates are analysed by means of species-specific models, all other (non-dominant) species lumped together in "SG_REST" are analysed using generalized models (Joubert 2024). A high level of flexibility was intended for adjusting SG per VTS and by applying preselected species-specific allometric models, which are explicit in both, SG and VTS.

However, flexibility in the concept and definition of SG was needed because the dominance values based on the total sample (for the project area) needed refinement at the level of VTS. For example, the same species being dominant in the first VTS wasn't necessarily in the second and species considered non-dominant in the overall picture have been dominant in a particular VTS. Thus, a threshold value of observations has been defined to prevent a very low number of observations to form a new SG and to ensure that species otherwise lumped into the SG "SG_REST" were sufficiently accounted for. While Joubert (2024) based first considerations on the SG per VTS on preliminary results of species' dominance per VTS, the final results were used to recombine SG and VTS based on the actual distribution of species and their categorization into SG. The result are VTS-SG combinations that go beyond Joubert (2024) with implications for the application of allometric models.

Definition and entry of species group and vegetation type-specific models

Substantial effort has been put into the attribution of species-specific and general allometric models to SG per VTS derived from Joubert (2024, 2012) and ground-based evidence of actually occurring species in woody classes "trees" and "shrubs" after final preprocessing of data (see Tables 2a and 2b).

Table 2a: VTS-SG Models (Trees)

VTS-SG Model Name	Model Type	Parameters			Joubert (2024)
		a	b	c	
M_ACA1	(DBH^2*H)^par_a*par_b	0.9309	0.0531		T1
M_ACA2	par_a*BA^par_b	0.0644	1.3341		T2
M_ACA3	(DBH^2*H)^par_a*par_b	0.9521	0.0502		T3
M_ACA4	par_a*BA^par_b	0.1975	1.1859		T4
M_ACA5	exp(par_a*log(BA)-par_b)	1.2723	3.61		T5
M_ACA_REST	DBH^par_a*H^par_b*par_c	1.9241	0.8883	0.0564	T9

VTS-SG Model Name	Model Type	Parameters			Joubert (2024)
		a	b	c	
M_COL1	(DBH^2*H)^par_a*par_b	0.9309	0.0531		T1
M_COL2	par_a*BA^par_b	0.0644	1.3341		T2
M_COL3	(DBH^2*H)^par_a*par_b	0.9521	0.0502		T3
M_COL4	exp(par_a*log(BA)-par_b)	1.2723	3.61		T5
M_COL_REST	DBH^par_a*H^par_b*par_c	1.9241	0.8883	0.0564	T9
M_COM1	(DBH^2*H)^par_a*par_b	0.9309	0.0531		T1
M_COM2	par_a*BA^par_b	0.0644	1.3341		T2
M_COM3	(DBH^2*H)^par_a*par_b	0.9521	0.0502		T3
M_COM4	exp(par_a*log(BA)-par_b)	1.2723	3.61		T5
M_COM5	exp(par_a*log(BA)-par_b)	1.3086	3.52		T7
M_COM_REST	DBH^par_a*H^par_b*par_c	1.9241	0.8883	0.0564	T9
M_DIO1	par_a*BA^par_b	0.0644	1.3341		T2
M_DIO2	(DBH^2*H)^par_a*par_b	0.9521	0.0502		T3
M_DIO3	par_a*BA^par_b	0.1975	1.1859		T4
M_DIO4	exp(par_a*log(BA)-par_b)	1.2723	3.61		T5
M_DIO5	par_a*exp(par_b+par_c*log(DBH))	1.018	-3.66	2.64	T6
M_DIO6	exp(par_a*log(BA)-par_b)	1.3086	3.52		T7
M_DIO_REST	par_a*(0.62*DBH^2*H)^par_b	0.0673	0.976		T10
M_KIR1	(DBH^2*H)^par_a*par_b	0.9309	0.0531		T1
M_KIR2	par_a*BA^par_b	0.0644	1.3341		T2
M_KIR3	par_a*BA^par_b	0.1975	1.1859		T4
M_KIR4	exp(par_a*log(BA)-par_b)	1.2723	3.61		T5
M_KIR5	exp(par_a*log(BA)-par_b)	1.3086	3.52		T7
M_KIR6	10^(par_a*log10(CIRC)-par_b)	2.88	3.5		T8
M_KIR_REST	DBH^par_a*H^par_b*par_c	1.9241	0.8883	0.0564	T9
M_XAN1	par_a*BA^par_b	0.0644	1.3341		T2
M_XAN2	(DBH^2*H)^par_a*par_b	0.9521	0.0502		T3
M_XAN3	par_a*BA^par_b	0.1975	1.1859		T4
M_XAN4	exp(par_a*log(BA)-par_b)	1.2723	3.61		T5
M_XAN5	par_a*exp(par_b+par_c*log(DBH))	1.018	-3.66	2.64	T6
M_XAN_REST	DBH^par_a*H^par_b*par_c	1.9241	0.8883	0.0564	T9

Table 2b: VTS-SG Models (Shrubs)

VTS-SG Model Name	Model Type	Parameters			Joubert (2024)
		a	b	c	
M_ACA1	10^(par_a*log10(CIRC)+par_b)	2.559	-2.571		S2

VTS-SG Model Name	Model Type	Parameters			Joubert (2024)
		a	b	c	
M_ACA2	10^(par_a*log10(CIRC)+par_b)	2.32	-2.3		S3
M_ACA3	par_a*BA^par_b	0.1507	1.2647		S1
M_ACA_REST	BSD^par_a*H^par_b*par_c	1.8873	0.4114	0.0811	S4
M_COL1	par_a*BA^par_b	0.1507	1.2647		S1
M_COL2	10^(par_a*log10(CIRC)+par_b)	2.559	-2.571		S2
M_COL3	10^(par_a*log10(CIRC)+par_b)	2.32	-2.3		S3
M_COL_REST	BSD^par_a*H^par_b*par_c	1.8873	0.4114	0.0811	S4
M_COM1	par_a*BA^par_b	0.1507	1.2647		S1
M_COM2	10^(par_a*log10(CIRC)+par_b)	2.559	-2.571		S2
M_COM3	10^(par_a*log10(CIRC)+par_b)	2.32	-2.3		S3
M_COM_REST	BSD^par_a*H^par_b*par_c	1.8873	0.4114	0.0811	S4
M_DIO1	par_a*BA^par_b	0.1507	1.2647		S1
M_DIO2	10^(par_a*log10(CIRC)+par_b)	2.559	-2.571		S2
M_DIO3	10^(par_a*log10(CIRC)+par_b)	2.32	-2.3		S3
M_DIO_REST	BSD^par_a*H^par_b*par_c	1.8873	0.4114	0.0811	S4
M_KIR1	10^(par_a*log10(CIRC)+par_b)	2.559	-2.571		S2
M_KIR2	10^(par_a*log10(CIRC)+par_b)	2.32	-2.3		S3
M_KIR_REST	BSD^par_a*H^par_b*par_c	1.8873	0.4114	0.0811	S4
M_XAN1	10^(par_a*log10(CIRC)+par_b)	2.559	-2.571		S2
M_XAN2	10^(par_a*log10(CIRC)+par_b)	2.32	-2.3		S3
M_XAN_REST	BSD^par_a*H^par_b*par_c	1.8873	0.4114	0.0811	S4

Each resulting VTS-SG model uses the codes of species contained in each SG per VTS to filter the required dendrometric variables per SG per VTS and do the calculations for the underlying allometric model identified by Joubert (2024).

The matrix of matching species to VTS-SG combinations for the woody classes “trees” and “shrubs” has been appended (Annexes 1a and 1b).

Due to the fact, that the specific allometric models to be used were not known prior to the ground data collection, a tentative check of plausible models particularly for shrub species was made. The task aimed at identifying the dendrometric variables that are very likely needed as inputs into the model, namely the BSD, the crown diameter (CD), and total height (H), which were part of the final datasets compiled. However, the final selection of suitable models revealed that circumference (CIRC) and BSD are required by functions for the shrub class (Joubert 2024), and, basal area (BA), DBH and H for tree class. CIRC has been calculated from DBH. Forest scientists and practitioners commonly treat the shape of stems as simplified truncated cones using form factors to deal with tapering from the bottom to the top end of the stem. Thus, it is conservative to use measured DBH values as proxies for BSD (which are assumed to be higher than the DBH values) and, furthermore, calculated BA from BSD.

The application of general models needs some explanation. The approach of covering dominant species by species-specific equation leads to a distortion of the species composition and diameter / height variation that enters into the generalized model. Given, that the generalized model is applied based on similar natural endowments, precipitation and other criteria, a similar species composition and diameter /height distribution could be assumed. This implies that if dominant species are covered by a species-specific equation, the actual allometry of remaining species is not properly reflected on by the used general model and potentially AGB for the remaining individuals is overestimated. However, this assumption is likely to not hold, since 1) in case of very clearly dominating species (e.g. Colospermum sp.-Stratum) the remaining species are only represented by a few stems / cumulative diameter and the total AGB – value is rather low 2) If there is a more even stem distribution, the equation parameter distortion can be assumed low.

Setting parameters

The following key parameters are defined in an external spreadsheet and read into the DAMAF modules 1 to 3. Parameters are different to variables (e.g. dendrometric variables) since they constitute fixed, time-invariant values.

Table 3: Key parameters used in DAMAF modules 1 to 3

No	Parameter	Value	Unit	Remark / Reference
1	p_plot_size	500	m^2	Size of sample plot
2	P_plot_to_ha_EF	20		Plot-to-ha expansion factor
3	p_min_DBH	5	cm	minimum DBH regarded
4	p_min_BSD_shrubs	5	cm	minimum BSD regarded
5	p_C_CO²_conv_fac	44/22		molecular weight ratio of CO^2 to C
6	p_carbon_frac	0.5		carbon fraction in wood biomass (default value IPCC 2003)
7	p_rs_ratio	0.24		Rozendaal et al (2022)
8	p_wd_default	0.62		Joubert (2024)
9	p_plot_radius	12.62	m	Radius of sample plot
10	p_DBH_outl_range	10		Multiplier to the ICR to manage extreme DBH values
11	p_H_outl_range	5		Multiplier to the ICR to manage extreme H values
12	p_stDW_outl_range	5		Multiplier to the ICR to manage extreme stDW values
13	p_confidence_level	0.9		Confidence level defined for margin of error (MoE)
14	p_target_precision	0.2		Target precision level for comparing actual MoE to target MoE
15	p_moist_content	25	%	Moisture content, used for converting fresh CWD to dry matter (approximately at fiber saturation level)

2.3 Step 2: Read in main survey data from standard digitized tally sheets (Module 1)

Step 2) reads the preprocessed tally sheets into the DAMAF (Module 1). This step is taken to structure meta data, sample plot characteristics, and dendrometric and soil variables in line with predefined data structures and data types.

Standard inputs of the Module 1 in a prescribed spreadsheet format are:

- 293 preprocessed digitized tally sheets
- Species list for species classes {trees, shrubs}

Standard output of Module 1 is a set of csv-files and copies in spreadsheet format:

- File containing XY coordinates and codes for vegetation types ID, plot ID, and classification as standard, QC or audit plot
- File containing the meta data of sample plots
- Five files containing the base data {trees, shrubs, soil and SOC, coarse wood debris) from tally sheets in a table format

The trees and shrubs base data files also contain data to distinguish living biomass from standing dead biomass. The soil base data file contains the meta data from soil sampling, while the SOC base data file contains the results from laboratory work regarding bulk density at a specific soil depth and the carbon percentage.

In R programming language, the read-in data is organized in data structures[2] and data types that are deemed efficient to facilitate the access and update of containing data in the SNP. The main data structures used are R tibbles (flexible by containing mixed data types such as numeric data, characters etc, but of flexible length) and lists (in nested and simple forms). The data structures including the data types characterize the objects, which are storage entities (containers) containing data and functions following the object-oriented programming paradigm.

In DAMAF Module 1, preliminary checks were conducted that aimed at revealing inconsistencies in the digitized data that may have resulted from erroneous transcription from physical tally sheets and could not be automatically revealed in the preprocessing substep prior to reading data into the R framework.

Specifically, the *conformity* of digitized tally sheets with the format of the provided spreadsheet template (row and column dimensions, position of data-containing grid cells, data types of digitized data) and *completeness* of filled out grid cells in the spreadsheets have been checked.

A Post-Mortem Analysis of Errors was conducted and results written out in dump files, in case an error occurred in the read-in routine for the objects within the scope of the analysis, i.e.

- The row and column dimensions of spreadsheets from digitized tally sheets,
- faulty species' codes for trees or shrubs,
- missing values in reference variables of trees (DBH) and shrubs (Basal diameter, BD).

In case remarks have been added to the standardized form of the tally sheets by the field team, these non-standardized additions have been dismissed to ensure the digital form's conformity with the requirements to automate the data read-in process.

2 https://swcarpentry.github.io/r-novice-inflammation/13-supp-data-structures.html

In addition, the workflow also entailed that odd or missing values in reference variables and missing conformity to the standard format were communicated by the data manager to the team leaders of the inventory teams and comparison checks of the physical tally sheets with the corresponding digitized version took place and corrections were done by the team leaders.

Reference variables have been defined as "must have" variables at level of each individual (stem) in order to organize data. Observations with missing values in reference variables have been removed if recollection wasn't possible, while for other variables, particularly height for multi-stem individual trees or shrubs, missing values could be eliminated by recycling values if at least one value was entered into the tally sheet.

2.4 Step 3: Management of data quality and preprocessing of input data (Module 2)

Step 3) conducts the main checks of data quality and preprocessing of input data into statistically usable data sets using rules to manage data quality (Module 2).

Standard inputs of the Module 2 in the prescribed csv- format are:

- Five files containing the base data (output from Module 1)
- File containing XY coordinates and codes for vegetation types ID, plot ID, and classification as standard, QC or audit plot (output from Module 1)
- File containing the meta data of sample plots (output from Module 1)
- Species list for species classes {trees, shrubs}

Standard output of Module 2 is a set of csv-files and copies in spreadsheet format:

- File containing XY coordinates and codes for vegetation types ID, plot ID, and classification as standard, QC or audit plot
- File containing the meta data of sample plots
- Five files containing the preprocessed base data {trees, shrubs, soil and SOC, coarse wood debris) from tally sheets in a table format
- The generated standard outputs of Module 2 are preprocessed dataset for trees, shrubs, CWD, SOC ready for C- stock analysis.

Main checks of data quality and data quality management

In addition to the initial checks of data *conformity* to formats and *completeness* (1st step of managing missing values) in Module 1, the checks of and management for high data quality in terms of correctness, consistency, precision, timeliness, and uniqueness are done.

Data quality testing typically involves checks to evaluate several critical characteristics of data, testing for:

- ***Correctness*** (Do the data sets correctly represent the values they're expected to model in allometric equations? Is the range of values plausible?)
- ***Consistency*** (Ensure, that there is non-conflict information provided about the same underlying data sets, e.g. meta data from different references in the tally sheets do not contradict or data types in a data set are consistent and not mixing e.g. numeric and character data types.)

- ***Precision*** (The measurement or classification detail used in specifying an attribute's domain, e.g. defining the number of species groups with a minimum number of observations per group to ensure statistical calculations)
- ***Uniqueness*** (to ensure that data sets are not repeated, e.g. species can only either be a "tree" or a "shrub", not both, plot-based data sets are stored with unique values based on unique identifiers)

Table 4: Data Quality issues and management

Data Quality Criterion	Data quality Issue	Management
Conformity	**Missing conformity to:** • standard format of tally sheets	• Omission of non-compliant additions to standard format
	• prescribed data types of digitized data in tally sheets	• Quality checks of submitted tally sheets and preprocessing after data recollection
	• species list, caused by faulty non-compliant species' codes for trees or shrubs	
	• max. distance from center point (DIC) in plot measurements	• Omission of observations beyond max. DIC
Completeness	**Missing values in:** • Reference variable DBH, BD	• 1st: Recollection or 2nd: Observation omitted
	• Non-reference variable H	• Recycling of available data
	• Non-reference variable Species Code	• Definition of rest category NN and allocation to general allometric model
	• Meta data XY coordinates	• Check in original tally sheets and recollection of XY coordinates
	• Other variables	• Omission after checks of NA in descriptive statistics
Correctness	• Extreme values	• Descriptive statistics and box plots of distribution of dendrometric variables, definition of extreme values based on a multiplier of the IQR • Winzoring (reducing extreme values) • Definition of minimum DBH to be included
	• Implausible H/DBH relationship	• Trimming at plausible upper and lower bounds derived from literature
Consistency	• Inconsistent meta data on different worksheets per tally sheet	• Use of main worksheet's meta data only
	• Inconsistent data types within a single data set	• Identify and correct inconsistent observations in tally sheets and re-run scripts
Precision	• Insufficient number of observations in VTS	• checks for required sample size to achieve target precision and recommendations made
	• Inconsistent number of digits across observations per data set	• harmonization of decimal digits (level of exactness) of numeric data sets
Uniqueness	• Species code is not unique in woody classes	• definition of unique four and five-digit codes based on the first two/three capital letters of the scientific names
	• Ambiguous plot IDs in case of remeasurements (QC and audit)	• plot-based data sets are stored with unique plot ID values as identifiers

Additional checks for data conformity to prescribed rules from the SOP of data collection have been conducted. The *conformity* of measurements to the max. distance from center point (DIC) is essential to generate valid data and a check of the permitted max. DIC (12.62 m) and the measured max. DIC revealed several deviations. So, only stems were allowed to enter further calculations, if the measured max. DIC stays within the permitted max. DIC, other observations being omitted from further analysis. The wrong attribution of species codes to species classes non-compliant to the species list has been uncovered in a few cases. Corrections have been manually done in the preprocessed tally sheets to ensure a clean repeated reading in Module 1.

The checks for *completeness* in Module 1 have been complemented by checks of missing values via descriptive statistics in trees, shrubs, CWD and SOC data. Observations containing missing values have been revealed by writing dump files and treated differently depending on whether they are indispensable for further processing (XY coordinates, DIC, so-called reference variables) or not (see table 4).

For example, there were 2 and 115 individuals in the same number of plots where the names of tree and shrub species respectively are not known. A consistent coding ("NN") has been applied to ensure further consideration in analyzing them in the species group "*Stratum-ID*_REST". "NA"s have been removed from the species names, because the dendrometric variables would have been discarded being defined as NA.

Checks regarding the correctness of dendrometric input data's variability and distribution have been conducted via descriptive statistics (min, max, mean, percentiles values and visually by boxplots). In addition to the left skewed data distribution of variables, the non-parametric Shapiro Wilks Test confirmed non-normality of the distribution of DBH, H and basal diameter. This result is typical for natural forest, where small diameter classes (and correlating height) dominate and shapes of negative exponential distribution functions are common.

The plausibility of biomass estimates strongly depends on the application of suitable allometric models (see Joubert 2024) and the dendrometric input data. Thus, extreme values of DBH, H of living trees and standing dead wood and, in addition, the plausibility of the H/DBH relationship has been checked and managed as follows.

Options range from dismissing individuals from further analysis, trimming (cutting them at predefined upper and lower bounds) or winsorizing values (reducing the extreme values). The decision has been taken to 1) winsorize extreme values for H and DBH if necessary and 2) to check the Height/Diameter (H/DBH) relationship to stay within in a plausible range according to literature and dismiss individuals that do not meet the requirements.

The following assumptions have been taken:

Individuals with extreme values have not been dismissed in the first step, because the distortion of AGB in t DM / ha by neglecting large dimension- individuals is assumed significant and very small extreme values doesn't matter in their contribution to AGB in t DM / ha.

Instead, height measurements are associated with uncertainties and obvious measurement errors (e.g. maximum height value of 141 meters), therefore winsorizing, i.e. reducing extreme values to a less extreme value is plausible. The derived threshold height is 35 meters, which corresponds to five times the interquartile range (IQR)). All height values above the threshold (10 individuals in total) have been reduced to 35 meters.

Winsorizing a vector means that a predefined quantum of the smallest and/or the largest values are replaced by less extreme values. Thereby the substitute values are the most extreme retained values. The deviation from the commonly used threshold of three times the IQR is explained by observed individual trees with outstanding dimensions (H and DBH) compared to a high number of individuals with significantly lower dimension. Thus, the application of the lower, standard threshold value would cut down height of those individuals to an unreasonable height compared to DBH.

The target value of the vector of extreme values that is used to reduce all values to has been defined by means of descriptive statistics. The minimum of all extreme values serves as the replacement value to the other extreme values.

DBH measurements are assumed to be more accurate, because of the relative ease of measurement. Therefore, the multiplier set to define the extreme value is factor 10 to the IQR. However, only the individual with the maximum DBH value of 151 cm has been replaced by the next extreme value (107 cm).

The AGB data of standing deadwood was derived from applying allometric equations to standing dead trees. This approach results in a proxy of aboveground standing dead biomass and leaves and small twigs are assumed to be negligible in total AGB estimates from employed allometric equations.

Extreme outliers were found in three out of 178 individuals, applying the same rule of defining extreme values like for H or DBH values. Those values, all above 74 t CO_2 / ha, have been dismissed.

Regarding the plausible range of the H/DBH relationship, the minimum and maximum H/DBH values were calculated as the ratio of the maximum H divided by the maximum DBH and minimum H divided by the minimum DBH for Miombo woodland and Acacia savanna in Tanzania (Mugasha et al. 2013, Table 2) who established height-DBH models to cope with the uncertainty from height measurement errors due to visual obstructions, rounded crown forms, leaning trees and terrain slopes. Furthermore, De Cauwer et al. (2018) provides H/DBH values for Mopane forest in Botswana.

Table 5: H/DBH relationship in different vegetation types

Reference	Vegetation type	Min. H/DBH ratio	Max. H/DBH ratio
Mugasha et al. (2013)	Miombo woodland, Tanzania	0.32	1.27
Mugasha et al. (2013)	Acacia savanna, Tanzania	0.46	1.36
Mugasha et al. (2013)	Overall, Tanzania	0.34	1.40
De Cauwer et al. (2018)	Mopane woodland, Botswana	0.23	
De Cauwer et al. (2018)	Miombo woodland, Zambia	0.50	
Sango Nature Project	All VTS	0.15	1.50

In order to take account of the limited literature review done, the lower and upper bounds of the H/DBH relationship was purposively set to 0.15 and 1.5 respectively, which are plausible in line with the reference values. 219 Individuals, which did not meet the lower and upper H/DBH bounds have been dismissed.

Regarding data's *consistency*, shortcomings in consistency of meta data have been observed in the tally sheets where redundant statements were purposively integrated across work sheets. The shortcomings have been managed by using the reconfirmed unique data sets from the main work sheet of the tally sheets only.

Inconsistent data types, e.g. the statement of character values where numeric values were required, occurred in a few cases, with corrections directly made in the preprocessed tally sheets as a second loop of preprocessing to ensure re-reading in Module 1 with consistent data sets.

The *precision* of dendrometric numeric data sets was set to one decimal digit. Calculations of the required sample size to achieve a predefined target precision in sampling per VTS have been done leading to recommendations on increasing the sample size in future (see Section on sample size, page 25 ff).

2.5 Step 4: Estimating carbon stocks across carbon pools (Module 3)

Step 4) tackles the estimation of carbon stocks across carbon pools per plot, per stratum (VTS) and for the total area (Module 3).

Standard inputs of the Module 3 in the prescribed csv- format are:

- Five files containing the preprocessed base data {trees, shrubs, soil and SOC, coarse wood debris) from tally sheets in a table format (output from Module 2)
- File containing XY coordinates and codes for vegetation types ID, plot ID, and classification as standard, QC or audit plot
- File containing the meta data of sample plots
- Species list for species classes {trees, shrubs}

Standard output of Module 3 is a set of spreadsheet formatted-files:

- Four files containing the plot-level aggregated results for four carbon pools (AGB and BGB for trees and shrubs, standing DW and CWD, SOC) in a table format
- Four files containing output statistics regarding the mean per hectare and total t DM and t CO_2 values, the relative MoE and the CI lower and upper bounds
- File containing XY coordinates and codes for vegetation types ID, plot ID, and total AGB per ha (trees and shrubs) as input for the spatially-explicit remote-sensing based modelling of AGB (used as training and validation data per stratum)
- File containing the comparison of actual versus target precision and required sample size

Additional outputs pertain to values for individually selectable stems per plot per stratum that have been traced from preprocessed tally sheets to the results of analysis (Modules 1 to 3). Additional descriptive statistics have been provided for the process of auditing the calculations and results.

The following sections provide an in-depth picture of the equations used to estimate the carbon stock in AGB of tree and shrub species groups. The section "*Estimating carbon stocks in additional carbon pools*" provides an overview of the methodological approach used in estimating

- BGB of trees and shrubs,
- Standing deadwood (stDW),
- Downed coarse woody debris (CWD), and
- SOC.

Aggregation of individual tree and shrub attributes to per-hectare per sample plot values

The statistical approach of the carbon inventory assumes that the sample plots represent the smallest sample unit. Thus, individual tree/shrub values have to be aggregated for each sample plot. The aggregation is accomplished by weighting each single tree attribute Y_{ij} with the weight

$$w_{ij} = A / a_{ij} = 1\ ha / a_{ij} \tag{1}$$

where *ij* represents the *j*-th tree on the i-th sample plot. a_{ij} denotes the area in hectares, which one tree represents, and allows taking different selection probabilities of individual trees for the derivation of estimators into consideration. Due to this type of weighting, the attributes of each individual tree $w_{ij} * Y_{ij}$ are related to an area of size one hectare, therefore w is also known as expansion factor EF to standardize values of attributes to 1 ha (= 10,000 m^2) based on the respective plot areas on which trees/shrubs with a certain diameter class were measured. That relates to a nested plot layout, where nested circular sub-plots, for example, are calculated from the individual sub-plot radii r from:

$$w_{ij} = \frac{A}{a_{ij}} = \frac{10000}{\pi * r_{ij}^2} \tag{2}$$

A non-nested plot layout has been chosen and all sample plots do not extend past the forest or woodland edge (per definition of woody vegetation types based on Joubert (2012), a remote sensing-based woody vegetation stratification [RSS 2024] and based on the sampling design), therefore the weights wij are constant for the 500 m^2 circular plot, respectively.

$$w_{ij} = w_{0.05} = \frac{A}{\pi * r_{ij}^2} = \frac{10000}{\pi * 12.61_{ij}^2} = 20, \text{ for trees/shrubs on a 500 m}^2 \text{ sample plot } i \tag{3}$$

If the individual trees/shrubs Y_{ij} are related to one hectare, the values of the respective attribute (e.g. tons DM) can be summarized to one value Y_{ij} for the *i*-th sample plot.

$$y_i = \sum y_{ij} w_{ij} \tag{4}$$

For the number of trees or shrubs per ha the expansion factor itself can be used. These up scaled single tree/shrub values can then be aggregated per plot. The total number of trees/ha would be the sum of all expanded single tree values.

All further estimation of means and totals for area related variables (derived from single trees) will be based on these aggregated plot observations (per ha values).

Derivation of mean and total values and corresponding error variance

Notation

L	Number of strata *h*=1,...,L
N	Total population size
N_h	Size of stratum *h(N=∑Nh)*
$\bar{y}$	Estimated population mean
$\bar{y}_h$	Estimated mean of stratum *h*
n	Total sample size
n_h	Sample size in stratum *h*
S_h	Sample standard deviation in stratum *h*
S_h^2	Sample variance in stratum *h*
τ	Total
τ_h	Total in stratum *h*
$\hat{\tau}_h$	Estimated total in stratum *h*
W_h	Relative share of stratum *h* or weight of stratum
$\widehat{var}(\bar{y})$	Estimated error variance of the population mean
$\widehat{var}(\bar{\tau})$	Estimated error variance of the population total
$\widehat{var}(\bar{y}_{post})$	Estimated error variance of the population mean in the post-stratification

For one-phase sampling designs, which were used in the carbon inventory in SNP, the mean $\bar{y}_h$ per vegetation type stratum h, its variance S_h^2 and standard deviation S_h can be calculated according to:

$$\bar{y}_h = \frac{\sum_{i=1}^{n} y_{ih}}{n_h} \quad (5)$$

$$s_h^2 = \frac{\sum_{i=1}^{n_h} \left(y_{i,h} - \bar{y}_h\right)^2}{n_h(n_h - 1)} \quad (6)$$

$$s_h = \sqrt{s_h^2} \quad (7)$$

The estimators of stratified random sampling are to be applied to stratified systematic sampling in the absence of a specific systematic sampling estimator (Fehrmann et al. 2017: p. 49, Kleinn 2007).

The estimator for the population mean, i.e. the mean value for the entire population, for stratified random sampling is derived based on the considerations above (also see Cochran 1977, Fehrmann et al. 2017: p.51) and analog to the estimator of simple random sampling as

$$\bar{y} = \sum_{h=1}^{L} w_h \, \bar{y}_h = \sum_{h=1}^{L} \frac{N_h}{N} \bar{y}_h = \frac{1}{N} \sum_{h=1}^{L} N_h \bar{y}_h \tag{8}$$

The weights must be proportional to the size of the sub-populations. In case of forest inventories the population is typically the total forest area (sample points are selected from this continuum), so that the individual stratum areas can be used to derive weighting factors (Kleinn 2007). The sum of all weights must be 1. In the SNP, the vegetation area is the population, which is the sum of the area of all VTS distinguished by RSS (2024).

The variance of the distribution of means is the error variance of the mean (which is estimated in contrast to the variance measuring the variability of the measured variables in samples), and the standard error is the standard deviation of the means.

The estimator for the error variance (selection without replacement) is:

$$\widehat{var}(\bar{y}) = \frac{1}{N^2} \sum \frac{N_h^2 S_h^2}{n_h} = \sum \frac{W_h^2 S_h^2}{n_h} \tag{9}$$

A finite population correction (fpc) term $\frac{N_h - n_h}{N_h}$ would be necessary to be added if the strata are small and/or the sample size is large. It is typically applied if the relation between sample size and population is larger than 0.05 (Kleinn 2007). A finite population correction is only needed in case that a selection without replacement is applied and the population size is significantly reduced by drawing the samples. As consequence the selection probabilities are changing with every sample drawn (because the remaining population decreases) what is corrected by this factor.

Therefore, if the sampling fractions $f = \frac{n_h}{N_h}$ are negligible in all strata, the finite population correction can be ignored (Cochran 1977, p.93).

Correction term for post-stratification in error variance

The stratification done in the SNP was a two-staged stratification, with the pre-stratification determining the area-proportional allocation of sample plots in VTS and the final (post-) stratification used to calculate the total / means of carbon stocks in AGB based on the supervised classification of remote sensing data (see RSS 2024). The first sample has been drawn for pre-strata, though a second sample in the final (post-) stratification has not been taken which led to the non-proportional distribution of sample plots drawn in the first sample across final VTS.

The deviation of the number of actually sampled plots per stratum from the area-proportional allocation requires adaptions to the error variance estimator. According to literature (Cochran 1977, Banning et al. 2012, Wallner et al. 2017), it is necessary to apply a correction term that increases the calculated variance if post-stratification violates the assumption of an area-proportional allocation of sample plots from pre-stratification. The post-stratification estimator to the error variance of the population mean $\widehat{var}\left(\bar{y}_{post}\right)$ with $\bar{y}_{post}=\bar{y}$ after final stratification of the vegetation area is

$$\widehat{var}\left(\bar{y}_{post}\right)=\sum\left(W_h\right)^2 S_h^2+\frac{1}{n^2}\sum\left(1-W_h\right)S_h^2 \tag{10}$$

The post-stratification estimator for the error variance of the population mean has been derived and expanded from equ. 9. in line with Cochran (1977, p. 135), where S_h^2 is the within-stratum variance and $W_h=\frac{N_h}{N}$. The first term corresponds to the value of the variance for the proportional stratification (see Cochran 1977, Fehrmann et al. 2017), without the finite population correction (see equ. 9), while the second term represents the increase in variance that stems from the non-proportional allocation of the sample drawn across VTS.

Fehrmann et al. (2017) provides the estimated total population value, the total for the entire population as

$$\hat{\tau}=N\,\bar{y}_{post}=\sum_{h=1}^{L}\frac{N_h}{N}\hat{\tau}_h=\sum_{h=1}^{L}N_h\bar{y}_{post} \tag{11}$$

where $\bar{y}_{post}=\bar{y}$

The error variance of the estimated population value is as follows. It bases on the modified equ. 10 to account for the increase in variance due to the non-proportional allocation of the sample in final stratification.

$$\widehat{var}\left(\hat{\tau}\right)=\widehat{var}\left(N\,\bar{y}_{post}\right)=N^2\,\widehat{var}\left(\bar{y}_{post}\right) \tag{12}$$

Precision estimates

The precision of the estimates has been based on the Standard Error of the Mean (SEM). The SEM measures the precision of an estimate of a population mean. It quantifies how much the sample mean might vary from the true population mean.

The SEM is commonly used as Relative Standard Error (RSE) which is estimated for the stratified population by the ratio of the estimated SEM and the estimated mean of the stratified population. It is an index of relative precision of the estimate and a recommend measure of uncertainty in LULUCF projects (Köhl et al., 2006 in: Wallner et al. 2017, IPCC 2003).

However, if normal distribution of the population mean and total over repeated samplings can be assumed, then the SEM is commonly expanded to the Margin of Error (MOE) by using parametric test statistics at a 90, 95 or 99 % confidence level, assuming normal distribution of the sample. Otherwise, non-parametric tests need to be done and based on median, trimmed mean and percentiles etc. and bootstrapping to overcome small sample sizes.

The precision of a confidence interval is defined by the MOE (or the width of the interval). It provides an estimate on the range within which the true population mean is likely to fall with the specified confidence interval. A larger MOE (wider interval) is indicative of a less precise estimate.

The MOE can also be expressed as a percentage (relative) MOE value (RMOE). As such, its use is prescribed in uncertainty estimations at a confidence level of 95 % in carbon pools in REDD+ projects in the voluntary carbon market (see VCS 2020, p.20). Additionally, the standard tool for the estimation of carbon stocks in Afforestation/Reforestation (A/R) projects of the Clean Development Mechanism (CDM) uses the RMOE at a confidence level of 90 % (UNFCCC 2015).

The RMOE is commonly applied in forest biomass inventories for determining the precision of the inventory (Parrott et al. 2012, VCS 2020). The target precision is 20% at a confidence interval of 90%, which is a valid target precision level at the confidence interval.

The standard error (SE), MOE and RMOE per vegetation type stratum h associated with aboveground biomass (AGB , tCO_2* ha-1) were calculated as follows:

$$SE_h = \frac{s_h}{\sqrt{n_h}} \quad (13)$$

where *s* = standard deviation, *n* = total number of sample points per stratum *h*

$$MOE_h = SE_h * t_{\alpha,v} \quad (14)$$

$$RMOE_h = \frac{SE_h * t_{\alpha,v}}{\bar{y}_h} * 100 \quad (15)$$

where *SE* = standard error, $t\alpha$ = t-statistic for the chosen confidence interval (90%) and appropriate degrees of freedom, and = $\bar{y}$ mean AGB (tCO_2* ha^{-1}).

Target sample sizes

For stratified sampling, the objective of defining a minimum overall sample size is to obtain a good overall inference by means of obtaining an acceptable standard error (SE) or margin of error (MOE) of the target variable, AGB (tCO_2* ha^{-1}). It can be derived from the calculated sample sizes per stratum.

The calculation of the sample size in strata may be simply based on the area-proportional allocation of sample plots in the final VTS *h*, as depicted hereafter (Table 6).

Table 6: Required sample size per vegetation type stratum based on the area-proportional allocation of samples in final (post-) stratification

Veg. Type Stratum (h)	Population (sum(n_h))	Actual sample size (n_h)	Target sample size (n_w)	Difference (n_w – n_h)
ACA	19999	46	103	57
COL	19378	160	100	-60
COM	10748	64	55	-9
DIO	2048	10	11	1
KIR	2984	4	15	11
XAN	1773	9	9	0
Total	**56930**	**293**	**293**	**0**

However, the area-proportional allocation results in too little sample sizes in some of the VTS, such as DIO, KIR and XAN. Cochran (1977, p. 134) requires the sample size in post-strata to be reasonably large, i.e. >20, to obtain acceptable precision estimates.

In addition, the question is about what sample size is necessary to derive an estimation with a predetermined precision (defined width of the confidence interval based on the sample mean and the MOE). The desired width of the confidence interval for the estimation is considered the target precision. The width of this interval is determined by a defined error probability α and a predefined allowable error (e.g. ±10%). Further the variability inside the population is affecting the required sample size that is necessary to meet the target precision of a single target variable, hereafter the AGB in tCO_2 .

The appropriate sample size in stratified sampling may be calculated for each vegetation type stratum VTS h from simple random sampling, taking into account the level of precision targeted, here 20% at a confidence level of 90%, the variability within each stratum.

$$MOE_h = \frac{t_{\alpha,v} * SD_h}{\sqrt{n_h}} \rightarrow n_h = \left(\frac{t_{\alpha,v} * SD_h}{MOE_h}\right)^2 \quad (16)$$

The overall required sample size is the sum of the per-stratum sample sizes (Table 7).

$$n = \frac{\dfrac{t^2_{\alpha,v} * \sum \dfrac{N_h^2 s_h^2}{n_h}}{n}}{N^2 MOE^2} \quad (17)$$

However, it should be clear, that the calculated target sample sizes in table 7 provides cross-sectional information that adjusts with additional samples done as the MOE changes iteratively, leading to decreasing numbers of sample plots required.

Table 7: Required sample size per vegetation type stratum and in total based on target precision estimates (woody class: trees)

Veg. Type Stratum (h)	AGB, Standard deviation (tCO_2)	MOE, Actual precision (tCO_2)	MOE, Target precision (tCO_2)	Actual sample size (n_h)	Target sample size (n_p)	Difference (n_p – n_h)
ACA	4.72	1.17	0.88	46	81	35
COL	20.76	2.72	5.75	160	36	-124
COM	8.78	1.83	2.00	64	54	-10
DIO	56.52	32.77	10.86	10	91	81
KIR	7.47	8.79	0.96	4	332	328
XAN	28.34	17.56	3.37	9	244	235
Mean/Total	**21.10**	**10.81**	**3.97**	**293**	**838**	**545**

Estimating carbon stocks in additional carbon pools

The reconnaissance survey in July 2023 has revealed the importance of AGB in trees and shrubs in terms of the contribution to the total carbon stock, justifying the major attention given to the AGB carbon pools. The stock taking in other carbon pools,

- BGB of trees and shrubs,
- Standing Deadwood (stDW),
- Downed Coarse Woody Debris (CWD), and
- SOC

followed pragmatic methodological approaches.

BGB of trees and shrubs

Module 3 incorporates the estimation of the carbon pool for BGB in SG per VTS based on a single parameter employed, the root-shoot ratio, as depicted in table 3 (Rozendaal et al. 2022). This ratio has been multiplied to the AGB per hectare per plot for the ease of calculations.

Since BGB undergoes estimation in Module 3 only, the data quality management (Modules 1 and 2) fully applies to the BGB carbon pool.

Deadwood

Module 3 also incorporates the estimation of the *standing deadwood* (stDW) based on the boolean information provided in each tally sheet whether a tree was dead or living at the time of measurement. The SOP for data collection provides details on the distinction of standing (even leaning) standing deadwood and downed coarse wood debris including stumps.

However, intermediate results have shown, that the differentiation was not always straightforward and particularly for broken dead trees misclassifications led to the fact, that stDW is rather over- than underestimated because allometric models have been applied similarly to the living AGB.

However intermediate results have shown, that their contribution to the overall carbon stock is rather negligible and thus no further management measures have been taken. In addition, dead standing shrubs have conservatively been excluded.

In order to estimate the downed *Coarse Woody Debris* (CWD) biomass, a simplified approach, deviating from other commonly approaches (e.g. Winrock's approach in Goslee et al. 2015, p21) has been pursued. All hardwood logs with a minimum mid diameter of 5 cm have been sampled and tallied in the sample plot at the size of 500 sqm which was also used for the sampling of trees and shrubs (see SOP for carbon field tree and deadwood sampling).

The volume of logs applying the formula for volume of a cylinder

$$V_{fresh} = \pi * \left(\frac{d}{2}\right)^2 * h \qquad (18)$$

where V is the log's volume in m^3 fresh matter, d is the mid-length diameter of the log in meter and h is its length in meter, which is also done in that simplified way in other studies (Jönsson et al. 2023).

The volume measure is a rough estimate, and using the mid-length diameter approximates a truncated cone shape, assuming an equal tapering angle of all tree species, however the CWD logs have not been differentiated by species.

The wood volume in m^3 fresh matter has been converted to the weight W_{dry} in kg dry matter

$$W_{dry} = \frac{\delta_{default} * V_{fresh}}{(1 + MC)} * 1000 \tag{19}$$

with the default wood density $\delta_{default}$ (Joubert 2024), the volume of fresh matter V_{fresh} and the moisture content MC (assumed to approximate the fiber saturation level at 25%). The weight in dry matter has been expanded to the per plot level using the same factor like for stems of living trees because of the non-nested plot layout. The conversion of tons DM to tons CO_2 has already been described.

Soil Organic Carbon

The soil samples for the estimation of the Soil Organic Carbon (SOC) have been aligned with the sample plots for the collection of dendrometric data for estimating the biomass of living trees and shrubs. The generally targeted soil depth of collected samples was 15cm, but at a subsample of 30 plots a depth gradient of 10 – 20 – 30 cm was employed to statistically check the differences of the means of bulk density, carbon percentage and derived SOC.

However, due to several reasons, the maximum sample size (293 units without QC-remeasurements) was reduced and data quality suffered.

- Some of the soil samples were either not taken, or the samples were contaminated or the bags broke so therefore soil samples for these plots were not sent to the lab (concerns samples from plots 5, 36, 112, 120, 163, 237, 243 and 274).
- Samples at plots 109 and 260 were taken and submitted to the lab, but no results returned, despite proper labelling. The lab still owes the response after requests for clarification.
- Faulty labelling led to the omission of the sample from plot 1.
- There are 4 results returned by the lab for plot 108. The plot was done twice due to the need for quality control while the second time, 3 soil samples were taken. The three samples were taken into account.
- The sample for plot 174 was sent twice to the lab as 2 samples were taken at the same depth of 15 cm.
- For plots 249 and 265, only one sample for each plot was logged as sent to the lab but 2 results were received. Without receiving a response by the lab, the mean value of the 2 results were used in further analysis.

Tests for normality uncovered the non-normal distribution of all three variables which lead to the usage of the non-parametric Wilcoxon test, instead of the standard paired t-test to check the 30 cm depth layer against 20 cm and 10 cm depth layers. Results did not show any significant difference between the layers, to be conservative, the values at 15 cm depth have been taken for further calculations to not overestimate the SOC.

The SOC in gC / cm² (SOC_A) has been calculated as follows (Zeng et al. 2021):

$$SOC_A = D_{soil} * BD * \frac{CP}{100} \quad (20)$$

The conversion to SOC in tC / ha values (SOC_B) has been achieved through

$$SOC_B = SOC_A * 100 \quad (21)$$

The SOC values have also been checked for extreme values and managed following the logic applied to dendrometric variables (winzorizing), but leavingthe extreme outlier range at the default value of three times the IQR.

3
Results, conclusions and recommendations

3. RESULTS, CONCLUSIONS AND RECOMMENDATIONS

3.1 Selected results

Table 8: Descriptive stats of vegetation data per VTS (Trees)

VTS	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
ACA	5.8	2.3	1.9	16.3	10.7	6.6	5	54.6
COL	7.2	3.2	1.2	35	12.7	8.2	5	107
COM	6.9	2.2	1.6	18.3	9.8	7	5	65
DIO	7.5	4.8	2.3	29.3	15.1	16.1	5.1	107
KIR	5.4	2.7	2.5	20.1	10.3	9.5	5	60.5
XAN	6.8	4.2	2.8	24.5	16.2	15.8	5	82

Table 9: Descriptive stats of vegetation data per VTS (Shrubs)

VTS	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
ACA	3.7	1.1	1	6.4	8.4	3.7	5	31.2
COL	3.7	1.9	1	40	7.3	3.2	5	35.8
COM	4.3	1	1.5	9.9	7.4	2.8	5	35.8
DIO	4.3	1.3	1.6	10	8.1	3.7	5	35.8
KIR	3.2	0.7	2	4.2	6.2	1.2	5	9.5
XAN	4.1	1.2	1.9	6.1	9.4	5.5	5	34.3

Table10: Dry matter and C-stock (t CO_2e) per vegetation type stratum and in total

C-Pool		Dry matter (tDM)				Carbon stock (tCO_2)				
		Mean per ha	Total	Lower bound @ 90% CI	Upper bound @ 90% C	Mean per ha	Rel. margin of error (%)	Total	Lower bound @ 90% CI	Upper bound @ 90% CI
Vegetation	**Total**		**2,590,388**	**2,321,009**	**2,859,767**			**4,748,187**	**4,254,370**	**3,849,434**
Trees	AGB	33.68	1,916,937	1,733,953	2,099,921	61.75	9.55	3,513,964	3,178,494	923,864
	BGB	8.08	460,065	416,149	503,981	14.82	9.55	843,351	762,839	377,988
Shrubs	AGB	3.02	172,086	137,829	206,342	5.54	19.91	315,219	252,449	90,717
	BGB	0.73	41,301	33,079	49,522	1.33	19.91	75,652	60,588	677,218
Deadwood			**276,611**	**183,793**	**369,429**			**507,058**	**336,899**	**268,890**
Standing deadwood		2.20	124,953	103,218	146,687	4.02	17.39	229,047	189,204	408,328
Coarse woody debris		2.66	151,658	80,575	222,742	4.89	46.87	278,012	147,695	4,132,201
Soil						**69.45**	**4.56**	**3,952,037**	**3,771,873**	**10,051,424**
Grand total			**2,866,999**	**2,504,802**	**3,229,196**			**9,207,282**	**8,363,141**	

Table 11: Share of carbon pools at total carbon stock

C-Pool		Carbon stock	
		Total (tCO_2)	% of Grand total
Vegetation	**Total**	**4,748,187**	**52%**
Trees	AGB	3,513,964	38%
	BGB	843,351	9%
Shrubs	AGB	315,219	3%
	BGB	75,652	1%
Deadwood		**507,058**	**6%**
Standing deadwood		229,047	2%
Coarse woody debris		278,012	3%
Soil		**3,952,037**	**43%**
Grand total		**9,207,282**	**100%**

3.2 Conclusions and Recommendations

Conclusions

- Particular attention has been given to AGB estimation of carbon stocks, which is valid because it takes the largest share at the overall carbon stock.
- SOC is the second largest carbon pool, but the process of analysis with an external lab faced several difficulties, which, once solved, may significantly increase the quality of data which has an impact due to the amount of carbon stored in soils.
- The final stratification without additional sampling to make up the area-proportional allocation of sample plots increases the error variance in total estimates and entails the risk of producing critical shortcomings regarding the number of sample plots needed for an acceptable level in analysis.
- Data quality management is among the most important tasks prior to data analysis as the need for preprocessing of tally sheets but also in the framework has well demonstrated.

Recommendations

Following large-scale forest inventories, using an online database with access granted to the inventory administration (data manager, QC personnel) via an online-client the work directly on the database in parallel to the field team may be beneficial to the work flow and feedback provided on data artefacts and missing values. In addition, this may allow the inventory administration, for example, to import data from external data sources, assign the sample points to the inventory teams and monitor the work progress. This approach has been followed, for example, by the national forest inventory team in Germany.

- In future assessments, the framework could be advanced to a framework, that incorporates a relational database (e.g. SQLite) at the back-end, where digital data is directly entered from the field via a web application, such as Open Foris Collect Mobile and checks of data quality are done immediately.
- The sample size in several of vegetation types is too little and precision estimates are not acceptable. Estimates would greatly benefit from increasing the sample size to be reasonably large, i.e. >20, to obtain acceptable precision estimates.

- Improve field trainings and introduce data quality check routines before tally sheets are submitted to the data manager in order to reduce the number of faulty entries and missing values and foster predefined workflows.
- Increase robustness of uncertainty estimates, the reliability of confidence intervals through bootstrapping, simulating repeated samples from the population of woody vegetation types. The aim would be to estimate the true error variance by means of repeated samples and the calculation of the variance of all the estimations produced
- Regarding SOC: Increase the data quality and procedure in collaborating with labs to get the analysis of samples done in a subsequent carbon inventory.

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Annex 1a: VTS-SG to species matrix (Trees)

VTS-SG M.	*	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9	SP 10	SP 11	SP 12	SP 13	SP 14	SP 15	SP 16	SP 17	SP 18	SP 19	SP 20	SP 21	SP 22	SP 23	SP 24	SP 25	SP 26	SP 27	SP 28	SP 29	SP 30
M_ACA1	T1	COAP																													
M_ACA2	T2	COMO	COIM	TEPR																											
M_ACA3	T3	DIQU	BEDI																												
M_ACA4	T4	ACTO	ACGA																												
M_ACA5	T5	ACNI	ACGR	ACNIL	ZIMU	ACGE	ACNIL																								
M_ACA_REST	T9	ALAN	ACKA	CAAB	COGL	PEAF	PHVI	SCBI	XAZA	SYGU	NN	NA																			
M_COL1	T1	COAP																													
M_COL2	T2	COMO	COIM	TEPR																											
M_COL3	T3	DIQU	BEDI																												
M_COL4	T5	ACNI																													
M_COL_REST	T9	ZIMU	STOP	PHVI	MAMO	LASC	DIME	CONE	COAF	CAAB	BOAL	ALAN	ALAM	BOFO	COGL	ACTO	BAAE	KIAC	PACA	STRO	NN	NA									
M_COM1	T1	COAP	COHE																												
M_COM2	T2	COMO	TEPR	COIM																											
M_COM3	T3	DIQU	BEDI																												
M_COM4	T5	ACNI	ACGE	DAME	ACNIL	ZIMU																									
M_COM5	T7	SCBI	CRME	KIAC	NN	NA																									
M_COM_REST	T9	DIME	LASC	PHVI	STMA	STOP	ACGA	ACTO	ADDI	AFQU	BOFO	BRSP	CAAB	COAF	COED	COGL	COMA	CONE	COZE	JUGL	MAZA	PEAF	PSMA	STPO	STRO	VIMO	XEST	FIAB	FITE	SELE	COMMO
M_DIO1	T2	COIM	TEPR																												
M_DIO2	T3	DIQU	BEDI																												
M_DIO3	T4	ACTO	ACGA																												
M_DIO4	T5	ACGE	ZIMU																												
M_DIO5	T6	DIME	PHVI																												
M_DIO6	T7	SCBI	CRME																												
M_DIO_REST	T10	BAMA	COHE	STOP	ALGL	DIUS	DRGE	DRMO	GAVO	KIAF	STPO	TAEL	XEST	SYGU	NN	NA															
M_KIR1	T1	COAP																													
M_KIR2	T2	COMO	COIM																												
M_KIR3	T4	ACTO																													
M_KIR4	T5	ACNI	ACNIL																												
M_KIR5	T7	KIAC																													
M_KIR6	T8	STRO	COGL	COMMO																											

* Joubert (2024)

VTS-SG M.	*	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9	SP 10	SP 11	SP 12	SP 13	SP 14	SP 15	SP 16	SP 17	SP 18	SP 19	SP 20	SP 21	SP 22	SP 23	SP 24	SP 25	SP 26	SP 27	SP 28	SP 29	SP 30
M_KIR_REST	T9	BEDI	DIME	DIQU	MAZA	SELE	STOP	XEST	NN	NA																					
M_XAN1	T2	COIM	TEPR																												
M_XAN2	T3	DIQU																													
M_XAN3	T4	ACTO																													
M_XAN4	T5	ACNI	ZIMU																												
M_XAN5	T6	STPO	PHVI																												
M_XAN_REST	T9	ALHA	ALAN	CRME	GAVO	XAZA	NN	NA																							

* Joubert (2024)

Annex 1b: VTS-SG to species matrix (Shrubs)

VTS-SG M.	*	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9	SP 10	SP 11	SP 12	SP 13	SP 14	SP 15	SP 16	SP 17	SP 18	SP 19	SP 20	SP 21	SP 22	SP 23	SP 24	SP 25
M_ACA1	S2	DICI	COMON																							
M_ACA2	S3	GRBI	GRFL	GRGR	GRIN	GRMO	BOMO																			
M_ACA3	S1	ACER	ACSC																							
M_ACA_REST	S4	ALAL	COGR	EHRI	GYBU	GYSE	RHZA	SAAU	SAPE	THAF	ZACA	NA	NN													
M_COL1	S1	ACER	XIAM																							
M_COL2	S2	DICI	COMON																							
M_COL3	S3	GRBI	GRFL	BOMO	GRMO																					
M_COL_REST	S4	COAD	COPA	DORO	GARE	PHRE	CAGL	RHZA	SAAU	SAPE	THAF	ZAAF	ZACA	ZAHU	NN	NA										
M_COM1	S1	ACER	XIAM																							
M_COM2	S2	DICI	COMON																							
M_COM3	S3	GRBI	GRFL	GRIN	GRMO																					
M_COM_REST	S4	ALAL	ARBR	BRMO	COAD	COGR	COPA	DILY	EHRI	EUDI	FLVI	GARE	GYBU	GYSE	MIUS	MOJU	MUSE	PHPI	PHRE	CAGL	THAF	VIFE	VIMO	BRRO	NA	NN
M_DIO1	S1	ACSC																								
M_DIO2	S2	DICI	COMON																							
M_DIO3	S3	GRFL	GRIN	BOMO																						
M_DIO_REST	S4	CLKI	BRCA	COAF	COGR	COPA	EUDI	FICA	FROB	GYSE	LACA	CAAF	NA	NN												
M_KIR1	S2	DICI																								
M_KIR2	S3	GRBI	GRFL																							
M_KIR_REST	S4	ACER	NA	NN																						
M_XAN1	S2	DICI	COMON																							
M_XAN2	S3	GRBI	GRFL	BOMO	GRIN	GRMO																				
M_XAN_REST	S4	ACSC	ALAL	BRCA	CAAF	LACA	NA	NN																		

* Joubert (2024)

Annex 2: AGB per ha as submitted to RSS for spatially-explicit AGB modelling

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ ha_trees	AGB_tDM_ ha_shrubs	AGB_tDM_ ha_total
32.1935	-20.19921	plot01	DIO	15.85	12.11	27.96
32.23554	-20.21029	plot02	XAN	4.6	2.34	6.94
32.24902	-20.22049	plot03	DIO	143.31	2.75	146.06
32.26065	-20.22701	plot04	DIO	6.68	0.16	6.84
32.32174	-20.18387	plot05	XAN	23.91	30.42	54.33
32.28271	-20.25298	plot06	DIO	203.87	0	203.87
32.28771	-20.26019	plot07	DIO	18.69	1.61	20.3
32.29891	-20.26867	plot08	XAN	181.83	0	181.83
32.30803	-20.27096	plot09	XAN	6.01	3.81	9.82
32.29677	-20.30298	plot10	XAN	0.03	0.07	0.1
32.14726	-20.21747	plot100	COL	62.98	0	62.98
32.15718	-20.20853	plot101	COL	57.32	0	57.32
32.16827	-20.19868	plot102	COL	71.66	0	71.66
32.15773	-20.21382	plot103	COL	111.32	31.97	143.29
32.1502	-20.21988	plot104	COL	72.69	2.52	75.21
32.10732	-20.27873	plot105	COL	87.33	0	87.33
32.13221	-20.2524	plot106	COL	25.19	0	25.19
32.1541	-20.22962	plot107	COL	61.36	0	61.36
32.17958	-20.20258	plot108	COL	74.02	0	74.02
32.10894	-20.28694	plot109	COL	13.8	0	13.8
32.13854	-20.25496	plot110	COL	47.91	0	47.91
32.1652	-20.22653	plot111	COL	189.22	0	189.22
32.17823	-20.21424	plot112	COL	4.16	6.15	10.31
32.17311	-20.22317	plot113	COL	94.43	0	94.43
32.1764	-20.22219	plot114	COL	105.62	0	105.62
32.1764	-20.22219	plot114	COL	105.62	0	105.62
32.20724	-20.18882	plot115	COL	223.04	0	223.04
32.22191	-20.17443	plot116	COL	35.15	0	35.15
32.22343	-20.17557	plot117	COL	28.95	0	28.95
32.11562	-20.30358	plot118	COL	45.29	0	45.29
32.12555	-20.29489	plot119	COL	81.06	0	81.06
32.28636	-20.35998	plot12	DIO	268.63	1.64	270.27
32.22971	-20.17688	plot120	COL	52.88	0	52.88
32.17208	-20.24346	plot121	COL	41.88	0.14	42.02
32.12208	-20.24126	plot122	COL	72.22	0	72.22
32.150388	-20.280128	plot123	COL	27.13	0	27.13

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ha_trees	AGB_tDM_ha_shrubs	AGB_tDM_ha_total
32.23769	-20.1818	plot124	COL	64.19	0	64.19
32.185311	-20.24633	plot125	COL	87.75	0	87.75
32.17661	-20.25945	plot126	COL	112.89	0	112.89
32.17212	-20.26762	plot127	COL	74.52	0	74.52
32.24624	-20.18481	plot128	COL	34.17	0	34.17
32.24709	-20.18657	plot129	COL	87.25	0.2	87.45
32.28631	-20.38311	plot13	DIO	197.13	4.22	201.35
32.24628	-20.19055	plot130	COL	109.98	0.06	110.04
32.25727	-20.18041	plot131	COL	42.54	0	42.54
32.17656	-20.27681	plot132	COL	62.96	0	62.96
32.18655	-20.26774	plot133	COL	63.32	0	63.32
32.18979	-20.26706	plot134	COL	80.76	0	80.76
32.19724	-20.26117	plot135	COL	15.95	0	15.95
32.20893	-20.25033	plot136	COL	95.75	0.13	95.88
32.26083	-20.19226	plot137	COL	65.25	0	65.25
32.18418	-20.28371	plot138	COL	46.92	0	46.92
32.19588	-20.27294	plot139	COL	45.2	0	45.2
32.02745	-20.18086	plot14	COM	9.83	0.63	10.46
32.19425	-20.27744	plot140	COL	64.57	0	64.57
32.2055	-20.26725	plot141	COL	35.34	0.76	36.1
32.2592	-20.2592	plot142	COL	103.16	0	103.16
32.27796	-20.18782	plot143	COL	60.35	0	60.35
32.19116	-20.29135	plot144	COL	97.45	0	97.45
32.20589	-20.277	plot145	COL	37.01	0	37.01
32.26902	-20.20552	plot146	COL	111.96	0	111.96
32.29095	-20.18275	plot147	COL	31.72	2.29	34.01
32.19462	-20.29742	plot148	ACA	4.84	0.83	5.67
32.29695	-20.181469	plot149	COL	14.8	0	14.8
32.02131	-20.19371	plot15	COM	4.57	3.87	8.44
32.19511	-20.19515	plot150	COL	55.93	0.16	56.09
32.22562	-20.27113	plot151	COL	58.88	0	58.88
32.21453	-20.28703	plot152	COL	27.79	0.15	27.94
32.22157	-20.28309	plot153	COL	104.82	0	104.82
32.22861	-20.27916	plot154	COL	102.55	0	102.55
32.17189	-20.34856	plot155	COM	27.2	1.23	28.43
32.17996	-20.34197	plot156	COL	69.2	0	69.2
32.22343	-20.29378	plot157	COL	99.83	0	99.83

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ ha_trees	AGB_tDM_ ha_shrubs	AGB_tDM_ ha_total
32.18585	-20.33947	plot158	COL	80.47	0	80.47
32.22876	-20.29197	plot159	COL	99.54	0.13	99.67
32.02485	-20.19526	plot16	COM	6.56	2.95	9.51
32.19762	-20.3299	plot160	COL	34.29	0	34.29
32.29807	-20.21478	plot161	COL	3.4	19.9	23.3
32.21969	-20.30833	plot162	COL	115.36	0	115.36
32.30092	-20.21579	plot163	COL	63.36	0.06	63.42
32.215336	-20.31768	plot164	COL	99.34	0	99.34
32.25588	-20.27313	plot165	COL	34.16	0.46	34.62
32.21266	-20.32517	plot166	COL	109.35	0	109.35
32.2479	-20.28677	plot167	COL	51.17	0.46	51.63
32.21757	-20.32411	plot168	COL	134.12	0.05	134.17
32.24413	-20.29555	plot169	COL	89.9	0.13	90.03
32.03983	-20.1834	plot17	COM	33.37	1.74	35.11
32.21008	-20.33695	plot170	COL	27.33	0	27.33
32.236175	-20.30925	plot171	COL	105.58	0	105.58
32.19615	-20.3299	plot172	COL	149.83	0	149.83
32.22882	-20.3222	plot173	COL	59.69	0.2	59.89
32.25969	-20.2888	plot174	COL	72.42	0	72.42
32.22746	-20.32812	plot175	COL	60.84	0.15	60.99
32.2559	-20.29753	plot176	COL	112.98	0	112.98
32.22541	-20.3347	plot177	COL	79.57	0	79.57
32.24499	-20.31474	plot178	COL	122.83	0	122.83
32.26204	-20.29756	plot179	COL	50.96	0	50.96
32.02217	-20.20713	plot18	COM	16.12	2.18	18.3
32.22017	-20.34822	plot180	COL	67.44	0	67.44
32.23911	-20.32819	plot181	COL	33.88	0.13	34.01
32.25677	-20.31095	plot182	COL	149.87	0	149.87
32.2721	-20.29588	plot183	COL	20.09	5.66	25.75
32.21827	-20.36056	plot184	COL	48.22	0	48.22
32.22216	-20.35887	plot185	COL	57.5	0	57.5
32.22126	-20.36282	plot186	COL	49.97	0	49.97
32.26728	-20.31308	plot187	COL	30.58	0	30.58
32.24957	-20.33678	plot188	COL	41.25	0	41.25
32.2265	-20.36678	plot189	COL	134.17	0.34	134.51
32.04958	-20.17926	plot19	COM	34.79	2.07	36.86
32.24618	-20.34804	plot190	COL	50.85	0.11	50.96

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ha_trees	AGB_tDM_ha_shrubs	AGB_tDM_ha_total
32.23337	-20.36736	plot191	COL	57.06	0	57.06
32.25885	-20.34609	plot192	COL	127.71	0.18	127.89
32.1503	-20.25572	plot193	COL	84.13	1.99	86.12
32.19075	-20.26447	plot194	COL	147.35	0	147.35
32.20918	-20.27023	plot195	COL	116.02	0.09	116.11
32.28289	-20.2125	plot196	COL	125.45	2.19	127.64
32.20997	-20.33076	plot197	COL	74.19	0.35	74.54
32.31633	-20.21927	plot198	DIO	36.88	44.58	81.46
32.227744	-20.336445	plot199	COL	36.29	0	36.29
32.03428	-20.2001	plot20	COM	22.14	1.45	23.59
32.233708	-20.346757	plot200	COL	156.65	0.33	156.98
32.25395	-20.33886	plot201	COL	125.55	0	125.55
32.246375	-20.373732	plot202	ACA	0.15	7.26	7.41
32.28674	-20.38109	plot203	DIO	162.88	6.24	169.12
32.0407	-20.25024	plot204	COM	25.09	0.61	25.7
32.10914	-20.18833	plot205	COM	3.22	0	3.22
32.07514	-20.23582	plot206	COL	19.76	0	19.76
32.09916	-20.21343	plot207	COL	21.18	0.17	21.35
32.07376	-20.24755	plot208	COM	0.86	46.76	47.62
32.07052	-20.25555	plot209	COM	17.83	3.08	20.91
32.03344	-20.20406	plot21	COM	17.01	12.73	29.74
32.12698	-20.19513	plot210	COL	8.93	0.7	9.63
32.12982	-20.19612	plot211	COL	16.42	0.65	17.07
32.12669	-20.20416	plot212	COL	54.51	0.3	54.81
32.10429	-20.23474	plot213	COL	2.54	3.66	6.2
32.108342	-20.23431	plot214	ACA	2.11	4.42	6.53
32.09483	-20.25303	plot215	COL	0.08	0.38	0.46
32.09273	-20.2584	plot216				
32.1455	-20.20222	plot218	COL	60.66	0	60.66
32.15838	-20.18995	plot219	KIR	7.41	1	8.41
32.03906	-20.20027	plot22	COM	13.42	5.09	18.51
32.15752	-20.1939	plot220	ACA	11.78	11.99	23.77
32.15838	-20.1957	plot221	KIR	0.16	1.9	2.06
32.12208	-20.24126	plot222	COL	4.06	1.35	5.41
32.09592	-20.27481	plot223	COL	3.65	0.43	4.08
32.09703	-20.27788	plot224	COL	18.19	1.31	19.5
32.12375	-20.25062	plot225	COL	36.35	22.74	59.09

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ ha_trees	AGB_tDM_ ha_shrubs	AGB_tDM_ ha_total
32.09418	-20.2884	plot226	ACA	5.62	2.76	8.38
32.19118	-20.17889	plot227	COL	8.51	0.08	8.59
32.08992	-20.29917	plot228	ACA	17.44	0.72	18.16
32.10881	-20.27989	plot229	COL	35.87	0.58	36.45
32.05076	-20.18939	plot23	COM	10.91	7.72	18.63
32.12351	-20.26553	plot230	COL	26.17	0.15	26.32
32.128	-20.26314	plot231	COM	4.64	0.16	4.8
32.13189	-20.26146	plot232	COL	59.25	5.58	64.83
32.15498	-20.23724	plot233	COL	19.46	0	19.46
32.15827	-20.23626	plot234	COL	4.35	0.23	4.58
32.19215	-20.1994	plot235	XAN	6.21	2.46	8.67
32.19421	-20.19976	plot236	XAN	10.12	0.45	10.57
32.12242	-20.28557	plot237	COL	50.26	0.09	50.35
32.14449	-20.26205	plot238	COL	10.38	1.32	11.7
32.16261	-20.24421	plot239	COL	18	0	18
32.04503	-20.19897	plot24	COM	4.06	15.83	19.89
32.22395	-20.17486	plot240	COL	19.88	0.17	20.05
32.13843	-20.27686	plot241	COL	39.75	0.7	40.45
32.16212	-20.25193	plot242	COL	67.2	0	67.2
32.181	-20.2326	plot243	COL	13.37	0	13.37
32.148918	-20.273238	plot244	COL	13.99	0	13.99
32.1408	-20.28561	plot245	COL	28.34	0	28.34
32.15384	-20.27463	plot246	COL	15.63	0	15.63
32.15427	-20.27849	plot247	COL	29.74	0	29.74
32.15535	-20.28154	plot248	COL	3.95	0.13	4.08
32.22494	-20.20687	plot249	COL	18.34	16.22	34.56
32.03992	-20.20786	plot25	COM	4.78	2.71	7.49
32.23513	-20.21223	plot250	XAN	96.84	4.79	101.63
32.0931	-20.17867	plot251	COL	32.19	13.42	45.61
32.10356	-20.18082	plot252	COL	103.31	0	103.31
32.0588	-20.24773	plot253	COM	82.22	3.39	85.61
32.13494	-20.18146	plot254	ACA	16.19	1.8	17.99
32.05177	-20.2936	plot255	COM	21.01	8.27	29.28
32.109819	-20.241228	plot256	KIR	0.31	0.83	1.14
32.07731	-20.2966	plot257	ACA	0.47	2.53	3
32.12339	-20.25269	plot258	COM	52.9	1.09	53.99
32.13102	-20.25384	plot259	COM	1.59	0.31	1.9

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ ha_trees	AGB_tDM_ ha_shrubs	AGB_tDM_ ha_total
32.04744	-20.20197	plot26	COM	3.84	3.87	7.71
32.18077	-20.20696	plot260	ACA	0.14	1.43	1.57
32.08264	-20.33076	plot261	ACA	23.56	1.24	24.8
32.18945	-20.21702	plot262	ACA	0.32	5.5	5.82
32.20002	-20.22401	plot263	ACA	5.94	0.64	6.58
32.20072	-20.23129	plot264	ACA	1.75	0.14	1.89
32.21539	-20.22398	plot265	ACA	32.15	9.88	42.03
32.22898	-20.21808	plot266	ACA	7.43	0.75	8.18
32.22262	-20.2329	plot267	ACA	0.17	3.83	4
32.23169	-20.22936	plot268	ACA	0.32	11.43	11.75
32.21313	-20.25695	plot269	COL	2.17	0.6	2.77
32.06815	-20.18056	plot27	COM	8.74	4.65	13.39
32.23058	-20.24355	plot270	ACA	1.45	11.93	13.38
32.25652	-20.23029	plot271	ACA	27.38	0	27.38
32.24449	-20.24029	plot272	ACA	17.29	0	17.29
32.23416	-20.25681	plot273	ACA	4.22	10.56	14.78
32.25334	-20.23996	plot274	ACA	31.1	4.83	35.93
32.25431	-20.24306	plot275	ACA	21	5.02	26.02
32.30156	-20.19184	plot276	COL	36.52	3.35	39.87
32.25517	-20.24938	plot277	ACA	10.93	0	10.93
32.31967	-20.17781	plot278	ACA	10.39	6.37	16.76
32.23605	-20.23605	plot279	ACA	8.82	0	8.82
32.01779	-20.24092	plot28	COM	22.47	3.5	25.97
32.25076	-20.26464	plot280	ACA	1.61	2.41	4.02
32.28538	-20.22828	plot281	ACA	18.74	0.68	19.42
32.30734	-20.2067	plot282	ACA	8.46	5.89	14.35
32.19788	-20.19788	plot283	ACA	39.13	1.71	40.84
32.31061	-20.21158	plot284	ACA	0	0.8	0.8
32.28534	-20.24566	plot285	ACA	0.14	17.59	17.73
32.30507	-20.22815	plot286	ACA	10.33	0.91	11.24
32.29611	-20.24455	plot287	ACA	0	15.74	15.74
32.29797	-20.24946	plot288	ACA	6.22	0	6.22
32.31256	-20.23965	plot289	ACA	6.66	5.66	12.32
32.02053	-20.24067	plot29	COM	29.02	0.93	29.95
32.28258	-20.28067	plot290	ACA	0.17	0.15	0.32
32.30131	-20.26586	plot291	ACA	0	1.82	1.82
32.29089	-20.28816	plot292	ACA	10.16	1.68	11.84

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ ha_trees	AGB_tDM_ ha_shrubs	AGB_tDM_ ha_total
32.29663	-20.29012	plot293	ACA	8.42	0	8.42
32.247	-20.35567	plot294	COL	33.13	3.41	36.54
32.27967	-20.32594	plot295	ACA	24.89	5.08	29.97
32.27202	-20.34216	plot296	COL	39.97	2.18	42.15
32.25656	-20.36754	plot297	COL	54.01	0	54.01
32.27604	-20.35332	plot298	ACA	0.92	0	0.92
32.27182	-20.36982	plot299	COL	41.52	0	41.52
32.02023	-20.24394	plot30	COM	26.49	0	26.49
32.28214	-20.37647	plot300	XAN	0	0	0
32.0163	-20.25135	plot31	COM	34.94	0.36	35.3
32.02233	-20.25009	plot32	COM	24.71	0.63	25.34
32.02233	-20.25009	plot33	COM	24.71	0.63	25.34
32.01241	-20.26467	plot34	COM	18.91	3.46	22.37
32.07587	-20.19457	plot35	COM	4.37	2.1	6.47
32.08816	-20.18304	plot36	COM	4.23	4.47	8.7
32.01211	-20.27371	plot37	COM	12.54	6.81	19.35
32.09529	-20.18039	plot38	COL	25.29	0	25.29
32.02223	-20.26754	plot39	COM	26.89	0.28	27.17
32.05016	-20.23766	plot40	COM	8.59	7.38	15.97
32.06325	-20.22674	plot42	DIO	5.76	2.12	7.88
32.03648	-20.25974	plot43	COM	11.26	2.52	13.78
32.01484	-20.28611	plot44	COM	55.79	1.26	57.05
32.06138	-20.23457	plot45	COM	19.21	1.28	20.49
32.03153	-20.27108	plot46	COM	7.07	5	12.07
32.00225	-20.30683	plot47	COM	25.86	2.54	28.4
32.03497	-20.27137	plot48	COM	16.22	3.07	19.29
32.00268	-20.31064	plot49	COM	11.04	0	11.04
32.03	-20.28151	plot50	COM	25.52	0	25.52
32.0555	-20.25449	plot51	ACA	13.14	3.82	16.96
32.01722	-20.3008	plot52	COM	50.97	0.34	51.31
32.06704	-20.24819	plot54	COM	4.44	0.75	5.19
32.03118	-20.29165	plot55	COM	2.06	2.92	4.98
32.04526	-20.27803	plot56	COM	32.16	8.54	40.7
32.06416	-20.25875	plot57	ACA	2.81	1.41	4.22
32.01808	-20.31421	plot58	ACA	37.47	3.44	40.91
32.03158	-20.30127	plot59	COM	35.33	3.24	38.57
32.04444	-20.28903	plot60	COM	17.69	0.6	18.29

X_COORD	Y_COORD	PLOT_ID	VEG_ID	AGB_tDM_ ha_trees	AGB_tDM_ ha_shrubs	AGB_tDM_ ha_total
32.01729	-20.32522	plot62	COM	79.76	1.81	81.57
32.02779	-20.3158	plot63	COM	13.41	1.41	14.82
32.02448	-20.32256	plot64	COM	1.07	0	1.07
32.06515	-20.27921	plot65	COM	24.09	1.18	25.27
32.05524	-20.29372	plot66	COM	46.06	1.02	47.08
32.04111	-20.31315	plot67	COM	21.79	3.87	25.66
32.03945	-20.32234	plot69	COM	98.49	6.53	105.02
32.06879	-20.29359	plot70	COM	29.38	0.65	30.03
32.05844	-20.3101	plot71	COM	13.66	0.63	14.29
32.059	-20.31514	plot72	COM	36.76	0.51	37.27
32.06044	-20.32212	plot73	COM	1.8	23.11	24.91
32.08928	-20.33006	plot74	KIR	35.89	0.38	36.27
32.06512	-20.18989	plot75	COM	28.99	31.19	60.18
32.05002	-20.21326	plot76	COL	85.45	0	85.45
32.07241	-20.19426	plot77	COL	66.95	3.45	70.4
32.05863	-20.21626	plot78	COM	9.89	3.24	13.13
32.04728	-20.23664	plot79	COM	43.13	0.39	43.52
32.08917	-20.19772	plot80	COL	51.38	0	51.38
32.09028	-20.2012	plot81	COL	12.6	10.38	22.98
32.10561	-20.19277	plot82	ACA	6.3	3.68	9.98
32.08026	-20.22692	plot83	COL	36.65	0	36.65
32.09693	-20.21296	plot84	COL	33.59	0	33.59
32.11667	-20.19425	plot85	COL	95.49	0.11	95.6
32.09194	-20.22776	plot86	COL	57.39	0	57.39
32.0887	-20.23563	plot87	COL	75.62	0.13	75.75
32.08799	-20.24087	plot88	COL	37.98	4.36	42.34
32.09082	-20.24189	plot89	COL	37.21	1.05	38.26
32.112266	-20.221055	plot90	COL	7.97	1.6	9.57
32.13071	-20.20297	plot91	COL	81.77	0.2	81.97
32.0956	-20.24782	plot92	COL	133.45	1.91	135.36
32.11658	-20.22897	plot93	COL	70.32	0	70.32
32.11956	-20.23123	plot94	COL	11.27	0	11.27
32.16502	-20.18221	plot95	COL	33.44	0.39	33.83
32.1095	-20.25026	plot96	COL	59.65	0	59.65
32.17647	-20.17585	plot97	COL	47.88	0.21	48.09
32.10168	-20.26518	plot98	COL	49.95	0	49.95
32.11277	-20.25506	plot99	COL	85.84	0	85.84

Annex 3a: Descriptive statistics of vegetation data per plot (trees)

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
plot01	5.8	2.5	4.6	13.5	10.8	8.2	5.2	35.5
plot02	6.4	2.8	5.2	11.4	13.8	8.5	6.7	27.5
plot03	11.3	6.9	3.3	22	30.2	20.4	7	66.9
plot04	5.3	1.6	3.3	7.9	12.5	4.3	5.3	16.5
plot05	7.4	4.2	3.8	18.9	14	14.8	5.1	54.4
plot06	6.5	3	3.8	18.5	12.3	15.8	5.1	75
plot07	8.2	2.7	5	14	12	6.9	5.5	35
plot08	17.5	7.8	7.9	24.5	53.3	30.2	13.1	82
plot09	5.2	1.1	2.8	6.2	11.4	4.8	5.3	24.5
plot10	3.4		3.4	3.4	5.1		5.1	5.1
plot100	7.4	2.2	3.7	12.4	12.2	5.8	5	28
plot101	8.3	2.6	3.3	12.8	11.8	4.8	5.1	36
plot102	8.9	3.1	3.1	13.1	13.6	5.1	5.9	25.7
plot103	7.8	2.5	2.2	13.6	12.2	7.9	5	53.8
plot104	6.9	3.4	1.6	13.3	13.9	8.7	5.1	42
plot105	11.1	3.3	2.6	14.2	19.3	9	6.7	43.9
plot106	7.3	1.7	3.1	10	11.1	3.5	5	18.8
plot107	7	2.9	2.1	12.3	12.1	6.9	5	37.6
plot108	7.5	3.3	2.7	14.4	12.5	7	5	33.7
plot109	8	5.1	4.6	14.5	14.4	10.2	6.1	33.3
plot110	7.4	2.2	1.6	12	11.6	4.8	5.2	30.2
plot111	7.8	3.5	1.9	13.1	14.7	14.1	5.3	85.2
plot112	4.6	0.8	2.9	5.6	7.1	1.8	5.1	10.6
plot113	7.1	2.8	3	11.7	13.6	10	5.3	59
plot114	8.8	3.2	3.5	14	18.3	10.7	5	42.8
plot115	7.9	4.9	3	22.2	16.4	17.8	5.1	80
plot116	7.4	1.7	3	8.8	9.8	3.3	5.2	19.2
plot117	7.2	2.1	2.9	9.6	12	5.8	5.1	30.1
plot118	7.7	2.7	3.6	12	13.2	5.5	5.2	24.5
plot119	10.4	3.6	3	18.6	21.1	8.3	10.1	39.4
plot12	11.1	6.9	3.3	29.3	19.6	17	5.2	95
plot120	7.8	2.4	3	11.9	12.9	7.7	5.1	36.3
plot121	7.8	2.7	2.7	11.2	14.4	7.4	6.1	30.8
plot122	6.1	2.8	3	11.9	12.1	8.6	5	38
plot123	6.2	1.9	4.3	10.7	9.6	7	5	39.8
plot124	6	2.4	2.5	11	11.1	5.9	5	32.9

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	**mean_H**	**sd_H**	**min_H**	**max_H**	**mean_DBH**	**sd_DBH**	**min_DBH**	**max_DBH**
plot125	7.5	2.2	2	10.8	12.8	5.8	5.3	31.4
plot126	8	2.4	2.1	12	14	8.5	5.5	45.6
plot127	7.4	3.3	2.8	18.5	12.3	6.5	5	30.5
plot128	7.1	2.1	3.7	12	11.3	5.1	5	31.3
plot129	8.5	2.7	2.5	13.6	14.7	6.6	5.6	37.5
plot13	5.3	4.5	2.3	25.8	13.4	19.4	5.3	107
plot130	7.8	2.1	2.8	10.6	15.3	8.5	5.1	38.5
plot131	7.2	3.2	2.3	14.6	13.6	8.3	5.5	44.6
plot132	7.7	2.5	2.5	12.3	11.2	5.8	5	40.8
plot133	7.1	2.5	2.2	12.6	10.3	6	5	33
plot134	8	2.4	3.1	11.9	12.6	7	5	42.6
plot135	4.3	1.6	1.8	7.3	7.3	2.2	5	15.9
plot136	10.4	4	2.7	13.9	17.2	8	5.2	31
plot137	6.8	2.5	2.3	10.1	16.5	9.5	5	33.4
plot138	9.3	3.1	3.4	14.7	13	5.5	5.3	28.1
plot139	7.7	2.6	1.9	11	11.3	5.8	5	29.5
plot14	6.4	1.3	2.9	12.3	6.8	3.2	5	26
plot140	9.3	3.6	2.8	15.3	14.6	7.6	6.4	43
plot141	6.7	3	2.5	13.3	13.4	6.6	5.1	34
plot142	8.2	3.2	2.4	13.5	14.8	7.4	5.1	40.4
plot143	5.6	3.7	2	15.6	11.7	7.7	5.1	36.7
plot144	9.1	3.4	2.2	13.7	16.3	8.7	6.6	39.6
plot145	7	2.2	2.3	11.4	10.7	4.9	5.1	22.9
plot146	8.2	4.2	3	16.5	20.3	12.3	6.4	53.3
plot147	7.8	3	2	12.1	12.7	4.5	5	24.3
plot148	4.5	0.7	3	5.2	7.1	2.5	5.3	14.5
plot149	3.8	1.2	2.2	7.5	9.3	3.9	5.4	20.5
plot15	6.8	2.3	4.3	10.3	9	3.9	5.1	15.5
plot150	6.9	7.1	1.2	35	13.7	9.7	5.1	37.5
plot151	7.2	1.8	2.5	11.1	12.6	4	6	23
plot152	5.9	2.9	3.2	12.2	10.8	7.3	5.1	28.8
plot153	7.8	2.4	2.1	12.5	13	7.8	5.4	44.3
plot154	7.9	3.3	1.8	13.4	15.6	7.2	5.5	34.5
plot155	6.7	1.8	3.8	13.3	9.4	4.9	5	36.5
plot156	8.7	3.3	3.1	12.9	19.4	11.1	5	35.3
plot157	8.9	3.3	2.7	15.3	15.8	9.4	6.1	37.4
plot158	9.3	2.9	2.4	12.7	14.9	6.6	5.3	33.5

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	**mean_H**	**sd_H**	**min_H**	**max_H**	**mean_DBH**	**sd_DBH**	**min_DBH**	**max_DBH**
plot159	7.1	3.4	2	17.4	12.7	9.3	5	55.7
plot16	9.5	0.7	8.4	9.9	14.5	4.6	9.3	19.7
plot160	8.7	2.2	3.7	11.3	11.8	4.7	5.4	24.8
plot161	4.7	2.5	2.9	6.5	14.9	8.3	9	20.8
plot162	6.7	2.8	1.5	14	11.7	9	5	46.2
plot163	7.6	2.7	2.9	12.2	14.6	6.7	5	29.1
plot164	7.9	3.5	1.8	11.4	13	7.4	5	36.3
plot165	6.4	2.4	2.4	9.7	13.6	4.1	6.5	23.4
plot166	10.8	3	6.3	15.7	23.4	10.8	7.2	42.8
plot167	7.8	3	2	11.9	13.2	6.8	5.1	38.7
plot168	10	5.6	2.4	15.7	25.4	18.5	6.2	57.5
plot169	7.2	3.7	1.5	16.2	11.8	6	5	34.7
plot17	8.8	2.5	4.9	12.2	12.4	5.1	5.1	26
plot170	5.4	1.8	2.4	8.3	9.8	3.9	5.2	24.3
plot171	8.4	2.7	1.9	13.4	15.8	10.1	5	46.1
plot172	11.8	3.6	2.9	15	22.9	11.1	6.5	41.9
plot173	6.8	2.3	2.7	9.8	10.5	5.9	5	42.2
plot174	7.4	3	2.7	12.5	14.3	8.1	5.4	37.7
plot175	6.3	1.7	2.7	10.2	9.9	5.2	5	37.5
plot176	7.1	3.7	2	15.6	14.3	10.5	5	42.3
plot177	5.6	2.8	1.5	10.9	11.1	8.6	5	53.7
plot178	8.7	2.7	2.5	13.3	15	9	5.3	48.7
plot179	5.7	2.6	2.5	12.2	11.6	7.2	5	30.3
plot18	8.4	1.9	5.6	11.9	11.3	5.8	5.5	27.7
plot180	6.8	1.9	2.1	13.2	11.1	6.3	5.1	39.8
plot181	5.6	1.8	1.7	10	9	4.2	5	27.6
plot182	8.3	4.2	2.1	14.9	17.7	12.4	5.2	46.4
plot183	5.6	3.1	2.7	12.2	11.3	6.1	5	27
plot184	7	2.7	2.3	11.5	11.2	5.4	5	29
plot185	6.6	2.6	1.9	12.4	11.4	6.8	5.2	43.4
plot186	7.2	2.7	2.5	12	12.6	5.2	5.8	27.9
plot187	5.1	2.4	2	9.2	11.5	5	5.1	22.7
plot188	6.3	3.5	2.3	13.8	11.4	5	5.7	32.5
plot189	10.5	3.7	3.1	18.1	16.6	11.7	5.6	59.6
plot19	7.1	3	3.4	14.7	10.9	11.4	5	43.8
plot190	5.4	2.6	1.5	10.7	12.5	7.8	5.4	39.2
plot191	7.6	3.7	2.5	13.2	13.8	7.6	5.1	40.1

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
plot192	7.8	4.5	2.2	15.2	17	15	5	54
plot193	7.8	3.9	4.8	16.5	15.7	14.8	5.4	53.9
plot194	12	5.1	2	19.6	25.5	12.4	5	38.9
plot195	8.3	4.4	2.5	15.5	13.9	9.7	5	47.6
plot196	8.2	4.9	2.9	21.6	19.6	16.5	5.4	70
plot197	7.7	3.7	2	15.1	13.3	7.4	5.7	36.2
plot198	7.9	5.2	5	18.5	22.4	21.8	7	65
plot199	8.9	2.2	3.2	13.3	14.7	6.1	6.8	36.7
plot20	7.2	1.5	3.7	10	9.3	4	5.2	23.9
plot200	12.4	4.7	4.8	20.9	27	18.7	10.4	71
plot201	6.4	3.4	2.2	14.1	14.2	10.4	5.2	49.8
plot202	3.2	0.7	2.7	4	6.6	0.5	6.2	7.1
plot203	9.6	6.2	4.2	25	30.5	26.5	9.9	80
plot204	7.1	1.2	4.8	10.8	8.6	4.7	5	33.9
plot205	5	1.5	3.3	6.6	8.7	3.4	5	14.4
plot206	3.8	2.7	2.5	16.2	8.4	6.3	5.2	37.8
plot207	5.9	2.1	2.1	11.5	9.7	6.4	5.1	29.5
plot208	5.3	0.2	5.1	5.5	6.6	1.1	5.4	7.7
plot209	9.1	2	4.5	10.3	16.2	7.5	6.9	24.7
plot21	6.8	1.4	3.4	8.9	7.9	2.5	5.1	15.2
plot210	6.6	2.9	3	11.1	11.4	7	5	24.4
plot211	5	0.9	3.4	7.8	10.2	3.8	5.3	18.7
plot212	7.2	2.4	3.2	11.2	14.3	13.8	5.7	56
plot213	6.4	0	6.4	6.4	7.1	1.6	5	11.2
plot214	3.6	0.6	2.5	4.2	7.2	1.3	5.7	9.9
plot215	3.1	0	3.1	3.1	6.3	0.1	6.3	6.4
plot218	7.5	2.8	2.5	12.4	11.5	5.9	5.1	36.2
plot219	5	1.1	3.2	6.8	7.5	2.3	5	12.4
plot22	8.6		8.6	8.6	48.6		48.6	48.6
plot220	5.3	0.8	3.7	6.3	8.3	3.7	5.1	20.8
plot221	3.5		3.5	3.5	5.3		5.3	5.3
plot222	3.4	2.7	1.8	10.5	9.2	4.2	5	18
plot223	4.6	0.9	2.7	5.7	7.4	3.1	5	16
plot224	6.4	1.9	4.4	11.9	9.7	5.9	5.5	28.2
plot225	8.9	3	3.9	11.6	17.2	7.6	5.7	29.5
plot226	5.2	0.9	4	5.8	10.6	3.8	5.5	13.7
plot227	6.7	1.5	5.5	8.9	17.6	5.8	8.7	23.4

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
plot228	5.4	1.3	4.3	9.1	9.4	4.4	5	24.5
plot229	10.9	1.8	8	13.4	25.4	6.7	20.7	38.8
plot23	5.7	1.5	2.2	9.9	7.5	2.5	5.2	15.9
plot230	5.9	4	2.1	12.3	11.5	6.6	5.2	23.4
plot231	5.1	1.1	3.2	6.8	7.1	2	5	13.1
plot232	9	2.5	4.5	15.9	17.4	7.9	5.2	30.8
plot233	5.6	1.5	2.7	10.1	7.9	4.2	5	28.8
plot234	6	1.4	3	8.2	7.9	3	5.2	15.5
plot235	4.9	1	3.6	7.5	10.2	3.8	5	17.1
plot236	6.4	0.8	4.6	7.6	12.2	5.9	5.1	21.6
plot237	6.3	3.2	2	13.4	11.1	7.7	5	33.8
plot238	5.5	1.8	4.2	9.5	9.8	4.8	5.1	23.4
plot239	5.1	1.4	2.7	9.8	7.5	4.3	5	27.2
plot24	5.5	1.1	4.1	6.8	13.6	3.3	9.6	21.8
plot240	4.4	1.5	3	8.2	9.9	6.7	5.1	36.4
plot241	5.5	2.8	2	9.8	13.8	9	5	32.2
plot242	6.1	2.9	1.9	11.6	12.2	8.2	5	34.2
plot243	5	1.3	2.8	8.3	8.9	3.2	5	17
plot244	5.3	1.4	2.7	7.2	9.3	4.8	5	22.4
plot245	5.8	1.4	3.8	8.3	7.5	4.5	5	38.4
plot246	6.2	2.4	2.8	9.6	10.8	3.9	5	16.5
plot247	5.9	1.6	2.5	12.4	7.6	3.1	5	28
plot248	5.2	1.1	3.7	6.3	7.5	1.8	5	10.3
plot249	6.7	1.9	4.1	10.7	12.5	6.7	5.2	27.7
plot25	5.2	1.3	3.5	7.2	9.7	3.6	5.3	19.3
plot250	8.3	5.3	3.1	15.5	28.1	20.7	5.5	60.1
plot251	8	2.8	4.4	13.1	12.3	7.3	5.1	29.9
plot252	8.3	3.7	2.5	13.4	17	9.2	5.1	42.1
plot253	14.6	7.5	3.3	18.3	39.1	21.1	7.5	51.4
plot254	6	1.2	4.7	7.3	18.6	4	14.6	23.7
plot255	6.3	1.1	5.6	8.5	21.5	8.3	11.9	39.9
plot256	3.9		3.9	3.9	13.5		13.5	13.5
plot257	5.4	2.5	3.7	7.2	10.9	6.4	6.4	15.5
plot258	5.5	1.9	2.2	9.5	10.5	12.9	5	57.3
plot259	4.4	0	4.4	4.4	6.3	0.9	5	8.1
plot26	4.7	1.4	2.9	6	8.4	2.3	5.2	12.6
plot260	3.4		3.4	3.4	5		5	5

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
plot261	16.3	0	16.3	16.3	33.9	6.6	29.2	38.6
plot262	2.8	0	2.8	2.8	6.6	1.4	5.1	7.9
plot263	5	0.8	4	6	7.7	2.3	5	13.5
plot264	4.2	0.7	3.1	4.6	7.8	2.5	5	10.8
plot265	7.5	1	6.6	9.4	11.5	5	5.3	24
plot266	6.1	2.2	2.7	7.7	10.3	5.3	5.1	18.9
plot267	3.5		3.5	3.5	7.8		7.8	7.8
plot268	3.8	0	3.8	3.8	5.3	0.5	5	5.7
plot269	4.1	1.1	2.3	4.8	9.1	4.6	5.1	15.6
plot27	6.5	2.2	4.5	8.8	17.9	7.9	8.4	30
plot270	5.9	0	5.9	5.9	8.5	0.9	7.5	9.1
plot271	5.7	4.3	3	16.3	15.1	14.1	5	48.6
plot272	7.1	2.3	4.4	9.4	10.6	4.6	5.8	25.6
plot273	4.1	3	2	6.2	19	16.3	7.5	30.6
plot274	5.5	2.4	3.5	11.2	9.3	7.7	5	42.2
plot275	7.5	6.1	2.5	15.7	12.4	7.7	5.6	34.8
plot276	6.5	2.3	4.4	11.5	14.1	8.1	5.6	41.4
plot277	4.5	1	3.2	5.5	10.6	4.1	6.1	17.6
plot278	6.6	0.3	6.4	7.1	14.4	3.8	6.2	19.4
plot279	5.4	1.3	3.2	7.6	10.1	2.8	6.6	14.5
plot28	6.7	1.6	4.1	11.7	7.8	3.2	5	27.6
plot280	5.3	0	5.3	5.3	11.2	2.8	8.5	14.1
plot281	5.8	3.5	1.9	13.7	10.3	8.8	5.1	33.5
plot282	6.2	0.5	5	6.5	11.7	4.4	5.1	18
plot283	13		13	13	54.6		54.6	54.6
plot285	3.2		3.2	3.2	5.1		5.1	5.1
plot286	6.5	0.8	5	7	11.1	3.3	6.1	17.8
plot288	4.9	0	4.9	4.9	10	2.8	5.1	14.1
plot289	6.2	0	6.2	6.2	14.6	5.9	7.5	25.5
plot29	6.8	2.4	2.5	14	9.7	5.6	5	32.6
plot290	3.2		3.2	3.2	5.5		5.5	5.5
plot292	4.4	0.7	3.2	5.2	11.8	4.6	8.9	22.6
plot293	5	1.2	3.7	7	11.2	6.9	5.1	21.6
plot294	8.3	5.9	2.6	16.7	16.6	11.2	6.6	36.1
plot295	6	1.7	3.2	7.7	12.2	3.9	5.3	20.1
plot296	8.4	5.2	4.1	15.6	27.7	14.8	14.2	48.9
plot297	15.2	1.5	12.5	16.3	30.7	4.4	24.2	35.5

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
plot298	4.1	0.7	3.3	4.6	6.9	1.6	5.1	8.1
plot299	17.4	0	17.4	17.4	38.5	20.4	24	52.9
plot30	7.3	1.4	4.5	12.8	10	7.3	5.1	34.8
plot31	7.6	2.5	3.9	13.5	10.4	6.5	5.2	39.8
plot32	7.1	1.5	3.2	10.5	8.5	3	5	19.6
plot33	7.1	1.5	3.2	10.5	8.6	3	5	19.6
plot34	7.2	1.8	6.1	9.2	31.1	0.5	30.6	31.6
plot35	5.2	0.8	3.6	6.7	6.7	1.6	5	10.9
plot36	4.6	0.6	3.6	5	11.2	4.9	5.3	17.7
plot37	7.4	1.3	6.7	8.9	16.3	16	6.5	34.7
plot38	5.4	3	2.8	15.3	11.3	7.6	5.7	32.2
plot39	6.9	1.9	2.7	14.6	8	4.2	5.1	30.1
plot40	5.5	1.4	4	10.6	7.3	4.3	5	26.2
plot42	4.4	0.9	2.6	5.2	8.1	3.2	5.3	15.1
plot43	6.5	1.5	4.3	11.7	7.4	5.2	5.1	36.8
plot44	7.1	2.8	3.5	15.4	10.1	8.2	5	38.8
plot45	6.5	1.9	2.7	12.9	8.4	4.5	5	28.7
plot46	5	2	2.5	11.2	9.1	4.8	5.2	26.2
plot47	6.8	2.2	3	10.7	11	4.1	5.4	22.2
plot48	6.2	1.2	2.9	9.2	7.6	2.4	5	17.5
plot49	6.1	1.5	4.5	13.3	7.3	5.7	5	37.2
plot50	6.4	2	4.2	9.9	13.8	8.1	5	27.2
plot51	6.1	1.7	3.2	8.9	9.5	7	5	37.8
plot52	8	3.3	3	18.1	11.6	11.6	5.1	64
plot54	5.7	1	4.4	7.1	6.4	1.2	5	9.2
plot55	6.2	0.7	5.1	6.8	8.1	2.2	5.7	11.8
plot56	8.8	1.7	7.5	13.4	13.7	11.4	5.7	48
plot57	5.7	1.1	4.3	7.4	8.7	3.9	5.1	20
plot58	7.5	3.7	3.5	16.1	16.7	13.7	5.1	49.8
plot59	7.6	2.4	3	12.2	13.2	10.8	5.4	57.7
plot60	8.3	2.8	3.5	12	12	7.8	5	28.4
plot62	8.3	2	6.7	13	20.3	20.7	5.7	65
plot63	5.7	2.6	1.9	10.5	9	4.1	5	21.4
plot64	7.5	0	7.5	7.5	7.8	3.9	5.4	12.3
plot65	8.4	2.5	2.9	12.2	13	7.5	5.3	34.1
plot66	8.8	3	4	14	15.6	8.8	5.5	37
plot67	8.7	2.2	5.9	14.4	12.4	10.7	5.4	42.7

Descriptive stats of vegetation data per plot (trees)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
plot69	8.9	3.1	3.4	16.2	16	12	5.2	59.4
plot70	8	3.2	2.5	16.6	12.1	7.5	5.5	44.8
plot71	8.1	1.6	5.2	9.8	9.7	5.7	5.8	32.6
plot72	8.4	5.8	1.6	15.5	18.1	17	5.3	49.9
plot73	5.4	0.8	4.5	6.2	6.3	0.9	5	7.7
plot74	7	4.6	2.5	20.1	17.8	16.4	5	60.5
plot75	6.6	2.4	2.6	12.2	11.4	6.9	5	35.6
plot76	9.1	4.5	4.5	14.9	19.3	10.4	5	40
plot77	8.6	5.4	5.4	17	17.3	12.7	5.6	42
plot78	6.1	0.9	0.9	7.5	7.4	2.2	5.1	15
plot79	7.5	2.1	2.1	10.6	11.9	8.1	5.2	32
plot80	5.2	2.9	2.9	12.9	11.1	7.2	5.2	42.9
plot81	4.5	0.9	0.9	7	8.4	3.2	5	21
plot82	5.4	1.6	1.6	7.3	8.8	3.1	5.5	16
plot83	7.5	4.7	4.7	16.2	14.1	8.3	5.2	29.8
plot84	7.7	4.6	4.6	19.1	13.4	9.1	5.3	36.1
plot85	7.7	3.5	3.5	12.9	14.3	9.6	5	53.3
plot86	6.7	3.7	3.7	14	12.7	8.9	5.1	36.4
plot87	9.4	4.6	4.6	16.2	16.4	9	5.6	33
plot88	7.6	4	4	14.1	13.6	6.6	6.2	26.9
plot89	9.2	4.5	4.5	14.4	21	10.1	5.3	33.8
plot90	4.1	0.9	0.9	7.1	9.1	3.7	6.6	22.7
plot91	10	3.7	3.7	15.9	15.8	7.5	5.5	42
plot92	9.3	6.4	6.4	18.8	30.1	38.6	5.6	107
plot93	5.6	3.2	3.2	18.9	9.9	9.2	5.2	49.9
plot94	5	2.7	2.7	14.4	8.7	5.8	5	28.3
plot95	7.9	4.6	4.6	14.9	15.7	9.1	8.2	31.5
plot96	10	3.3	3.3	13.5	18.3	5.4	7.1	28.7
plot97	6.2	2.2	2.2	9.2	15.3	10.5	5	46.2
plot98	6.9	3	3	13.2	10.8	6.8	5	27.6
plot99	10	4.3	4.3	16.3	17.5	12.6	5.2	45.1

Annex 3b: Descriptive statistics of vegetation data per plot (shrubs)

Descriptive stats of vegetation data per plot (shrubs)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
plot01	5.1	0.9	2.9	7.2	7.4	2.4	5.1	20.1
plot02	3.1	0.7	1.9	3.9	7.7	2.8	5	13.2
plot03	4.2	0.5	3.7	4.8	6.6	2.4	5	14.9
plot04	4		4	4	5.4		5.4	5.4
plot05	4.6	1.3	2	6.1	11.4	7.1	5.1	34.3
plot07	3.1	0.7	2.4	4.2	7	2.1	5	12
plot09	4.1	1.3	2	5.4	8.1	2.1	5.3	12.6
plot10	3.3		3.3	3.3	5.5		5.5	5.5
plot103	1		1	1	35.8		35.8	35.8
plot104	2.4	0.5	1	2.7	10.6	3.4	5.5	15.4
plot112	2.6	0.6	2.1	3.3	13.9	14.6	5.9	35.8
plot12	3.6	0.9	2.2	4.5	9.3	3.2	5.3	13.4
plot121	3.8		3.8	3.8	7.8		7.8	7.8
plot129	2.2	0.1	2.1	2.2	6.2	0.1	6.2	6.3
plot13	3.4	1	2	5	11.1	4.9	5.9	22.5
plot130	3		3	3	5.1		5.1	5.1
plot136	1.8	0.1	1.7	1.8	5.6	0.6	5.1	6
plot14	4.1	1.8	1.5	5.9	5.8	0.4	5.2	6.2
plot141	2.8	0.1	2.7	2.8	7.3	1.8	5.5	10.3
plot147	3.2	0.4	2.5	3.5	8.7	3.6	5.6	16.4
plot148	3.1	0	3.1	3.1	7.1	1	5.2	8.2
plot15	4.5	0	4.5	4.5	9.1	2.2	6.4	11.7
plot150	2.8		2.8	2.8	9.1		9.1	9.1
plot152	1.9	0.3	1.7	2.2	5.3	0.5	5	5.9
plot155	3.9	0.8	2.6	5	7.4	2.1	5	11.9
plot159	3.5		3.5	3.5	7		7	7
plot16	3.3	0.9	2.3	5.6	7.5	2.3	5	12
plot161	5.4	5.5	2	40	10	3.5	5.3	20.9
plot163	3		3	3	5.5		5.5	5.5
plot165	2.6		2.6	2.6	12.1		12.1	12.1
plot167	1.7	0.6	1.1	2.3	8.2	1.9	7	10.4
plot168	2.3		2.3	2.3	5		5	5
plot169	1.5	0.7	1	2	5.2	0.3	5	5.4
plot17	3.6	0.9	1.9	4.4	7.3	1.9	5.3	11
plot173	2.4	0	2.4	2.4	7.3	0.5	7	7.7
plot175	2.1	0	2.1	2.1	6.4	1	5.7	7.1

Descriptive stats of vegetation data per plot (shrubs)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
plot18	3.9	0.9	2	4.9	6.3	1.3	5.1	10.6
plot181	1.5		1.5	1.5	5		5	5
plot183	3.2	0.7	1.7	4.3	7.6	3	5	16.9
plot189	2.3	0.7	1.1	2.6	5.7	0.6	5	6.6
plot19	4.1	0.3	3.9	4.6	7.7	3.6	5.4	13.8
plot190	2	0.7	1.5	2.5	5.8	0.6	5.3	6.2
plot192	2.8	0.1	2.8	2.9	5.4	0.6	5	6.1
plot193	3.8	0.6	2.5	4.4	6.7	1.6	5	11.3
plot195	2.8		2.8	2.8	5.9		5.9	5.9
plot196	2.9	0.6	2	4	7.1	2.5	5.2	14.7
plot197	3	0	3	3	6.5	1.3	5	8
plot198	3.8	2.1	1.7	10	8.9	6	5.1	35.8
plot20	4.9	0.9	3.2	6.8	5.7	0.6	5	7
plot200	1.7	0.4	1.5	2.2	6.7	1.2	5.9	8.1
plot202	3.9	0.8	2.3	5	8.8	3.1	5.3	17.9
plot203	3.8	0.8	2.4	4.9	9.5	4.5	5	19.7
plot204	3.7	0.8	3.2	4.9	5.7	1	5.1	7.7
plot207	3.1		3.1	3.1	7.4		7.4	7.4
plot208	4.7	0.9	2.7	6.2	7.8	3.1	5	27.3
plot209	4.1	0.8	2.8	5.6	7.4	2	5.1	12.2
plot21	4.4	1	3.5	6.4	9.8	7.1	5.2	26
plot210	3.1	0.4	2.6	3.4	6.2	0.7	5.5	7.2
plot211	3.4	0.4	2.8	3.7	5.8	0.9	5	6.8
plot212	2.5	0.1	2.5	2.6	6.2	0.2	6	6.4
plot213	3.3	0.5	1.9	3.8	7.7	2.6	5.2	13.2
plot214	4.5	1.2	2.9	6	7.8	2.5	5.3	13.3
plot215	2.8	0	2.8	2.8	6.5	1.5	5	7.9
plot219	4.1	0.1	4	4.2	5.9	1	5	8.3
plot22	4.6	0.7	3	5.9	6.5	1.8	5	12
plot220	4.3	1.2	3.2	6.3	11.7	5.3	5	22.5
plot221	2.9	0.5	2	3.3	6	1	5	8
plot222	3.1	0.5	2.7	4	5.9	0.7	5	7.3
plot223	2.8	0.5	2.5	3.5	6.2	0.6	5.7	6.9
plot224	4.1	0.5	3.4	4.6	7.4	2	5	10
plot225	4.9	0.8	3.5	7	6.3	1.2	5	11.1
plot226	3.6	0.7	2.7	5	7.4	2.5	5.1	14.2
plot227	2.9		2.9	2.9	5.6		5.6	5.6

Descriptive stats of vegetation data per plot (shrubs)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
plot228	4.1	0.6	3.7	4.5	9.9	0	0	9.9
plot229	3.3	0.7	2.3	3.9	6.8	1.7	1.7	9.2
plot23	3.7	0.4	3	4.2	9.8	5.9	5.9	21.5
plot230	2.4	0	2.4	2.4	5.6	0.1	0.1	5.6
plot231	3.4	0.4	3.1	3.7	5.6	0.8	0.8	6.2
plot232	4.2	0.5	3.2	5	6.2	0.9	0.9	8.5
plot234	2.5	0.2	2.4	2.7	5.4	0.4	0.4	5.9
plot235	3.9	0.8	2.5	5	7	1.6	1.6	10.6
plot236	3.6	0.6	3	4.5	6	0.6	0.6	6.5
plot237	2.8		2.8	2.8	6.1			6.1
plot238	2.9	0.5	1.9	3.5	6.1	1.7	1.7	10.3
plot24	4.8	0.7	2.5	5.5	9.1	3.7	3.7	26
plot240	3.6	0.1	3.5	3.7	5.8	0.1	0.1	5.9
plot241	2.6	0.2	2.3	3	5.6	0.5	0.5	6.5
plot248	2	0	2	2	5.2	0.4	0.4	5.5
plot249	4	0.9	2.7	5.3	8.8	7.2	7.2	35.8
plot25	4.3	1.2	2.4	6.6	7.5	2.5	2.5	12.8
plot250	3.1	0.4	2.7	3.5	12.4	8.4	8.4	28.5
plot251	3.6	0.9	2	5.5	8	3.2	3.2	16.4
plot253	3.3	0.8	2	4.2	7.4	1.7	1.7	11.1
plot254	3.4	0.2	3.2	3.6	8.4	2.1	2.1	12.6
plot255	4.3	1	2.5	5.5	8.6	3	3	15.7
plot256	2.8	0.6	2.3	3.7	7.9	1.4	1.4	9.5
plot257	4	0.2	3.5	4.2	8.6	2.3	2.3	12.1
plot258	3	0.3	2.5	3.2	7.1	2.3	2.3	10.3
plot259	3.8	0	3.8	3.8	7.1	0.1	0.1	7.2
plot26	4	0.5	2	4.5	6.8	1.5	1.5	10.5
plot260	2.5	0.4	2	3.3	7.5	2.5	2.5	12.2
plot261	2.4	0.6	2	3.5	6.6	1.6	1.6	10.4
plot262	3.5	0.8	1.5	4.8	7	1.9	1.9	13.9
plot263	2	0.2	1.9	2.2	9.4	1.6	1.6	10.5
plot264	2		2	2	6.9			6.9
plot265	3.4	1.2	1.6	5.5	8.5	3.6	3.6	19.8
plot266	2.3	0.4	1.5	2.5	6.3	1	1	7.8
plot267	3.5	1.3	1.8	4.6	8.8	3.4	3.4	17.8
plot268	3.5	0.8	1.9	4.3	7.2	2.6	2.6	19.4
plot269	1.9	0.2	1.7	2	7.2	1.7	1.7	9.7

Descriptive stats of vegetation data per plot (shrubs)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
plot27	4	1.3	2.4	6	6.9	1.6	5	13
plot270	4.4	0.6	3.8	5	12.2	4.5	6.1	23.9
plot273	3.8	1	2.2	5.3	8.3	2.8	5.1	20.3
plot274	2.8	0.5	2	3.2	9.3	4.4	5.2	21.5
plot275	3.6	0.2	3.4	3.9	11.5	7.1	5	24.6
plot276	3.1	0.4	2.8	3.5	12.8	2.5	9.1	15.8
plot278	3.1	0.9	1.2	5	8.8	6.3	5.3	29.8
plot28	4.2	0.8	3	6.1	7.1	1.4	5.2	10.4
plot280	2.6	0.3	2	2.8	8.7	3.5	6	17
plot281	1.6	0.6	1.1	3	6.3	0.6	5.4	7.6
plot282	4.6	0.9	3.6	6	10.3	2.9	6.5	16
plot283	3.7	1.1	2.5	4.7	7.3	2.1	5.3	12.3
plot284	2.1	0.6	1.4	3	6.1	0.8	5	7.1
plot285	5	0.6	1.3	5.6	10.1	3.6	5.1	17.8
plot286	2.7	1.5	1.7	4.4	8.9	3.1	6.1	12.3
plot287	4	1.3	1.8	6.1	10.5	6.7	5.1	31.2
plot289	4.8	0.3	4	5.2	10.6	6.1	5	26.5
plot29	3.2	0.4	2.7	4.2	5.8	0.6	5	7.2
plot290	2.1		2.1	2.1	7		7	7
plot291	5.6	1.3	3.7	6.4	10.1	2.3	6.5	13.4
plot292	2.2	0.8	1	3.8	7.1	2	5.1	12.2
plot294	2.4	0.9	1	4	8.8	5.3	5.1	23
plot295	3.8	0.6	2.6	4.2	10.2	4	5.5	17.7
plot296	2.6	0.2	2.3	3.1	8	2.1	5.2	12
plot31	3.5	0	3.5	3.5	7.4	1.8	5.5	9
plot32	3.2	1	1.6	4	6.5	1.2	5.1	7.9
plot33	3.2	1	1.6	4	6.5	1.2	5.1	7.9
plot34	4.3	1.3	2.3	6.5	8.2	4.1	5	20.9
plot35	3	0.3	2.7	3.8	5.7	0.7	5	7.3
plot36	4.1	0.6	3	5.6	6.8	1.7	5	11.3
plot37	5.2	1.1	3.2	7.1	8.1	2.6	5	16.8
plot39	3.4	0.2	3.2	3.5	7.2	0.4	6.9	7.5
plot40	4.8	1.2	3.2	6.4	7.7	4	5.1	21
plot42	4.5	1.2	1.6	5.5	7.4	1.7	5	11
plot43	4.6	0.9	3.2	6	6.4	1	5.1	8.1
plot44	4.2	0.4	3.5	4.7	6.5	1	5.1	8.1
plot45	4.8	0.5	4	5.1	6.7	1.7	5	9.2

Descriptive stats of vegetation data per plot (shrubs)								
PLOT_ID	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
plot46	4.7	0.7	2.7	5.3	6.7	1.6	5	11.5
plot47	4.4	0.9	3	6	6.1	1.4	5	11.3
plot48	4.6	0.5	3.4	5	7.3	1.7	5.8	10.7
plot51	4.4	0.9	2.5	5.8	6.9	2	5	12
plot52	3.9	1.1	3.1	5.2	6.4	1.1	5.5	7.7
plot54	3.6	0.5	3.1	4.2	6.2	0.9	5.1	7.4
plot55	4.8	0.6	3.5	5.8	7.8	2.5	5	13
plot56	5.3	1	2.7	6.5	9.1	3.4	5.3	16.4
plot57	5	0.8	3.2	5.5	6.9	0.9	5.5	8.1
plot58	4.5	0.8	3.3	5.3	7	1.2	5	9.2
plot59	4.3	0.9	2	5.5	8.4	2.8	5.3	17.7
plot60	4.2	0.7	3.8	5.3	6.1	1	5.1	7.9
plot62	4.8	1.1	3	6.2	6.2	1.4	5	9.6
plot63	4.4	0.6	4	5.3	8.9	1.3	6.2	10.2
plot65	3.5	0.2	3.3	3.7	8.8	2.6	5	10.6
plot66	3.6	1	2.5	5.3	7	1.5	5.2	9.4
plot67	4.7	1.2	2.5	7.3	7.1	2.9	5.1	16
plot69	3.9	0.7	2.5	4.5	8	5.7	5.1	22
plot70	5.4	2.5	3.3	9.9	6.2	0.9	5.3	7.4
plot71	4.9	0.2	4.7	5	6.2	1.5	5.1	9.1
plot72	4.3	0.9	3.2	4.8	7.3	1.9	5.4	9.2
plot73	3.3	0.3	2.4	3.7	9.8	9.8	5.1	35.8
plot74	2.8	0.9	2	4.1	6.4	1	5.2	7.3
plot75	4	0.9	2	6	8.2	2.5	5.1	14
plot77	3.7	0.5	2.7	4.2	6.8	1.6	5.2	10
plot78	4.4	0.9	2.8	5.1	8.6	4.2	5	15.2
plot79	3.8	0.3	3.5	4.1	6.6	1.2	5.5	7.9
plot81	4.4	1	3.1	6.6	7.2	1.7	5	11.3
plot82	3.4	0.6	2.5	4.3	6.6	1	5.2	8.5
plot85	2	0.6	1.6	2.5	5.4	0.1	5.3	5.5
plot87	4.6		4.6	4.6	6.7		6.7	6.7
plot88	3.6	0.3	3.3	4	6.8	1.6	5	10.6
plot89	3.7	0.6	2.7	4.4	6.3	0.9	5.2	8
plot90	3.1	0.5	2	3.6	6.5	1	5.2	8.4
plot91	2.5	0	2.5	2.5	7.1	1.1	6.3	7.9
plot92	3.5	0.5	2.5	4.1	6.6	1	5.1	8.7
plot95	4.1	0.1	4	4.2	8.3	0.4	8	8.6
plot97	3.3	0.2	3.2	3.5	5.6	0.4	5.3	6.1

Annex 4a: Descriptive statistics of vegetation data per species (trees)

Descriptive stats of vegetation data per species (trees)								
SP	**mean_H**	**sd_H**	**min_H**	**max_H**	**mean_DBH**	**sd_DBH**	**min_DBH**	**max_DBH**
ACGA	11.1	7	5.1	18.2	40.5	29.6	14	72
ACGE	4.3	1.7	1.9	8.2	8.3	3.6	5	16.5
ACGR	3.6	0.8	1.9	4.5	6.2	1	5.1	8.4
ACNI	6.2	3	2.3	18.1	11.2	9.2	5	64
ACNIL	5.3	1.1	3.3	8	11.8	4.1	5.7	21.8
ACTO	5	1.2	1.9	13	9.2	5.1	5	54.6
ADDI	12.9		12.9	12.9	18.9		18.9	18.9
ALAN	6.6	1.8	2.7	10.3	13.2	5.2	5.1	30.6
ALGL	27.6	2.5	25.8	29.3	101	8.5	95	107
BAAE	3.7	1.8	1.9	7.5	7.3	1.6	5	10.6
BAMA	8.9	6.5	3.8	18.5	28.8	35	5.6	75
BEDI	10.9	5	3.1	16.3	34.6	16.1	5.9	48.6
BOAL	3.5		3.5	3.5	8.8		8.8	8.8
BOFO	6.5	1.7	5.3	7.7	14.2	4.5	11	17.3
BRSP	14.4	0.4	14.1	14.7	41.1	3.7	38.5	43.8
CAAB	9	3.1	4	12.8	21.8	9.2	5.1	30.5
COAF	2.8	0.7	2	4	7.1	2.1	5	9.6
COAP	6.8	1.7	2.2	16.6	8.2	3.7	5	42.1
COED	5.8		5.8	5.8	25.2		25.2	25.2
COGL	3.4	1.4	1.8	5.7	9.6	4.4	5	17
COHE	7	1.7	3.7	10.9	11.1	4.6	5.2	30
COIM	8.9	4.4	2.2	24.5	19.5	15.2	5.4	70
COMA	7.9		7.9	7.9	39.9		39.9	39.9
COMMO	8.7	1.8	7.4	9.9	25.6	0.6	25.2	26.1
COMO	7.3	3.3	1.2	35	13	8.2	5	85.2
CONE	6.9	4.9	3.4	10.4	18.9	18.2	6	31.7
COZE	5.4	1.2	4.4	6.5	7.2	2	5.3	10.6
CRME	6.6	2.1	3.3	14	9.8	5.1	5.1	35
DAME	3.4	1.2	2.2	5.4	8.3	3.6	5.1	15.9
DIME	7.5	5.6	1.6	21.4	14.4	12.1	5.3	65
DIQU	5.9	1.7	2	11.5	10	4.7	5	41.4
DIUS	6.8	0.1	6.8	6.9	16.7	3.2	11	20.1
DRGE	5.4		5.4	5.4	10.3		10.3	10.3
DRMO	3.5		3.5	3.5	9.6		9.6	9.6
FIAB	7.8	2.1	6.3	9.2	23	11.3	15	31
FITE	6.1		6.1	6.1	31.6		31.6	31.6

Descriptive stats of vegetation data per species (trees)								
SP	**mean_H**	**sd_H**	**min_H**	**max_H**	**mean_DBH**	**sd_DBH**	**min_DBH**	**max_DBH**
ACGA	11.1	7	5.1	18.2	40.5	29.6	14	72
ACGE	4.3	1.7	1.9	8.2	8.3	3.6	5	16.5
ACGR	3.6	0.8	1.9	4.5	6.2	1	5.1	8.4
ACNI	6.2	3	2.3	18.1	11.2	9.2	5	64
ACNIL	5.3	1.1	3.3	8	11.8	4.1	5.7	21.8
ACTO	5	1.2	1.9	13	9.2	5.1	5	54.6
ADDI	12.9		12.9	12.9	18.9		18.9	18.9
ALAN	6.6	1.8	2.7	10.3	13.2	5.2	5.1	30.6
ALGL	27.6	2.5	25.8	29.3	101	8.5	95	107
BAAE	3.7	1.8	1.9	7.5	7.3	1.6	5	10.6
BAMA	8.9	6.5	3.8	18.5	28.8	35	5.6	75
BEDI	10.9	5	3.1	16.3	34.6	16.1	5.9	48.6
BOAL	3.5		3.5	3.5	8.8		8.8	8.8
BOFO	6.5	1.7	5.3	7.7	14.2	4.5	11	17.3
BRSP	14.4	0.4	14.1	14.7	41.1	3.7	38.5	43.8
CAAB	9	3.1	4	12.8	21.8	9.2	5.1	30.5
COAF	2.8	0.7	2	4	7.1	2.1	5	9.6
COAP	6.8	1.7	2.2	16.6	8.2	3.7	5	42.1
COED	5.8		5.8	5.8	25.2		25.2	25.2
COGL	3.4	1.4	1.8	5.7	9.6	4.4	5	17
COHE	7	1.7	3.7	10.9	11.1	4.6	5.2	30
COIM	8.9	4.4	2.2	24.5	19.5	15.2	5.4	70
COMA	7.9		7.9	7.9	39.9		39.9	39.9
COMMO	8.7	1.8	7.4	9.9	25.6	0.6	25.2	26.1
COMO	7.3	3.3	1.2	35	13	8.2	5	85.2
CONE	6.9	4.9	3.4	10.4	18.9	18.2	6	31.7
COZE	5.4	1.2	4.4	6.5	7.2	2	5.3	10.6
CRME	6.6	2.1	3.3	14	9.8	5.1	5.1	35
DAME	3.4	1.2	2.2	5.4	8.3	3.6	5.1	15.9
DIME	7.5	5.6	1.6	21.4	14.4	12.1	5.3	65
DIQU	5.9	1.7	2	11.5	10	4.7	5	41.4
DIUS	6.8	0.1	6.8	6.9	16.7	3.2	11	20.1
DRGE	5.4		5.4	5.4	10.3		10.3	10.3
DRMO	3.5		3.5	3.5	9.6		9.6	9.6
FIAB	7.8	2.1	6.3	9.2	23	11.3	15	31
FITE	6.1		6.1	6.1	31.6		31.6	31.6
FITE	6.1		6.1	6.1	31.6		31.6	31.6

Descriptive stats of vegetation data per species (trees)								
SP	mean_H	sd_H	min_H	max_H	mean_DBH	sd_DBH	min_DBH	max_DBH
GAVO	5.2	1.2	3.7	6.1	13.3	6.1	7	23.3
JUGL	9.4	0	9.4	9.4	25.7	5.9	21.5	29.9
KIAC	14.3	5.1	4.7	20.1	51.3	30.8	8.2	107
KIAF	15	6.8	10.1	25	61.4	25.5	24	80
LASC	8.2	3.5	3	15.3	22.2	13.2	5.9	49.9
MAMO	4.1	0	4.1	4.1	8.4	2.4	6.7	11.1
MAZA	6	1.2	4.2	7.8	8.4	4.9	5	19.5
PACA	2.3		2.3	2.3	5.7		5.7	5.7
PEAF	5.1	0.6	4.7	5.8	9.2	6.1	5.1	21.4
PHVI	7	5.5	2.9	22	16.1	14.9	5.3	54.4
PSMA	3.6		3.6	3.6	7.6		7.6	7.6
SCBI	9.9	1.7	8.5	12.2	38.2	13.9	25.7	57.7
SELE	5	0	5	5	8.8	0.8	8.1	9.6
STMA	4.5	1.6	2.5	6.5	7.7	3.1	5.3	15.8
STOP	7.2	2.5	4.4	11.5	11.3	6	5.2	25.3
STPO	6	2	3.8	9.3	10.5	5	5.1	19.3
STRO	5.3	1.3	3.5	7.2	15.2	7.1	5.4	32.6
SYGU	3.5	0.8	2.3	4.5	8.7	1	7.3	10.3
TAEL	6	2.2	3.3	9.1	14.8	5.5	9.9	26.1
TEPR	7.3	2.1	3.2	13.5	12	8.6	5.1	53.3
XAZA	13.8	6.4	4.4	23.2	30.7	26.7	11.8	82
XEST	14.1	6.5	4	20.1	25.5	15.7	5.3	52.3
ZIMU	5	1.6	2.6	8.1	11.2	4.7	5.1	24.5

Annex 4b: Descriptive statistics of vegetation data per species (shrubs)

Descriptive stats of vegetation data per species (shrubs)								
SP	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
ACER	4.4	1	2	7	7.6	3.3	5	35.8
ACSC	3.5	0.7	2.7	5	6.4	1.4	5.1	8.8
ALAL	3.6	1.2	2.2	5	7.3	1.9	5	10.1
ARBR	3.1		3.1	3.1	5		5	5
BOMO	3.9	1.2	1	6.3	11.7	6.4	5	35.8
BRCA	2.5	0.4	1.7	3	9	1.6	6.4	10.7
BRMO	3.5	0	3.5	3.5	7.4	1.8	5.5	9
BRRO	5.5	0.5	5.1	6.5	11.1	5.6	5.7	20.9
CAAF	4.1	0.9	2.5	5.4	9.4	4.3	5.1	22.5
CAGL	4.1	0.6	3.2	4.5	5.9	1	5.2	8

Descriptive stats of vegetation data per species (shrubs)								
SP	mean_H	sd_H	min_H	max_H	mean_D_BAS	sd_D_BAS	min_D_BAS	max_D_BAS
CLKI	4.8	0.4	4.2	5	10.2	2.7	7.9	14.1
COAD	4.4	1.9	2.6	7.1	6.5	1.5	5.2	9.7
COAF	3.9	0.5	3.5	4.8	8.7	3.5	5	16.5
COGR	4.2	1	2.6	5	6.6	1.4	5	8.7
COMON	4.1	1.5	1.4	10	8	2.7	5.1	16.3
COPA	4.7	0.9	3.3	9.9	6.5	1.4	5	12
DICI	4.2	1.6	1.7	40	7.6	2.8	5	35.8
DILY	4	0.6	3.2	4.5	5.5	0.7	5	6.5
DORO	4	0.3	3.4	4.3	6.2	1	5	7.9
EHRI	3	0.8	2.3	3.8	6.2	0.7	5.5	6.9
EUDI	4.2	0.9	1.6	5.7	6	1	5	7.8
FICA	3.8	0	3.8	3.8	5.2	0.2	5	5.4
FLVI	4.2	0.6	3.1	4.6	7.1	1	5.5	8.4
FROB	2.2		2.2	2.2	5.3		5.3	5.3
GARE	2.8	0.5	1.6	4.5	7.9	3.2	5	17.7
GRBI	3.2	1	1	5.5	7.3	2.5	5	23
GRFL	3.5	1	1.1	7.3	6.3	1.3	5	11.7
GRGR	3.1	0.9	2.5	3.8	6	0.8	5.4	6.6
GRIN	4.6	1.2	2	7.2	7.5	2.7	5	20.1
GRMO	3.8	1.3	1.5	7.1	7.6	3.4	5	35.8
GYBU	4.1	0.3	3.2	4.2	6.8	2.3	5.1	15.8
GYSE	4.1	1	2.4	5.7	7.8	3	5	19.7
LACA	2.4	0.6	2	3.3	9.2	3.5	5.9	12.4
MIUS	5.7	1.2	3.7	6.8	6.6	1.7	5.1	9
MOJU	4.4	0.6	3.7	4.7	5.6	0.7	5.1	6.4
MUSE	4.6	0.4	4.3	4.8	7	0.8	6.4	7.5
PHPI	3.7	0.9	3	5.3	6.2	1.4	5.3	9
PHRE	3	0.6	2.1	3.8	5.9	0.5	5.5	6.8
RHZA	2.8	0.2	2.7	3.1	7.4	0.9	6.8	8.4
SAAU	2.5	0.7	1.1	3.5	7.8	2.7	5.2	16.4
SAPE	3.7	1.8	1	6.4	8.1	2.4	5.1	13.4
THAF	2.7	0.9	1.3	5	6.3	1.2	5	9.1
VIFE	4.3	1.1	2.3	6	8.1	2.4	5	16.8
VIMO	6	0.2	5.6	6.1	7.5	2.4	5.3	13.8
XIAM	3.7	1.5	1.5	4.4	10.1	8	5	22
ZAAF	2.5		2.5	2.5	8.7		8.7	8.7
ZACA	3.2	1.3	1.7	4.6	7.6	2.5	5	13.1
ZAHU	2	0.4	1.7	2.3	8.6	2.5	6.8	10.4

Annex 5: stDW per ha per plot (in tCO_2)

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
DIO	plot01	24.18
XAN	plot02	4.24
DIO	plot03	0
DIO	plot04	34.3
XAN	plot05	0
DIO	plot06	0
DIO	plot07	0
XAN	plot08	0
XAN	plot09	1.36
XAN	plot10	0
COL	plot100	21.73
COL	plot101	0
COL	plot102	3.31
COL	plot103	9.62
COL	plot104	0
COL	plot105	12.12
COL	plot106	0.15
COL	plot107	17.4
COL	plot108	8.95
COL	plot109	19.63
COL	plot110	1.42
COL	plot111	21.65
COL	plot112	0
COL	plot113	8.05
COL	plot114	6.88
COL	plot115	13.72
COL	plot116	0
COL	plot117	0
COL	plot118	1.58
COL	plot119	1.45
DIO	plot12	8.62
COL	plot120	0
COL	plot121	0
COL	plot122	35.35
COL	plot123	0
COL	plot124	26.48
COL	plot125	0.42

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
COL	plot126	17.26
COL	plot127	12.75
COL	plot128	9.22
COL	plot129	0.33
DIO	plot13	0
COL	plot130	14.59
COL	plot131	8.4
COL	plot132	0.27
COL	plot133	8.52
COL	plot134	0
COL	plot135	0
COL	plot136	0
COL	plot137	0
COL	plot138	15.9
COL	plot139	0
COM	plot14	0.09
COL	plot140	0
COL	plot141	0
COL	plot142	5.23
COL	plot143	0
COL	plot144	16.22
COL	plot145	5.38
COL	plot146	5.28
COL	plot147	5.56
ACA	plot148	0
COL	plot149	0.9
COM	plot15	0
COL	plot150	0
COL	plot151	14.26
COL	plot152	0.22
COL	plot153	12.42
COL	plot154	1.04
COM	plot155	3.46
COL	plot156	0
COL	plot157	2.04
COL	plot158	2.26
COL	plot159	0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
COM	plot16	3.69
COL	plot160	0.84
COL	plot161	0
COL	plot162	37.06
COL	plot163	7.63
COL	plot164	2.01
COL	plot165	3.74
COL	plot166	15.32
COL	plot167	2.09
COL	plot168	0
COL	plot169	11.53
COM	plot17	11.12
COL	plot170	1.3
COL	plot171	0.78
COL	plot172	0
COL	plot173	16.69
COL	plot174	1.26
COL	plot175	1.78
COL	plot176	0.39
COL	plot177	2.87
COL	plot178	0
COL	plot179	14.45
COM	plot18	2.84
COL	plot180	9.39
COL	plot181	0.29
COL	plot182	8.23
COL	plot183	1.91
COL	plot184	2.6
COL	plot185	1.13
COL	plot186	26.89
COL	plot187	1.78
COL	plot188	4.04
COL	plot189	33.13
COM	plot19	8.43
COL	plot190	0
COL	plot191	12.27
COL	plot192	0
COL	plot193	0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
COL	plot194	10.21
COL	plot195	5.24
COL	plot196	0
COL	plot197	7.04
DIO	plot198	0
COL	plot199	7.52
COM	plot20	1.48
COL	plot200	45.65
COL	plot201	0
ACA	plot202	0.75
DIO	plot203	0
COM	plot204	7.63
COM	plot205	0
COL	plot206	2.29
COL	plot207	14.28
COM	plot208	0.6
COM	plot209	0
COM	plot21	1.38
COL	plot210	13.2
COL	plot211	0
COL	plot212	1.52
COL	plot213	0
ACA	plot214	10.83
COL	plot215	0
COL	plot218	35.77
KIR	plot219	0
COM	plot22	8.53
ACA	plot220	0
KIR	plot221	1.9
COL	plot222	0
COL	plot223	0.51
COL	plot224	0.2
COL	plot225	7.93
ACA	plot226	0
COL	plot227	21.8
ACA	plot228	6.01
COL	plot229	2.11
COM	plot23	6.11

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
COL	plot230	4.69
COM	plot231	1.43
COL	plot232	1.08
COL	plot233	4.46
COL	plot234	0
XAN	plot235	0
XAN	plot236	8.42
COL	plot237	8.51
COL	plot238	0
COL	plot239	6.93
COM	plot24	0.29
COL	plot240	0
COL	plot241	0
COL	plot242	3.72
COL	plot243	0.26
COL	plot244	0
COL	plot245	6.27
COL	plot246	0.18
COL	plot247	0.2
COL	plot248	0
COL	plot249	1.3
COM	plot25	0
XAN	plot250	0
COL	plot251	6.57
COL	plot252	0
COM	plot253	0
ACA	plot254	12.1
COM	plot255	0
KIR	plot256	0
ACA	plot257	0
COM	plot258	24.79
COM	plot259	0
COM	plot26	14.98
ACA	plot260	0.07
ACA	plot261	0
ACA	plot262	0
ACA	plot263	0
ACA	plot264	0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
ACA	plot265	0
ACA	plot266	0
ACA	plot267	0
ACA	plot268	0
COL	plot269	0
COM	plot27	31.91
ACA	plot270	0
ACA	plot271	0
ACA	plot272	0
ACA	plot273	0.51
ACA	plot274	3.08
ACA	plot275	2.74
COL	plot276	0
ACA	plot277	6.49
ACA	plot278	11.09
ACA	plot279	8.37
COM	plot28	3.32
ACA	plot280	0
ACA	plot281	0
ACA	plot282	0
ACA	plot283	0
ACA	plot284	0
ACA	plot285	0
ACA	plot286	9.09
ACA	plot287	0
ACA	plot288	0
ACA	plot289	1.65
COM	plot29	3.83
ACA	plot290	0
ACA	plot291	0
ACA	plot292	5.44
ACA	plot293	0
COL	plot294	0
ACA	plot295	0
COL	plot296	3.28
COL	plot297	19.97
ACA	plot298	14.68
COL	plot299	0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO_2
COM	plot30	0
XAN	plot300	0
COM	plot31	5.85
COM	plot32	1.08
COM	plot33	1.08
COM	plot34	0
COM	plot35	2.26
COM	plot36	0
COM	plot37	0
COL	plot38	6.47
COM	plot39	33.77
COM	plot40	0
DIO	plot42	6.14
COM	plot43	6.05
COM	plot44	0
COM	plot45	2.63
COM	plot46	0.36
COM	plot47	1.2
COM	plot48	0
COM	plot49	4.71
COM	plot50	1.42
ACA	plot51	7.07
COM	plot52	0.13
COM	plot54	0
COM	plot55	3.85
COM	plot56	0
ACA	plot57	0
ACA	plot58	0.26
COM	plot59	5.57
COM	plot60	6.26
COM	plot62	0.53
COM	plot63	0.15
COM	plot64	0
COM	plot65	0
COM	plot66	1.06
COM	plot67	0.24
COM	plot69	13.42
COM	plot70	0.8
COM	plot71	3.13
COM	plot72	3.79
COM	plot73	2.22
KIR	plot74	14.3
COM	plot75	1.13
COL	plot76	1.87
COL	plot77	0
COM	plot78	0
COM	plot79	6.8
COL	plot80	0
COL	plot81	0.84
ACA	plot82	4.14
COL	plot83	6.96
COL	plot84	6.07
COL	plot85	0.79
COL	plot86	7.16
COL	plot87	7.37
COL	plot88	0.26
COL	plot89	0
COL	plot90	0
COL	plot91	2
COL	plot92	1.16
COL	plot93	5.14
COL	plot94	37.32
COL	plot95	2.69
COL	plot96	8.03
COL	plot97	0
COL	plot98	3.4
COL	plot99	0.95

Annex 6: CWD per ha per plot (in tCO_2)

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
DIO	plot01	2.7
XAN	plot02	12.8
DIO	plot03	5.3
DIO	plot04	3.1
XAN	plot05	0.0
DIO	plot06	0.0
DIO	plot07	0.0
XAN	plot08	0.0
XAN	plot09	0.0
XAN	plot10	15.5
COL	plot100	0.8
COL	plot101	0.9
COL	plot102	1.9
COL	plot103	0.5
COL	plot104	2.1
COL	plot105	9.9
COL	plot106	0.9
COL	plot107	5.7
COL	plot108	3.7
COL	plot109	1.8
COL	plot110	0.2
COL	plot111	1.2
COL	plot112	6.3
COL	plot113	2.1
COL	plot114	16.4
COL	plot115	4.5
COL	plot116	0.0
COL	plot117	0.0
COL	plot118	0.0
COL	plot119	0.0
DIO	plot12	1.5
COL	plot120	3.4
COL	plot121	6.3
COL	plot122	8.8
COL	plot123	2.9
COL	plot124	10.6
COL	plot125	0.0
COL	plot126	0.5
COL	plot127	1.3
COL	plot128	2.5
COL	plot129	0.7
DIO	plot13	13.9
COL	plot130	0.0
COL	plot131	2.5
COL	plot132	1.0
COL	plot133	1.2
COL	plot134	0.0
COL	plot135	1.2
COL	plot136	1.2
COL	plot137	0.7
COL	plot138	0.5
COL	plot139	0.0
COM	plot14	0.0
COL	plot140	0.0
COL	plot141	1.3
COL	plot142	1.7
COL	plot143	1.3
COL	plot144	11.9
COL	plot145	4.3
COL	plot146	1.1
COL	plot147	8.3
ACA	plot148	0.0
COL	plot149	14.0
COM	plot15	0.8
COL	plot150	5.8
COL	plot151	0.7
COL	plot152	6.7
COL	plot153	3.0
COL	plot154	1.2
COM	plot155	0.1
COL	plot156	0.3
COL	plot157	0.0
COL	plot158	0.5
COL	plot159	1.0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO_2
COM	plot16	3.4
COL	plot160	0.0
COL	plot161	0.0
COL	plot162	7.9
COL	plot163	6.0
COL	plot164	0.4
COL	plot165	19.4
COL	plot166	0.8
COL	plot167	0.9
COL	plot168	3.0
COL	plot169	11.9
COM	plot17	18.9
COL	plot170	44.3
COL	plot171	0.9
COL	plot172	15.8
COL	plot173	3.5
COL	plot174	10.5
COL	plot175	3.0
COL	plot176	7.7
COL	plot177	3.3
COL	plot178	0.0
COL	plot179	4.8
COM	plot18	0.4
COL	plot180	3.2
COL	plot181	3.7
COL	plot182	3.1
COL	plot183	1.0
COL	plot184	3.7
COL	plot185	1.7
COL	plot186	1.1
COL	plot187	12.7
COL	plot188	0.3
COL	plot189	11.8
COM	plot19	6.5
COL	plot190	11.9
COL	plot191	8.4
COL	plot192	1.9
COL	plot193	13.7

VEG_ID	PLOT_ID	HA_P_Cpool_tCO_2
COL	plot194	3.8
COL	plot195	75.3
COL	plot196	16.9
COL	plot197	1.0
DIO	plot198	0.0
COL	plot199	5.9
COM	plot20	0.8
COL	plot200	0.2
COL	plot201	0.5
ACA	plot202	0.0
DIO	plot203	3.1
COM	plot204	0.2
COM	plot205	1.7
COL	plot206	1.9
COL	plot207	0.3
COM	plot208	0.0
COM	plot209	5.7
COM	plot21	0.0
COL	plot210	9.5
COL	plot211	2.3
COL	plot212	18.6
COL	plot213	0.0
ACA	plot214	0.7
COL	plot215	0.0
COL	plot218	1.5
KIR	plot219	0.1
COM	plot22	0.0
ACA	plot220	1.1
KIR	plot221	103.1
COL	plot222	0.3
COL	plot223	2.8
COL	plot224	0.0
COL	plot225	2.0
ACA	plot226	0.4
COL	plot227	0.0
ACA	plot228	0.6
COL	plot229	3.7
COM	plot23	24.0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO$_2$
COL	plot230	10.9
COM	plot231	0.1
COL	plot232	0.0
COL	plot233	3.2
COL	plot234	0.5
XAN	plot235	0.0
XAN	plot236	11.4
COL	plot237	2.2
COL	plot238	3.4
COL	plot239	0.1
COM	plot24	1.4
COL	plot240	0.0
COL	plot241	4.9
COL	plot242	0.1
COL	plot243	13.1
COL	plot244	0.0
COL	plot245	1.5
COL	plot246	9.9
COL	plot247	0.3
COL	plot248	0.0
COL	plot249	10.9
COM	plot25	4.3
XAN	plot250	2.9
COL	plot251	4.0
COL	plot252	2.1
COM	plot253	10.7
ACA	plot254	0.8
COM	plot255	21.1
KIR	plot256	0.0
ACA	plot257	0.3
COM	plot258	1.1
COM	plot259	9.5
COM	plot26	2.0
ACA	plot260	0.8
ACA	plot261	4.3
ACA	plot262	0.0
ACA	plot263	5.4
ACA	plot264	0.1

VEG_ID	PLOT_ID	HA_P_Cpool_tCO$_2$
ACA	plot265	0.1
ACA	plot266	0.0
ACA	plot267	0.0
ACA	plot268	39.7
COL	plot269	0.8
COM	plot27	1.2
ACA	plot270	0.0
ACA	plot271	0.0
ACA	plot272	0.0
ACA	plot273	4.4
ACA	plot274	3.3
ACA	plot275	0.3
COL	plot276	4.3
ACA	plot277	0.0
ACA	plot278	0.0
ACA	plot279	0.4
COM	plot28	0.0
ACA	plot280	0.0
ACA	plot281	1.5
ACA	plot282	0.0
ACA	plot283	0.0
ACA	plot284	0.0
ACA	plot285	0.0
ACA	plot286	1.6
ACA	plot287	0.0
ACA	plot288	0.0
ACA	plot289	0.0
COM	plot29	4.5
ACA	plot290	0.0
ACA	plot291	0.0
ACA	plot292	3.4
ACA	plot293	0.8
COL	plot294	3.6
ACA	plot295	2.4
COL	plot296	2.7
COL	plot297	12.5
ACA	plot298	2.6
COL	plot299	8.5

VEG_ID	PLOT_ID	HA_P_Cpool_tCO_2
COM	plot30	0.3
XAN	plot300	4.2
COM	plot31	2.7
COM	plot32	0.0
COM	plot33	0.0
COM	plot34	0.0
COM	plot35	2.6
COM	plot36	20.5
COM	plot37	0.0
COL	plot38	13.4
COM	plot39	1.9
COM	plot40	2.3
DIO	plot42	4.9
COM	plot43	1.9
COM	plot44	7.5
COM	plot45	2.1
COM	plot46	1.9
COM	plot47	7.2
COM	plot48	1.7
COM	plot49	1.3
COM	plot50	0.0
ACA	plot51	0.1
COM	plot52	0.0
COM	plot54	1.0
COM	plot55	1.9
COM	plot56	0.7
ACA	plot57	0.5
ACA	plot58	1.4
COM	plot59	7.0
COM	plot60	1.5
COM	plot62	0.0
COM	plot63	0.4
COM	plot64	0.0
COM	plot65	1.7
COM	plot66	13.7
COM	plot67	0.2
COM	plot69	2.2
COM	plot70	2.1

VEG_ID	PLOT_ID	HA_P_Cpool_tCO_2
COM	plot71	7.1
COM	plot72	24.7
COM	plot73	32.5
KIR	plot74	10.5
COM	plot75	7.5
COL	plot76	7.5
COL	plot77	3.2
COM	plot78	0.4
COM	plot79	3.5
COL	plot80	2.1
COL	plot81	3.0
ACA	plot82	0.0
COL	plot83	6.9
COL	plot84	6.7
COL	plot85	16.3
COL	plot86	1.8
COL	plot87	12.6
COL	plot88	0.8
COL	plot89	33.0
COL	plot90	0.5
COL	plot91	15.1
COL	plot92	0.4
COL	plot93	0.0
COL	plot94	5.5
COL	plot95	3.2
COL	plot96	23.7
COL	plot97	0.5
COL	plot98	2.3
COL	plot99	3.8

Annex 7: SOC per ha per plot (in tCO_2)

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
DIO	plot01	
XAN	plot02	76.8
DIO	plot03	87.5
DIO	plot04	60.1
XAN	plot05	
DIO	plot06	92.5
DIO	plot07	54.1
XAN	plot08	117.7
XAN	plot09	62.6
XAN	plot10	131.6
COL	plot100	99.1
COL	plot101	47.3
COL	plot102	76.6
COL	plot103	68.0
COL	plot104	55.3
COL	plot105	71.2
COL	plot106	74.6
COL	plot107	63.5
COL	plot108	23.7
COL	plot109	46.9
COL	plot110	65.5
COL	plot111	57.0
COL	plot112	
COL	plot113	79.3
COL	plot114	89.6
COL	plot115	120.8
COL	plot116	122.3
COL	plot117	95.9
COL	plot118	78.8
COL	plot119	158.5
DIO	plot12	57.3
COL	plot120	
COL	plot121	76.3
COL	plot122	61.8
COL	plot123	53.5
COL	plot124	51.9
COL	plot125	75.8
COL	plot126	38.7
COL	plot127	78.3
COL	plot128	85.6
COL	plot129	44.8
DIO	plot13	88.7
COL	plot130	81.6
COL	plot131	89.1
COL	plot132	63.3
COL	plot133	52.0
COL	plot134	54.2
COL	plot135	54.4
COL	plot136	53.8
COL	plot137	84.1
COL	plot138	71.6
COL	plot139	59.7
COM	plot14	183.7
COL	plot140	98.2
COL	plot141	108.4
COL	plot142	83.5
COL	plot143	49.4
COL	plot144	59.1
COL	plot145	31.0
COL	plot146	54.9
COL	plot147	52.7
ACA	plot148	43.6
COL	plot149	40.0
COM	plot15	24.7
COL	plot150	58.4
COL	plot151	39.8
COL	plot152	48.3
COL	plot153	58.9
COL	plot154	54.6
COM	plot155	
COL	plot156	85.8
COL	plot157	69.2
COL	plot158	64.4
COL	plot159	47.7

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
COM	plot16	68.6
COL	plot160	48.1
COL	plot161	76.0
COL	plot162	48.9
COL	plot163	
COL	plot164	54.8
COL	plot165	
COL	plot166	54.0
COL	plot167	40.7
COL	plot168	46.0
COL	plot169	54.3
COM	plot17	76.2
COL	plot170	71.4
COL	plot171	72.1
COL	plot172	68.7
COL	plot173	52.9
COL	plot174	60.0
COL	plot175	43.5
COL	plot176	42.5
COL	plot177	58.9
COL	plot178	52.3
COL	plot179	39.8
COM	plot18	62.7
COL	plot180	63.9
COL	plot181	50.7
COL	plot182	89.0
COL	plot183	58.7
COL	plot184	14.3
COL	plot185	63.5
COL	plot186	45.6
COL	plot187	127.7
COL	plot188	42.9
COL	plot189	51.7
COM	plot19	73.2
COL	plot190	44.4
COL	plot191	52.7
COL	plot192	67.0
COL	plot193	68.8

VEG_ID	PLOT_ID	HA_P_Cpool_tCO₂
COL	plot194	83.3
COL	plot195	72.7
COL	plot196	48.0
COL	plot197	59.2
DIO	plot198	82.8
COL	plot199	49.0
COM	plot20	102.0
COL	plot200	70.5
COL	plot201	67.8
ACA	plot202	63.3
DIO	plot203	106.2
COM	plot204	48.8
COM	plot205	55.2
COL	plot206	75.8
COL	plot207	54.3
COM	plot208	58.1
COM	plot209	50.2
COM	plot21	41.6
COL	plot210	51.8
COL	plot211	55.5
COL	plot212	57.1
COL	plot213	77.9
ACA	plot214	103.6
COL	plot215	41.5
COL	plot218	43.5
KIR	plot219	74.5
COM	plot22	101.3
ACA	plot220	42.2
KIR	plot221	80.9
COL	plot222	59.5
COL	plot223	58.4
COL	plot224	54.4
COL	plot225	56.9
ACA	plot226	51.9
COL	plot227	45.9
ACA	plot228	65.4
COL	plot229	101.3
COM	plot23	80.0

VEG_ID	PLOT_ID	HA_P_Cpool_tCO$_2$
COL	plot230	49.0
COM	plot231	29.4
COL	plot232	68.0
COL	plot233	61.9
COL	plot234	51.7
XAN	plot235	7.4
XAN	plot236	130.5
COL	plot237	
COL	plot238	82.8
COL	plot239	78.1
COM	plot24	79.7
COL	plot240	118.0
COL	plot241	63.3
COL	plot242	63.7
COL	plot243	
COL	plot244	78.5
COL	plot245	82.5
COL	plot246	61.4
COL	plot247	75.4
COL	plot248	53.3
COL	plot249	56.9
COM	plot25	100.9
XAN	plot250	101.1
COL	plot251	172.3
COL	plot252	68.1
COM	plot253	143.2
ACA	plot254	41.2
COM	plot255	88.2
KIR	plot256	62.3
ACA	plot257	43.8
COM	plot258	52.5
COM	plot259	71.8
COM	plot26	111.9
ACA	plot260	
ACA	plot261	87.9
ACA	plot262	60.3
ACA	plot263	67.4
ACA	plot264	43.1

VEG_ID	PLOT_ID	HA_P_Cpool_tCO$_2$
ACA	plot265	48.8
ACA	plot266	60.8
ACA	plot267	41.8
ACA	plot268	50.1
COL	plot269	41.7
COM	plot27	172.6
ACA	plot270	42.5
ACA	plot271	26.4
ACA	plot272	51.9
ACA	plot273	34.7
ACA	plot274	
ACA	plot275	56.8
COL	plot276	69.7
ACA	plot277	42.4
ACA	plot278	34.0
ACA	plot279	35.3
COM	plot28	63.2
ACA	plot280	41.1
ACA	plot281	92.1
ACA	plot282	50.2
ACA	plot283	53.6
ACA	plot284	44.1
ACA	plot285	93.6
ACA	plot286	16.3
ACA	plot287	90.4
ACA	plot288	85.0
ACA	plot289	42.1
COM	plot29	40.1
ACA	plot290	60.7
ACA	plot291	119.3
ACA	plot292	58.4
ACA	plot293	55.3
COL	plot294	63.1
ACA	plot295	45.7
COL	plot296	47.9
COL	plot297	51.7
ACA	plot298	68.1
COL	plot299	67.6

VEG_ID	PLOT_ID	HA_P_Cpool_tCO2
COM	plot30	74.3
XAN	plot300	80.5
COM	plot31	36.8
COM	plot32	44.4
COM	plot33	26.3
COM	plot34	
COM	plot35	63.6
COM	plot36	
COM	plot37	155.8
COL	plot38	75.9
COM	plot39	102.1
COM	plot40	55.9
DIO	plot42	70.0
COM	plot43	53.9
COM	plot44	61.9
COM	plot45	81.6
COM	plot46	73.9
COM	plot47	102.6
COM	plot48	105.4
COM	plot49	98.8
COM	plot50	101.1
ACA	plot51	74.1
COM	plot52	106.9
COM	plot54	76.6
COM	plot55	57.5
COM	plot56	68.6
ACA	plot57	183.7
ACA	plot58	91.1
COM	plot59	93.1
COM	plot60	62.9
COM	plot62	111.0
COM	plot63	109.2
COM	plot64	128.9
COM	plot65	51.8
COM	plot66	128.0
COM	plot67	140.0
COM	plot69	81.4
COM	plot70	60.4

VEG_ID	PLOT_ID	HA_P_Cpool_tCO2
COM	plot71	97.4
COM	plot72	127.6
COM	plot73	97.2
KIR	plot74	72.1
COM	plot75	85.3
COL	plot76	65.7
COL	plot77	127.2
COM	plot78	67.1
COM	plot79	42.5
COL	plot80	71.0
COL	plot81	79.2
ACA	plot82	81.1
COL	plot83	69.1
COL	plot84	105.1
COL	plot85	69.1
COL	plot86	81.0
COL	plot87	89.2
COL	plot88	106.3
COL	plot89	85.6
COL	plot90	72.2
COL	plot91	66.8
COL	plot92	70.1
COL	plot93	183.7
COL	plot94	121.3
COL	plot95	107.7
COL	plot96	61.5
COL	plot97	70.1
COL	plot98	73.4
COL	plot99	58.3