Pacific Islands National Forest Inventory for REDD+

BOOKLET 3:FIELD OPERATIONS

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Pacific Islands National Forest Inventory for REDD+

Booklet 1: Guidance for Policy makers

Booklet 2: Guidance for Planners and Mangers

Booklet 3: Field Operations

Booklet 4: Data Analysis

Pacific Islands National Forest Inventory for REDD+

Field Operations

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List of Abbreviations

FAO: Food and Agriculture Organization of the United Nations

GPS: Global Position System

MRV: Measurement, Verification and Reporting

NFI: National Forest Inventory

NFMS: National Forest Monitoring System

PICs: Pacific Island Countries

PNG: Papua New Guinea

QA: Quality Assurance

QC: Quality Control

REDD+: Reducing Emissions from Deforestation and Forest Degradation in developing countries; and the role of conservation, sustainable management of forest and enhancement of forest carbon stocks in developing countries.

SPC: Secretariat of the Pacific Community

UNFCCC: United Nations Framework Convention on Climate Change

UN-REDD: United Nations collaborative program on reducing emission from Deforestation and Forest Degradation

Measurements

cm: centimeters

dbh: diameter at breast height, 1.3m above ground, over bark

g: grams

ha: hectare

m: meters

Foreword

Booklet 3 details the responsibilities and operations of the field measurement component of the National Forest Inventory (NFI) design. It is primarily a guiding tool for field team leaders and crew members responsible for carrying out a country's national forest inventory activity under REDD+. The field activity component is critically important for accuracy, transparency and credibility purposes required by forest management and the UNFCCC. This booklet facilitates the explanation of the measurement methods involved in quantifying carbon, volume and tree diversity for a broader audience and to assist in sustainably managing a country's forest resource.

Booklet 3 is part of a series of four booklets to provide the appropriate guidance to policy makers, managers, technical and field personnel on the proper conduct of a national forest inventory, from planning to implementation. The booklet series will ensure a common understanding that would help facilitate the regional sharing and mobilization of relevant expertise to support the conduct of national forest inventories in pacific island countries. The aim is to foster a consistent approach to the planning and conducting of NFI within the pacific communities, noting that the specific details may vary from country to country.

Background

The target audience for booklet 3 on field operations includes foresters, forestry field technicians and forestry trainees who are involved in carrying out a National Forestry Inventory (NFI).

The booklet provides guidelines for the collection of biometric data in different forest types, with modifications to cover the upland and mangrove forest. It also provides detailed guidance about field survey protocols associated with a forest inventory field survey design. While there are many different plot designs and sample distributions to consider, the protocol in this booklet is designed to provide participants with the techniques to collect forest inventory data in the field for analysis and reporting.

The booklet is intended to be used to support training in NFI and to serve as a starting point for implementing the earliest phases of a pilot NFI design.

Purpose and Scope

With field operations, there are core components to ensure the success of an NFI. These include identifying the aims and objectives of the inventory; obtaining consent of the landowners within the study area; being knowledgeable of the sample designs; field data collection procedures; and identifying the specific variables to measure or observe during the inventory field survey.

While there are many aspects to a field inventory design, depending upon the objectives agreed, this booklet focuses on protocols associated with collecting the information necessary to quantify standing carbon stocks and wood volume.

This booklet focuses on NFI producing information on forest carbon, wood volumes and tree diversity for forest management and carbon accounting purposes

The approach presented here is relevant to the Measurement, Verification, and Reporting (MRV) aspects of the REDD+ National Forest Monitoring System (NFMS). National circumstances may dictate alternative approaches resulting to differing plot shapes, samples sizes, and allometric equations (equations that are used to estimate tree volume from more easily measured attributes such as diameter at breast height (dbh) and height) may be more appropriate for conducting carbon, biomass and wood volume inventories to meet specific national circumstances. The approach serves as a guide for countries in the Pacific to evaluate with their existing and/or proposed NFI objectives, local knowledge, resources and personnel, training and other factors. It was developed from the inputs of participating PICs in two forest inventory training workshops events facilitated by the FAO and the SPC.

Components to be Measured

Overview of Carbon and Volume

There are five major components, or pools, in a carbon inventory:

1. Above ground biomass (live trees and shrubs);
2. Below ground biomass (live roots);
3. Dead wood (standing and downed wood);
4. Litter (leaves, fine branches, bark);
5. Soil (mineral/organic).

In the upland forest, the majority of carbon stocks are found in the above ground components, particularly the trees. For mangroves, while the carbon stocks in the trees are important, the majority of the carbon stocks are found in the rich organic soils down to about 1 m in depth.

Carbon pools are in the above and below ground biomass, dead wood, litter and soils

In many forest types, the fine leaf litter and live ground cover does not contribute to a large amount of the biomass, and can also be costly and time consuming to collect. However a very small subsample of plots could be measured to provide an indicative estimate.

While it is important to acknowledge the carbon stocks in all ecosystem components, it is acceptable to measure the more significant pools and either estimate values using data reported in published literature, or exclude but acknowledge the un-measured carbon stocks. In other cases, it is possible to estimate pools based on global, regional or country-level models. For example, the below ground root biomass can be estimated using equations based on the above ground biomass.

National-level estimates can be evaluated on two levels: the standing volume of trees of merchantable size (e.g. ≥10cm dbh), and the status of regenerating cohorts in the understory strata (e.g. < 10cm dbh). The determination of potential merchantable timber volume will also depend on species identification of important species.

Both forest carbon and tree volume are dependent on tree height, yet it is not always possible, economical or necessary to measure every tree in every stand.

The development and use of diameter-height relationships can greatly reduce the amount of time required to collect field data, and can provide the needed national-level estimates for both tree volume and forest carbon. Thus, using a sub-sampling approach for determining tree heights can provide the necessary information for estimating heights for trees not measured for height.

Upland Forest

The upland forests collectively contain the primary and secondary forests found in the montane, hill and lowland forest types. In this booklet, plantation forests are included in the upland forest (Heider, 2014).

In the upland forests, the majority of carbon is in the tree biomass

To obtain carbon stocks and tree volume, this example focuses on two major size classes of trees for the upland types: Trees ≥10 cm dbh and trees ≥5 but <10 cm dbh. These are measured in two different plot configurations in the field (see Figures 3 and 4). Trees and shrubs >1.3 m in height are measured for dbh, with a sub-sample measured for height.

Biomass and carbon are calculated using allometric models that include dbh and tree height in the equations (see Data Analysis in Booklet 4). Tree species are identified to recognize diversity. Trees, vines, and other components <5 cm dbh and >1.3 m in height are tallied. Standing dead trees are classified into one of three clusters and measured. Downed wood pieces are counted or measured, and leaf litter may or may not be included. Below ground roots are estimated from above ground biomass measures using published models and soil pools will be estimated using soil map information extrapolated at the country scale, using published values. This inventory model produces information to capture the carbon stocks of the forest, using regional and global estimates for stocks not measured.

Depending on the national capacity, an NFI can include more of these components, or can include other important aspects affecting biodiversity (flora and fauna species identification), habitat characteristics, wood quality, and other factors that meet the national circumstances as part of the design.

Mangrove Forest

The mangrove forest is a unique ecosystem type along some coastal and estuarine zones that typically represents 2-4% of the land area of PICs, and can contain 2-3 times as much carbon for the equivalent land area as the upland forest types. Mangroves are important for other ecosystem services, including nursery grounds for fish, capture of sediment that protects the reef environments, and a source of protection from storm surge events.

> *Depending on the objectives and national circumstances, mangrove forests should be included in the overall NFI design, unless specified otherwise*

The majority of the carbon stocks within mangrove forests lies below ground, in the rich marine sediments that are held together by a dense root mat that often exceeds 1 m in depth. The organic soils typically contain between 10-20% organic carbon to depths of about 1m, where upland forest types may only contain about 5% in the first 10-20 cm, with 1-2% carbon at increasing depths.

As such, it is important to sample the mangrove forest in a different way from the upland forest to accurately assess the carbon stocks.

> *In a mangrove forest, the bulk of carbon is stored below ground at depths exceeding 1m*

Trees and shrubs >1.3 m in height are measured for dbh, with a sub-sample measured for height. Biomass and carbon are calculated using allometric models that include dbh and tree height in the equations (see Data Analysis in Booklet 4). Downed wood pieces are counted or measured. Because of the frequent tidal action, leaf litter is near non-existent and as such is not collected. Below ground biomass is estimated using models based on tree biomass. Soil carbon is estimated by measuring the depths of the soils to the coral sands, and then core samples are carefully extracted for analysis. The core sampler pulls a fixed volume sample to calculate bulk density, and then laboratory analysis provides the carbon content for each sample.

Species Composition

There is the capacity within PICs to identify tree species, at least to the local name. Other rooted plant species will not be identified.

Tree spotters are essential resources in the field operations

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Field Survey Plot Layout

Clusters, each of five field plots, are located on the systematic grid across the country. Clustered field plots are useful tools for capturing the local variability at a sample point. Advantages include sampling in a plot frame that is small enough to allow the field crew to measure the appropriate components without getting "lost" in the plot and double measuring or missing trees.

For this example, Figures 1 and 2 display a clustered plot layout for both the upland and mangrove forest types. Each cluster is composed of 5 subplots, where the center point of Subplot 1 is the GPS coordinate identified from the NFI plot grid.

Cluster plot layout can be used in both upland and mangrove forest to capture the variation of the site:

- For upland forests, subplots are established 50 m horizontal distance from this center point in the cardinal directions (north, south, east and west) (Figure 1); subplots are numbered with Subplot 1 in the center, and 2-5 being numbered in a clockwise direction. All trees >1.3 m in height are measured, with trees ≥10 cm dbh being measured within a 12 m radius circular plot and 5-10 cm dbh in a 2 m radius nested circular plot. All radii are horizontal distances.
- For mangrove forests, subplots are established in a similar manner, separated by 25 m between each subplot (Figure 2). Because mangroves are often in smaller strips of land, it can be

difficult to establish a cluster design with a large distance between sub-plots. Dwarf mangroves (i.e. mangrove shrublands) can be separated by less distance (e.g. 10 m). All trees >1.3 m in height are measured, with trees ≥5 cm dbh being measured within a 7 m radius circular plot and ≥1.3 m in height but <5 cm dbh in the center, 2 m radius circular. All radii are horizontal distances.

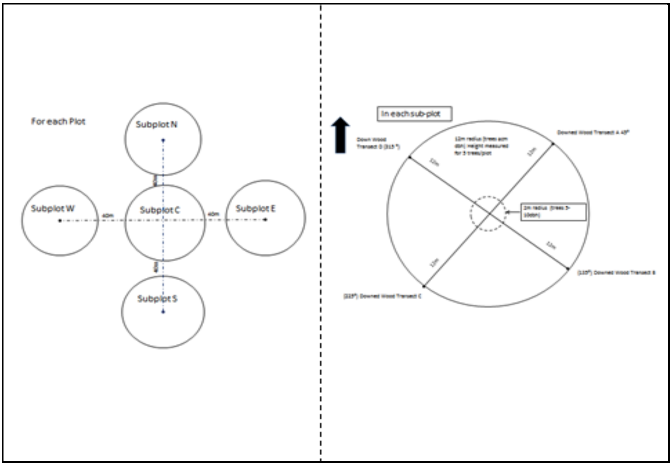

Figure 1. Cluster design for each sample plot (left) and plot layout for carbon stock and forest volume sampling for ***upland forest types*** *(right).*

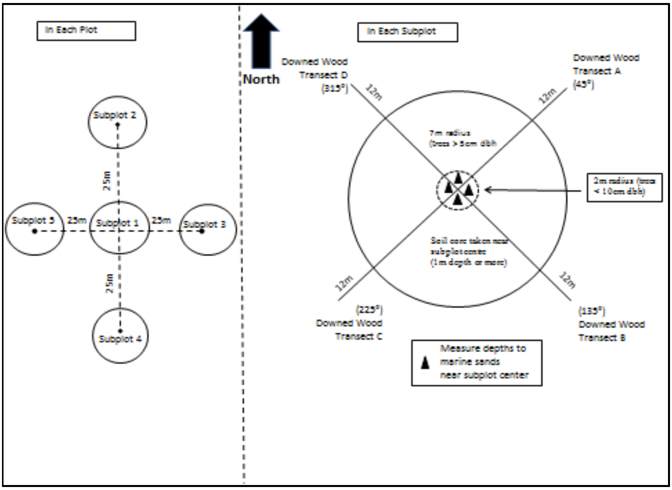

Figure 2. Cluster design for each sample plot for ***mangrove forest*** *(left), and the plot layout for carbon stock.*

Occasionally, it may be difficult or impossible to locate a sub-plot due to safety, weather, flooding, or for cultural reasons. It is important to note the **plot locations are fixed and cannot be moved**. While it may be tempting to relocate plots in a more convenient area, this will add bias to the sampling. If a sub-plot cannot be measured for some reason, then the reason will need to be documented, photographed (if possible), and recorded. Documentation on why a plot was missed is key for the verification process.

No, the plots cannot be moved. If they cannot be sampled, then document, document, document

Where the forest or mangrove boundary lies within a plot then procedures that are country specific need to be prescribed. For example, a plot is measured if more of its area falls within forest or mangrove; if more area falls outside then the plot is not measured.

Plot Establishment

The center point will be located using GPS. Under thick canopy the GPS location is unreliable. For the last 20m, the location is determined using compass and tape (Ellis and Hayes, 1995).

In order to relocate the cluster of plots on a subsequent re-measurement, the plot markings should be highly visible. An access route should be marked on maps and in the forest. Witness trees should be marked close to the plot, and the central point of the cluster marked if possible. Each tree should be numbered with either long lasting paint or a permanent tag. The point where dbh has been measured should also be identified.

Information to be Collected

Once the sample design and plot layout have been identified and established in the field, there are two categories of information that the NFI crew should collect. The first is the *General Information* about the plot location and establishment, and the second are the *Specific Measurements* to be taken in the field.

Because field crews will traverse over typically large areas to access plot locations, additional information can be gained, depending on national circumstances. Examples include the traditional owners' priorities and practices, road conditions, post-harvest surveys, cultural site locations, illegal timber operations, or other observations that will assist management. While not directly part of NFI, it is wise to take advantage of the opportunity the team of observers have while in the field to collect this additional information.

NFI teams collect plot level information, but can also contribute to other management observations while traveling to sites

General Information: The following are basic characteristics about the overall site and subplot. This information is obtained relatively inexpensively, and should assist in the overall understanding of the plot, and allow for re-entry and audit at a later date:

- Plot identifier: The NFI grid location that is connected with the sample design and remote sensing data. Sub-plot values are also denoted;
- General information about the plot location, including other identifying information (e.g. management district, traditional landowners, directions to plot location, etc.);
- Sample date, GPS and precision, crew members present;
- Any heritage resources observed or learned on en route to the location (with GPS);
- Site characteristics, topographic features, ecological condition and land use;
- Disturbance evidence, including storm damage, timber harvest, type of harvest, diseases or insects etc.;
- GPS photo points in cardinal directions.

Specific Measurements: For this example of forest carbon and inventory volume, the following apply:

- Tree measurements (upland forest): Trees ≥10 cm dbh in 12m radius circular plot[1] and trees ≥5 but <10 cm dbh in a 2 m radius circular plot (Figure 1). All radii are horizontal distances;
- Tree measurements (mangrove forest): Trees ≥5 cm dbh in a 7 m radius circular plot; trees >1.3 m in height but <5 cm dbh in a 2 m radius circular plot (Figure 2). All radii are horizontal distances.

[1] A 12 m circular plot (0.04524ha) was established to simplify the nested design with the downed wood transects.

Guidelines to Field Measurements

Field measurements involving direct measurement comprise primarily of the tree parameters, which consists of the diameter at breast height (dbh), species identification, tree status, tree height, tree quality code and tree wood density, and the downed debris and soils.

Trees

Diameter at Breast Height (dbh)

Tree diameter is measured on the uphill side of the tree at 1.3 m in height above the mineral ground surface (see Figure 3, *A*) preferably using a diameter tape.

Tree diameters are only measured on trees that have at least 50% of the observed roots within the plot.

Trees with less than 50% of the observed roots within the plot are excluded:

- In cases where large branch patterns exist (e.g. a "forked tree") the diameter is measured for each branch intersecting the point 1.3 m in height (*B*). Where branch patterns create a branch-enlargement at 1.3 m in height, then diameter is measured directly above the enlargement *(C)*, or below in the forked-tree example (*B on left*).

If tall buttresses are present at or above 1.3 m in height, then diameter is measured at the point directly above the buttress where the tree bole normalizes.

- For stilt rooted species (e.g. *Rhizophora* spp.) diameter is measured above the highest stilt root;
- Tree diameters are measured and recorded in centimeters, to the precision of 0.1cm.

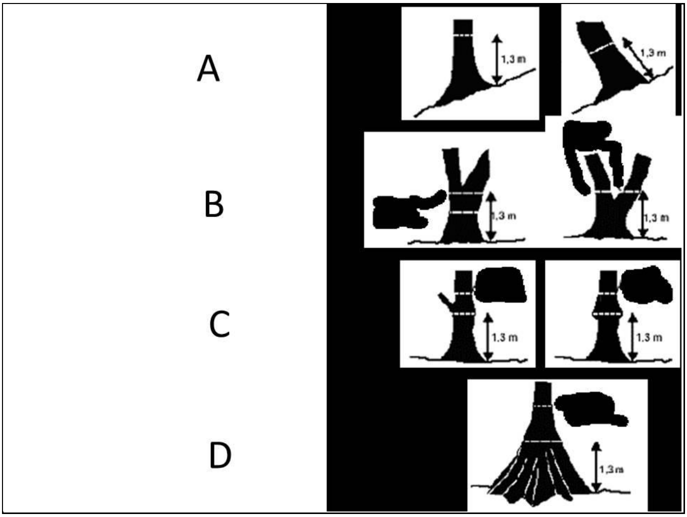

Figure 3. Diagram of Circumstances affecting diameter measurements. Source: FAO.

Species Identification

For botanical identification and collection, it is suggested that a tree spotter and or botanist accompanies the field crew to assist with the NFI.

Each PICs has a designated species code that is used to identify the proper tree code. During the NFI all trees measured must be identified to species level where possible.

Where species cannot be identified, the genus-level identification code can be used. Where genus is not known, then family is used, or recorded with UNKNOWN as the species code. In this case, a field sample is taken, recorded, and sent to the respective herbaria for verification.

Tree Status

Standing dead trees are measured for diameter (and species if possible) and are identified to one of 3 standing dead tree status (Figure 4). Tree heights are estimated and recorded for trees in status 3; tree heights for status 1 and 2 are estimated from the diameter-height model.

Decay classes are only used for downed wood (lying dead wood) on the forest floor, measured through use of transects (see downed wood section).

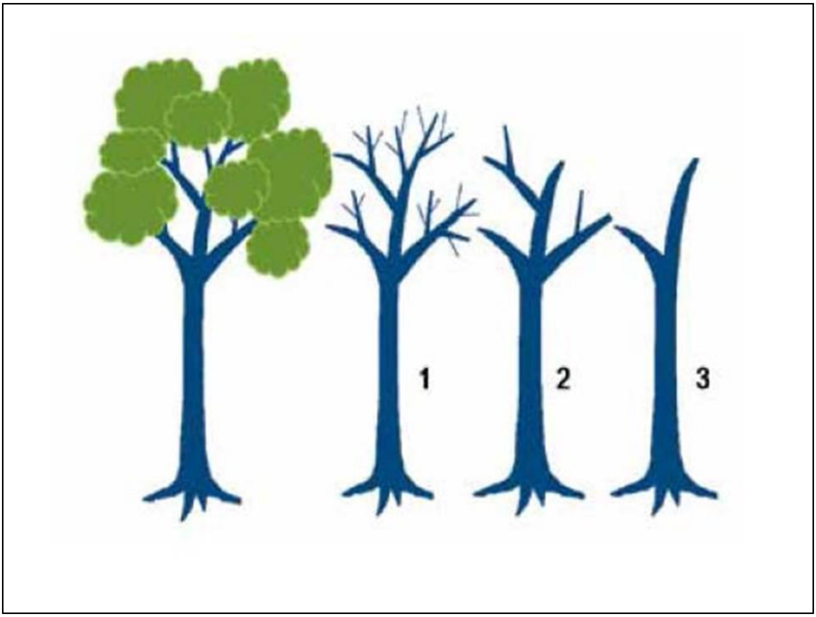

Figure 4. Diagram of standing Dead Tree Status. Source: FAO.

Tree Height

In addition to diameter and species identification, tree heights are only measured for 5 trees ≥10 cm dbh per subplot in upland forest types (total of 25 trees per cluster).

The five trees per subplot are systematically selected as every 5th tree measured, beginning in the north and measuring in a clockwise direction.

If fewer than 25 trees are in the subplot, then heights can be systematically measured at a higher frequency to ensure a good distribution is achieved.

Tree heights are measured using a clinometer to measure the angles from a known distance from the base of the tree, or if budget allows, using a laser rangefinder (or Hagloff vertex) can increase the accuracy and ease of tree height measurements (Figure 5).

The distance from the tree should be measured as the *slope distance* that is approximately equal to the tree height (Figure 5).

The operator uses the clinometer to take 3 measurements: angle to the base of the tree, angle to the first branch, and angle to the top of the tree (Figure 5).

Horizontal distances and heights to first branch (bole height) and total height are calculated during the analysis phase (Figure 5).

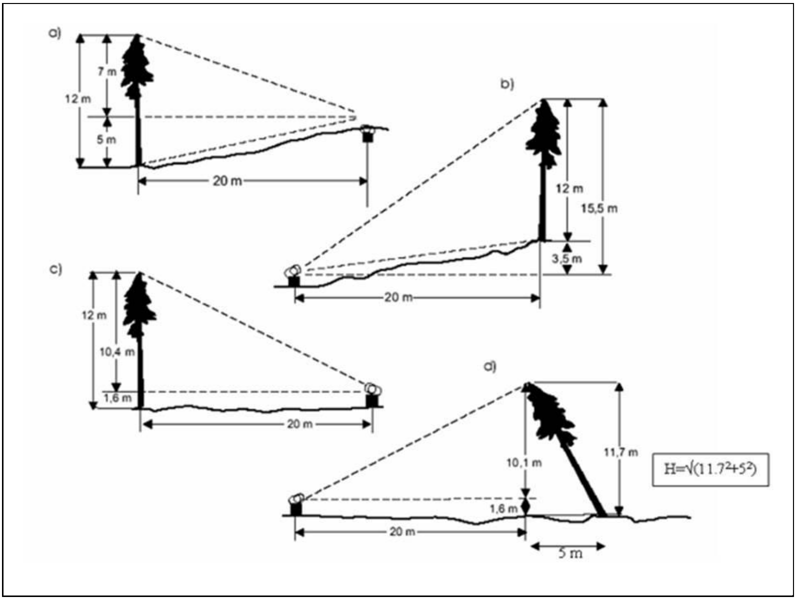

Figure 5. Examples of estimating tree heights. Source: FAO.

Tree Quality Code (Height trees only)

For each of the trees measured for species, height, wood density and diameter, a qualitative evaluation of the tree bole, up to the first branch, is recorded (Table 1).

These are on the basis of "sweep", or yaw in the potential log, "branching", or any forks or large branches that interfere with the bole, and "defects" such as breakage, insect or cyclone damage.

Table 1. Decision matric for determining tree quality code. Tree quality is recorded for height trees only.

Sweep	Branching	Defects	Tree Quality Code
No	No	No	A
No	No	Yes	B
No	Yes	No	B
Yes	No	No	B
No	Yes	Yes	C
Yes	No	Yes	C
Yes	Yes	No	C
Yes	Yes	Yes	D

Wood density, or the dry weight per unit volume of wood, is an important parameter that can be used in allometric equations to estimate tree biomass and carbon stocks from stem diameter values.

Wood density is also a measure of wood quality (denser wood tends to have higher structural strength for timber products and higher calorific value as firewood or as source of charcoal).

Wood density varies with tree species, growth conditions and part of the tree measured.

In the field, wood density samples are collected for each of the 5 height trees using an increment borer (Figure 6 and 7). The bored hole should go in past the center pith, where possible, but not to exceed ¾ of the length of the borer.

Wood cores are collected (1 per tree, 5 trees total per subplot, 25 total for each cluster) and recorded by site number and height tree number.

The data recorder should have a species identification, dbh, height angles, and wood density sample identifier code.

For mangroves, only 5 samples for each dominant tree species are needed per cluster.

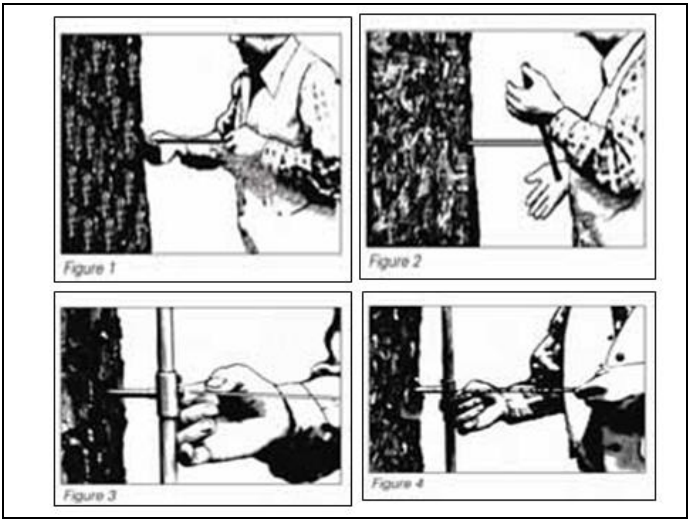

Figure 6. Illustration of how to sample wood density using the increment borer from a tree wood species. Source: Chave, J. 2002-2006.

Figure 7. Wood core on the extract. Source: Chave, J. 2002-2006.

Downed Wood

Measurements of dead and downed material are used to estimate the carbon pools from wood that is present on the forest floor. Transects use the line intercept technique, which assumes that any wood material in a vertical plane above the transect is measured as "downed wood".

To capture this ecosystem component, four 12m transects are established at azimuths 45° from the cardinal directions (45°, 135°, 225° and 315°), originating from the subplot center. At each transect, all downed wood pieces ≥ 7.6cm in diameter that cross the transect line are measured for diameter along the full 12m transect.

Diameters of pieces ≥7.6cm diameter should be measured at the point where the piece meets the transect. The diameter is measured at right angles to the length of the piece. Medium wood pieces 2.5-7.6cm are tallied (diameters are not measured) within a 5m transect only. If no wood is present in the transect, the recorder indicates a '0' (zero) for the transect. Calipers are useful to measure diameter, and maybe necessary where it is difficult to get the diameter tape around the girth.

Litter

Litter does not contribute a large amount of carbon to the overall stocks in PICs, and can be costly and time consuming to collect. Often this component is excluded from collection of information in the upland forests.

Soils

Soil Sampling (Mangrove plots only, not upland forest)

As indicated in the subplot layout for mangrove plots (Figure 8, right), the carbon stocks within the organic soils are to be measured as part of the total ecosystem carbon stocks.

To quantify the soil carbon stocks, three measurements are required:

1) Soil depth;

2) Soil bulk density; and

3) Organic carbon concentration.

Soil Depth

Within or near the center of the plot, taking care to select an area that has not been trampled, insert the soil depth probe into the soil.

The probe should be pushed down carefully, with the operator listening to the sounds generated by the metal rod.

The operator should listen for the sounds of meeting the underlying sands or bedrock.

This commonly sounds like a scratching or grating noise.

Once this depth has been reached, extract the soil probe and measure the depth and record this depth on the datasheet Repeat this process at least 3 times; depth measures should be somewhat similar, though not exact.

Caution should be made not to push too fast and miss the depth (overestimating depth) or mistaking the sound and resistance of the depth rod against below ground roots (underestimating depth).

Soil Core Extraction

Using the open-faced peat auger, locate a sample point near to the plot center, but in an area that is not trampled.

Insert the auger into the soil, rotating the handle constantly to shear roots and avoid compressing the sample core.

Continue in this motion until the soil core has either reached the depth of the auger (if soil depth is ≥100 cm), or to the depth of the underlying coral or bedrock (if soil depth is <100 cm).

To extract the core, continue rotating the auger while lifting out of the sample hole.

Mark the sample hole with a stick or flagging to sample greater depths, using caution to not step on or near the sample hole.

Measure the sample core from the top to the bottom to identify the depth sampled (and the starting place for the next extraction).

Follow the instructions for soil sample preparation, and then repeat to obtain a sample >100 cm, if soil depths indicate so. If evidence of base layer sands or bedrock is present in the sample, confirm the depths recorded with the soil core extracted.

Soil Sample Extraction

Once a successful core has been extracted, it requires several steps to prepare for selecting relatively undisturbed soil samples with a known volume.

The steps are displayed in Figure 8, and include the following: (A) using a serrated knife, carefully cut the core sample along the open face to create a flat surface (B).

With a measuring tape, measure the entire length of the soil core to determine actual depth (C).

Starting from the top of the core, delineate 0-15 cm, 15-30 cm, 30-50 cm and, 50-100 cm by scribing the soil surface with the knife (D).

In each fraction, select an intact sample that is 4 cm wide and slice the core very carefully in a straight, perpendicular line to obtain a core sample.

Being very cautious to not compress the sample or area around it, gently extract the sample from the core (E) and place into a numbered soil can (F).

Record the soil can number on the datasheet to indicate the subplot number and soil fraction obtained.

Following extraction of the first fraction (0-15 cm), proceed to the other fractions in the core. If the soil depth exceeded 100 cm, then obtain another core in the same hole and repeat this process to obtain a single sample >100 cm in depth, bearing in mind the depth of the last core will be the top of the second core.

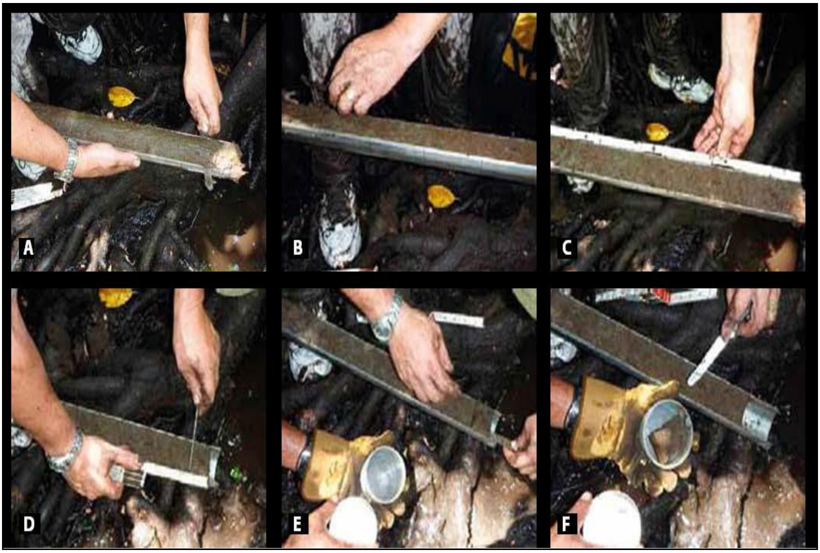

Figure 8. Stepwise photo series of the collection of soil samples from an open faced peat auger. Source: Kauffman & Donato, 2010.

Notes: A) Cutting the soil away from the auger face; B) cleaned, flat surface of soil core; C) measuring and marking the depth intervals; D) cutting the sample for precise volume; E) extracting the sample from the auger; F) collection of sample in a numbered container.

Field Personnel and Equipment

NFI field personnel and or crew carry out the field work that is required of any inventory. It is important to identify the capacity, skills and equipment required prior to the commencement of field work so that uniform training and auditing can ensure the quality of the inventory.

Roles and Responsibilities of Field Crew

The forest inventory crew comprises four team members. Depending on the scale of the project, the primary roles of any field crew team should consist of a team leader, foresters, tree spotter and at least one local guide.

Field crews are the implementing group for a National Forest Inventory

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Team Leader: responsible for the organization and operational planning of the field work. Their tasks primarily are to:

- ensure the availability and utilization of resources and field equipment;
- establish plot accessibility in the sampled area;
- carry out the implementation of field protocols and data sheets;
- ensure quality assurance and quality control of field data;
- ensure that proper workplace health and safety equipment and procedures are in place.

Forestry technicians/Foresters: responsible for laying out the plot and for the field measurements. The number of personnel required will depend on the scale of the sampling area and capacity of the team.

Tree spotters or botanist: persons skilled and experienced in tree identification and who work closely with plant specialists to verify the identifications.

Guides: are responsible for accompanying the Forest Inventory crew into the field. They are most familiar with the terrains, taboo areas and the traditional knowledge of the forest.

Quality Assurance and Quality Control

A formal report should be made on any errors and any biases of the field procedures as part of QA/QC. Usually a proportion (5 to 10%) of the field plots should be re-measured and reanalyzed. The field methods should be the same.

QC can be carried out:

- by the field crew manager, accompanying the field crew;
- by an audit team and the original field crew team together remeasuring the plot cluster (this is the preferred method, provided there is no collusion, as a discussion and resolution of problems can be made on site);
- as an independent audit carried out by a team that did not measure the plot, shortly after the plot was originally measured.

Inventory of Field Equipment

Specialty field equipment is an important part of NFI implementation. Proper equipment that is durable and requiring little maintenance is essential for collecting accurate field data. In this example, field equipment is classified under three categories: Core Items, Common Items and Additional Items.

Durable equipment are essential tools for field sampling in any NFI

Core Items

- Tape, Nylon Clad, 50m;
- GPS;
- Clinometer – or Haglöf ECII electronic clinometer (and height meter, or Hagloff Vertex – but note requirement for calibration to occur every day before use);
- Fuel Gauge, Wildland Fire;
- Safety clothing, including high visibility Vest (mesh), hard hat and safety boots;
- Vest, ArmyDuck w/Backpack;
- Tape guard for Spencer Tape;
- Spencer (Loggers) Tape w/dbh 30m;
- Replacement Loggers Tape line;
- Compass;
- 10 m dbh tapes;
- 3m Hand tapes;
- Multitool;
- Thin Rope, ~15 m;

- Small solar calculator;
- Clipboard;
- Small rings for vests;
- Large drybag backpack;
- First Aid kit;
- Field Radio;
- Digital field camera, shockproof/waterproof;
- Height Pole (preference);
- Hardcover notebooks (loose leaf).

Common Items

- Flagging, pink;
- Rite-In-Rain paper;
- Whirlpak bags;
- Pens, pencils;
- Marine radios;
- Action packer boxes;
- Digital Scale to 0.01 g (wood density);
- Increment borer;
- Large drinking straws;
- Ziplock bags;
- Rite in rain notebooks;

- Rite in rain paper for hard books.

Additional Equipment

- Clippers;
- Plastic bags;
- 50x50 cm folding rulers;
- Digital scale to 0.1 g (kg);
- Loggers Tape Replacement;
- Handle, Cross Chromemoly/RC;
- Probe, Tile extendable, 4' base;
- Probe, Extension 4';
- Tin sample boxes;
- Peat Sampler w/handle and extension rod;
- Calipers (for small dimension trees).

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