Climate Impact Monitoring Plan

Carbon Monitoring and Verification Protocols for the Suruí Forest Carbon Project

Frequency of measurement

The field measurements for estimating the above ground biomass will happen every 5 years. The first measurement happened in 2011, and the next one is planned to be carry on in 2016. Then, it will be updated in 2021, 2026, 2031, 2036, 2038.

1.0 Background

The purpose of the Carbon Monitoring and Verification Protocol (“Protocol”) for the Suruí Forest Carbon Project (PCFS) is to establish the factual basis and procedures for documenting changes over time in the greenhouse gases (GHGs) that are attributable to changes in carbon stocks. It describes the procedures and methodologies that will ensure credibility and transparency in the Project’s GHG offset accounting system.

The focus of the monitoring and verification work is on carbon stocks and the resulting emissions of carbon, as carbon dioxide, caused by changes in carbon stocks.

2.0 Monitoring and Verification Protocols

Protocols for measuring, monitoring and verifying changes in carbon stocks on project lands have been developed and presented in several reports.

2.1 Carbon stocks

The IDESAM, ACT e Metareilá conduced a forest inventory in the TISS, reported in the supplementary material 02. This inventory followed all protocols presented here, and will be monitored every 5 years interval. The inventory measured all palms and trees over 10cm of DBH, considering the stratum presented and came up the overal area-weighted mean estimated. The total carbon stock was estimated to within +/- 7.06% of the mean with 95% confidence.

The estimated carbon stocks is for live biomass (above and below) only. For belowground biomass, we used a root / shoot ratio of 34.3%[1] of dry biomass. This is a median value obtained from direct measurements, incorporating other references[2].

All other pools are conservativelly excluded from the carbon stock changes accounting and monitoring. The assumption used in the baseline is that additional gains in carbon stock would occur during the 30-year life of the project. The permanet units will be measured *ex-post* using the same method for the inventory estimate.

2.1.1 Shapes and Placing of Plots

Plot shape and sizes

[1] Silva *op. cit.*

[2] Some values for root / shoot ratio for tropical forests that can be used were obtained indirectly, such as those based in other forest types, *ie* boreal forests, as 21% in Cairns et al. (1997), or even more extensive reviews that suggest a value of 42% as Mokany et al. (2006). Therefore, we used a value obtained through primary data by Silva (2007), weighing about 175 trees (biomass above and below ground), to obtain the value of this ratio of 34.3%.

The TISS area contains a part of the Amazon Rainforest, a natural ombrophyllous rainforest sellectively logged. Due to the heterogeneity of this forest, the rectangular plots are the most recommended because, in comparison with the square ones, they have a larger area and are able to comprise a bigger variety of the population.

Each Primary Unit is considered a Conglomerate of four sample units, or Secundary Units. The conglomerate is choosen placing a central point and extending it 25 meters to North, South, West and East, placing in the beginning of each direction one of the Secondary or sample units of 10m to 250m. In some cases that is not possible to use exactly these directions, plots can be place if it maintains the 90 degree azimute of distance from each plots.

The conglomerate sampling method is view as a variatino of the two-stage sampling, where the second stage is sistematically organized whithim the first sampling stage (Péllico Netto & Brena, 1997). Compared to the simple sampling method, this method offers advantages when the target population of the inventory is extended and the variable of interest presents moderate homogeneity, as it reduces the sampling effort and the costs.

Although, specifically for this work objective, which is to measure the biomass and the carbon stocks, the minimum diameter to be measured is 10cm, and the size is 2,500 m², sized 10m wide and 250m long, which, according to Higuchi *et al.* (1982), presented very satisfactory values of uncertainty, error limit, and relative efficiency for trees with Diameter at Breast High above 10 cm.

Placing Plots

To execute the inventory, the used plots must be shaped as a cross-shaped conglomerate, having a Primary Unit divided into Secondary Units. The Secondary Unit (or sample unit) is a rectangle of 10X 250 meters.

The method of stratified sistematic sampling was used, according to the three sub-classes presented in the TISS. Initially a grade of cells of 1 sq-km created on the TISS area to ramdonly choose nine cells where the Sample Units for the inventory were allocated. This method was used for the pilot inventory. When it was not possible to reach the selected point, the team made the effort of getting closer as much as possible of the center of the primary unit. The temporary plots are placed preferable within the project area, in regions where there is easier access for facilitanting remeasurement events.

In the case of the plots installed along the rivers, the conglomerates must be installed in a perpendicular fashion. Each unit must be placed at least 300 meters away from a main logging road. Permanent conglomerates must be at least 3,000 away from another, while being at least 500 meters from Temporary Units.

Sampling Intensity

According to Higuchi *et al.* (2008), in every forest inventory made in a tropical rainforest area, regardless of the vegetation type, an average of 89 sampling units were installed, obtaining a 5% uncertainty, half of the precision required for the IPCC and the VM0015 VCS methodology. The Suruí inventory, considering the relatively small area inventoried, used 84 sampling units, and around 41% out of those were permanent plots (36 sampling units). Despite the sampling intensity adopted in the inventory, for any sampling intensity option, the uncertainty for the parameter estimates must be lower than 10%. In the cases where the uncertainty is statistical higher than that, it is necessary to increase the sampling intensity. The inventory for the Suruí (supplementary material 02) followed these steps and 84 sample units were enough to give an uncertity of 7.06% at 95% of confidence.

2.1.2 Future monitoring

The Forest inventory is to estimate the live biomass pools (above and below ground) and carbon in tropical rainforest areas of Sete de Setembro Indigenous Territory (TISS). The forest will be inventoried through samplings every three years in areas with the same plot shape and size, distributed in a way as to contemplate the three sub-classes that compose the Ombrophyllous Degrading Forest *stratum* present inside the TISS.

Based on the analysis of the first inventory (84 plots or 21 conglomerates distributed among the three sub-classes of the only stratum presented: Ombrophillous Degrading Forest), the remeasurement of the 36 permanent plots (9 conglomerates) located within the project area would suffice.

Every arboreal individual with the DBH equal or higher than 10 cm is to be monitored. To analyze the biomass and carbon stock, death rate, and recruiting differences between different periods, the permanent plots must be measured again every five (05) years. In the second field inventory, the permanent plots will be measured again.

The permanent plots will be used, mainly, to monitor the recruitment and death rate, as well as the carbon increase due to regrowth. The group of sampling units will be used to monitor the forest dynamics as a whole, focusing on the Project Area. The field data collection will involve forest inventory data and use the allometric equation for Open Ombrophillous Forest in southern Amazonia (Nogueira et. al. 2008).

The protocol relates only to the carbon stocks, but monitoring of the project to ensure that illegal activities that remove carbon do not occur is also necessary. An independent method for verifying that clearing or timber harvesting is not occurring is to use high resolution remote sensing imagery covering the project area on a 3 year cycle over the project duration. These products should be coupled with ongoing surveillance by park guards to ensure no illegal activities.

2.1.3 Field Procedures

a- Data to be collected

After installing the plot, the team carrying out the inventory activities must measure and register the DBHs (Diameter at Breast High), which should be measured 1.30 meter high from the ground, for every individual with DBH higher than 10 cm found within the sampling plots (See item 3. QA/QC plans below). Also, the team must register observations such as the condition of the tree (whether alive or dead, broken canopy, etc) as well as observe and register the presence of lianas. The measured trees of the permanent plot must be identified with an aluminum tag containing a number, which must be registered on the field datasheet. Also, it is a procedure to paint a stripe at the location of the measurement, as a way of assuring that the next measurement will be made at the same location.

Regarding the death rate, the trees that were measured in the first inventory and that are identified as dead will be excluded from the forest's biomass stock. The recruitment rate will be obtained using the same procedure, but the trees that will be considered are those that, in the first inventory, did not have at least 10 cm of DBH, but that, in the following inventory had reached the 10 cm. This way, this tree can be considered as a recruited tree and included in the biomass stock database and the death rate will be identified through the inverse process, which means the individuals that are measured in the first inventory and that, in the next inventory, are identified as dead, will be inserted in the database as emitter source.

b- Collection Methodology

The diameter must be collected with a diametric tape or metric tape with precision up to one decimal place. In the permanent plots, all the measured individuals must be identified with metal tags and painted, so in the later inventories, it is possible to measure the same diameters at the same height for the same individuals and identify new ones over 10cm of DBH.

When marking the diameters, the tree's skin should not be taken out and the bole should not be damaged. For the temporary plots, there is no need for identifications or individual markings, as these won't be measured again.

c- Field Files

At the header of the field file, the following information should be found: name of the person responsible for the inventory team, plot coordinates, name of the place or community, phytopshysiognomy, start and end time, date, plot number and type (permanent or temporary). Apart from the info contained in the header, the field file should have the number of the tree, , DBH, and qualitative observations, when necessary.

2.1.4 Accounting Process and Statistical Analysis

The forest inventory allows for the survey of some descriptive statistic such as: minimum, middle, and maximum DBH, variance, standard error, and standard deviation. The minimum DBH is the lowest value found in the inventory, and the maximum DBH is the highest. The middle diameter is determined by the arithmetic mean of the DBH. The variance, standard deviation, and error must be calculated through the respective formulas described by Koehler (1999), as shown below:

Utilized notation:

L = number of strata;

N_h = potential number of strata ;

$$N = \sum_{h=1}^{L} N_h$$

= total potential number of h strata units;

n_h = number of sample units of h strata;

$$n = \sum_{h=1}^{L} n_h$$

= total number of sample units in the population;

$W_h = N_h / N = A_h / A$ = proportion of h strata in the population;

$W_h = n_h / n$ = proportion of h strata in the total sample;

A_h = h strata area

$$A = \sum_{h=1}^{L} A_h$$

= total area of population;

$f_h = n_h / N_h$ = sample fraction of h strata;

f = n/N = sample fraction of the population;

X_{ih} = variable of interest.

Strata Average: corresponds with the arithmetic average of sample variable for each strata.

$$\bar{X}_h = \frac{\sum_{i=1}^{n_h} X_{ih}}{n_h}$$

Stratified Average: corresponds wiht the weighted average for L stratas of the sample variable X_{ih}.

$$\bar{X}_{st} = \frac{\sum_{i=1}^{L} n_h . \bar{X}_h}{n}$$

Strata variance: corresponds to the variancy of the sample variable X on the h strata.

$$S_h^2 = \frac{\sum_{i=1}^{n} \left(X_{ih} - \bar{X}_h \right)^2}{(n_h - 1)}$$

wherein:

S_h^2 = variancy of the sample variable on the h strata;

n = number of samples.

Standard Deviation for each Strata: correspnds with variant roots of sample variable.

$$S_h = \pm\sqrt{S_h^2}$$

wherein:

S_h = standard deviation of the sample variable on h strata

S_h^2 = variance of the sample variabel on h strata

Stratified Variance: corresponds with weighted variance for L stratas of the X_{ih} variable

$$S_{st}^2 = \sum_{i=1}^{L} A_h . S_h^2$$

Standard Error for each Strata: The standard error express the precision of the sample average in the linear form and on each unit of measure. It's obtained according with the following expression:

$$S_{\bar{X}_h} = \frac{S_h}{\sqrt{n}}$$

Standard Error Stratified:

$$S_{\bar{X}st} = \frac{\sum_{i=1}^{L} A_h . S_{\bar{X}h}}{A}$$

Relative Standard Error for each Strata

$$S_{\bar{X}h}(\%) = \frac{S_{\bar{X}h}}{\bar{X}_h}.100$$

Relative Standard Error Stratified

$$S_{\bar{X}st}(\%) = \frac{S_{\bar{X}st}}{\bar{X}_{st}}.100$$

Confidence interval for each strata

$$IC_h = \bar{X}_h \pm 1{,}96.S_{\bar{X}h}$$

Stratified Confidence Interval

$$IC_{st} = \frac{\sum_{i=1}^{L} A_h . IC_h}{A}$$

Total of the Population

a) Total for Each Strata

$$\hat{X}_h = A_h . \bar{X}_h$$

b)Grand Total

$$\hat{X}_{st} = A.\bar{X}_{st}$$

Confidence Interval for the Mean

$$IC = \left[\hat{X}_{st} - \left(1{,}96.S_{\bar{X}st}.A\right) \leq \hat{X}_{st} \leq \hat{X}_{st} + \left(1{,}96.S_{\bar{X}st}.A\right) \right] = P$$

Note: Based on the normal distribution, the trust interval will be calculated based on the standard deviation, with a 95% probability

Sampling Intensity:

$$n = \frac{Nt^2 \times s_x^2}{\left(LE \times \bar{x}\right)^2}$$, where:

n = number of sampling plots;

N = total number of population units

t = value previously defined due to the admitted probability and the freedom degrees;

s_x^2 = variance

LE = error limit accepted on the inventory

X = mean of the population.

Number of trees per hectare (N/ha) according to Sanquetta *et al.,* (2006)**:**

To know the N/ha, first it is necessary to calculate the proportionality factor, the value that expresses how many times the characters of a sampling unit are represented in one hectare.

$$F = \frac{A}{a}$$

where:

F = proportionality factor;

A = 1 hectare area, i.e., 10,000m²;

a = area of the sampling unit.

$$N = m \times F$$

where:

m = number of trees included in the sampling unit

Basal Area (G), according to Sanquetta *et al.,* (2006)**:**

$$G = \sum_{i=1}^{m} g_i \times F$$

where:

g_i = transversal or sectional of each tree *i* for the considered sampling unit

Dry Aboveground biomass weight (PS_{abg}): fresh weight (PF) of the living matter will be estimated, from simple entrance allometric equations (DBH as independent variable), which were developed by Nogueira et al. (2008).

$$PS_{abg} = EXP - 1{,}716 + 2{,}413 * Ln(DAP)$$

Whereby:

PS_{abg} = estimated dry weight for each individual

DAP = diameter at breast height

To estimate the biomass of palms, we used equation[3] , most frequently used in the Amazon, as follows:

$$PS_{abg} = EXP - 6{,}3789 - 0{,}877 * Ln\left(\frac{1}{DAP^2}\right) + 2{,}151 * Ln(H) \qquad (8)$$

Whereby:

PS_{abg} = estimated dry weight for each individual

DAP = diameter at breast height

H = Height

Carbon stock was estimated converting measured dry weight for each individual to carbon, according to equation 9 [4], as follows:

$$C_{abg} = PS_{abg} \times 0{,}485 \qquad (9)$$

whereby:

C_{abg} = Above-ground;

PS_{abg} = estimated dry weight for each individual.

The dry weight (PS) is obtained, preliminarily, using the water contents determined by Silva (2007), which are, respectively, 40.8% and 41.6%.

$PS_{abg} = (PF_{abg}) * 0.592$

$PS_{tot} = (PF_{tot}) * 0.584$

where:

PS_{abg} = Dried aboveground weight, in kg;

PS_{tot} = Total dried weight, in kg.

Carbon (C) of arboreal vegetation: the C is obtained, preliminarily, using the carbon contents determined by Silva (2007), which is 48,5%.

$C_{abg} = (PS_{abg}) * 0.485$

[3] Saldarriaga et al. 1988.
[4] Silva 2007.

$$C_{tot} = (PS_{tot}) * 0.485$$

where:

C_{abg} = Aboveground carbon, in kg;

C_{tot} = Total Carbon, in kg.

To convert the carbon (C) into carbon dioxide (CO_2), all one has to do is multiply the 3.6667 constant, i.e.:

$$CO_2 = C * 3.6667$$

where:

C = Estimated carbon quantity, in kg.

After the field survey, it is necessary to analyze if there are, statistically, differences between the sampling units. To do this, it is necessary to do a Variance Analysis (ANOVA). If there is any significant difference, the averages for the estimated parameters must be analyzed separately. Otherwise, in case there are no significant differences, the averages will be analyzed normally. Below is the chart of ANOVA, described by Koehler (1999):

Variation Sources	**GL**	**SQ**	**MQ**	**F**
Between plots (Treatments)	t - 1	SQE	MQE	MQE/MQD
Inside the plots (residues)	n - t	SQD	MQD	
Total	n - 1	SQT		

Where:

t = Plots numbers;

n = amount of repetitions;

GL = degrees of freedom;

SQ = Sum of the Squares / SQE = Between Plots / SQD = inside the plots / SQT = total;

MQ = Mean of the Squares MQE = Between Plots / MQD = inside the plots;

F = probability.

In case of low probabilities (around 5%), i.e., if the result of the F test is significant for differences between the averages among Primary Units, it is necessary to apply the Tukey post hoc test to identify which ones are the different plots. After identifying the different sampling units, their average must be separately analyzed and weighed for a full assessment of the whole area.

2.1.5 Losses due to disturbances

The annual losses, whether or not due to disturbances, will be determined through the continuous forest inventorying. The biomass stock will be determined in the first inventory, and from such inventory, the results of following inventories will say if there was any loss or increase in the forest biomass.

In the event of biomass loss, the possible reasons for such loss are to be analyzed, as well as in the event of forest stock increase. To conclude that there was loss, the result of the first inventory must be higher than the following, and, to conclude that there was increase, the results of the first inventory must be lower than the ones of following years.

3.0 Quality Assurance and Quality Control Plan

Monitoring requires provisions for quality assurance (QA) and quality control (QC) to be implemented via a QA/QC plan. Such plans provide confidence that the reported carbon credits are reliable and meet minimum measurement standards. The plan should become part of project documentation and cover procedures for: (1) collecting reliable field measurements; (2) verifying laboratory procedures; (3) verifying data entry and analysis techniques and; (4) data maintenance and archiving. Forms to demonstrate these procedures are found in Appendix 2 of this document.

To develop reliable carbon benefit estimates for climate action projects, steps must be taken to control for errors in sampling and analysis. To ensure that the work is of the highest quality possible, standard operating procedures (SOPs) were developed and must be followed during all aspects of work, including field data collection as well as data and laboratory analyses.

To ensure continuity it is important that all data collected use the same procedures during the project life and is archived using acceptable standards by all partners involved in the project. Adhering to these procedures will ensure that in the event there is a change in personnel among participating organizations, or if any of the people involved are questioned about any aspect of the project, all will be well informed. In addition to the procedures outlined in Appendix 1, it is also important that a record be maintained to demonstrate that the steps are being followed (see forms in Appendix 2).

3.1 QA/QC for field measurements

Collecting reliable field measurements is an important step in the quality assurance plan. Those responsible for the carbon measurement work should be fully trained in all aspects of the field data collection and standard operating procedures should be followed rigidly to ensure accurate measurement and remeasurement. It is recommended that a verification document be produced and filed with the project documents that show that QA/QC steps have been followed.

Field crews should receive training and be fully cognizant of all procedures and the importance of collecting data as accurately as possible. In addition an audit program for field measurements and sampling should be established to verify data and to provide unbiased estimates of measurement variance.

A typical audit program consists of two types of checks. During a *hot check*, the lead investigator should observe field crew members during data collection of a field plot to verify measurement processes. Hot checks permit the correction of errors in techniques. *Blind checks* represent the complete remeasurement of a plot by the lead investigators. Measurement variance can be calculated through blind checks. At the end of the work on the conglomerate, there will be a random sample fliping a coin to decide if the conglomerate will be or not remeasured by the chief of the crew. If yes, then, one of the 4 plots will be chosen ramdonly. With this procedure, it is expected that 12,5% of the sampling units to be remeasured, reaching at least 10%. Field data collected at this stage can be compared with the original data. Any errors found should be corrected and recorded. Any errors discovered could be expressed as a percentage of all plots that have been rechecked to provide an estimate of the measurement error.

3.2 QA/QC for data entry

To produce reliable carbon estimates the proper entry of data the project will use two ways: spreadsheets and the use of Xforms through ODK Collect in a Android devices (The Ruggedized Pidion BIP 6000). This device Specially designed by SDG Systems, has coupled GPS, 3MP Camera Photo, Barcode Reader, is waterproof and shockproof, designed for field use. This device is the one we recommend for this type of inventory. The potential for the current tool tested in the Suruí Forest Inventory (ODK Collect) to significantly impact the efficiency, speed and efficacy of Forest Carbon data collection has been effectively demonstrated in the first inventory. The versions of ODK Collect used performed excellently and demonstrated their considerable advantages over traditional paper methods of data collection. The use of Xforms reduce the probability of enter wrong data and gives tips on doing that, as well as jump the step of typing the spreadsheet data in a computer program. Whenever possible, Xforms and ODK Collect will be used.

Neverthelees, it is important to analyses the data collected. It is important that steps are taken to ensure that errors are minimized. Common sense should be used when reviewing the results of the data analysis to make sure that they fit within the realm of reality. Communication between all personnel involved in measuring and analyzing data should be used to resolve any apparent anomalies before final analysis of the monitoring data can be completed. If there are any problems with the monitoring plot data (that cannot be resolved), the plot should not be used in the analysis. Errors can be reduced if the entered data is reviewed using expert judgment and, if necessary, through comparison with independent data.

3.3 QA/QC for data archiving

Because of the relatively long-term nature of forestry activities, data archiving (maintenance and storage) will be an important component of the work. Data archiving should take several forms and copies of all data should be provided to each project participant.

- Original copies of the field measurement (either data sheets or electronic files) and laboratory data should be placed in folders and on electronic media, and stored in a secure location, by the carbon measurement implementers.
- Copies of all data analyses, and models; the final estimate of the amount of carbon sequestered; any GIS products; and a copy of the measuring and monitoring reports should all be stored in a dedicated and safe place, preferably offsite.

It is recommended that given the time frame over which projects will take place and the pace of production of updated versions of software and new hardware for storing data, that the electronic copies of the data and report be updated periodically or converted to a format that could be accessed by any future software application.

1. Appendix 1: Standard Operating Procedures

These SOP's are designed to be used in conjunction with the Winrock International publication: "A Guide to Monitoring Carbon Storage in Forestry and Agroforestry Projects". The procedures must be strictly followed to insure that the data collected are of high quality, with an acceptable level of precision, accuracy, and completeness.

1. List of Equipment

The tools for this work needs to be accurate, rugged, and durable to withstand the rigors of field use under adverse conditions (Table 1). They should also contribute to efficient planning, data collection, analysis, and reporting.

Table 1. Minimun Equipment list for field work.

Product	Product
Aluminum nails	Folding saw
Aluminum numbered tags	GPS
Backpack	Hammers
Batteries (AA&9-volt)	Permanent marker pens
Bulk density rings	Plastic marking tags (for labeling plot centers)
Clip plot sampling frames	Plastic tarps (1 m^2)—at least two
Ruggedized Pidion BIP 6000 -	PVC pipe & caps
Compass	Sheet holder/clip boards
Cotton rags (for cleaning equipment)	Shovel
DBH tapes (Metric or diametric)	Stakes and machete
Fiberglass meter tapes—50 m & 10 m	1 kg, 300 g spring scales
Field vests	First aid kit
Flagging tape	

General field procedures and crew management

Two field teams composed by four to five persons each will be formed in order to increase efficiency in the sampling procedure. Each team will be responsible for the allocation, marking and measumerement of tree individuals in the sampling plots. It is desirable that each team performs in on of the ways North-South or West-East. To accomplish this procedure, the following steps should be make: (SOPs 1, 2, 3, and 4):

SOP 1 Plot establishment

The following steps should be followed when establishing a permanent plot. The crew chief should always keep in mind that someone will be returning to the same location during future inventories. The crew chief should make the job of future inventory crews as easy as possible by flagging the plot center, painting the stakes, and following the instructions for measurements in a systematic way.

1. After defining the center of the primary unit, the closer trees should be identified with tapes to make it easier to visualize.
2. At the center of the primary unit a white PVC pipe should be placed and painted. The pipe should be 1,5 meters height, being 0,5m digged in the soil.
3. The location pipe should contain a cap with a metal tag inside (showing the conglomerate number, the forest type, the coordinates and the data of implementation), attached in a wire. External to the pipe the conglomerate number should be written with a permanent marker.
4. The crew chief must take GPS location from each plot corner (it is reccomended to use the Garmin 76 CSX or similar).
5. After the plot implementation, the chief crew should define the subplots azimutes taking the magnetic north as reference when possible and aligning the other three sublplots away 90 degrees after the prior one.
6. The openning of the track is lead by the crew chief, using two assistants to cut brunches and handling and holding stakes to give the direction of the plots with a compass. In each 50 m interval, using a measuring tape of 50m mininum and avoind obstacles keeping the tape stretched, the stakes are held and the PVC pipes are hammered and painted. In each pipe is written the distance from the initial way of the plot (00,50,….250). Also is recommended to take the GPS location of each one of the pipes.For the temporary plots, the same procedure is used, but the stakes and not from PVC pipes. Instead, they are thin boles taken from the forest.

SOP 2 Global Positioning System (GPS) setup

All permanent plots that are established must have GPS coordinates to insure the plot can be relocated in future inventories. The GPS settings must be the same for all data collection. The following describes the settings and steps for collecting GPS data in permanent plot centers.

1) Stand over the plot center, or if the canopy is too heavy to receive a signal move a few meters to either sideThe GPS should use the following settings:
    a) The coordinate system should be UTM not Lat/Long (if possible)
    b) The datum to use is WGS-84
    c) The data should be collected using metric units not English units.
2) Let the GPS collect data for a few minutes before collecting a data file. The GPS should already have a current almanac before starting any work. The almanac file should be collected at least once a month. Once the GPS has been tracking satellites for a few minutes, the crew chief can collect a data file.
3) At the end of that days field work the GPS files should be downloaded to a computer and checked to make sure everything was collected properly. Aditionally, the chief crew should written the plot coordinates in a hard fieldbook

SOP 3 Measuring dbh of trees

It is important that a dbh tape is used properly to insure consistency of measurements over time. The definition of dbh varies among countries and systems of measurement. For our purposes we will define dbh as 1.3 m above the ground.

A numbered tag will be attached to all live trees. Once the location of the dbh of the tree is decided upon (see next steps), a numbered tag is attached to the tree with an aluminum nail (use ONLY aluminum). Do not insert the nail fully so that there is room for the tree to grow; insert it deep enough to hold the tag firmly. All dbh measurements will be taken with the tape resting firmly on top of the nail.

1) Before any measurements take place a sturdy stick (at least 2 cm in diameter) should be cut to a length of exactly 1.3 m. The measurement stick should not bend easily and should be from a young hardwood tree not a palm or liana. This stick should be used untill the

person is trained and confident in measuring the bdh in relation to his own body. Also, it is optional to use a stripe glued in the body at 1.3m of height. The technician taking the measurement should first place the measuring stick against the tree to indicate where the dbh should be taken. Placement of the measuring stick depends on the slope of the ground as well as the tree's shape (Figure A).

2) If the tree is forked at DBH, the first bigger DBH should be taken and them the other forks that are > 10cm of DBH. The metal tag should be nailed in the thicker fork and all others should be marked with the same number followed by, A, B, C…and so on.If the three has butresses (sapopema ou catãna) at the DBH, the tree is measured above it when possible. If is not possible to measure it, the measumerent should be done at the maximum DBH possible. If the tree has buttresses at dbh, measure above the buttress where the bole is of normal shape.
3) If the tree is fallen over but is still alive, then place the measuring stick towards the bottom and measure at dbh just like if the tree was standing upright. Trees are considered alive if there are any green leaves present. Even if there are only one or two green leaves present the tree is considered alive.
4) The dbh tape should always start left and be pulled right around the tree. Even if the person taking the measurement is left-handed.
5) As the dbh tape wraps around the tree and returns to the hook the tape should be above the hook, as shown (Figure B). The tape should not come around the tree below the hook. The tape should not be upside down; the numbers must be right side up.
6) The technician should take precautions not to bend the tape when measuring the tree. The crew chief should remind the technician to handle the dbh tape with care.
7) If the tree is leaning, the dbh tape must be wrapped according to the trees natural angle, not straight across parallel to the ground (Figure B).
8) If there is an abnormal formation or branch at dbh do not measure at this point. Move slightly higher or lower and mark on the data sheet.

Trees belonging to "special" groups (e.g. *Cecropias*) will be noted on field sheets in the OBS cell.

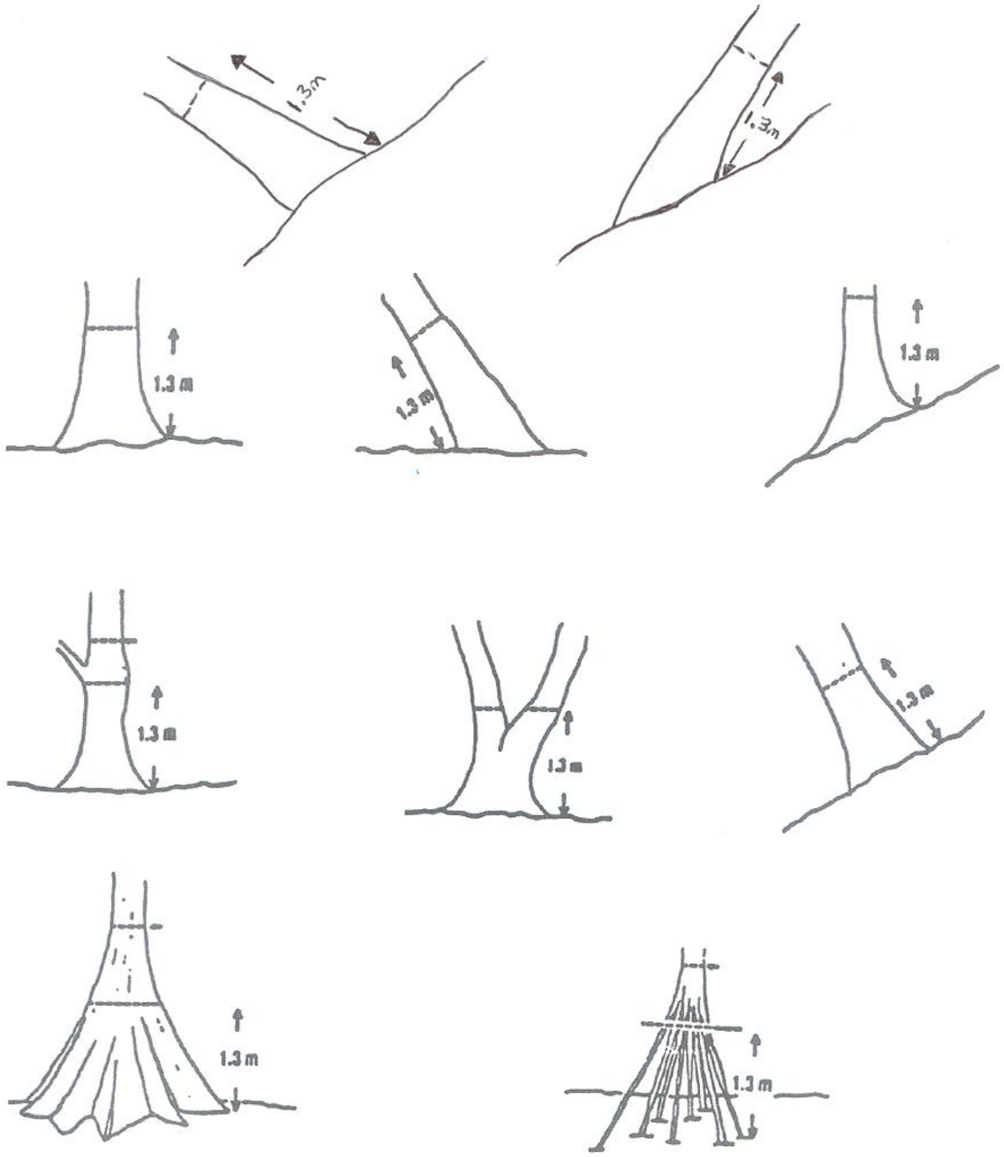

Figure A. Locations for dbh measurement *for irre*gular and normally shaped trees.

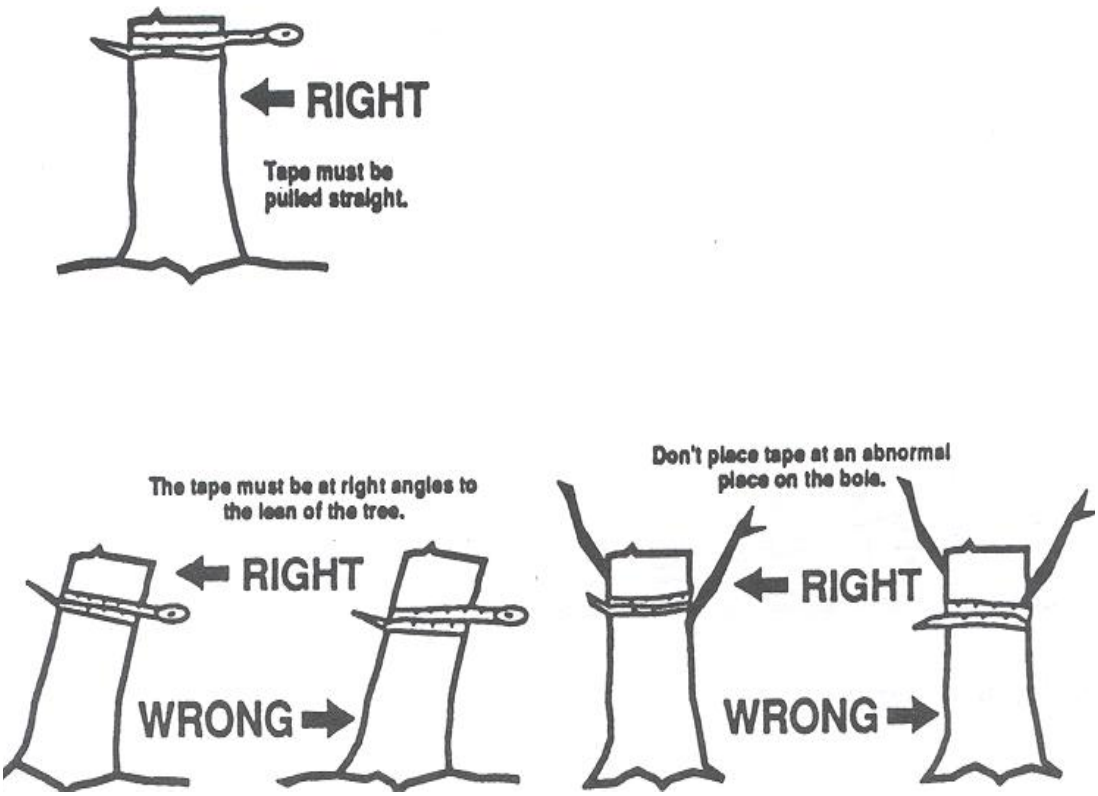

Figure B. Proper use of a dbh tape

SOP 4 Boundary trees

It is important to carefully decide if a tree is in or out of a plot.

1) Place the measuring tape directly by the center of the tree and take a reading of distance to the plot center. If it is exactly on the border of the plot flip a coin to decide if it is in or out of the plot.
2) If the tree is leaning (either towards the plot center or away) place the measuring tape at the center of the base of the tree where it enters the ground. If it is exactly on the border flip a coin to decide if it is in or out.
3) For any tree in question, take three readings with the measuring tape to confirm the measurement.

2. FIELD DATA SHEET FOR PERMANENT PLOT MEASUREMENTS

Where field sheets are used on paper, we suggest the following models with the minimum information that should be collected.

Example of the Temporary Spreadsheet

Nº Conglomerado: ______	**Localização: ______________________________ __________**	**Nº de Integrantes da Equipe: ______**
Fisionomia Vegetal: _______________	**Líder da Equipe: __________________**	**Date: ____/____/____**
Hora de Início:___________	**Término:___________**	**Tempo Total:_________**

Nº Arv.	CAP	H	Obs.

Nº Arv.	CAP	H	Obs.

GPS coordinates: N

E

Notes:

MSL

Example of the Permanent Spreadsheet

Nº Conglomerado: _____	**Localização: _______________ _______________ _____**	**Nº de Integrantes da Equipe: ______**
Fisionomia Vegetal: _____________	**Líder da Equipe: _______________ _**	**Date: ____/____/__ __**
Hora de Início:__________	**Término:_______ ___**	**Tempo Total:______ ___**

Nº Arv.	**CAP**	**H**	**Nome Científico**	**Nome Vulgar**	**Observações**

GPS coordinates: N

Notes:

E

MSL

3. Appendix 1: QA/QC worksheet documents

For this work we adapted procedures for measuring, checking, data entry and register. The use of the Open-Data-Kit was adopted for field data collection. To ensure that proper procedures are followed a Quality Assurance / Quality Control (QA/QC) plan has been developed that describe the activities in detail.

The QA/QC plan describes four main activities:

1) Collecting reliable field measurements
2) Procedures to check field data
3) Data entry and analysis procedures
4) Data maintenance and storage

1) Collecting reliable field measurements

To ensure the collection of accurate field data the following steps should be implemented:

- The team members need to be fully cognizant of all procedures and the importance of collecting accurate data.

- The field teams will install test plots if needed in the field and measure all pertinent components using the SOPs.

- All field measurements need to be checked by a qualified person in cooperation with the field team and correct any errors in techniques.

If trees tagged, aluminum nails and tags should always be used. Regular nails can damage the trees. A compass with declination adjustment is preferred. DBH tapes are critical when making tree measurements. First aid-kits are essential to treat injuries that might occur during field work in remote areas. Any Global Position System (GPS) that is going to be used in the field should have the capability of collecting coordinate file information for later differential correction (if necessary). The GPS should also have adjustable settings so that erroneous signals are not recorded during position data collection. If the GPS does not have file collection capabilities and inflexible settings for PDOP, SNR mask, datums , and coordinate systems then that unit should not be used for the project

Form A

Field equipment

Document

Surui Forest Carbon Project

Name of organization	
Name of project	
Project manager	
Crew Chief	
Date	
Location	

Does field equipment meet Winrock International’s standards for accuracy and durability?

If there are any exceptions, please list and explain below.

____

Crew Chief (print name)

________________________________ __________

Signature Date

Form B

Field crew training and data collection

document

Surui Forest Carbon Project

The following table should be filled out by the individual (crew chief) responsible for training field crews for plot measurements. The crew chief will be responsible for certifying all team members are cognizant of the field procedures and that the data collected is accurate and of high quality.

Name of organization	
Name of project	
Project manager	
Crew Chief	
Date	
Location	
Type of data collected: , Trees (T),	
Have members of field crew read SOP's ?	
Have test plots been installed ?	

In addition, by signing below the Crew Chief certifies that all members of the field crew have read the Standard Operating Procedures and that all steps for training and testing have been followed. The Crew Chief will, to the best of his/her ability, insure that the data collected will be of the highest quality possible.

____

Crew Chief (print name)

_______________________________ __________

Signature Date

2) Procedures to check field data

On a regular basis during field work, each team will re-measure at least one plot done by another team. The re-measurement of permanent plots is to verify measurement procedures were conducted properly. New field sheets should be used and compared against the originals.

At the end of the field work, the project leader and one other field person should revisit at least 10%(depending on resources and time) of the plots not checked during the inventory period. New field sheets will be used for data collection and these will be compared with the original sheets. Any errors found will be corrected and recorded. Any errors discovered will be expressed as a percent of all plots rechecked to provide an estimate of measurement error

What will be remeasured during the plot checks is dependent on the carbon pool that is measured. If forest plots were installed checks should be of live trees only. In this case the key items to check are the location of dbh and the diameter measurements of each tree. The results of the check cruise will be compared to each other and any problems identified will be discussed with the members of all teams. Errors are corrected and the corrected field sheet is included with the original, and noted as such. For the rechecked plots, double data sheets will serve as the record that the procedure was followed. A copy of the data sheets is available in the Measuring and Monitoring Plan document.

Form C

Field plot check

document

Surui Forest Carbon Project

The following table should be filled out by the individual (crew chief) responsible for checking the field crews plot measurements. The crew chief should also report the results of the field checks and describe any problems encountered.

Name of organization	
Name of project	
Project manager	
Crew Chief	
Date	
Location	
Type of plots checked	
Number of plots checked	

Description of any problems encountered in plot checks:

Steps undertaken to correct problem:

____

Crew Chief (print name)

______________________________ __________

Signature Date

3) Data entry and analysis procedures

The key procedure to produce reliable carbon offsets is the proper entry of data into the data analyses spreadsheets. There are two main types of data in this process: field and laboratory data. It is important that the team leader be responsible for this step to ensure that errors are minimized. Common sense should be used when reviewing the results of the data analysis to make sure that they fit within the realm of reality. Results should be compared with those from other similar types of projects when possible. There will be a great deal of variety in plot results during carbon measurements.

Measurement	Typical range	Notes
Tree biomass (t C/ha) of secondary forests	30-100	These values are approximate but are the typical range that can be expected for secondary forests
Tree biomass (t C/ha) of old growth forests	185 and above	Approximate carbon content values for old growth forests (age 200 years old and above). But any values 500 t C/ha and higher should be re-checked

Not all projects will report values in metric tons of carbon per hectare (t C/ha) like the values in the above table. For reference purposes the following list is provided for the most common conversions used in Winrock calculations.

Value		Equivalent	Multiply	by	To obtain
1 metric ton	=	2,205 lbs	short t	0.9072	metric t
1 short ton	=	2,000 lbs	metric t	1.1023	short t
1 metric ton	=	1.1023 short tons	acres	0.405	ha
1 short ton	=	0.9072 metric tons	ha	2.47	acres
1 hectare(ha)	=	2.47 acres	C	3.667	CO2
1 acre	=	0.405 ha	t C/ha	0.405	t C/acre
1 ton of C	=	3.667 t of CO2	t C/acre	2.47	t C/ha

To check for data entry errors, it is suggested that another independent person should enter data from about 15% of the field sheets into the data analysis software. These two data sets can then be compared to check for errors.

4) Data maintenance and storage

Because of the relatively long-term nature of these projects, data archiving (maintenance and storage) will be an important component of the work. All eletronic archives and paper copies printed will be maintained and stored until at least 2 years after the end of the crediting period of the project.

Data archiving should take several forms and copies of all data should be provided to the partners.

Original paper copies of the field measurement sheets, laboratory data sheets, and data analyses will be placed in folders and stored in a secure location by the carbon measurement implementers and project managers.

Paper copies of all data sheets, data analyses, and models (excel spreadsheets); the final estimate of the amount of carbon sequestered and/or retained; any GIS products; and a copy of the measuring and monitoring reports should all be stored in a dedicated and safe place.

All the electronic data and reports should be organized in a well defined framework and folders and be copied onto durable media such as CDs. We recommend that given the time frame over which this project will take place and the pace of production of updated versions of software and new hardware for storing data, that the electronic copies of the data and report be updated periodically.

Form E

Data maintenance and storage document

Surui Forest Carbon Project

Name and contact information of participating organizations:

a) Carbon measurement implementing organization

b) Project manager

c) Funding organization

d) Others

Are paper copies of field measurement sheets, laboratory data sheets, and data analyses on file of project implementers and copies sent to project managers?

Are paper copies of data sheets, data analyses, and models (excel spreadsheets); the final estimate of the amount of carbon sequestered and/or retained; any GIS products; and a copy of the measuring and monitoring reports on file of project implementers and managers?

Have all the major files and reports been copied an electronic medium (CD)?

Have copies been sent to project managers?

Person who mailed the documents (include contact information)?

Who is the responsible party for periodic updates of electronic data (include contact information)?

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