Forest Resource Assessment in Nepal

[Re-Measurement of Permanent Sample Plots]

Field Manual, 2019

Government of Nepal

Ministry of Forests and Environment

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Foreword

Forest inventory is a fundamental element of sustainable forest management. In Nepal, forest inventories have been carried out since 1960s with different purpose, scale, scope as well as in different design and technology . To carry out national level Forest Resource Assessment (FRA) , the FRA Manual (2010 -2014) was developed in consultation with a series of national and international experts. The manual describes methodological procedures and steps to collect data from the field. This manual includes globally accepted instruments and equipments, methodologies, procedures and standards in forest inventory.

It is necessary to revise and update the manuals regularly to cover additional parameters. A number of changes have been occurred during and after project period. This Field Manual aims at revising and updating the existing manual to facilitate the re-measurement of Permanent Sample Plots (PSPs) with additional parameter such as IAS, forest disease and pest etc.

I wold like to thank Mr. Ananda Khadka, Assistant Forest Survey Officer for his rigorous and hard work to revise this manual. I would like to express my gratitude to Mr. Yam Prasad Pokharel and Dr. Buddi S. Poudel, DDG/FRTC for providing suggestions and guidance in revising the manual. I am further thankful to Mr. Bimal K. Acharya, Forest Survey Officer and Mr. Rajkumar Giri, Asst. Forest Survey Officer for their support in revising the manual. I also would like to acknowledge all professionals and organizations involved in this hard work.

I hope this manual will work as a guideline and reference material in forest resource assessment and report writing as well.

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Director General
Forest Research and Training Centre

ABBREVIATIONS

ACL	Assistant Crew Leader
BZ	Buffer Zone
CC	Crown Cover
CCSP	Concentric Circular Sample Plot
CFUG	Community Forestry User Group
CL	Crew Leader
DFO	Divisional Forest Officer
DFRS	Department of Forest Research and Survey
E	East
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resource Assessment
FRTC	Forest Research and Training Centre
GFRA	Global Forest Resource Assessment
GIS	Geographic Information System
GPS	Global Positioning System
IAS	Invasive Alien Species
LRMP	Land Resource Management Project
LRP	Local Resource Person
N	North
NE	North East
NTFP	Non-Timber Forest Product
NW	North West
QA	Quality Assurance
QC	Quality Control
RS	Remote Sensing
S	South

SE	South East
SOP	Standard Operating Procedures
SP	Soil Pit
SW	South West
TA	Technical Assistant
TOF	Trees Outside Forest
UN-REDD	United Nations' program "Reducing Emissions from Deforestation and Forest Degradation in Developing Countries"
UTM	Universal Transverse Mercator
VDC	Village Development Committee
VP	Vegetation Plot
W	West
WGS	World Geodetic System
WRB	World Reference Base

Definition of Variables

Breast height: A fixed height of 1.3 meters above the ground level. If the ground level cannot be defined, the breast height is determined as 1.3 meters from the seeding point.

Sample tree: A tree selected for the measurement of additional variables (e.g. tree height) that are often generalized to cover the tally trees.

Sapling: Sapling is a tall perennial woody plant having a main trunk and branches forming a distinct elevated crown; includes both gymnosperms and angiosperms. Sapling generally has greater than 1.3 m height and having a diameter at breast height less than 5 cm.

Seedling: Seedling is a young plant sporophyte developing out of a plant embryo from a seed. Seedling development starts with germination of the seed having a height less than 1.3 m. It can be considered as regeneration materials.

Shrub: Shrubs are woody perennial plants, generally of more than 0.5 m and (usually) less than 5 m in height on maturity and **without** a definite stem, i.e. they produce several shoots or trunks from the base. It has several stems, none of which is dominant. When much-branched and dense, it may also be called bush. These distinctions cannot be regarded as unambiguous. In fact, under especially favorable environmental conditions, some shrubs (e.g. *Rhododendron* spp.) may grow to the size of tree like having the dimensions and form of a (small) tree.

Stump height: stump height should measure at 15 cm above from the ground level.

Stump: Remaining part of cut tree usually height is less than 1.3 m.

Tally tree: A tree within the plot fulfilling the diameter threshold determined by the plot radius including stump and climber.

Tree: A perennial woody plant that has many secondary branches clearly above the ground on a single main stem or trunk with clear apical dominance.

Contents

1. INTRODUCTION

The purpose of this field manual is to improve the provision of adequate forestry data and its processing for national forest policy development and for national level forestry sector decision making in Nepal. National level information is especially required to assess regionally sustainable utilization potentials of forest-based resources. National-level information on forest resources and their development is also needed for committing the country to new international initiatives and processes in relation to climate change mitigation with a focus on deforestation and forest degradation. The need for the full coverage of forest attribute data with forest carbon estimates is well established in the case of Nepal that is one of the pilot countries of the UN-REDD program "Reducing Emissions from Deforestation and Forest Degradation in Developing Countries".

Due to the demanding natural conditions of Nepal, it is a justified requirement to efficiently utilize modern data collection, management and processing techniques together with remote sensing -based information to produce cost-efficient inventory procedures. In order to obtain the quality standards for the inventory results, the priority cannot, however, be given to the efficiency requirements instead of firm, statistically sound inventory design. The field sampling design to be used in the FRA bases on the two-phase cluster sampling method that is used to locate the basic sampling units, i.e. sample plots, in the field. The plot design used for tallying trees is **Concentric Circular Sample Plot (CCSP)**.

Together with the field sampling design a special care has been given for the determination of measurement setups appropriate for the long-term monitoring of forest resources and change detection in terms of forest characteristics including soil components. Therefore, the basic principle is that all the second phase sample plots, i.e. all the plots located in the field, are treated and established as permanent sample plots, which are needed for obtaining growth data for forest modelling and assessing removals and changes in land use.

The previous inventories (except FRA 2010–2014) mainly focused on estimating timber volumes and partly to biomass of the forest trees. Limited efforts were made to generate the information on non-timber forest products (NTFPs) and biological diversity of forests, trees and vascular species, for instance. In the ongoing FRA, the

inventory data to be collected will not only provide information on the traditional forest and tree characteristics, but also on dead wood, forest and soil carbon, human impacts, and biodiversity variables including, for instance, Non-Timber Forest Products (NTFPs), other vascular plants, macro fungi and flagship mammals, invasive and alien species (IAS), diseases and pests, etc.

This Field Manual was initially developed by the Department of Forest Research and Survey (DFRS) in order to carry out Forest Resource Assessment (FRA) project (2010-2014). A series of consultation with national and international experts was held to prepare this manual. The manual describes methods, procedures and steps for executing the FRA. It includes globally accepted equipment, instruments, methodologies, procedures and standards in forest inventory and offer detailed instructions to use them more efficiently and effectively. Furthermore, it offers guidance on defining clusters with the help of Remote Sensing, maps and tools, as well as a complete set of procedures on application of Remote Sensing, GIS and ground inventory (DFRS/FRA, 2010).

Later, during and after the project period, a number of amendments have improved this manual to complement the collection procedures of additional parameters, for instance: IAS, forest diseases and pest, etc. Nevertheless, amendments didnot complement the re-measurement of permanent sample plots (PSPs) and thus this manual has been revised to facilitate a re-measurements of PSPs.

2. ORGANIZATION OF FIELDWORK

2.1. Overview of data collection process

Data are collected by the trained field crews. The main information source for the inventory is field measurement and observation. The information provided by local resource person, land owners, key external informants such as divisional forest officer (DFO), warden and community forestry user group (CFUG), collaborative forestry user group responsible for the area where the inventory site is located are also useful.

2.2. Field crew composition

Forest Resource Assessment will be executed by a number of field crews. A forest inventory field crew, taking into account the amount of information to be collected and

the tasks of each individual, is composed by four members. Each field crew consists of a crew leader (CL), an assistant crew leader (ACL), a technical assistant (TA) all with forestry expertise and an ecologist (taxonomist). Additional person for example driver, cook, porter and local helpers may be included to improve performance of the field crews, when conditions require greater resources. In addition, it is desirable that local resource persons (LRPs) are hired to act as guides in the field. All the crew members should be trained and qualified to standard forestry practices.

Training of the crews on the assessment methodology should be undertaken at the beginning of the fieldwork in both theoretical and practical sessions. In each crew, the responsibilities of each crew member must be clearly defined and their tasks are proposed in the following paragraphs.

2.2.1. Responsibilities of the crew leader

The crew leader is responsible for organizing all the phases of the fieldwork, from the preparation to the data collection. He/she has the responsibility of contacting and maintaining good associations with the community and all the relevant stakeholders and he/she should keep a good overview of the progress achieved in the fieldwork. He/she will specifically:

1) Coordinate all FRA inventory works with the Forest Inventory and Carbon Measurement Section of the FRTC, plan the measurements and provide the crew members with specific instructions regarding inventory actions and practical arrangements;
2) Plan the field work, collect field forms and maps;
3) Administer the location of clusters and plots;
4) Plan the work division for the crew members;
5) Contact local forestry officers, authorities and the community and request their assistance to contact local people, identify stakeholders, guides and workers;
6) Conduct Quality Assurance and Quality Control (QA/QC) of measurements and verification of their correspondence to the instructions as per the field manual;
7) Take care of all the safety instructions while executing inventory in the field;
8) Organize meetings after field work in order to sum up daily activities;

9) Take care of logistics of the crew by organizing and obtaining information on accommodation facilities, recruiting local workers, organizing access to the clusters;
10) Take care of financial matters as per the financial and administrative guideline of the Government of Nepal;
11) Organize interview and discussion with local stakeholders and local people, as and when required;
12) Record and delineate both plot and forest stand - specific characteristics, disturbances and time measurements;
13) Before departing from the plot ensure that field forms are correctly filled up and that collected data are reliable;
14) Enter or organize entering of field data in the field computer/field device as soon as possible after each working day; and
15) Keep keen coordination with other crew leaders to assure unified conduct in all FRA actions.

2.2.2. Responsibilities of the assistant crew leader

1) Sign out all equipment for measurements and keep responsibility on them;
2) Properly fill the Tally and sample tree field forms, Dead tree field forms, Shrub and Seedling/Sapling Field form, and participate in the related measurements;
3) Measure the bearing of tally trees and heights of sample trees, measure height of each sample tree by using Vertex IV and Transponder T3;
4) Ensure that the equipment of the crew is always complete, in proper order and operational before, during and after the field measurement and take care of all equipment;
5) Take pictures of the field activities for the documentation purpose;
6) Assist crew leader on QA/QC of measurements and verification of their correspondence;
7) Takeover in the crew leader's absence; and
8) Assist the crew leader to organize social survey and discussion, as per necessity.

2.2.3. Responsibilities of the technical assistant (Forest Ranger)

1) Assist the assistant crew leader to measure the horizontal distance of trees from plot centre by using loggers tape or Vertex IV and Transponder T3 with support of local helpers, if needed;
2) Distinguish all the tallied trees, sample trees and their characteristics as per their different diameter threshold size within the CCSP according to the field manual;
3) Measure diameter of each tallied tree within the CCSP as per the standard forestry practices;
4) Assist the height measurements;
5) Determine crown cover density at five points within CCSP i.e. at the plot centre and at the four cardinal points 20 meters apart from a plot centre, using a spherical densitometer;
6) Quantify shrubs, saplings and seedlings within four sub-plots of each CCSP as per the instruction given by field manual;
7) Measure dead wood (i.e., fallen stems, stem fragments and large branch fragments) from the plot with a radius of 10 m by determining the tip and base diameter along with the total length; and
8) Assist the crew leader to organize social survey and discussion, as per necessity.

2.2.4. Responsibilities of the ecologist/taxonomist

1) Collect biodiversity information's (both plant and animal) as per the instructions provided by the field manual;
2) Identify the plant/wildlife species with support from local helpers;
3) In the tree measurements, assist the technical assistant in identifying the tree and shrub species, as per necessity;
4) Collect samples (specimen) of unidentified plants or traces of wildlife and take pictures to document them;
5) Assess the soil characteristics (e.g. soil depth, soil texture and proportion of coarse fractions) as per necessity with support from local helpers as per the instructions provided by the field manual;
6) Collect wood debris, leaf litter and soil samples from the sub-plots as per the instruction

provided by the field manual as per necessity with support from local helpers;

7) Collect data on invasive alien species and forest diseases and pests as per the field manual;
8) Collect data on NTFPs, mammals, epiphytes, parasites and other herbaceous plants in coordination with other crew members and local people; and
9) Assist the crew leader to organize and collect data in social survey and discussion.

2.2.5. Responsibilities of the local resource person

1) Assist to take field measurements;
2) Open ways to facilitate access and visibility to team members;
3) Provide the common/local name of forest species, NTFP, vascular plants and wildlife;
4) Inform about access to the cluster;
5) Provide information about the local forest uses and management; and
6) Assist to organize discussion at local level by contacting local authorities and community.

2.3. Preparatory measures prior to fieldwork

The GPS-based approaching to the target cluster and positioning of the plots in the cluster can be supported by using topographic maps and satellite images. Before going to the field, the FRTC experts provide the crew leaders with the following information and set of printed material:

1) Each field crew, through its crew leader, should start its work by contacting staff of the local forestry services in charge of the area where the clusters are located.
2) Inventory Section of the FRTC will prepare and print, for each crew, the necessary field forms to cover the clusters assigned to it. Eleven (11) field forms, of one or more pages, are needed for each sample plot.
3) A map for planning the shortest accessible route from camp or other starting point to the cluster. Printed topographic map in the scale of 1:250,000 for determining driving routes and walking paths. Clusters with numbered plots are printed on the map.

4) A printed copy of the topographic map in the scale of 1:25,000 for specifying the more accurate location of the target cluster with plots. The cluster with plots and coordinates (latitude and longitude, and the coordinates in the WGS UTM system) are printed on the map.

5) A satellite image in the scale of 1:5,000 with the target cluster and plots.

6) A sketch drawing sheet with printed cluster and plot identification parameters for recording information needed for documentation purposes and localization of the plot at the time of re-measurement, for instance. File names of plot-wise taken digital photographs are also written in the sheet.

7) The condition of the inventory equipment is also verified prior to field work and missing or damaged items are replaced with new or fixed tools. A field crew-wise determined list of inventory equipment is given in **Annex I**.

8) GPS location of each plot should be stored in the field computer and/or Tally Sheet.

3. FIELD SAMPLING DESIGN

3.1. Sampling

Stratified systematic cluster sampling design has been used in FRA throughout the country. This is a method of sampling from a population. When sub-populations vary considerably, it is advantageous to sample each sub-population (stratum) independently. **Stratification** is the process of grouping of the population into relatively homogeneous sub-groups before sampling. It can produce a weighted mean that has less variability than the arithmetic mean of a simple random sample of the population. Stratification also helps in organizing the data collection by dividing the population in sub-populations. **Systematic cluster sampling** is applied within each stratum. This often improves the representativeness of the sample by reducing sampling error.

Cluster is the group of sample plots and it is used when the population can be divided to separate groups. In forest inventory these are typically groups of sample plots or groups of trees located near each other. The usefulness of cluster design is based on cost efficiency. In forest inventory a cluster design will reduce walking distance in forest.

Furthermore, two-phase cluster sampling method has been applied in FRA. At the first-

phase, a grid of 4 km by 4 km has been established, and at each grid point/knot a cluster of plots has been established. Each plot of the clusters has been classified for land use class and accessibility using very high-resolution satellite images (e.g rapidEye). At the second phase, a sub-sample of the clusters has been drawn for field measurements.

For the Hilly Region, including Siwaliks, there are 6 sample plots per cluster. The plots are positioned along two parallel lines in North South direction, 300 m apart from each other. On two lines the distance between plots is 150 meters (**Figure 1**). For the Terai physio-geographic zone (including the Inner Terai as specified in the map), there are only 4 sample plots per cluster. The plots are positioned in a square with a side length of 300 m. The reason for different sampling design in the Terai region is due to the low variability in forest resources in this region, because elevation does not cause changes in the ecotypes. Therefore, larger distance between plots is required for efficiency. Due to relatively easy accessibility it is possible to use smaller clusters in Terai. In some cases, a cluster of 4 plots is expected to be measured within two working days, whereas in the Hilly region a cluster with 6 plots is regarded rather as a camp unit, requiring a number of working days.

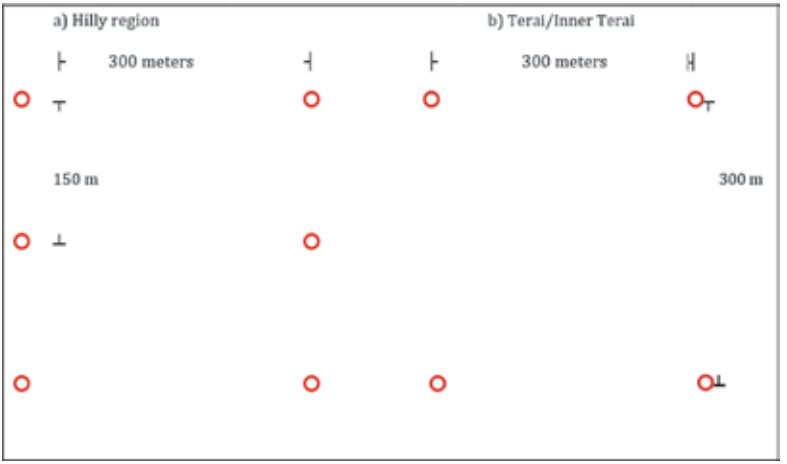

Figure 1. One cluster, belonging to a sub-sample of the first-phase clusters selected in the second-phase to be measured in the field. In the Hilly region (a) the clusters consist of 6 basic sampling units, i.e. sample plots, whereas in Terai/Inner Terai (b) each of them comprises 4 sample plots.

3.2. Sample plots

Nepal is a diverse country with complex geomorphology, landform and climate with a short span in width. About three quarters of the Country's topography is rugged and fragile. In the case of inventories of natural forests, where trees with respect to wide variety of size, age and species are present, it is recommended that Concentric Circular Sample Plots (CCSPs) are used for tallying trees (see e.g. van Laar and Akça, 1997). In addition to that, the CCSP is easy to locate as it needs only one single point (i.e. plot centre), it has lesser edge effects as compared to square/rectangular plot and border line trees are easily recognized. Likewise, because of the rugged and fragile topography of the country, CCSP is at all times easy to locate as compared to square and rectangular plots. The circles of a CCSP with different radii and diameter thresholds, respectively, are centered at the same point. The outermost plot is used for tallying the larger trees (DBH>30 cm), whereas inner plots are used for measuring trees belonging into smaller size classes, respectively. Every single plot is considered as a permanent sample plot (PSP). The CCSP to be applied in the FRA consists of four circular plots as follows (see **Figure 2A**):

- from the plot with the radius of 20 m (r_1, area: 1256.6 m^2) all big-size trees with diameter at breast height equal to or greater than 30 cm are measured;
- from the second largest plot with the radius of 15 m (r_2, area: 706.9 m^2) trees with diameter at breast height from 20 to less than 30 cm are measured;
- from the third largest plot with the radius of 8 m (r_3, area: 201.1 m^2) trees with diameter at breast height from 10 to less than 20 cm are measured; and
- from the plot with the radius of 4 m (r_4, area: 50.3 m^2) trees with diameter at breast height from 5 to less than10 cm are measured.

On the CCSP the tree positions are obtained through bearing and distance measurements (**Figure 2B**). Seedlings, saplings and shrubs are measured from four sub-plots with the radius of 2 m (area: 12.6 m^2) that are located 10 meters from the centre of the CCSP (**Figure 2A**) in the four cardinal directions (N, E, S and W), respectively. Both diameter near the root collar and height are determined for each sampled shrub, whereas seedlings and saplings, which are considered as regeneration material, are assessed with counting the number of stems by means of estimating their mean height.

Information on vascular plants/non-woody plants is collected from four rectangular plots located to the cardinal points (N, E, S and W) 5 metres apart from the plot centre (**Figure 2A**). Dead and decaying wood material, on the contrary, will be assessed from the plot with the radius of 10 m. Soil depth is assessed from the soil pit(s) located outside the sample plots (**Figure 2A**). The data are recorded using field computers (mobile devices), if available. Otherwise, data are manually recorded in the tally sheets (Field Forms).

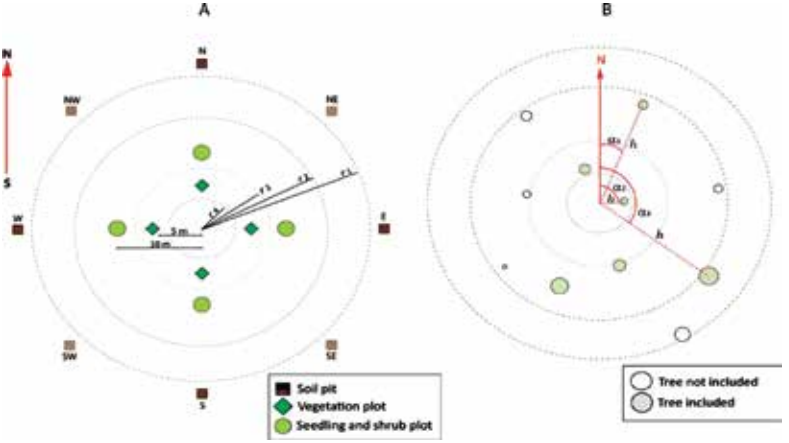

Figure 2. Layout of the concentric circular sample plot (CCSP) (A) and determination of tree positions based on bearing and distance measurements (B). In Figure 2A, the symbols r_1–r_4 are for radii 20, 15, 8 and 4 m of the four circular plots, respectively, whereas a_1– a_3 and l_1–l_3 in Figure 2B are determining bearings and distances, respectively, measured for locating individual trees within the CCSP.

4. INSTRUCTIONS FOR DATA COLLECTION IN THE FIELD

4.1 Locating sample plots in the field

The sample plots are positioned with a GPS-device. The procedure to use the GPS will be as follows:

1) Plan the route to the plots in the camp. If using a car in approaching, mark the point where to leave the car in the GPS as a waypoint. Mark also the other possible

waypoints, e.g. a point where to leave the trail.

2) Use the map to navigate to the point where to leave the car. Check the point with the GPS.
3) Navigate to the plots by using the map and GPS. Plan the easiest and shortest possible route from one plot to another by considering their reachability.
4) When arriving to the plot, select an open point where the GPS works well. Collect GPS data 0.5–1 min. The GPS will average the collected data, calculate the current location. Due to the limitation of GPS precision, one cannot find the plot centre right away.
5) Use the Fixed Points (Reference Trees/Points) to find the plot centre.
6) Then use metal detector to exactly locate the Centre Peg.
7) GPS reading is not required during re-measurement of the plots. GPS locations of the previous FRA is transferred to the new Tally Sheet.
8) Crew members should remove and replace the metal pegs with new ones (both Centre and North 5m) compulsorily.

In addition to a metal hook, a metal screw is also fixed at 5 m towards magnetic North direction apart from the plot centre. The marking in the plots centre is very valuable for periodic monitoring, as GPS alone could give a few meters of difference in locating the centre of the permanent plot. Furthermore, a natural landmark is determined and located nearby the plot to help the localization of the plot centre at the time of re-measurement. Appropriate landmarks are large stones, boulders and large trees, for instance. The distance between the natural landmarks (fixed points) from the plot centre should not be more than 15 meters, if possible. For each landmark, bearing and distance from the centre of CCSP must be recorded. If landmark is tree, then record its diameter at breast height as well. Following data on the fixed points should be recorded on the Field Form 1:

General information common for all sheets

Physiographic zone

Physiographic zones are coded as follows: pre-printed on the sheets with the following codes.

1 Terai (including Inner Terai) 2 Siwaliks

3 Mid Hills 4 High Mountains 5 High Himal

District code

Code number of the district, where the plot is located (Annex XIV).

Plot code

Plot codes are determined on the basis of column, row and plot number as the situation of the sample plot. Plot code consist of three variables: the first indicates the column number (from West to East), second indicates the row number (from South to North) and the third indicate the plot number (from 1 to 6) (e.g. 43-50-1).

UTM map zone

The UTM map zone is either 44 or 45. The GPS shows the correct UTM zone in the display. For a general reference, west of Nepal is UTM zone 44 and Eastern part of Nepal is UTM zone 45. The border line lies at the more or less centre part of the country crossing South to North direction (Nawalparasi district).

Coordinates in metres

The pre-determined coordinates of plot centre within a cluster are stored in the GPS - device and old tally sheet that determines the geographic coordinates of easting and northing in the UTM zone (44 or 45) projection system. The coordinates of the plot centre are pre-filled in the office. The GPS coordinates recorded with Garmin 62s in last FRA should be transferred to the new tally sheet (form 1).

E **Easting** in meters according to the UTM zone (44 or 45) Precision in metre.

N **Northing** in meters according to the UTM zone (44 or 45) Precision in metre.

Fixed points information

Fixed points are the reference points which will be helpful in finding the plot centre during the resource assessment. Field crew should decide number of reference points (usually four in each of the four quadrants) closer to the plot centre which are unique and easily identifiable.

Number

Running number of the fixed points should be mentioned in the field form starting from 1 to maximum 5.

Fixed point type

Fixed point (or witness tree / reference point) should be permanent in nature. The fixed point should be unique for the plot. Normally trees with large sized, single tree of the specific species, tree surrounded by climber, hollow tree, bifurcation of tree, leaning in nature, foot trail, stone, house and other structures nearby the plot centre are preferred.

Bearing, degrees (001−360º)

Bearing (from plot centre to the fixed point), in degrees (001/360).

Distance in meters (with one decimal)

Distance from plot centre to the fixed point is recorded in meters with one decimal.

Finally, a sketch drawing (**Field form 1**) is compiled for identifying locations of the fixed points/landmarks and plot centre. The distance and bearing from the plot centre to the landmark is also recorded on the sketch drawing. The sketch drawing should include the stand border, also, if they exist within the 20 m radius plot (see Chapter 4.2.2).

PHOTO ID

Photographs from five different sides (canopy from plot centre and four cardinal directions) are taken and the IDs of each should be recorded.

4.2. Collection of attributes describing plots and forest stands

4.2.1. Plot variables

General data are collected for identifying the measurement events by sampling units, i.e. clustered sample plots (**Field form 2**). These data are entered, when the measurement of a new sample plot is started.

Relocating method

Usually, GPS is used for positioning the plots and centre point (iron peg) will be relocated with the help of fixed points and a metal detector. In case, iron peg is missing, it will be difficult to find the plot centre; however, with the help of fixed points and tallied tree information as well, the plot centre can be found. The following codes should be recorded in field form as a used method in relocating the plot centre.

1. with iron peg found at centre.
2. with the help of additional iron peg (5 m apart from plot centre)
3. with the help of fixed points and tallied sample trees.
4. with the help of sampled trees of the plots and tallied sample trees.
5. with the help of other methods and patially tallied sample trees.
6. with the help of other methods and not tallied sample trees. (mostly converted land use pattern- road, canal. Landslide, agriculture etc.).
7. could not find centre point and establish new sample plot and measured.
8. drop to re-measure the sample plot after expending sufficient time to relocate the plot.
9. could not access the plot.

Date

Date of the measurement day according to English calendar in the form of 'day/month/year', i.e. *dd/mm/yyyy* (e.g. 23/10/2010 or 05/02/2010).

Crew leader

Crew leader is identified by writing his/her full last name and the first names (e.g. Giri Rajkumar).

FAO Land use class 1

Determined and pre-filled in the office as a part of the previous FRA data. FAO-FRA land use class developed for the FAO Global Forest Resource Assessment (GFRA). According to the GFRA-2005 guidelines, land occupied by trees and woody plants is divided into two classes 'forest land' and 'other wooded land' based on the tree height characteristics and crown cover in maturity. Land full filling neither the forests nor the other wooded land criteria is classified into 'other land'.

FRA land use class is registered for both the sample point stands and for the secondary plot stands. Note that FRA stands must fulfil the minimum size and width criteria of the FAO definitions. If there has been a cutting, the removed trees must be considered in the classification. FAO land use class 1 field should be filled using the FAO land use class 2 data in previous FRA and has following codes;

1. **Forest land**. The crown cover of the stand exceeds 10 % as it grows towards maturity. Trees are able to reach the height of 5 meters. The size and minimum width of the forest stand must be greater than or equal to 0.5 hectares and 20 m, respectively.
2. **Other wooded land.** In maturity the height of trees is at least 5 meters and crown cover 5–10 %, orthe crown cover of trees and shrubs exceeds 10 %. Shrubs are usually more than 0.5 m and less than 5 m high multi-perennial, usually multi-stemmed woody plants. Other wooded land must exceed 0.5 hectares in size and 20 meters in width.

Agricultural land

3. Agricultural land with tree cover; must fulfil the forest criteria (CC> 10%, minimum width 20 m and area 0.5 ha) Note: agriculture land with scattered trees is not included in this class if the crown cover is less than 10 %.
4. Agricultural land not fulfilling the forest criteria

Built-up land

5. **Built-up land** with tree cover, must fulfil the forest criteria (CC> 10%, width 20 m, area 0.5 ha)
6. **Built-up land** not fulfilling the forest criteria
7. **Roads.** Minimum width of roads is 15 m (from outer side of ditch to the outer side of the other ditch); roads with lesser width are included in the surrounding land use class.
8. **Other land, including ice, grass land etc**.
9. **Water** Area covered by major rivers, lakes and reservoirs.

LRMP Land Use Class 1

LRMP Land Use Class 1 is literally the previously collected LRMP land use data. LRMP land use data recorded in last FRA should be transferred into LRMP Land Use Class 1 field of current FRA. This will be useful in comparing the land use change in the particular plot.

The following codes and description will be used to determine the LRMP land use classes;

0 Forest land

1 Shrub land

2 Grass land

3 Agricultural land

4 Built up land (settlement, urban land, roads, parks)

5 Rocks

6 Ice/ Snow

7 Water body

8 Sand, Gravel & Boulders

9 Abandoned land / Open land

Trees outside Forest area 1

Determined and pre-filled in the office with the following codes as a part of the first-phase sampling.

0 Not applicable

1 Agriculture, built-up land, other land etc. without trees

2 Agriculture, built-up land, other land etc. with trees

Reachability_1

Reachability_1 of the plot has been determined using the reachability_2 code of the previous FRA. Crew should simply transfer the Reachbility2 code of last FRA to this field.

Reachability has the following codes.

0 Plot non-reachable Plot is regarded as non-reachable if the slope within the plot is more than 45 degrees (100 %).

1 Plot reachable but surrounded by inaccessible area

2 Plot reachable

Local level

Name of the local level (*Gaupalika or Nagarpalika*) with ward number is required where the plot centre is located.

Forest name

As local people explain the specific name of the forest where the plot is located. (for example- Gairikhola forest, Mathillo ban, Rani ban etc.).

Bearing to nearest settlement, degrees *(001-360º)*

Bearing from the centre of CCSP to the nearest human settlement. Recording unit is a degree (001/360). The bearing is measured with the help of compass or the interpretation of Remote Sensing (RS) data.

Distance to nearest settlement in metres

Distance from the centre of CCSP to the nearest human settlement. If the settlement is within the CCSP, the distance is measured in 1 m accuracy with the use of vertex or linear tape. If the distance is between 20 and 50 m, 5 m accuracy (20. 25. 30. 35. 40 or 45) is enough. For the distances between 50 m and 99 m, 10 m accuracy (50,60,70,80,90 or100) is used, but recording unit is metre. If the distance is 100 m or more, write 99 indicating that the distance measure is to be determined from the interpretation of remote sensing data.

Bearing to other land use class in degrees *(001-360º)*

Bearing from the centre of CCSP to the nearest border between forest and other land use class. Recording unit is a degree (001/360). The bearing is measured with the help of compass or the interpretation of Remote Sensing (RS) data.

Distance to other land use class in metres

Distance from the centre of CCSP to the nearest land use. If the land use is within the CCSP, the distance is measured in 1 m accuracy with the use of vertex or linear tape. If the distance is between 20 and 50 m, 5 m accuracy (20. 25. 30. 35. 40 or 45) is enough. For the distances between 50 m and 99 m, 10 m accuracy (50,60,70,80,90 or100) is used, but recording unit is metre. If the distance is 100 m or more, write 99 indicating that the distance measure is to be determined from the interpretation of remote sensing data.

Aspect in degrees (001-360º)

Direction of the main gradient of the slope. It is determined from the plot centre to the direction of the main gradient (downhill) and taking a bussle (compass) reading in

degrees (001-360). For flat land (slope=0) write 0.

Slope, percent

Average gradient of plot is determined at the plot centre by taking uphill and downhill measurements with the hypsometer. The slope gradient is the average of the two readings. The assessment is limited to the plot area, i.e. the radius (20 m).

Recording unit is in percent, i.e. 45 degrees equals to 100 percent.

Altitude in metres

Altitude of the plot above the mean sea level in metres. Altitude will be recorded in field.

Macro-topography

Classify the location of the plot according to the following codes (see **Figure 3**):

1 Valley
2 Ridge
3 Upper part of the slope
4 Middle part of the slope
5 Lower part of the slope
6 **Plain (Slope is less than 10 %).**

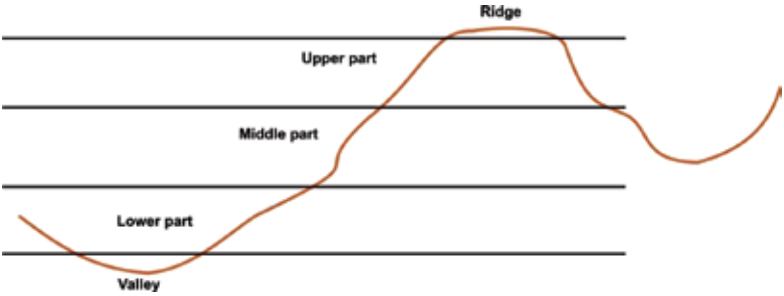

Figure 3. Illustration of classes used to determine macro-topographic location of the sample plot.

4.2.2. Stand delineation

The CCSP should be delineated in to two or more stands if there exist more than a single forest or land cover type within the plot area. In such cases, a clear stand delineation is required for estimating areas respective to different stands (e.g. natural forest stand and plantation forest stand) or land cover classes (e.g. forest, agriculture, grassland, etc.) within the sample plot (see **Field form 1 and 2**, **Figure 4**). Borders of the forest stand are determined by compiling a sketch and by numbering the forest stands within the CCSP (**Field form 1**). The minimum requirement of multiple stands within a CCSP is stand area (at least 0.5 ha) and/or stand width (20 m) that could be extending outside the CCSP area.

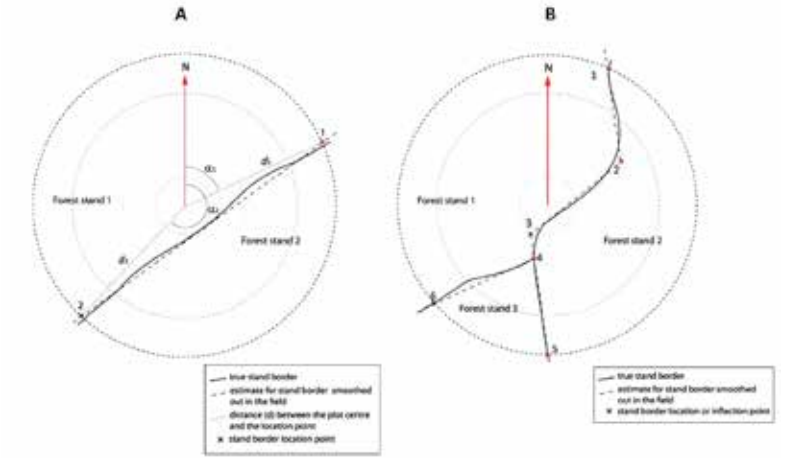

Figure 4. Determination of a straight stand border with two location point measurements (A) and an example of multi-border situation, i.e. three forest stands delineating one CCSP (B).

4.2.3. Stand description

The plot area can be delineated into several stands as described in chapter 4.2.1. the stand where the centre point of the sample plot is located should always be considered as Stand 1.

Soil sampling pits (**Annex X**) must follow and coincide with the forest stand division.

Enough soil samples are to be retrieved from each stand if there are more than one forest stands. The cardinal and sub-cardinal points are to be used. If less than 3 sub-samples could be taken from a forest stand, then the soil samples from that forest stand are not taken.

Reachability_2

Reachability of the plot determined in the field. Plot that are accessed in previous FRA might not be reachable in current FRA. Plot is regarded as non-reachable, if the crew could not access the plot due to various reasons such as inaccessible way, dense grasses, some restrictive area, river moved to the plot etc.

0 **Plot non-reachable** Plot is regarded as non-reachable if crew could not access and inventory the plot due to any reason.

1 **Plot reachable but surrounded by inaccessible area**

2 **Plot reachable**

FAO Land use class_2

Determined in the field using the same codes as land use class 1

LRMP Land Use class2

LRMP land use class 2 is the land use observed in the current FRA in the plot. The following codes and description will be used to determine the LRMP land use classes;

0 Forest land
1 Shrub land
2 Grass land
3 Agricultural land
4 Built up land (Settlement, Urban land, roads, parks)
5 Rocks
6 Ice/ Snow
7 Water body
8 Sand, Gravel & Boulders

9 Abandoned land / Open land

Management Regime

One of the following codes depending on the management regimes prevalent in Nepal is to be noted:

0 Not Determinable;
1 Private Forest;
2 Government Managed Forest;
3 Protected Forest (National Park, Wildlife Reserve);
4 Buffer Zone (BZ) Forest managed by Government;
5 Buffer Zone Community Forest;
6 Conservation Area
7 Community Forest;
8 Religious Forest;
9 Collaborative Forest;
10 Leasehold forest;
11 Public Land Forest
12 Other

Soil depth (NE, SE, SW, NW)

Soil depth is estimated by forest stands from soil pits (**Annex X**) with the use of auger or determined from bare bedrock outcrops. If the plot is not defined as a soil plot, and actual soil pits are not made, then soil depth is estimated using the auger from the soil surface at 5 locations randomly within the CCSP.

A soil sampling auger with a 1 m shaft is used to measure the soil depth. Soil depth is determined for each forest stand or land use class demarcated within the sample plot. Classes according to the World Reference Base (WRB) are recorded as follows:

0 bare bedrock **1 soil depth 1–10 cm**
2 soil depth 11–25 cm **3 soil depth 26–50 cm**
4 soil depth 51–100 cm **5 soil depth over 100 cm**

Mean penetration depth, cm

Penetration method is used to determine proportions of coarse fractions (stone and boulder proportion) in surface layer**.** A steel rod of 1 m (with markings at 5 cm intervals) should be pushed down to the depth of 30 cm. Altogether 20 pushes (five along each pit) are to be done starting from the edge of CCSP towards plot centre (**Fig. 5**). And the arithmetic mean of penetration depths (mean of 20 penetration readings) is calculated and recorded at an accuracy of 1 cm. If the mean of penetration depth is greater than 30 cm, only 30 is to be written in the field form 2.

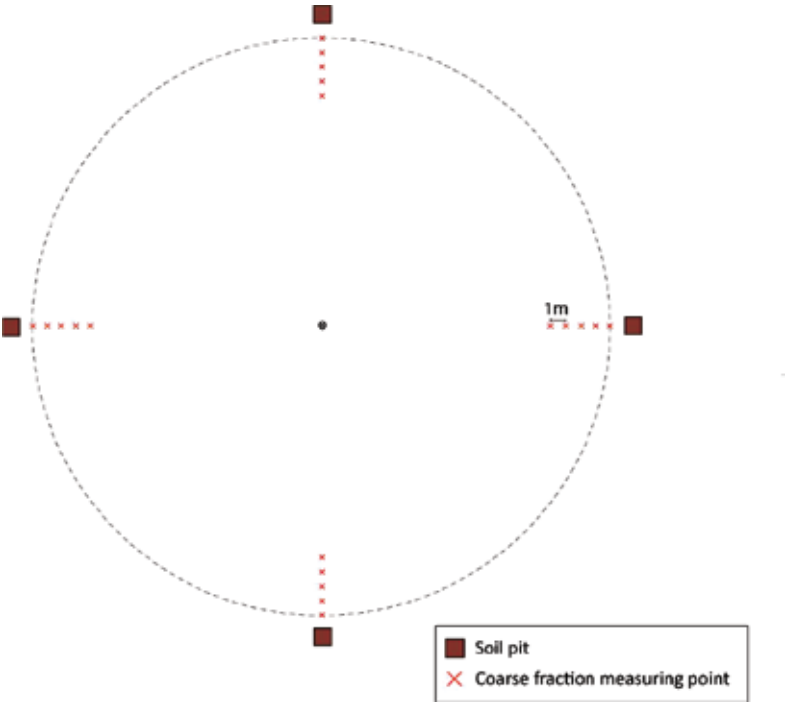

Figure 5. Default observation points for coarse fraction proportion at soil sampling pits. If half-cardinal points are used, the observation points are located accordingly.

Type of the organic layer

The thickness of the organic layer is defined using 1 cm accuracy at each soil pit by each forest stand within the plot. The type of organic layer is recorded according to the

following codes;

0 **Missing**. Organic layer missing or very thin (< 1 cm).

1 **Raw humus**. Formed from the dead vegetation growing on mineral soils, a "felt" layer clearly distinctive from the mineral soil.

2 **Humus.** Typically, thin, lower part mixed with mineral soil, but in the upper part there is a clear decomposed dead vegetation layer under the litter fall.

3 **Mull**. Organic layer fully mixed with mineral soil, between the litter and mineral soil. Occurs on the richest sites and abandoned agricultural land.

4 **Peat**. Formed of litter from peat land vegetation, mostly sedges or mosses but also remains of woody plants such as shrubs or trees. Decomposition stage of peat can vary in different layers resulting in different consistencies. If there is a layer of raw humus above the peat layer, the organic layer is recorded as peat, only when if the peat layer is more than 50 % of the total thickness of the organic layer, otherwise it is recorded as raw humus.

Thickness of the organic layer, cm

The thickness of the organic layer is defined at the soil sampling pits (**Figure 6**). It is measured with the reading accuracy of 1 cm. With more than one forest stand the type and thickness of organic layer is to be measured from the pits established in each forest stand separately.

Soil texture

Estimate for the soil texture is obtained from the surface soil, i.e. 10 to 30 centimeters below the ground level, using soil pits excavated for soil depth measurements. Estimates are determined by forest stands using the classification codes as follows:

B Boulders. Grain size > 200 mm

RS Rocky sand. Sand mixed with stones (60 – 200 mm)

S Sand

SL Sandy Loam

LS Loamy Sand

SCL Sandy Clay Loam

SC	Sandy Clay
SiL	Silt Loam
SiCL	Silty Clay Loam
SiC	Silty Clay
L	Loam
CL	Clay Loam
C	Clay

For the definitions of soil texture classes 3 to 13 and for their estimation in the field conditions see the instructions given in **Annex II**. Note that the soil sample used for feeling the constituents of soil must be in a moist to frail wet state. Gravel and other constituents > 2 mm must be removed.

Figure 6. Observation points for the type and thickness of organic layer r1 + 1 m apart from the centre of the CCSP (Rearrange as NE, SE, SW, NW)

Main site type

The main site type is used to classify the forest land into mineral soils, peat lands and wetlands. The peat land main types are fens typically occupied by *Graminae* (e.g. sedges) and receiving water and nutrients from adjoining uplands or water courses, treed (forested) swamps or open bogs that are fed by nutrients in rain water only. The stand is deemed as peat land, if the organic layer is peat. Otherwise, the main site type is mineral soil.

The 2003 National Wetland Policy of Nepal denotes wetlands as swampy areas with flowing or stagnant fresh or salt water. Wetlands are natural or man-made, or permanent or temporary (minimum duration of flooding 3 months). They include marshy lands, riverine floodplains, lakes, ponds, water storage areas and agricultural lands. Classification codes are as follows:

1 Mineral soils

2 Peat lands

3 Wetlands

Forest Type

Forest stands within the sample plot are classified into one of the forest types as mentioned below:

A	Abies Forest	*Abies spectabilis*
Bu	Betula Forest	*Betula utilis*
Ce	Deodar Forest	*Cedrus deodara*
Ct	Cupressus Forest	*Cupressus torulosa*
Jw	Juniper Forest	*Juniperus wallichiana*
KS/SK	Khair Sissoo Forest	*Acacia catechu, Dalbergia sissoo*
Pr	Khote Salla Forest	*Pinus roxburghii*
Pw	Gobre Salla Forest	*Pinus wallichiana*
Q	Quercus Forest	*Quercus spp.*
S	Sal Forest	*Shorea robusta*

Sp	Spruce Forest	*Picea smithiana*
Td	Hemlock Forest	*Tsuga dumosa*
TMH	Terai Mixed Hardwood Forest	*Mixed Species at < 1000m altitude*
LMH	Lower Mixed Hardwood Forest	*Mixed Species between 1000m - 2000m altitude*
UMH	Upper Mixed Hardwood Forest	*Mixed Species at > 2000m altitude*
SB	Shrub	*Shrub Species*

Pure forest type will be used if the basal area of the dominant species is more than 60 %. If none of the species exceeds 60 % but exceeds 33 %, the forest type will be considered as mixed type. If there are two species each exceeding 33 %, the forest type will be considered as mixed forest of the two species and coded as a combination of them (e.g. Q/Pr). If the first species is more than 33 % and the second species less than 33 % the forest type will be considered as the mixed type of the dominant species and mixed type, e.g. Q/LMH. If none of the species exceed 33 %, the forest type will be considered as mixed (TMH, LMH, and UMH).

Origin

Origin of forest stand is recorded based on the formation of stand whether the stand is developed from natural regeneration or is from planting. Following codes should be used to denote the **Origin**.

1. Primary forest

Naturally regenerated forest of native species where there are no clearly visible indications of human activities and the ecological processes is not significantly disturbed. Some key characteristics of naturally regenerated forest are:

- they show natural forest dynamics, such as natural tree species composition, occurrence of dead wood, natural age structure and natural regeneration processes;
- the area is large enough to maintain its natural characteristics;
- there has been neither any intervention e.g. management practice nor any disturbances e.g. tree cutting, cattle grazing, etc.

2. Other naturally regenerated forest

Naturally regenerated forest where there are clearly visible indications of human activities.

3. Planted forest

Forest predominantly composed of trees established through planting and/or deliberate seeding, where trees are expected to constitute more than 50% of the growing stock at maturity. This also includes coppice from trees that were originally planted or seeded.

4. Enrichment plantations

Enrichment planting is such a method of silvicultural management that re-habilitates poorly stocked over-logged forest without eliminating the existing individuals. It is essentially a process of supplementing the natural regeneration with seedlings of commercial species inside the natural forest to enhance its stocking. Usually indigenous species are planted in enrichment planting. It is followed for the degraded patches of the forests for successfully rehabilitation with the species.

Crown cover, percent

Crown cover is determined by estimating or measuring the area of ground covered by tree canopies, ignoring overlap and gaps within individual canopies. In the FRA, the spherical densiometer is used to measure the horizontal projection of the tree crowns covering the area of the sample plot (see **Annex VII**). If a plot is sub-divided in to several stands, crown cover is estimated for each stand.

Crown cover measurements are implemented at five points in a plot, i.e. at the plot centre and at the cardinal points (N, E, S and W) 20 meters apart from the plot centre (facing towards the plot centre) using a spherical densiometer (**Figure7**). If the plot is sub-divided in to two stands one or more of the cardinal points may be needed in the second stand. In such a case, for the first stand only those cardinal points located within the stand should be measured and additional random points should be measured to obtain 5 measurements in total of that stand. In each of the five measurement points, altogether 9 grid point values (0 or 1) are determined. Thus, the total number grid points become $5 * 9 = 45$ per stand. The stand wise crown cover percentages are calculated by multiplying the number of points with 2.2 and the result is recorded in the sheet.

Crown cover % = (Total readings from 5 points*100)/45

Crown cover can be calculated at 1percent accuracy level, i.e. without decimals. If any one of the stands is NR or Other land, then

Crown cover % = (Total readings from 4 points*100)/36

If two sides are NR or other land use, then

Crown cover % = (Total readings from 3 points*100)/27

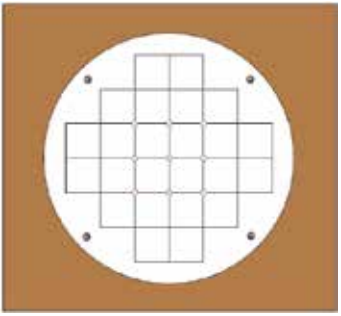

Figure 7. Square grid on the convex mirror of the spherical densiometer. The innermost nine grid points denoted by the red circles should be counted

Development status

Developmental status is recorded based on the average size of trees dominant in the forest stand. Following codes are used to classify the development status;

1. **Seedling and Sapling stand.** A stand comprised of trees with diameter at breast height less than 12.5cm and not qualified as pole timber or saw timber.
2. **Pole timber stand**. A stand with majority of basal area is occupied by trees of 12.5 cm–25 cm DBH.
3. **Small saw timber stand.** A stand with majority of basal area is occupied by trees of 25 cm–50 cm DBH.
4. **Large saw timber stand.** A stand with majority of basal area is occupied by trees of 50 cm or more DBH.

4.3. Collection of tree-level characteristics

4.3.1. Measuring principles

Tree tallying starts always from the magnetic North in the clockwise order. The horizontal distance is measured from plot centre to the centre of the tree trunk at base of the tree. The horizontal distance is also measured for fallen and leaning trees.

Diameters at breast height are measured in right-angle to the plot radius. The correct direction of the measurement must be defined with specific care. Also, determining a correct measuring point at breast height is vital to periodic re-measurements at the same point for which a measuring stick of 1.3 m must always be used. Furthermore, loose epiphytic lichens on the stem and breaking branches must be avoided during measurements and should be mentioned in remarks. Besides, other obstacles to accurate DBH measurement like climbers, lichens, mosses, hanging barks, orchids, etc. should also be removed before measuring the DBH. Special attention should be paid not to measure DBH at any abnormal points of the tree e.g. nodes, swelling point, buttress, etc. However, if the tree is hollow at DBH points, DBH should be measured as normal and instead remarks of hollow trunk should be mentioned in remarks.

For the sake of efficiency and data accuracy, only easily assessable characteristics are measured for tally trees, whereas sample trees are sampled for obtaining variables that are difficult and tedious to measure. The **sample trees** are selected as follows:

1. Sample tree in previous measurement will continue in the remeasurement as well.
2. Every 5th tree of ingrowth should be considered as a sample tree.
3. If sample tree of previous measurement was cut or damaged, immediate next tree should be considered as sample tree.
4. All trees with crown classes 6, 7, 8, 9 and 10 (abnormal trees) should be considered as sample trees.
5. At least one tree of each species should be selected as a sample tree in each CCSP.

Climbers are recorded for biomass estimation. For climbers, only diameter (at 15 cm above the ground level) and estimated length are recorded. The data on climbers (having diameter of 5 cm or more) are recorded for whole area of CCSP (radius=20

m) in the Tally and Sample Tree Form (**Field form 3**). The principle of CCSP (distance-diameter threshold) is not applied for climbers.

Note: Dead lying climbers are recorded on the Dead Wood sheet (not necessary to mention in Field Form 3).

4.3.2. Characteristics of tally trees

General data

General data are recorded as described in Chapter 4.2.

Number of enumerated trees

Number one is given for the first tallied tree on each plot, and the numbering continues without interruption up to the last tree tallied (**Field form 3**). Stumps and dead standing trees are also numbered along with living tally trees.

Forest stand

It is the stand number (for CCSP with multiple stands) where the tally tree lies. The number must equal to the numbering applied in the stand description and the sketch. The stand of each tree should be clearly mentioned in this column. If tree is not measured in any of the stands, **No Trees** should be written.

Bearing in degrees (001-360^{o})

The bearing from the plot centre to the middle of the stem at base of the tree (see **Figure 2B**). Recording unit is degree (001/360). If the current bearing is different from previous measurements, then also previous bearing should be mentioned, however, the corrected bearing can be mentioned in remarks column.

Distance in metres (with one decimal)

The horizontal distance from the plot centre to the centre of the tree trunk at the base of the tree (see **Figure 2B**). Recording units are meters up to one decimal e.g. 5 meters 20 centimeters is recorded as '***5.2***'. If the distance is in absolute figure, 0 should be mentioned in decimal. For example, 5m distance be should written as 5.0 m. If the current distance is different from previous measurements, then also previous distance should be mentioned, however, the corrected distance can be mentioned in remarks column.

Species Code

Tree species is recorded by codes for each tallied tree on the sample plot. This is much faster in the field (field crews learn the most typical codes quickly) and also data entry is less prone to errors. The species name should be written only, if the species code is not in species code list given to field crews. The list of species-specific codes is presented in **Annex VI**. Species is also recorded for stumps, if identified. Herbarium should be collected for unidentified species from the same tree or the plot or near by the plots.

Species Name

If the species code is missing from the list, then the species name should be written. If the species is not identified, herbarium collection is must. If a specimen is taken, the cluster number, plot number, and running specimen number (starting from 1 on each plot) must be recorded and attached to the specimen. In the data sheet, the species is coded as 01, 02..., where 01 or 02 indicates the running specimen number and this code should be written in the species name column. If a photograph is taken, the photo number should also be written in brackets after the unknown species code, e.g. 01 (23). If the local name is known it should be written in the data sheet (but in this case also, specimen and/or photo number should be mentioned.

Diameter in centimetres (with one decimal)

Diameter at breast height is measured at 1.3 m above the ground level for the standing tally trees. When the ground level cannot be defined, the breast height is determined from the seeding point. If the trunk is deformed at breast height, the diameter is measured from the nearest (above or below the breast height) well-formed point of the stem. When the measuring point for diameter at breast height differs from 1.3 m, the measuring height should be written at remarks (e.g. "DBH measured at the height of 1.72 m"). DBH can be measured by using diameter tape or caliper. However, for consistency, it is recommended to use diameter tape only. In order to avoid overestimation of the volume and to compensate measurement errors, diameter is measured in centimeters in one decimal (example: 16.8 cm).

A forked tree is recorded as one tree, if the tree is forked above the breast height, i.e. 1.3 m. If a tree is forked below breast height, each fork is recorded as an individual tree. The diameters of stumps are measured at the height of 15 cm above ground level and

recorded into the column for the variable 'Diameter'. The principal of CCSP is applied while measuring diameter of tallied stumps. Stump height is the vertical distance from the ground on the uphill side to the top of the stump on cut trees. Heights of all tallied stumps are mandatory to measure and recorded in centimetres (e.g. 26 cm). If tree was measured in previous measurement and now tree is cut or removed, then stump height is not necessary but diameter should be measured. The crown class for such cut/ removed trees should be marked as 11 and tree status is 3. If there is no sign of removal in the ground but there was a tree in previous measurements, in such situation also, only diameter is recorded with crown class 12 and tree status 4. If DBH of previously measured trees is decreased in current measurement and tree is not tallied according to CCSP rule, tree status should be marked as 5. Sometime, in previous measurement few trees might have been missed (not measured), in such situation, these trees should be measured as ingrowth with tree status 6. In a situation where distance (of tree) in previous measurement was recorded wrongly and for corrected distance the tree does not tally the CCSP rule, then such tree should also be measured and recorded with status 7. Tree status will be normally 0 for remeasured tree.

The diameter thresholds respective to the radii of the CCSP, is also applicable to stumps.

Tree quality class

Tree quality is based on the present or prospective form, roughness and soundness of a tree. For a tree with exploitable diameter, observation is based on its present condition. For smaller trees the quality class should be assessed based on their expected ability to reach exploitable size. Tree quality classes should be recorded using the following codes:

1 **High quality sound tree**. A tree with good form and now or prospectively having a length of at least 6 m in sound saw logs.

2 **Sound tree.** A sound tree not qualified in the class 1. The tree must have now or prospectively at least one 3 m section of saw log or two 1.8 m or longer saw log sections.

3 **Cull tree.** A tree having poor form, roughness, injury or decay stem and that does not (now or in the future) yield logs of merchantable quality. Climbers are also included in this class.

(All trees not included in class 1 and 2)

Crown class

Crown class is determined by tree heights and depends on the size and condition of the crown of the tree and its position in relation to other trees in the forest stand. Crown class (1-5) should denote the condition of receiving light from sunlight and crown class (6-14) should represent the condition/nature of the tree.

1 **Dominant**. A tree with a larger crown that the average size in or above the level of the surrounding canopy and receiving full light from above and more than one side.

2 **Co-dominant**. A tree with a medium-sized crown in the level of the general canopy and receiving fulllight from above and at least on side.

3 **Intermediate**. A tree with a smaller crown than the average, reaching the general level of the canopy butnot above it and receiving some direct light from above but little if any from the side.

4 **Suppressed**. A tree with a crown that is smaller than what is normal to a tree of this age and size. The tree is receiving little or no direct sunlight and showing signs of retarded growth resulting from the competition of dominant trees.

5 **Understory**. A tree with a crown that is below the level of the general canopy layer. Receiving little or nodirect sunlight, but not showing signs of suppression or retarded growth. Such trees may be tolerant to shade. Or saplings not yet seriously affected by the competition of other vegetation.

6 **Broken**. A tree of which the top or trunk is cut or naturally broken.

7 **Dead usable**. A dead tree that can be used as fire wood, for instance.

8 **Dead unusable**. A tree is dead or it is expected that the tree will die during the growing season.

9 **Stump.** A cut or broken tree with height less than 1.3 m

10 **Climber**

11 **Removed**

12 **Missing**

13 Missed in previous measurement

14 Wrongly measured in previous measurement.

Lopping in percentage

Lopping has a direct and significant impact on biomass calculation of a tree. If any tree in the plot is found to be lopped, estimated lopping should be recorded at 5% accuracy.

Sample tree type

0 Tally tree, not a sample tree

1 Sample tree selected from among tally trees using systematic sampling (every 5thtree).

2 Additional sample tree from among tally trees (e.g. species-specific median tree).

3 A tree having a broken top and therefore measured for height.

4 A newly measured sample tree that was not measured in last inventory.

4.3.3. Characteristics of sample trees

Height in metres (with one decimal)

Heights of sample trees should be recorded in metres to one decimal place (e.g. 23.4 m). In the remeasurement, heights are principally measured using a Vertex IV and Transponder T3 (see **Annex VII**).

A transponder attached to a tree bole on a leaning tree will result a biased estimate of tree height unless the lean is exactly at 90^{o} to the observer. While using Vertex IV and Transponder T3, few problems have been reported with environmental sounds (e.g. forest insects, high velocity of water wave, etc.) interfering with the sonic pulses. In case of smaller trees, a measuring pole can also be used depending upon situation. Total tree height refers to the vertical distance from ground to the tip of the tree.

Crown height in metres (with one decimal)

Crown height of sample trees are also measured. It is recorded in metres to one decimal place (e.g. 12.6 m). It is a distance from tree base up to the first living crown of tree. However, living branches, which are separated by two or more whorls of dead branches from other living branches, are not considered.

Base in metres of leaning tree (with one decimal)

The base distance is measured in meters with one decimal. Tree base is the horizontal distance from the centre of the tree stump to the ground projected tip of the leaning tree and projected point of the tip at the ground. Stem of a tree looks vertical at the first look but most of the trees are not vertically straight from base to top. In such condition, to measure exact height, tree base should also be measured. Both, the bases of tree top **(Base_Tree)** and lowest living crown **(Base_Crown)** should be measured (figure 8).

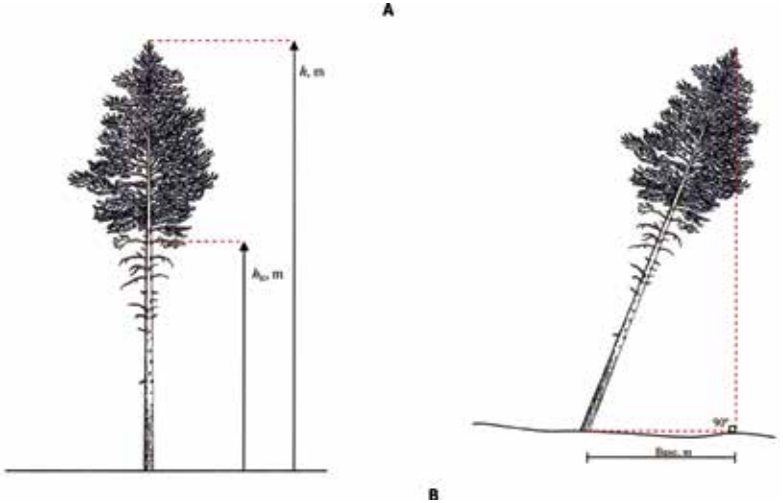

Figure 8. Determination of the total tree height (h, m) and the base of first living crown (h_{lc}, m) (Fig. A), and the base measure (Fig. B), i.e. the horizontal distance from the centre of the tree stump to the ground projected tip of the leaning tree (Base, m).

–Measuring Principle of Height

The height of a tree is measured with the help of Vertex IV and Transponder T3. Transponder height had been calibrated to 1.3m, thus this should be checked and verified during the measurements. Special attention is needed in a slope where the height from the tree base and transponder may not be exactly 1.3m. In such condition the differences should be noticed and adjusted to derive the total height of tree.

Age in years

It is the time elapsed since the germination of the seed, or the budding of the sprout or cutting, from which the tree is developed. For trees in planted compartments, the age is generally taken from the plantation database, i.e. establishment records. Only the species that are known to produce visible annual rings may be bored for the estimation of age. These comprise of *Abies* sp., *Picea* sp., *Pinus* sp., and *Tsuga* sp. Due to the destructive nature of the technique, the age should be bored from a tree that is similar to the sample tree (species, DBH, height) but growing outside the plot. However, in case of an uneven aged forest it is not always possible to find the tree having same characteristics outside the plot. The borer must be used perpendicularly against the tree and it must penetrate up to the centre of the tree. The breast height age is obtained by counting the annual growth rings from the pith to the last full growth ring. To obtain the total age of the tree, a number of years, that the tree took to up to the breast height, must be added to the breast height age. This can be estimated by counting the branch whorls between the ground level and the breast height.

However, the age of the tree had been already recorded in previous measurement, and the current age can be calculated using the software.

Radial growth in millimetres

No need.

Remarks

The remarks should be clearly written if the DBH is measured above or below the 1.3 m mark. The tree species of unlisted code should also be indicated in the remarks. CL can write other tree information worth writing in this field. The correct bearing and correct distance should also be recorded here. Other necessary explanations can also be mentioned.

Status of Tree

Please refer from the above "***Diameter in centimetres***".

4.4. Measurement of dead wood

All dead trees, dead twigs, branches and stems of trees and bush that have fallen and lied on or above the ground and have at least 5 cm diameter at base are measured from the plot with a radius of 10 m with its centre (Form 4). Likewise, all stumps that are within the radius of 10 m from its plot centre are measured and recorded.

In this regard, diameter at tip, diameter at base and length of stumps are measured and recorded (**Field form 4**). Both, downed dead trees and stumps inside the 10 m radius of plot are measured, no matter if the tree has fallen from outside the plot. Dead lying climbers are measured in a similar way.

If a stump is older than 5 years, it is also regarded as dead wood and should be measured accordingly within a 10 m radius.

Deadwood should be measured up to 5cm diameter at tip and thus length (in m.) should also be measured up to 5 cm diameter.

If a stump is taller than 1.3 m, it should be measured in the same way as standing dead trees.

The following characteristics are recorded for stems or their fragments lying within the plot:

General data

General data are recorded as described in Chapter 4.2.

Particle Number

All measured downed dead wood particles are numbered, and the numbering continues without interrupts for all the particles of a plot.

Species Code

Species of the downed dead wood or stem or particle (which has at least 5 cm diameter lying within the plot radius of 10 m). For the list of tree species, see Annex VI.

Species name

If the species code is missing from the list, then the species name should be written.

Diameter at base in centimetres (with one decimal)

Diameter at base of the particle within the plot radius of 10 m. It is recorded in **centimeters** with **one decimal**.

Diameter at tip in centimetres (with one decimal)

Tip diameter of the particle (which has at least 5 cm diameter) within the plot radius of 10 m. It is recorded in **centimetres** with **one decimal**.

Length in meters (with one decimal)

Total length of the particle (up to 5 cm tip diameter) lying within the plot radius of 10 m. It is recorded in **meters** up to **one decimal**.

Note: if the particle is partly outside the plot, only the part inside the plot is measured.

4.5. Disturbances

Disturbance is a temporary change in average environmental conditions that causes a pronounced change in an ecosystem. Human induced or natural disturbances that have affected the stand structure and the natural processes are recorded in a separate sheet (**Field form 4**). For each observed disturbance, the cause of disturbance and intensity are recorded. The largest plot of the CCSP (i.e. 20 m radius plot) is taken into account to observe the causes and intensity of disturbance.

The following characteristics are recorded for disturbances within the plot:

General data

General data are recorded as described in Chapter 4.2.

Number

The entire disturbances observed in the plot are serially numbered starting from 1 (**Field form 4**).

Cause of disturbance

A factor of disturbance that is affecting the development of vegetation in the plot. Codes for recording and causes of disturbances are given below;

ND No disturbances. No signs of significant disturbance observed in the plot.

LS Landslide. Landslide and flood sings observed in the plot.

LG Livestock Grazing. Presence of the hoof-marks and dung of the animal, broken tops of the seedlings and saplings, trampling signs, disturbed forest litter within the entire CCSP due to the cause of grazing.

LO Lopping. Cutting of side branches of trees for fodder, etc. The intensity of lopping is estimated on the basis of the number of the lopped trees (N/plot) that fall within the plot radius used for the measurement of largest trees on the concentric circular sample plot.

LP Litter picking/collection. A percentage cover (0–100%) estimated on the basis of ocular observation. Collection intensity of the fallen leaves of the plants is assessed within the entire CCSP.

BC Bush cutting. A percentage cover (0–100%) of the overall signs indicating the collection of seedlings of tree species and others plants within the entire CCSP.

FF Forest fires. A percentage cover (0–100%) of the overall signs indicating forest fire originated damages within the entire CCSP.

EN Encroachment. Encroachment of forest land for cultivation and plantation areas.

RT Resin tapping. Resin tapping trees can be identified by cuts made in the boles of trees (normally pines) so as to enable the resin to ooze out.

LC Lathra cutting. Cutting of saplings and pole-sized stems. The intensity of Lathra cutting is estimated on the basis of the number of stumps present that fall within the plot radius used for the measurement of largest trees on the concentric circular sample plot.

TC Tree cutting. Targeted to trees with diameter at breast height > 30 cm. The intensity of tree cutting is estimated on the basis of the number of stumps present that fall within the plot radius used for the measurement of largest trees on the concentric circular sample plot.

IA Insect attacks. Some live insects or their life form present or plant leaf having the sign of insect attacks (e.g. holes, nest etc).

PP Plant Parasites. Presence of parasitic plant in the tree.

PD Plant Disease. Diseases to the plant mainly due to fungi (e.g. black rot), or from some bacteria (e.g. rotting). Note: if tree is rotting due to e.g. resin tapping the

disturbance should be recorded as resign tapping, not as plant disease.

WI Wind, storm, hails (frozen rain)

OH Other human induced disturbances. Disturbances from human other than described as above (e.g. ringed - removing the bark from the base of tree, cage snaring, foot trail, forest road etc.)

The number of disturbance recordings (~ record rows) varies from one sample plot to another.

Intensity of disturbance

0 No significant disturbances.

1 Minor disturbance. With only little or no effect on trees and regeneration. Less than 10 % of the trees/seedlings affected by the disturbance.

2 Medium disturbance. With some effect on the trees and regeneration. 10–25 % of the trees/seedlings affected by the disturbance or some trees felled/died.

3 Strong disturbance. With remarkable effect on the trees and regeneration. More than 25 % of the trees/seedlings affected by the disturbance or several trees felled/died.

4.6. Shrub and small tree measurements

4.6.1. Assessing the crown cover of shrub vegetation

Shrub measurements are carried out on the four subplots with the radius of 2 m (area: 12.6 m^2) that are located 10 metres far from the centre of the plot in the four cardinal directions (N, E, S and W; see **Figure2A**), respectively (**Field form 5**). Crown cover of shrub vegetation is the percentage (0–100 %) obtained for the horizontal projection of the shrub crowns covering the area of the subplot. Following attributes are recorded:

General data

General data are recorded as described in Chapter 4.2.

Subplot

N Shrub plot 10 meters **North** from the centre.

E Shrub plot 10 meters **East** from the centre.

S Shrub plot 10 meters **South** from the centre.

W Shrub plot 10 meters **West** from the centre.

Crown cover of shrub

Crown cover of shrub vegetation is the percentage (0–100 %) obtained for the horizontal projection of the shrub crowns covering the area of the subplot. Technically, the estimation of the crown cover of shrub vegetation (0–100 %) is implemented by four quadrants of the circular subplot; four quadrants should be assessed separately the mean is recorded.

4.6.2. Tallying shrubs

Shrubs are identified and measured from the four subplots with the radius of 2 m (area: 12.6 m^2) that are located 10 metre far from the centre of the CCSP in the four cardinal directions (N, E, S and W; see Figure 2A) (**Field form 5**). Diameter near root collar and height of shrub are measured. Species wise number of shrub and their average diameter and height will be determined and recorded in each direction.

General data

General data are recorded as described in Chapter 4.2.

Subplot

N Shrub plot 10 meters North from the plot centre.

E Shrub plot 10 meters East from the plot centre.

S Shrub plot 10 meters South from the plot centre.

W Shrub plot 10 meters West from the plot centre..

Number

Number one is given for the first recorded shrub on each subplot, and the numbering continues without interrupts to the last shrub of the subplot (**Field form 5**).

Species code

Shrub species is recorded by codes. For the list of tree and shrub species see **Annex VI**.

Species name

If the species code is missing from the list, then the species name should be written. If the species is not identified, a photo or specimen is taken. If a specimen is taken, the cluster number, plot number, subplot code, and running specimen number (starting from 1 on each subplot) must be recorded and attached to the specimen with local name.

Frequency

The total number of shrubs of each species will be recorded as frequency in the form.

Diameter in centimetres (with one decimal)

Diameter of the shrub is measured near the root collar and recorded in centimetres with one decimal.

Height in metres (with on decimal)

The average height of the shrub for each species will be assessed and recorded in metres with one decimal. A measuring pole can be used for determining the height of shrub.

4.6.3. Seedling and sapling measurements

Seedlings and saplings are measured and recorded separately from the four subplots with the radius of 2 m (area: 12.6 m^2) that are located 10 metres far from the centre of the plot in the four cardinal directions (N, E, S and W; see Figure 2A), respectively (**Field form 5**). Species wise number of seedlings of tree species are counted and their mean height will be assessed and recorded for each sub plot. Similarly, species wise saplings of tree species are also counted and assessed their mean height and recorded. Measuring pole can be used for measuring the mean heights of seedlings and saplings.

General data

General data are recorded as described in Chapter 4.2.

Subplot

N Seedling and sapling plot 10 meters **North** from the centre.

E Seedling and sapling plot 10 meters **East** from the centre.

S Seedling and sapling plot 10 meters **South** from the centre.

W Seedling and sapling plot 10 meters **West** from the centre.

Number

Seedling and sapling are counted by species.

Species code

Species code is taken from the list of **Annex VI**.

Species name

If the species code is missing from the list, then the species name should be written. If the species is not identified, a specimen should be collected Similar procedure of specimen collection as that of the unidentified shrub is followed in case of unidentified seedling or sapling. If the local name is known it should be written in the data sheet as well as in herbarium sheet.

Frequency

Number of seedlings and saplings of a species.

Mean height in metres (with one decimal)

Mean height of seedlings and saplings is estimated separately with the measuring pole and recorded in meters with one decimal. If there is only one seedling/sapling for a species, the height of that seedling/sapling is measured, otherwise mean value is calculated.

4.7. Collecting soil samples

4.7.1. Principles of soil sampling

Soil sampling is performed at a pre-selected set of inventory plots, based on stratification of site types. At each selected plot, by default four sub-cardinal points are sampled for soil

organic carbon determination and soil characterization. The soil samples are drawn from, sub-cardinal points. If the plot is divided into two or more stands, soil sampling must follow as stand. When the share of a forest stand of the plot is so small that at least three sub-cardinal points cannot be taken, then that forest stand must be dropped from soil sampling.

The basic location setup for soil sample points is illustrated in **Figure 9**. When the principal points of **Figure 9** are not reachable or usable due to physical obstacles (e.g. deep slopes, trees and large stones protruding above the ground), the pit can be made at any corner or 2 x 2 m around the original sampling point location. If even those are not reachable, then the nearest sampling point in clockwise direction is selected.

The soil samples are taken from soil layers 0-10 cm, 10-20 and 20-30 cm. whenever possible, undisturbed volumetric samples are taken.

The sample code consists of variables (cf. chapter 4.6.2): cluster column, cluster row, number of CCSP, code of soil sampling point, sample type and sampling layer. For example, a sample with code '23-1-2-NW-2-2' is identified by the variables with respective values that are as follows: cluster = 23-1 (column = 23 and row = 1), CCSP = 2, sample point = NW (point selected for the collection of samples from deeper soil layers), sample type = 2 (surface soil sample) and sampling layer = 2 (mineral surface soil 10–20 cm), number of sub-samples in the composite sample.

Soil sampling is quantified through the volumetric measurement procedure making it possible to calculate area estimates for the soil characteristics (kg/m^2, kg/ha or Mg/ha). If a volumetric soil core cannot be obtained due to heavy stoniness, the soil can be sampled using the techniques detailed in **Annex XIII**. Wet weights (fresh mass) of individual soil samples are determined in the field with 1 g precision. Thereafter, soil samples should be air-dried as quickly as possible to prevent harmful changes for instance in acidity. Soil sample treatment is detailed in **Annex XII** for field and in **Annex XIII** for laboratory.

4.7.2. Sampling of soil layers

Loose litter is first collected from the soil surface. The soil sample top begins below the new, loose litter layer and may contain only slightly or more degraded older litter that has already began to form the soil humus layer.

Soil samples are taken below the area cleared and the "new" litter is collected as a sub-sample (see **Annex X**). The first soil sample from the layer of 0–10 cm is taken directly

starting from the soil surface below the new litter. The following soil samples (10–20 cm and 20-30 cm) is taken from a level made with the spade exactly 10 cm from the soil surface. Soil sample collected from four sub plot of 0-10 cm (first layer) should be kept in a single plastic bag. Similarly, samples from second layer (10-20cm) and third layer (20-30 cm) are also kept in different two plastic bags mixing up of four sub plots of same layer together but samples from different layers should not be mixed up.

Composite samples for each soil layer are closed into strong 3L plastic bags with a label of codes identifying the sample clearly. It is useful to write the depth on each composite sample bag so that the sub-samples became collected to the correct bags. The location codes are not necessarily written on the bag, but on a separate water-proof paper tag using graphite pencil and enclosed with the sample in a plastic bag. This paper tag must also contain the soil depth information. That is because the soil samples are opened and dried at the base camp using a solar dehydrator. For drying the paper tag is then placed in an open aluminum foil vessel with the soil sample. After drying the sample and paper tag are packed into a plastic bag for storage until reaching the laboratory. Actual number of volumetric composite sub-samples representing the layer must be written on the label.

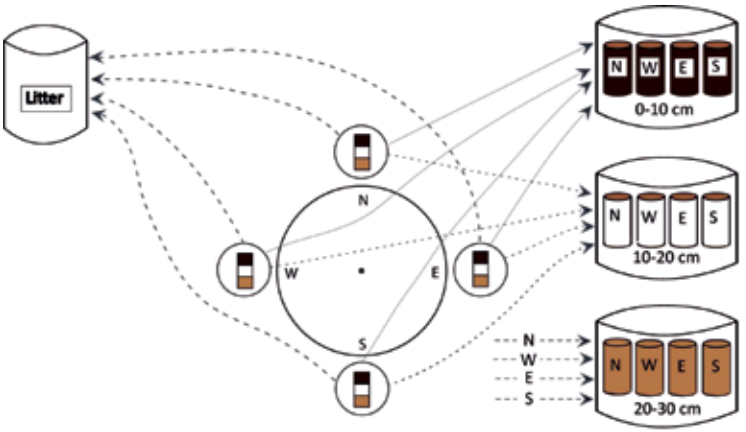

Figure 9. A schematic presentation of collection of the composite litter and soil samples. The tags in soil cores indicate the soil pit where the core was taken. Only cardinal points are shown in this illustration, but sub-cardinal points can be used if some of the default points are not accessible. Note that it is possible to place the soil pit in an accessible

corner of a 2x2 m area surrounding the original pit location. In this illustration all four subsamples have been taken, but a shallow soil or forest stand division within the CCSP can restrict the number of subsamples. In that case it is very important to indicate the true number of sub-samples in the bags.

General data

General data are recorded as described in Chapter 4.2.

Sample point

Code of the sampling point used to collect (volumetric) samples of soil (see **Figure 10**).

Sample volume

Volume of the soil sample. By default, it is the volume of the corer, but if the corer is not used, the volume of the soil taken by other means should be recorded. For determining the volume see **Annex XI**.

Sampling layer

D	**Debris (less than 5 cm diameter)**	**Li**	**Litter**
L1	**0 – 10 cm**	**L2**	**10 – 20 cm**
L3	**20 – 30 cm**		

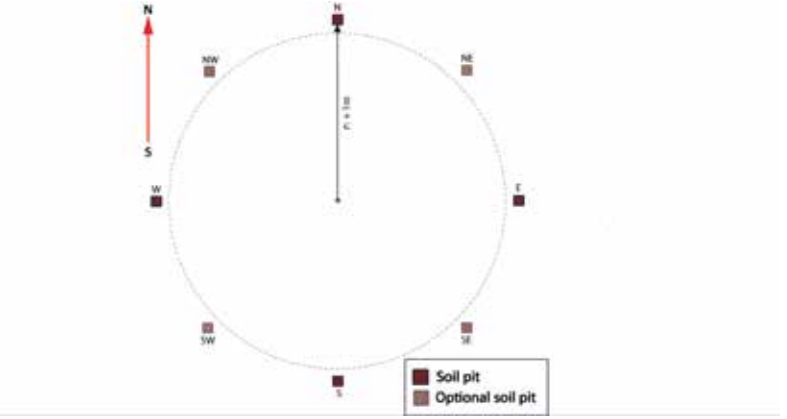

Figure 10. The systematically located soil sample collection points on the CCSP. If one of the points (and its 2 x 2 m surroundings) is not accessible, the point following in

the clockwise direction is selected Soil pits are used to collect samples from deeper soil layers and to obtain information on soil profiles. Sub-cardinal sampling points are used when the cardinal points are not usable due to physical obstacles (e.g. trees and large stones).

Weight

Fresh mass of the composite sample per each layer. Determined using an electronic scale with 1 g precision.

Thickness of organic layer, cm

Thickness of the organic layer, recorded in centimetres.

4.7.3. Assessing soil profiles

Soil profiles can be characterized in the plots while collecting samples from deeper layers (**Field form 6**).

Soil profiles are located and excavated 1 m outside the plot edge in either of the sub-cardinal points (NE, SE, SW, NW). A digital photo over the profile from each soil pit is taken for the documentation and post-verification purposes. A scale and site label must be included in the photo. The photos are labelled with id-numbers and -codes for cluster, plot and soil pit.

General data

General data are recorded as described in Chapter 4.2.

Sample point

Code of the soil pit (NE, SE, SW, NW) used to assess the soil profile and to collect (volumetric) samples of soil layers (see **Figure 10**).

Horizon

Code identifying the horizon. H/O, A, E, B, C, and R represent the master horizons and layers in soils (p. 67-71 of the FAO's guidelines). This information is valuable for characterizing the soil profile in association of the digital photo. However, as the pit is only 40 cm deep, some horizons may not be visible.

Thickness of the horizon, cm

Thickness of the horizons is determined with the reading accuracy of 1 cm.

Munsell's colour

Maximum/minimum moist colours are defined in terms of hue, value and chroma according to Munsell's (2009) 'Soil Colour Charts' to characterize the soil profile.

Soil texture of the horizon

For determining the variable see chapter "4.2.3 Stand description".

Coarse fractions percentage

Coarse fractions percentage in mineral soil. For estimating the proportions of coarse mineral fragments (> 2 mm) and mottles in the mineral soil see **Annex IX**.

4.8 Assessing biodiversity characteristics

4.8.1. Coverage of species

Percent coverage of the herbaceous plants, grasses and pteridophytes will be recorded from four square vegetation plots (VP) of the size 1 m^2 (**Figure 2A**, **Field form 7**). Square plots are used because **small** squares are easy to delineate using a 1 m $\times$ 1 m square PVC pipe frame placed on the ground. Also, the estimation of coverage is easier with squared plots than circles, because squares can easily be divided into sub-squares to make separate assessment for the sub-squares (needed when the density is very high in some parts of the vegetation plot and less in some parts). Cornerwise placed VPs are located to the cardinal points (N, E, S and W) from the centre of the CCSP, and the distance between the centre of the CCSP and the corner of the VP next to the centre of the CCSP is 5 metres. The area of the VP is delineated using a 1 m $\times$ 1 m square PVC pipe frame placed on the ground. Percent covers of the vascular plants and ferns are determined by VPs meaning that separate forms are filled in for the four VPs (VP North – VP West), respectively. For each species by the square vegetation plots, respectively, the following attributes are recorded:

The number of recordings (~ record rows) varies from one sample plot to another and equals to the number of species observed in the vegetation plot.

General data

General data are recorded as described in Chapter 4.2.

Number

Running number of the data row. Numbering start from 1 at each plot and runs over the sub-plots.

Vegetation plot

N Vegetation plot 5 meters North from the centre of the CCSP.

E Vegetation plot 5 meters East from the centre of the CCSP.

S Vegetation plot 5 meters South from the centre of the CCSP.

W Vegetation plot 5 meters West from the centre of the CCSP.

Species code

Species is recorded by codes (refer Annex VI for species list and code). Species are identified by the ecologist in the crew along with the help of local helpers.

Species name

If the species code is missing from the list, then the species name should be written. If the species is not identified, a specimen should be taken. If a specimen is taken, the cluster number, plot number, sub-plot code, and running specimen number, local name (starting from 1 on each sub-plot) must be recorded and attached to the specimen.

***Cover % of* Species**

The cover% of the species is estimated visually and recorded in integer numbers (0-100) in the tally sheet.

4.8.2. Epiphytes, parasites, climbers and their host trees

A plant that germinate on the forest floor and grow, at least for part of their life, or when the forest closes up around them, by winding around, leaning on, or anchoring or adhering to other plants. Stranglers (e.g. *Figus*) and epiphytes (e.g. Orchidaceae) are included if they characteristically germinate on other plants rather than in the soil, and

even if they grow downwards to root in the soil later. The entire epiphytes, parasites and climbers with their host trees are identified from the plot with the radius of 20 meters and listed (**Field form7**). None field measurement is required. The number of recordings (~ record rows) varies from one sample plot to another and equals to the number of species observed in the sample plot.

General data

General data are recorded as described in Chapter 4.2.

Number

Running number of the data row. Numbering start from 1 at each plot.

Species code

Species is recorded by codes. Species list is in the separate Plant Species List (**Annex VI).**

Code of host or supporting tree species

Species code (see **Annex VI**) of the host tree respective to the observed epiphyte, parasite and climber species.

Host Species name

If the host species code is missing from the list, then the species name should be written.

4.8.3. Large wildlife species

Flagship mammals, other large wildlife and the indicators regarding their presence are collected from the plot surroundings and from the cluster area when walking between the circular plots (**Field form 8**). When and where it is appropriate, digital photos are taken for the documentation purposes (date and time recording enable connection with other recorded data).

General data

General data are recorded as described in Chapter 4.2. Plot number is not needed for this form because the data are collected also between plots and when walking to the plots.

Number

Running number of the observation starts from 1 for each plot.

Wildlife species

0	**Asiatic Wild Dog**	**1**	**Asiatic Wild Elephant**
2	**Assamese Monkey**	**3**	**Barking Deer**
4	**Bengal Fox**	**5**	**Bengal Tiger**
6	**Black Buck**	**7**	**Blue Bull**
8	**Blue Sheep**	**9**	**Brown Bear**
10	**Chinese Pangolin**	**11**	**Clouded Leopard**
12	**Common Langur**	**13**	**Common Leopard**
14	**Four Horned Antelope**	**15**	**Gaur Bison**
16	**Golden Jackal**	**17**	**Grey Wolf**
18	**Himalaya Ibex**	**19**	**Himalayan Black Bear**
20	**Himalayan Goral**	**21**	**Eurasian Lynx**
22	**Himalayan Serow**	**23**	**Himalayan Tahr**
24	**Hog Deer**	**25**	**Indian Pangolin**
26	**Musk Deer**	**27**	**Nayan sheep, Argali**
28	**One-horned Rhinoceros**	**29**	**Red Fox**
30	**Red Panda**	**31**	**Rhesus Macaque**
32	**Sambar Deer**	**33**	**Sloth Bear**
34	**Snow Leopard**	**35**	**Spotted Deer**
36	**Striped Hyena**	**37**	**Swamp Deer**
38	**Tibetan Antelope**	**39**	**Tibetan Wild Ass**
40	**Wild Boar**	**41**	**Wild Water Buffalo**

The number of recordings (~ record rows) varies from one sample plot to another and equals to the number of flagship mammal species observed in the sample plot.

Type of observation/species

1 **Direct observation**

2 **Pug marks:** Foot print

3 **Droppings:** Scats, dung, pellets etc.

4 **Marking:** Urinating, digging, scraping, claw marks on tree etc.

5 **Call/sound:** Sound or call of animal

6 **Carcass:** Skull, Stomach contents, bones etc. of the prey species

7 **Other:** skull, antler, etc. (specify in remarks column).

The number of recordings (~ record rows) varies from one sample plot to another and equals to the number of flagship mammal species observed in the sample plot.

4.9. Non-Timber Forest Products

Non-Timber Forest Products data on their use value is collected and recorded on **Field Form 8**.

General data

General data are recorded as described in Chapter 4.2.

NTFP Species Code

Non-timber forest products (NTFPs) are a collection of biological resources derived from both natural and managed forests and other wooded areas (Peters, 1996). Examples include a variety of fruits, nuts, seeds, oils, spices, resins, gums, medicinal plants and many more products specific to the particular areas, from which they originate. For species detailed information refers a tentative list of NTFPs in **Annex IV**.

The number of species-specific recordings (~ record rows) varies from one sample plot to another and equals to the number of NTPFs observed in the sample plot.

Usage of NTFPs

Usage of NTFP species is determined on the basis of local uses based on the focus group discussion and recorded in field form 8, using the following usage codes:

Plant products

1. **Animal beddings.** Animal bedding provided by leaves and branches and other plant parts.
2. **Beverages**. Plant parts (e.g. Fruit, seeds, leaf) used as beverages.
3. **Dying/tanning.** Plant material (bark and leaves) providing tannins and other plant parts (especially leaves and fruits) used as colorants.

4. **Exudates.** Substances such as gums (water soluble), resins (water insoluble) and latex (milky or clear juice), released from plants by exudation.
5. **Fiber and fiber yielding.** Whole plant or part (mainly bark) used for extracting fibers.
6. **Fodder.** Animal and bee fodder provided by leaves fruits, flowers, etc.
7. **Fruits and nuts.** Plant fruit and nuts produced are useful for the edible purpose.
8. **Fumitory and masticators materials.** Plant parts having smoke or chew value for pleasure or exhilaration.
9. **Insecticides and herbicides.** Plant and its parts (leaf, bark, seed, flower, fruit, etc.) used as insecticide as well as herbicides.
10. **Legumes or pulses.** Fruit and seeds of some legume plants can be used as food and vegetables.
11. **Medicinal plants.** Medicinal plants (e.g. leaves, bark, roots, fruit, seeds) used in traditional medicine and/or for pharmaceutical companies.
12. **Seeds.** Seeds collected for regeneration purposes.
13. **Soap/cosmetics.** Aromatic plants providing essential (volatile) oils and other products used for cosmetic purposes such as soaps, perfumes etc.
14. **Spices, condiments and other flavorings.** Plant parts (e.g. flower, fruits, seeds, barks, roots) used for the spices as well as for flavorings.
15. **Starches and cellulose products.** Plant parts providing starches (e.g. yam) and other cellulose products (e.g. paper).
16. **Vegetable oils and fats.** Vegetable oils (other than essential oils) extracted from the plant part, especially from the seeds.
17. **Vegetables**. Plant parts (e.g. Leaf, fruit, seed, bulbs) used as vegetables.
18. **Utensils, handicrafts.** Non-wood products.
19. **Construction material.** Includes thatch, bamboo, rattan, wrapping, leaves and fibers.
20. **Ornamentals.** Entire plants (e.g. orchids) and parts of plants (e.g. pots made from roots) used for ornamental purposes.
21. **Biofuel.** Diesel produced from the plant parts, especially from seed.
22. **Support for climber (***Thankro*). Plants (whole or part) used as a support material

for the climber in agricultural land.

23. **Veterinary medicine.** Plants (e.g. leaves, bark, roots, fruit, seeds) used in medicines for pet animals.
24. **Religious plants:** Whole plant or parts used for religious purpose.

Animal products

25. **Living animals.** Mainly vertebrates such as mammals, birds, reptiles kept/ bought as pets.
26. **Honey, beeswax.** Products provided by bees.
27. **Bush meat.** Meat provided by vertebrates, mainly mammals and birds.
28. **Other edible animal products**. Mainly edible invertebrates such as insects (e.g. caterpillars) and other "secondary" products of animals (e.g. eggs, nests).
29. **Hides, skins for trophies.** Hide and skin of animals used for various purposes.
30. **Medicines from animals.** Entire animals or parts of animals such as various organs used for medicinal purposes.
31. **Dying/tanning.** Entire animals or parts of animals such as various organs used as colorants
32. **Tools.** Bones used as tools.
33. **Ornaments.** Wildlife parts used for ornamental purpose.
34. **Religious.** Wildlife parts used for religious purpose.

The number of species-specific usage recordings (~ record rows) varies from one sample cluster to another.

Importance of NTFPs

Importance of NTFP species is determined on the basis of local uses according to the qualitative classification based on the focus group discussion, using the codes as follows:

0 Products of high importance.

1 Products of medium importance.

2 Products of low importance.

The number of NTFP species varies from one cluster to another.

4.10. Invasive Alien Species

Data on common invasive alien plant species (*Chromolaenaodorata, Senna tora, Lantana camera, Ageratina adenophora, Ageratum haoustonianum, Mikania micrantha*, and *Parthenium hysterophorus*) are recorded from plot within 10 m radius from plot centre and in the transect when walking to the plot. When and where possible, photographs should be taken for documentation purpose. Within the permanent sample plot, ground coverage of each species are categorized and recorded by using visual estimation method. Information on invasive alien species are also collected from five circular plots, each with 10 m radius, in walking transect when walking towards the plot. After leaving the car, plots are established every 100 m on route to plot, and plot attributes (major land use type: Forest land, Shrub land, grassland, agricultural land, built up land, rocks, ice/snow, abandoned land; latitude and longitude in WGS UTM system; elevation in meter, aspect; slope; canopy cover percent, and ground coverage percentage of each invasive alien species are recorded. Data are recorded in **Field Form 9**.

4.11. Forest Disease and Pest

Data on forest disease and pest are collected on **Field form 10**. During the measurements of aforementioned parameters, a thorough observation is to be done whether existing trees and vegetation are infected with any kind of disease or pest. If any such problems are noticed, they should be recorded in the field form accordingly.

Tree species

The tree species which are infected should be listed, Furthermore, the code of species should be mentioned in the ***Remarks*** column.

Disease/Pest

If distinguished whether the infection is due to a disease or pest, it should be written here.

Parts infected

The parts of trees which are infected should be mentioned in this column. Infected parts of plants can be *root, stem, branch* or *leaves*.

Severity

The severity of infection should also be recorded. Severity, in this case, is usually recorded in terms of infection prevalent over the CCSP. If the infection is seen on only one quadrant, then the severity should be recorded as ***Low***, for the infection spreading over any two quadrants, the severity should be recorded as ***Medium*** and for infection spreading over any three or four quadrants, the severity should be recorded as ***High***.

Photograph No.

For all those infected trees, photographs should be taken and the number should be recorded in this column.

4.12. Time measurements

Time measurements are conducted for obtaining information on the time consumption of different phases of the inventory work. Information is needed for the analysis of selected inventory design and measurement setups and selecting plots for control assessments. Data on the time consumption, i.e. the starting times of different phases of the inventory workday, are recorded on **Field form 11**.

General data

General data are recorded as described in Chapter 4.2.

Camp departure time – travel by car

Time when the camp or other accommodation was left and the travel by the vehicle started (e.g. 7:05).

Departure time – travel on foot

Time when walking from the camp, vehicle or sample plot to the next sample plot started (e.g. 7:42).

Plot reaching time

Time when the plot area was reached (e.g. 10:15).

Plot location time

Time when the plot centre was reached and located (e.g. 10:35).

Work completion time

Time when measurements on the plot were completed (e.g. 15:11).

Arrival time to the car or camp – travel on foot

Time when the camp or car was reached by walking from the last sample plot of the day (e.g. 16:02).

Arrival time to the camp – travel by car

Time when the camp was reached by car (e.g. 16:32).

4.13. Instructions for photographing

Digital photos are taken for the visual documentation of forest site, sceneries and structures, soil profiles and biodiversity characteristics respective to the sample plots measured in the field. These image data are needed for the post-verification of field recordings, for interpretation of remote sensing data and for collecting information to be utilized in reporting inventory results and compiling training catalogues. During the inventory, photographs are taken from the following objects:

1) sample plot/forest stand(s) (5 photographs per plot, one photograph from the plot centre to the canopy and other 4 in the four-cardinal directions);

2) soil profiles (4 photographs/plot, are taken from soil pits (SP) excavated on the sample plots selected for assessing characteristics of deeper soil layers);

3) vascular plants and herbs (photographs taken from the species that cannot be identified in the field); and

4) Flagship mammals, large wildlife and their indicators.

Before photography, it is essential to check that the date and time settings are correct. Photographs are taken using basic, i.e. 'auto shooting', settings with wide enough focus frame. Photographing against the sun is not recommended. On each sample plot, the photographing starts by taking a photo of the sketch drawing sheet with printed cluster and plot identification parameters (see Field form 1). It is essential that the quality of photographs is verified in the field, before the field crew leaves the sample plot. In the base camp photographs are transferred from the camera into the folder 'Photographs'

in the field computer and the image files (*.jpeg) are labelled. In the case of the plot 2 within the cluster 23-1, for instance, the photographs are labelled as follows:

1) sample plot/forest stand(s): 23-1-2-C.jpeg, 23-1-2-N.jpeg, 23-1-2-E.jpeg, 23-1-2-S.jpeg and 23-1-2-W.jpeg
2) soil profiles: 23-1-2-SP1.jpeg, 23-1-2-SP2.jpeg, 23-1-2-SP3.jpeg and 23-1-2-SP4.jpeg
3) vascular plants and herbs, unidentified plants: 23-1-2-N01.jpeg, 23-1-2-N02.jpeg, ...

   (where N indicates the vegetation sub-plot, 01, 02... indicates the running number of the unknown species
4) flagship mammals and their indicators: 23-1-FM1.jpeg, 23-1-FM2.jpeg, (NOTE: no plot number recorded, because observations are taken also between plots)

Information on photographs is captured on the plot wise filled sketch drawing sheet (**Field form 1**) by writing the names of image files on it.

5. QUALITY ASSURANCE AND QUALITY CONTROL (QA/QC)

Provisions for quality assurance (QA) and quality control (QC) must be implemented to ensure that the recorded data and followed procedures are reliable and meet minimum measurement standards.

QA/QC for Field Measurements

This Field Inventory Manual describes the SOP for Forest Resource Assessment in Nepal. The SOP ensures that measurements executed by different teams or at different times are consistent and comparable. Once the SOP is developed, field crews must be fully trained in all aspects of field data collection. Field crews should receive extensive training so as to be fully cognizant of all procedures and the importance of collecting accurate data.

Hot check: During the field measurement, FRTC will send government official to supervise and coordinate the field work. At that time, they will directly observe the field work and provide feedbacks to the crew for further improvements. Similarly, they will also re-measure a few plots immediately as cold checks.

QA/QC

Later, when the field data is submitted, FRTC conducts quality check for QA/QC. About 10% of sample plots will be selected and re-measured to assess the quality of field data and error.

QA/QC for Laboratory Measurements

Standard Operations Procedures for laboratory measurements should be prepared by the laboratory staff and be followed for each part of the analyses. If an external laboratory performs the analyses, a record of the procedure(s) must be obtained. Typical steps for the guidelines for laboratory measurements include calibrating combustion instruments for measuring total carbon or carbon forms using commercially available certified carbon standards. Similarly, all balances for measuring dry weights should be calibrated periodically against known weights. Fine-scale balances should be calibrated by the manufacturer. Where possible, 10 to 20 percent of the samples should be re-analyzed/re-weighed to produce an error estimate.

QA/QC for Data Entry

Data entry can be done immediately in the field, using field computers. However, in most cases, measurements are written down in the field and must be entered manually into spreadsheets. Data entry into spreadsheets is often a significant source of error. Ongoing communication between all personnel involved in measuring and analyzing data is critical for resolving apparent anomalies before final analysis of the monitoring data is completed. Special attention must go to units used in the field. Typical mistakes are confusion between diameters or circumferences if trees are measured, or the length unit (mm, cm, and inches). All measurements contained in spreadsheets must have the unit clearly indicated. Errors can be reduced by spot checks of the entered data by independent personnel. In addition, outliers can be identified by checking whether each value is within an expected range. If during spot-checks or range checks, a significant number of errors are found, all data must be re-checked by independent personnel. If there are any anomalies that cannot be resolved, the plot should note used in the analysis

QA/QC for Data Archiving

Because of the relatively long-term nature of forestry activities, data archiving and

storage is important and should include the following steps:

1) Original copies of the field measurement (data sheets or electronic files) and laboratory data should be maintained in original form, placed on electronic media, and stored in a secure location.

2) Copies of all data analyses, models, the final estimates, GIS products, and a copy of the measuring and monitoring reports should be stored in a secure location (preferably offsite).

3) Given the period for reporting and the pace of production of updated versions of software and new hardware for storing data, electronic copies of the data and report should be updated periodically or converted to a format that can be accessed by new or updated software.

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9 Pearson, T., Walker, S. and Brown, S. 2005.*Sourcebook for land use, land-use change and forestry projects*. Winrock International and the BioCarbon Fund of the World Bank.

10 Van Laar, A., and Akça, A., 1997. Forest Mensuration. Cuvillier Verlag, Göttingen. 418 p.

FIELD FORMS

Field form 1: Sketch Drawing and Fixed-Point

Field form 2: Sample Plot Description

Field form 3: Tally and Sample Tree

Field form 4: Dead Tree and Disturbances

Field form 5: Shrub and Seedling + Sapling

Field form 6: Soil Sample + Horizon

Field form 7: Biodiversity Plant and Fungus

Field form 8: Biodiversity (Mammals), Non -Timber Forest Product and Tree outside Forest

Field form 9: Invasive Alien Species

Field form 10: Forest Disease and Pest

Field form 11: Time Measurement

Annex I : List of measuring tools and equipment determined for one field crew.

A. Navigation and data recording

Item	*N*/Crew	Purpose
Digital camera	1	For documentation of pictures and videos
Cell phone (CDMA)	1	For regular communication
Field computer	1	For recording data in the field
Field forms	*N*	For recording field data manually
GPS device	1	For navigation to the field and locating sample plots
Pens, pencil, eraser	*N*	For recording
Pocket calculator	1	For quick mathematical calculation
Sheet holder	1	For protecting data sheet in the field
Topographic map	1	For navigating and establishing sample plots in the field
Satellite images	*N*	For navigating and establishing sample plots in the field
Metal detector	*1*	For detecting the centre and 5 m North peg

B. Sample plot measurements

Item	*N*/Crew	Purpose
Axes/billhooks	2	For field work
Suunto clinometer		For measuring bearings, slopes and aspects
Calliper	1	For measuring tree diameter at breast height
Chalk/Marker	*N*	For instance, for marking the sample trees and boundary trees temporarily to ensure that they are measured
Spherical densiometer	1	For measuring crown density
Enamel paint	1	For permanent marking
Hammer	1	For field work
Increment borer	1	For identifying age of tree

Linear tape (50 m)	1	For measuring distances
Linear tape (20 m)	1	For measuring distances
Loggers tape	1	For plot boundary delineation
Measuring pole/rod (4–7 m)	1	For measuring heights of seedlings, saplings and shrubs
Plastic cover	*N*	For storing increment specimens
Survey Master	1	For measuring the ground slope
Diameter Tape	1	For measuring diameter of the tree at breast height
Calliper	1	For measuring diameter of the tree at breast height
Vertex IV and Transponder T3	1	For measuring tree height, distance, angle and establishing circular plots without the use of tapes, compass and survey master

C. Herb and grass collection and observing biodiversity characteristics

Item	*N*/Crew	Purpose
Binocular	1	For climber and wild live identification
Clothes bags	*N*	For collecting samples
Knife/Sickle	1	For cutting herbs and grasses
Plastic bags	*N*	For collecting samples
PVC pipe frame (1 m $\times$ 1 m square)	1	For delineating vegetation plots
Scissors	1	For cutting herbs and grasses

D. Soil sample collection

Item	*N*/Crew	Purpose
Metal ruler (aluminium)	1	For measuring thicknesses of organic soil samples and soil horizons
Munsell's soil colour chart	1	For determining soil colours (i.e., hue, value and chroma)

Plastic bags	*N*	For storing samples
Soil sample corer	1	For collecting soil samples from various depths
Spade	1	For excavating soil pits
Electronic balance	1	For weighting soil samples in the field
Steel rod (1 m)	1	For measurement of coarse fraction proportion
Sticking tape	1	For labelling plastic bags for soil samples
Polythene sheet	N	For determining soil sample volume in special cases
Water container syringe syringe syringe	1	For determining accurate volume of water
Measuring cylinder	1	For measuring water volume
Stainless steel knife	1	For soil profile study
Auger	1	For measuring soil depth
Shovel	1	For soil profile study

Annex II : Key to the soil textural classes according to the Guidelines for Soil Description USDA.

Soil Texture Determination by feel method

1. Take about 25 g of soil in the palm, add water and moisten it and try to form ball, if ball not formed, the sample is Sand (S)

If ball is formed

2. Place ball of soil between the thumb and the forefinger, squeeze it upward and form a ribbon, if ribbon not formed, the sample is Loamy Sand (LS)

If ribbon is formed, then determine the size of the ribbon into either a short (<2.5 cm), medium (2.5 to 5 cm) or long (>5 cm); Place a pinch of the soil ribbon on the palm of one hand and add water to make it wet and gently rub it with the fore-finger of another hand to feel the grittiness or smoothness, finally observed the result as given below:

Feel	Ribbon Size (cm)		
	<2.5	**2.5 – 5.0**	**> 5.0**
Gritty	Sandy Loam (SL)	Sandy Clay Loam (SCL)	Sandy Clay (SC)
Smooth	Silt Loam (SiL)	Silty Clay Loam (SiCL)	Silty Clay (SiC)
Neither gritty nor smooth	Loam (L)	Clay Loam (CL)	Clay (C)

Annex III : Forest types based on the LRMP inventory.

A	Abies Forest	*Abies spectabilis*
Bu	Betula Forest	*Betula utilis*
Ce	Deodar Forest	*Cedrus deodara*
Ct	Cupressus Forest	*Cupressus torulosa*
Jw	Juniper Forest	*Juniperus wallichiana*
KS/SK	Khair Sissoo Forest	*Acacia catechu, Dalbergia sissoo*
Pr	Khote Salla Forest	*Pinus roxburghii*
Pw	Gobre Salla Forest	*Pinus wallichiana*
Q	Quercus Forest	*Quercus spp*
S	Sal Forest	*Shorea robusta*
Sp	Spruce Forest	*Picea smithiana*
Td	Hemlock Forest	*Tsuga dumosa*
TMH	Terai Mixed Hardwood Forest	*Mixed Species at < 1000 m altitude*
LMH	Lower Mixed Hardwood Forest	*Mixed Species between 1000 m - 2000 m altitude*
UMH	Upper Mixed Hardwood Forest	*Mixed Species at > 2000 m altitude*
SB	Shrub	*Shrub Species*

Pure forest type will be used if the basal area of the dominant species is more than 60 %. If none of the species exceeds 60 % but exceeds 33 %, the forest type will be considered as mixed type. If there are two species each exceeding 33 %, the forest type will be considered as mixed forest of the two species and coded as a combination of them (e.g. Q/Pr). If the first species is more than 33 % and the second species less than 33 % the forest type will be considered as the mixed type of the dominant species and mixed type, e.g. Q/LMH. If none of the species exceed 33 %, the forest type will be considered as mixed (TMH, LMH, UMH).

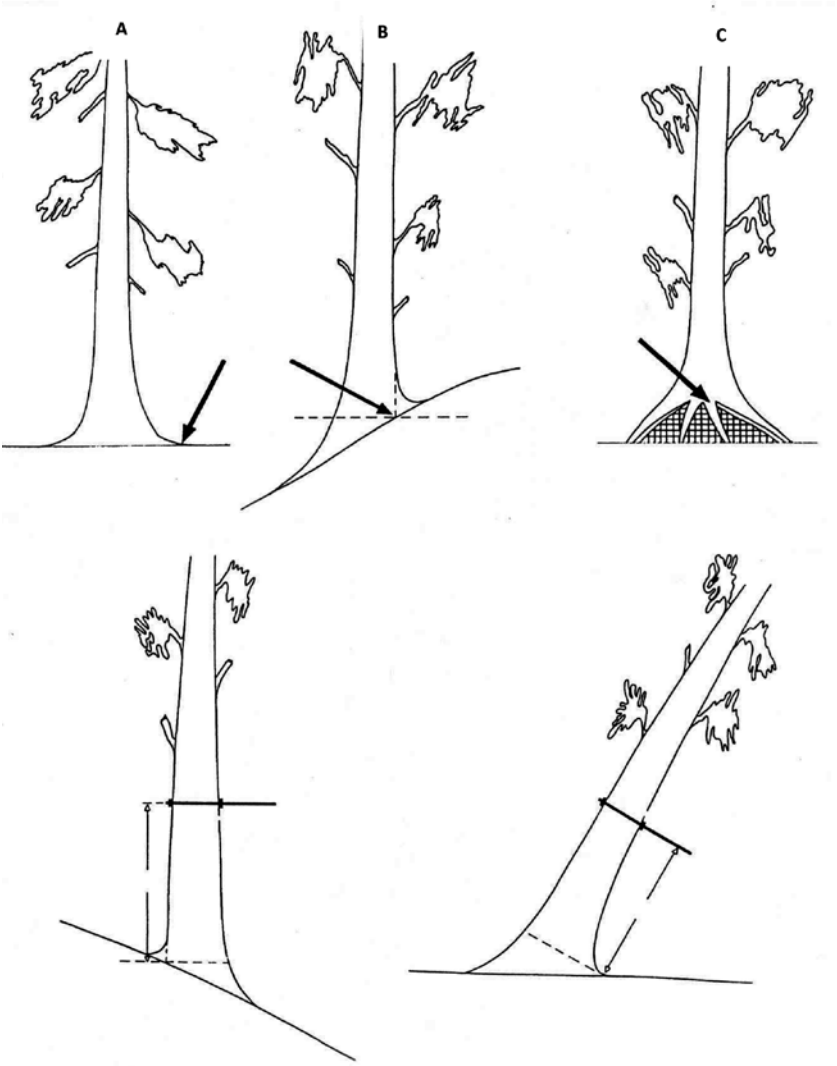
Annex IV : Names of some Non-Timber Forest Product species. Please refer annex VI for detailed names and provided codes

S.No	Vernacular name	English name	Latin name
1	Bans	Bamboo	*Bambusa arundinacea*
2	Lokta	Daphne	*Daphne bholua*
3	Babio	Sawai grass	*Eulaliopsis binata*
4	Kurilo, Satavari	Asparagus	*Asperagus racemosus*
5	Thakal		*Phoenix humilis*
6	Nigalo		*Arundinaria falcate*
7	Maling		*Arundinaria maling*
8	Nagbeli, Banmala		*Lycopodium clavatum*
9	Silajit		
10	Bikh, Aconite		*Aconitum spicatum*
11	Banlasun, Jimbu		*Allium wallichii*
12	Chutro (I)	Barberry	*Berberis aristata*
13	Chutro (II)	Barberry	*Berberis asiatica*
14	Pakhaved		*Bergenia ciliate*
15	Malagiri, Sugandha kokila		*Cinnamomum glaucescen*
16	Tejpat (leaves), Dalchini (bark)	Cinnamo	*Cinnamomum tamala*
17	Panch Aunle, Hatajadi		*Dactylorhiza hatagirea*
18	Rudraksha, Gedi	Utrasum bead tree	*Elaeocarpus sphaericus*
19	Somalata		*Ephedra gerardiana*
20	Karu		*Gentiana kurroo*
21	Dhupi (I)	Black juniper	*Juniperus indica*
22	Dhupi (II)	Drooping juniper	*Juniperus recurva*
23	Jatamanshi, Bhutle, Naswa	Spikenard	*Nardostachys grandiflora*
24	Mangen, Naadar		*Panax pseudo-ginseng*

S.No	Vernacular name	English name	Latin name
25	Satuwa		*Paris polyphylla*
26	Kutki		*Neo-picrorhiza scrophulariiflora*
27	Laghupatra	Podophyllum	*Podophyllum hexandrum*
28	Sarpagandha, Chandmaruwa	Serpentine	*Rauwolfia serpentina*
29	Padamchal, Chulthi amilo	Rhubarb	*Rheum austral*
30	Sun pate		*Rhododendron anthopogon*
31	Majitho		*Rubia manjith*
32	Chiraito		*Swertia chirayita*
33	Silangi, Singhi, Tali swan, Dhingre salla, Talispatra, Laundh salla	Himalayan yew	*Taxus baccata*
34	Amriso	Broom grass	*Thysanolaena maxima*
35	Gurjo		*Tinospora sinensis*
36	Sugandhawal	Valerian	*Valeriana jatamansi*
37	Dhanyaro, Amaar phool		*Woodfordia fructiosa*
38	Timur	Nepal paper	*Zanthoxylum armatum*
39	Yarsa gumba		*Cordyceps sinensis*
40	Asuro		*Justicea adhatoda*
41	Dhatelo		*Princepia utilis*
42	Sarmaguru		*Swertia multicaulis*
43	–	Other: specify vernacular, English and Latin names	–

Annex V : Standard forestry practices

(i) Determination of ground level (A, B) and seeding point (C), and measurement of diameters at breast height of trees growing on the slope (D) and that are leaning (E).



(ii) Measuring diameter at breast height 1.3 m

Figure (i) Position for diameter measurement at breast height in flat terrain

Notes: One single dotted line indicates the place for DBH measurement.

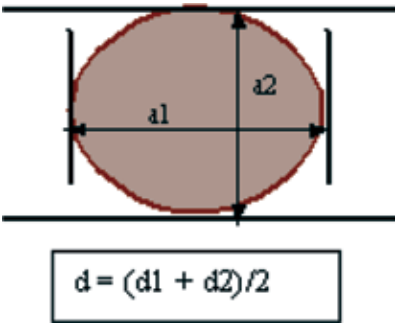
Figure (ii) Caliper

Some preventive measures must be taken into account:

- Measurement instruments are kept in a position that perpendicularly cuts the tree axe at 1.3 m;
- Make sure the calliper tightly holds the stem, in order to prevent the caliper clasps from grasping without compressing the bark;
- If the diametric tape is used, make sure it is not twisted and is well stretched around the tree in a perpendicular position to the stem. Nothing must prevent a direct contact between the tape and the bark of the tree to be measured.

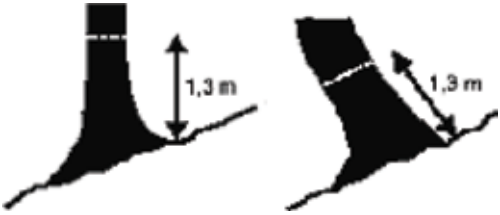
If the caliper is used, non circular trees are to be measured in two perpendicular diameters located as close as possible to the largest and the smallest diameter in that point, the average of these two is thus retained.

Figure (iii) Non circular tree measurement with caliper



On inclined terrain, DBH tree measurement at 1.3 m is taken from an uphill position.

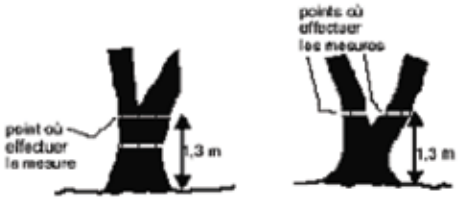
Figure (iv) DBH measurement position for a tree on steep terrain.



Fork tree: Several cases exist, according to the point where the fork divides the stem.

- If the fork begins (the point where the core is divided) below 1.3 m height, diameter measurement of each stem will be taken at 1.3 m height.
- If the fork begins between 30 cm and 1.3 m, each stem will be considered as separate tree and will be measured. The diameter measurement will be taken at 1 meter above the fork origin.
- If the fork begins at 1.3 m or a little higher, the tree will be counted as a single tree. The diameter measurement is thus carried out below the fork intersection point, just below the bulge that could influence the DBH.

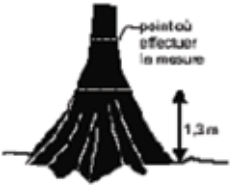
Measurement point measurement points



- Coppice: Coppice shoots originate between ground level and 1.3m on the stem of a dead or cut tree. These are considered in the same way as forked trees, except that the coppice shoots do not necessarily reach 1/3 diameter of a dead tree. Coppice shoots originating below 30 cm are measured at 1.3 m above the ground; those that originate between 30 cm and 1.3 m are measured at 1 meter above the originating point.
- Trees with an enlarged stem base or buttressed tree: diameter measurement is made at 30 cm above the enlargement or main width of buttress, if the buttress/ enlargement reaches more than 90 cm height above the ground (see Figure V).

Figure (V) DBH measurement position for buttressed tree

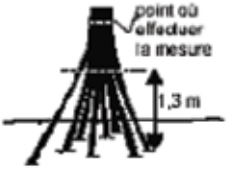
Measurement point



Trees with aerial roots: diameter measurement is done at 1.3m from the limit between the stem and roots.

Figure (VI) DBH measurement position for a tree with aerial roots

Measurement point



- Trees with irregular stem at 1.3m: trees with bulges, wounds, hollows and branches, etc. at breast height, are to be measured just above the irregular point, there where the irregular shape does not affect the stem.

Figure (VII) DBH measurement position for a tree with branch enlargement at 1, 3m

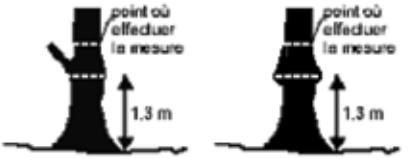


Figure (VIII) DBH measurement position for other trees.

Measurement Point

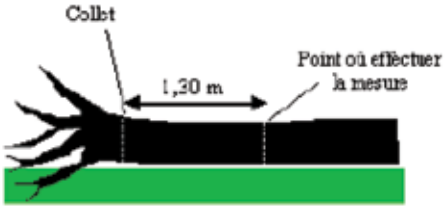
- Inclined trees: diameter measurement is made at 1.3 m. The stem height is measured where the stem base and the ground meet forming an angle.

Figure (IX) DBH measurement position for an inclined tree.

- Fallen tree: diameter measurement is made at 1.3 m from the transition point between the stem and the root.

Figure (X) DBH position for a fallen tree.

Transition point measurement point



- In the case of stump, if the stump height is less than 1.30 m, stump diameter is measured outside bark at stump height (15 cm), if the bark is damaged or missing, mention in remarks.

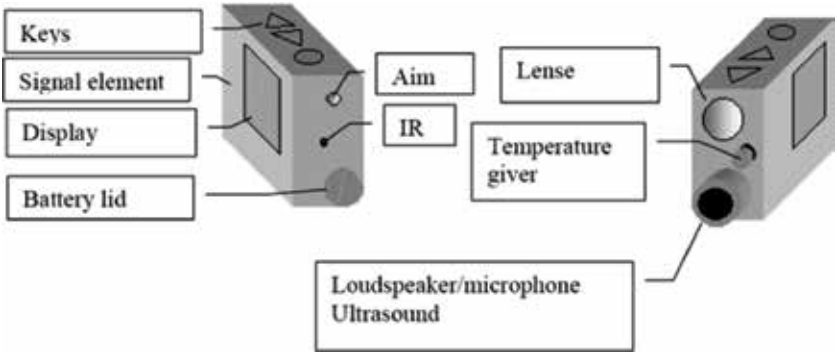
Annex VI : Species lists had been published and can be obtained from FRTC

Annex VII : Description of equipment

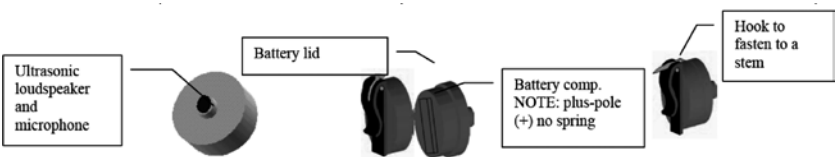
1. Vertex IV and Transponder T3 (Source: Vertex IV and Transponder T3 manual January 2007, v.10)

1.1 Description

The Vertex IV is primarily used to measure the height of standing trees. The instrument can also be used to measure distance, horizontal distance, angle and inclination. The Vertex instrument uses ultrasonic measuring technique for measurements.



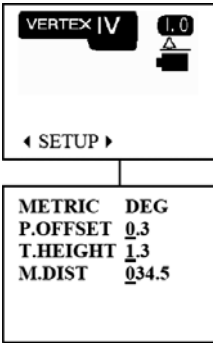
To define a reference point in a secure and reliable way, the Vertex IV communicates and works with the transponder T3



The Vertex IV has three keys: Two arrow keys and one ON key. To turn the Vertex IV off, press DME and IR keys together.

Vertex IV and the transponder T3 each use an alkaline or a rechargeable battery of 1.5 V AA. The battery is placed under the battery cap, plus pole + down. Data in the Vertex can be sent through IR or Bluetooth.

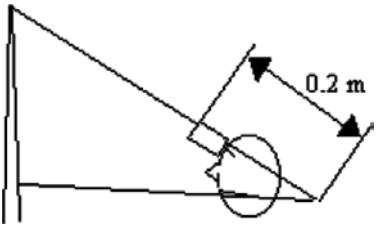
1.2 Setting-up the equipment



All settings to measure heights, distances and angles are made in the SETUP menu. Choose between metric or feet, degrees or percentage, pivot offset, transponder height and manual distance. Start the Vertex IV by pressing ON. Press any of the arrow keys to go to the SETUP page and press ON to enter into settings. Step to the parameter using ON and change values with the arrow keys.

METRIC/FEET Choose if height and distance values should be featured in METRIC or FEET. Shift with the arrow keys and confirm your choice with ON.

DEG/GRAD/% Select Angle unit as Deg (degrees 0 to 360), GRAD (gradients 0 to 400) or % (percentage) by pressing the arrow keys. Confirm by pressing ON.



P.OFFSET (Pivot Offset) Change the value with the arrow keys and confirm your choice with ON. The value is shown in Metric/Feet.

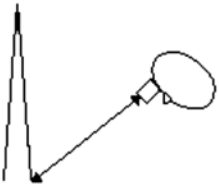
The “Pivot offset” is equal to the distance between the front side of the instrument to the aimed point where the prolonging of the sight line from the transponder and the top of the tree coincide. The imagined point is located somewhere behind your neck and the value should in normal cases be set to 0.3 m (1.0 feet).

Since the Vertex IV will presume that the transponder T3 is placed directly under the aimed height of the measuring object (when the object is equal to a tree), a half of the objects diameter should be added to the Pivot Offset. This compensates for the diminishment of the tree top. When measuring tree heights, it is recommended to add half the average diameter in the area, for improved accuracy.

T.HEIGHT (Transponder height)

Change the value with the arrow keys and confirm with ON. The value is set in metric/feet. T.HEIGHT is the height where the transponder is set, the reference height for the measuring unit. The Vertex IV adds the preset T. HEIGHT to the measured height. Normal breast height value is set to 1.3 m (4.5 ft).

M.DIST (Manual distance)



This function is useful when measuring without the transponder. Change value with the arrow keys and confirm with the ON key. The value is shown in metric or feet. M. DIST is the manual distance to the reference point on the object where the height is measured. Make sure that the T.HEIGHT is correctly set, i.e. the height to the chosen reference point.

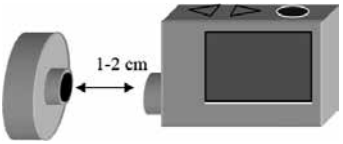
To perform any of the operations described below, ensure a battery in placed in the T3 properly and keep the measuring unit’s loudspeaker towards the T3’s loudspeaker.

1.3 Turning the T3 on and off

The T3 has no switch and the Vertex is used as a remote control to turn T3 off and on. For both turning the T3 on and off, turn on the Vertex IV, press any of the arrow keys to go to the

CALIBRATE page and press ON to enter into calibration and do as follows:

To turn T3 **ON**	Press ON until two signals beeps from the T3.
To turn T3 **OFF**	Press ON until four signals beeps from the T3.

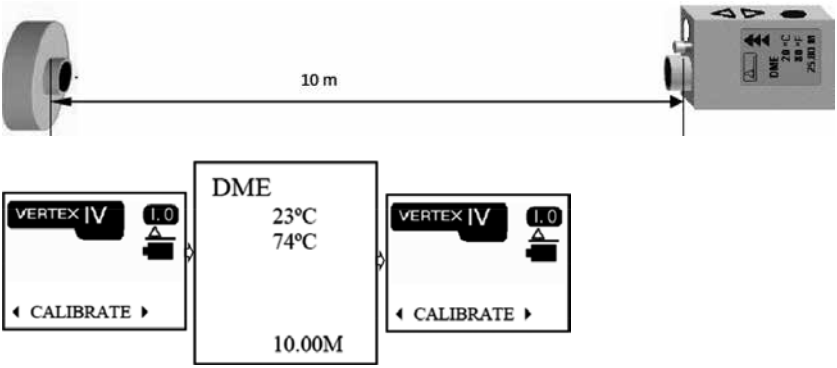


The T3 is equipped with an audible signal that tells if the transponder is activated or not. Once turned on, the T3 Transponder stays activated for approximately 20 minutes.

1.4 Calibration

To increase and optimize the measuring accuracy, the instrument should be calibrated on a regular basis. The measuring fault can be made permanent if the instrument is calibrated before reaching the correct current temperature. Therefore, when calibrating, it is of utmost importance that the instrument has been given enough time to stabilize at ambient temperature.

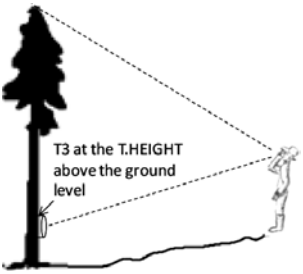
Use a measuring tape to measure the exact distance of 10.0 m (32.8 feet) between the T3 and the Vertex front.



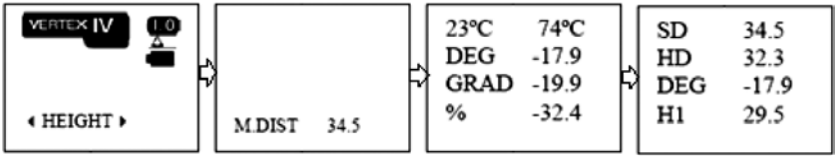
Press ON to start the Vertex instrument, step in the menu to CALIBRATE and press ON. The instrument will calibrate to 10 m, automatically exit from the calibration and display the CALIBRATE page.

Again, it is important to give the instrument approximately 10 minutes to set to the correct temperature before calibrating.

1.5 Measuring tree height with transponder T3



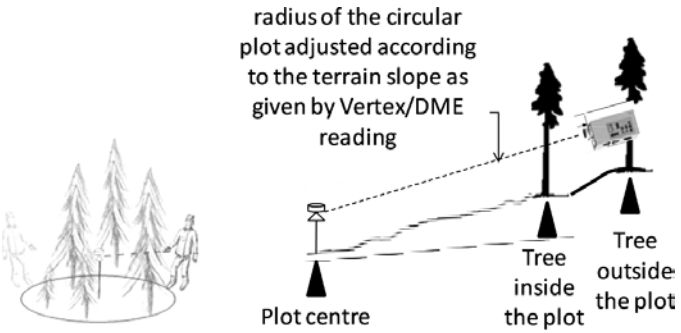
Start the transponder T3 and place it on the tree to be measured. Note that the transponder should be placed at the T.HEIGHT (transponder height) that has been determined in the settings menu. Walk a suitable distance from the object – for optimal result accuracy, a distance equal to the approximate tree height.



1. Press ON to start the Vertex, scroll to the HEIGHT page and aim at the transponder. Keep pressing ON until the cross hair sight goes out momentarily. Now release ON. The Vertex has measured the distance, the angle and the horizontal distance to the transponder.
2. Aim at the height to measure with the sight cross blinking. Press ON until the cross hair disappears. The height of the tree is locked and displayed.

1.6 Detecting the trees on the edge (circumference) of a circular plot

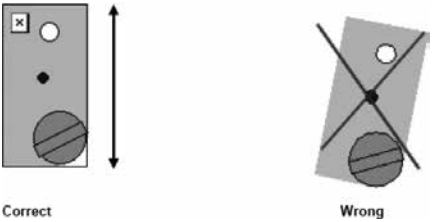
When the T3 is used with the adapter (graduated staff), the ultrasound is spread and it is possible to take measurement from any direction. This is particularly useful when working in circular plots, where the distance from the plot centre to trees within a defined circle should be measured.



To determine the radius in case of a circular plot, first fix the T3 at T. HEIGHT at the centre of the plot. Then press the DME key (left arrow key) when the Vertex IV is turned off. The distance between the Vertex IV and the T3, is presented in the Vertex display. Now move away from the centre until the distance reading on the Vertex equals to the radius of the circular plot (in case of sloping terrain, the radius should be adjusted according to the slope). As the Vertex gives reading of the shortest distance, make sure you hold the Vertex at T.HEIGHT above the ground level while taking Vertex reading. Now you can determine whether the surrounding trees are within or outside the circular plot.

1.7 Important precautions to take while using the Vertex IV

- The Vertex IV uses ultra sonic signals to determine distances. Humidity, air pressure, surrounding noise and, above all, the temperature can affect the range and extension of the ultra sonic signals.
- In some cases, distances of 50 meters and greater can be measured without problems, and in other cases, the maximum distance can be shorter than 30 meters.
- Check your instrument daily and recalibrate if necessary. Do not touch the temperature sensor at the front of the instrument (the metal knob between the sight and the loudspeaker) and never calibrate the instrument before it has reached ambient temperature.
- When measuring heights, it is important to hold the instrument as straight as possible.



For further information and technical specifications of the set of the equipments, consult the user manual.

2. Spherical Densiometer

2.1 Description

A spherical densiometer is common yet simple instrument for measuring forest over story density or canopy cover. The instrument has reflective spherical surface divided into 16 equi-spaced square grids. When the instrument is taken under forest canopy, the images of overhead crown can be seen in mirror and the amount of canopy coverage is estimated based on proportion of the mirror surface reflecting the overstory crown.

2.2 Estimating canopy cover using densiometer

Although it is ideal to take canopy cover measurements in each sample plot, but depending on resources availability canopy measurements can be taken in skipped in several plots.

However, the plots where canopy measurements are taken should be allocated in proportion to the area of different strata. Prior to taking the canopy cover measurements, all trees should be already tagged, and diameter at breast height (DBH) measured. This measurement procedure can be efficiently handled by one person using the following procedure.

1) Hold the densitometer far enough away from your body so that your head is just outside the grid (30-45 cm away). Maintain the densiometer approximately at elbow height. Keep the densiometer instrument leveled, as indicated by the round level in the lower right hand corner.

2) Count the number of canopy opening squares. If there are squares that are only partially filled, these can be added to make a complete square. Each square represents an area of canopy opening (sky image or unfilled squares) or canopy cover (vegetation image or filled squares). For deciduous trees in late fall to winter, when trees have no leaves, the crown area needs to be visualized for a proper reading. Only squares that are completely free of branches should be counted as sky.

3) The total number of squares that are filled is denoted on the sampling sheet.

Annex VIII : Field method for Forest, NTFPs and biodiversity survey

This method is aimed to incorporate forest, NTFPs, ToF and wildlife survey techniques in the forested areas of Nepal. This also tried to incorporate the recent and previous survey techniques applied for similar works which seems to useful for FRA Nepal.

A. Preparation of habitat map

Techniques: A preliminary habitat map will be prepared by using Satellite Imageries and GIS. The smallest area distinguished as a habitat will be 0.5 ha (>20 m width). The resulting habitat types will consist of mosaic of little and highly disturbed types, depending on site-specific human impacts in the past. Types of habitats will be categorised in: a) forest, b) Shrubland/ scrubland, c) Wetland, and d) Grasslands. Main data on floristic composition, NTFPs and biodiversity will be collected directly during field sampling by applying different methods described in following pages. The habitats distinguished from the Satellite Imageries will be surveyed to find-out the composition & dominant species in the tree layer, prominence value of the understory layer and ground layer.

Aim: This techniques will be helpful to assess ecological diversity in terms of: Physiographic zone (terai, siwalik, mid mountain, high mountains, and high Himalaya), ecosystems (forests, shrubland/scrubland, savana, grassland, wetland and deserts), and broad classification of habitats (forest types, grassland types, wetland types and shrub/scrubland types). It will also provide the information on Tree outside Forest (ToF).

B. Sampling

Basic data to calculate phyto-sociological parameters of the different habitat types will be collected by stratified sampling procedures. The distribution of the cluster will be identified by randomizing the number laying systematic sampling grids of 4*4 kilometre for the whole country.

Number of sampling plots

The total forest area of Nepal is 4.27 million ha and scrubland 1.56 million ha. The minimum forest covered area subject to national FRA is 5.83 million ha resulting in 9183 first stage clusters in the field while using 4 x 4 km grids. By applying the probability of wooded sample points, around one fourth of these clusters will be measured in the field (2-Phase sampling) equalling to 400 clusters.

The field clusters will be two sets of groups of 6 sample plots. The starting sample plot (the most south-western and north-eastern ones) will be considered as first plots. All the plots in one cluster will be established and measured as permanent sample plots. The distance between other sample plots from these core plots will be 150 m and 300 m. The straight line between these plots will be considered as transects for line inventory. Data on biodiversity will be collected from these transects. The shape of sample plots will be circular . They will be co-centric in nature having four (4) co-centric circles with various radiuses.

C. Data collection from community

Techniques: Simple Participatory Rural Appraisal (PRA) method will be applied to gather more information on biodiversity, NTFPs, and ToF. The techniques included Key informant survey and Focused Group Discussion (FGD) by using semi-structured questionnaire. Focused Group Discussion program will be organized at local level by incorporating key informants and knowledgeable persons to gather information about the ToF, NTFPs and wildlife (flagship species and large mammals). General discussion and some visual photographs will also be used to attract people and gather more information. To find-out the most important NTFPs in the local area the participants will ask individually to mark the five main plants which they think most useful for them. Priority of individual NTFPs species at local level will be distinguished by counting the mark in individual species.

Aim: Main intention of this method will be to gather specific information about the distribution of wildlife, NTFPs and ToF. This method will help to find-out the distribution of large wildlife in the specific area and NTFPs which cannot be recorded during the survey time. Thus, this is quite useful method to validate and backstop the information collected from the survey.

D. Line inventory

Techniques: Line inventory will be conducted between two circular plots in one cluster. The main focus of the line inventory will be to get primary information on wildlife (flagship species and large mammals). Both direct observation and indirect evidences will be used to gather information on wildlife. The information will be recorded in the field data forms

Aim: The main aim of this survey is to get data on wildlife (large mammals & flagship species).

E. Data analysis

Collected data will be grouped on the basis of prepared habitat maps. The data will be analysed

to find the species composition/plant sociology of the particular habitat/forest types.

Name of each forest type will be determined by ordering the Importance Values of each tree species. Importance Value will be obtained by summation of the relative frequency, relative density, and relative dominance (Krebs 1994). Relative dominance of trees will be determined by calculating the basal area. The coverage of ground flora will be calculated by converting the recorded cover percentage to midpoint cover classes according to Zobel *et al.* 1987. In case of grassland and scrubland Prominence values (Dinerstein 1979) will be used for classification:

$PV_x = C_x (\sqrt{f_x})$

PV_x = Prominence value for species x

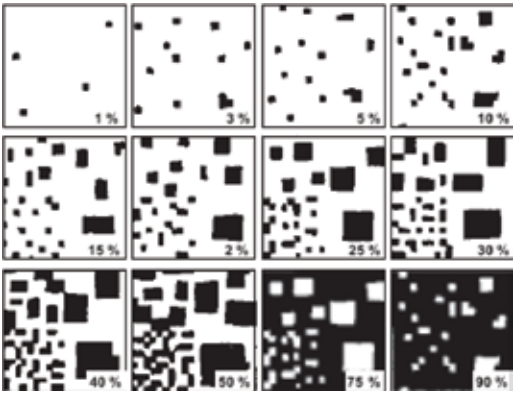
C_x = Mean percent cover of species x

f_x = Frequency of species x

By incorporating the wildlife related data on satellite images and habitat classification it will provide prime map for distribution of large wildlife in the different areas/habitat of this country. The direct and indirect evidences will be analysed to prepare the species diversity of flagship wildlife and large mammals. Different types of survey forms will be used for the survey. Photo documentation of the indirect evidences and directly observed wildlife will be provided later.

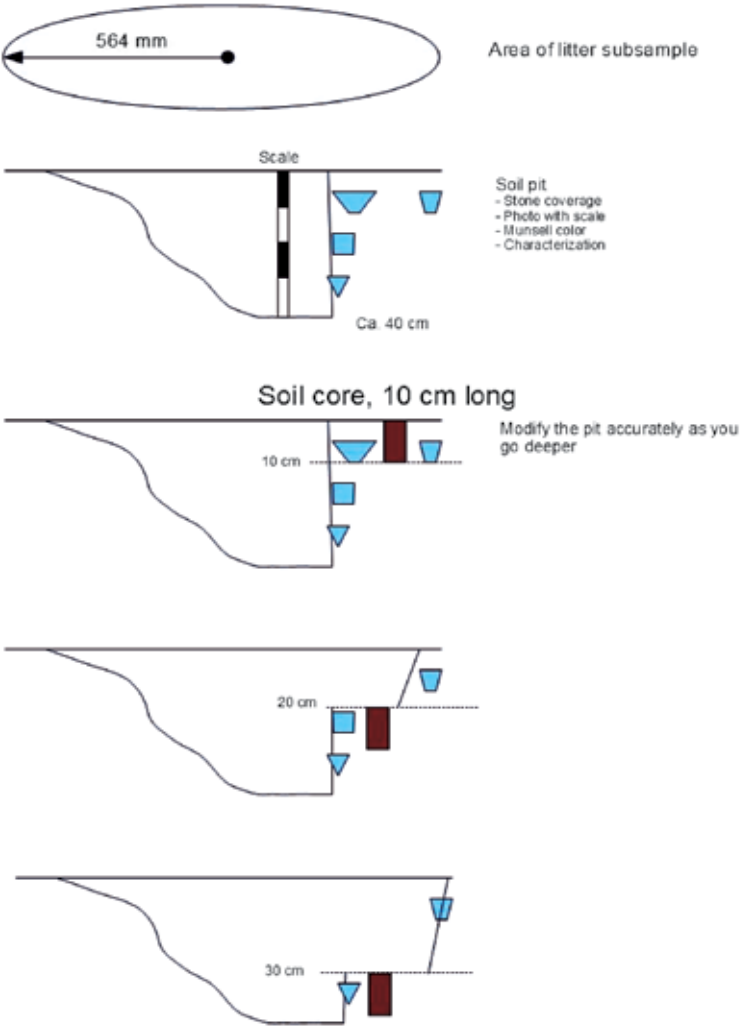
Annex IX : Charts for estimating the proportions of coarse mineral fragments

Charts for estimating the proportions of coarse mineral fragments (> 2 mm) and mottles in the mineral soil (FAO 2006, p. 30).



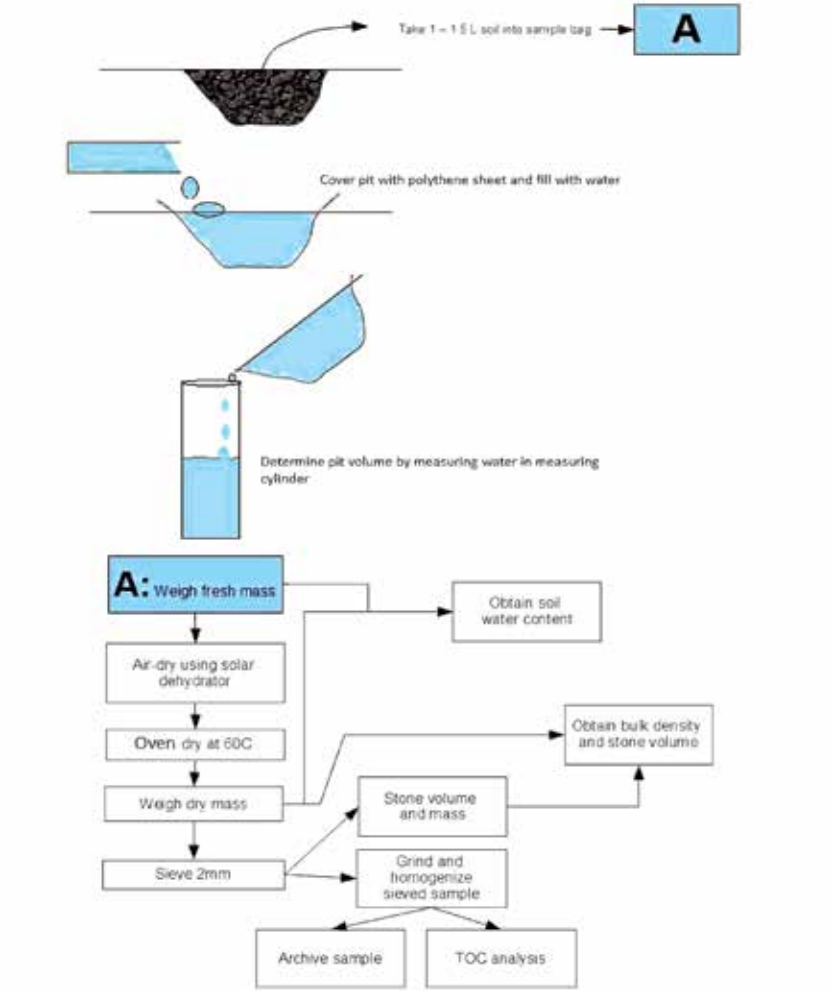
Annex X : Schematic presentation of a soil pit for taking volumetric soil

Schematic presentation of a soil pit for taking volumetric soil samples 0–10 cm, 10–20 cm and 20–30 cm. For taking the samples from layers 10–20 cm and 20–30 cm, a new surface must be exposed at top of the sample depth using e.g. spade.



Annex XI : Taking a volumetric sample from soil where the volumetric corer cannot be used

The pit can be covered by a polythene and fill the sheet with water until the water reaches the soil surface. Measure the amount of water retained in the soil pit with measuring cylinder. Record the volume of water in the form.


Take 1 – 1.5 L soil into sample bag
A
Cover pit with polythene sheet and fill with water
Determine pit volume by measuring water in measuring cylinder
A: Weigh fresh mass
Obtain soil water content
Air-dry using solar dehydrator
Oven dry at 60C
Obtain bulk density and stone volume
Weigh dry mass
Stone volume and mass
Sieve 2mm
Grind and homogenize sieved sample
Archive sample
TOC analysis

Annex XII : Soil sample treatment from field to laboratory

The soil samples taken in Nepal FRA from soil layers "New litter", 0–10 cm, 10–20 cm and 20–30 cm, are primarily intended for Total Organic Carbon (TOC) analysis. As the samples constitute from by default 4 volumetric compound sub-samples, the amount of soil taken allows other analyses to be made from the same samples. Therefore, it is important to manipulate, preserve and archive the samples in such a way that also other analyses became possible.

Taking the sample

The corer should be used so that an undisturbed sample is taken from the proper depth below the soil surface. The soil surface is defined to include the at least partly decomposed "old" litter below the layer of the "new litter". The consecutive depts. are taken as indicated by figures in the Annex XY.

The corer must be cleaned carefully between each use. The sample should not be touched by bare hands, and clean plastic cloves should always be used to avoid contamination. Skin contact could affect e.g. the nitrogen content of the sample. All subsamples from the same soil layer are collected in the same plastic bag and marked with a tag containing unique cluster, plot, and point codes **and the actual number of subsamples** written by a graphite pencil on a waterproof paper tag enclosed in the bag with sample. A suitable piston is used to completely empty the corer from the sample. All sample materials are put in the sample bag. After each sample the corer and piston are wiped clean to avoid "tailing" of the sample to the next.

Determination of fresh mass

The volumetric composite sample is weighed for fresh mass using a battery-operated kitchen scale with 1 g accuracy. This would facilitate the determination of volumetric water content at the time of sampling.

Preservation of the sample in field

The samples should reach the laboratory within 1–2 days of sampling. That may not always be possible. In that case the samples cored from the plot are taken to the base camp, where a solar dehydrator cabin has been erected. The plastic bags are completely emptied to ca. 0.5 L aluminum foil vessel *with the paper tag containing the origin information* and dried in the

cabin until air-dry. Temperature in the solar dehydrator should not exceed 60°C so that the organic matter would not decompose (e.g. lose nitrogen). The air-dried sample is collected back to a clean, dry plastic bag with the paper tag, and is carefully closed and stored in a dark, preferably cool place.

Example of an aluminum vessel for drying the samples.

Annex XIII : Preservation and preparation of the soil sample in laboratory

Sample preservation and oven drying

If the samples come directly with field moisture, they are immediately oven dried at **60°C** (not higher) until constant weight. That may take at least 24 h. If immediate drying is not possible, the samples can be saved in refrigerator (+4°C) until the next day or freeze (–20°C) over longer periods of time. The sample may not be manipulated with bare hands, but plastic gloves are to be used at all times.

Determination of dry mass

The oven dry sample is immediately weighed from dry mass using at least 1 g accuracy. Similar accuracy was used for fresh mass in the field.

Roots, stones, and soil homonization

After oven-drying and weighing the sample is sieved using a 2 mm sieve. Plant roots are picked out of the sample using atulas and their dry mass is weighed with accuracy of 0.1 g. Stones and gravel that remain in the sieve are also weighed as dry and their volume is determined using the water replacement technique.

The sieved soil sample is completely homogenized using a grinder so that the materials pass a 0.5 mm sieve. The grinder must be completely clean until a new sample is homogenized.

TOC and archive samples

The homogenized sample is divided for TOC analysis and archive. For TOC sample, at least 20 g of the sample is set aside. From the rest at least 50 g, but preferably 100 g of the sample is archived in a plastic container with a tight cap and label containing all the original information from the sample tag.

It is paramount that the archived sample is attached with information so that it can be accurately connected to other data in the database concerning location, TOC and forest data.

The rest of the original soil sample can be discarded.

Annex XIV : District Code

Code	District	Area(km^2)	Zone
1	Achham	1,680	Seti
2	Arghakhanchi	1,193	Lumbini
3	Baglung	1,784	Dhawalagiri
4	Baitadi	1,519	Mahakali
5	Bajhang	3,422	Seti
6	Bajura	2,188	Seti
7	Banke	2,337	Bheri
8	Bara	1,190	Narayani
9	Bardiya	2,025	Bheri
10	Bhaktapur	119	Bagmati
11	Bhojpur	1,507	Kosi
12	Chitwan	2,218	Narayani
13	Dadeldhura	1,538	Mahakali
14	Dailekh	1,502	Bheri
15	Dang Deokhuri	2,955	Rapti
16	Darchula	2,322	Mahakali
17	Dhading	1,926	Bagmati
18	Dhankuta	891	Kosi
19	Dhanusa	1,180	Janakpur
20	Dolakha	2,191	Janakpur
21	Dolpa	7,889	Karnali
22	Doti	2,025	Seti
23	Gorkha	3,610	Gandaki
24	Gulmi	1,149	Lumbini
25	Humla	5,655	Karnali
26	Ilam	1,703	Mechi
27	Jajarkot	2,230	Bheri
28	Jhapa	1,606	Mechi
29	Jumla	2,531	Karnali
30	Kailali	3,235	Seti
31	Kalikot	1,741	Karnali
32	Kanchanpur	1,610	Mahakali
33	Kapilvastu	1,738	Lumbini
34	Kaski	2,017	Gandaki
35	Kathmandu	395	Bagmati
36	Kavrepalanchok	1,396	Bagmati
37	Khotang	1,591	Sagarmatha
38	Lalitpur	385	Bagmati

Code	District	Area(km^2)	Zone
39	Lamjung	1,692	Gandaki
40	Mahottari	1,002	Janakpur
41	Makwanpur	2,426	Narayani
42	Manang	2,246	Gandaki
43	Morang	1,855	Kosi
44	Mugu	3,535	Karnali
45	Mustang	3,573	Dhawalagiri
46	Myagdi	2,297	Dhawalagiri
47	Nawalparasi	726	Lumbini
48	Nuwakot	1,121	Bagmati
49	Okhaldhunga	1,074	Sagarmatha
50	Palpa	1,373	Lumbini
51	Panchthar	1,241	Mechi
52	Parbat	494	Dhawalagiri
53	Parsa	1,353	Narayani
54	Pyuthan	1,309	Rapti
55	Ramechhap	1,546	Janakpur
56	Rasuwa	1,544	Bagmati
57	Rautahat	1,126	Narayani
58	Rolpa	1,879	Rapti
59	Rukum	1,213	Rapti
60	Rupandehi	1,360	Lumbini
61	Salyan	1,462	Rapti
62	Sankhuwasabha	3,480	Kosi
63	Saptari	1,363	Sagarmatha
64	Sarlahi	1,259	Janakpur
65	Sindhuli	2,491	Janakpur
66	Sindhupalchok	2,542	Bagmati
67	Siraha	1,188	Sagarmatha
68	Solukhumbu	3,312	Sagarmatha
69	Sunsari	1,257	Kosi
70	Surkhet	2,451	Bheri
71	Syangja	1,164	Gandaki
72	Tanahu	1,546	Gandaki
73	Taplejung	3,646	Mechi
74	Terhathum	679	Kosi
75	Udayapur	2,063	Sagarmatha
76	Nawalpur	1,425	Lumbini
77	Rukum East	1,682	Rapti