Forest Laboratory, Conifer Forest Research Sub-Centre, Yusipang
Ugyen Wangchuck Institute for Conservation and Environmental Research
Department of Forest and Park Services
Ministry of Agriculture and Forests
Royal Government of Bhutan
Post Box: 2049
Phone: 975-03-631926
Fax: 975-03-631925
www.uwice.gov.bt

Laboratory Protocol for Drying of Aboveground Tree Biomass Sample

Forestry Laboratory, CFRSC, Yusipang
Ugyen Wangchuck Institute for
Conservation and Environmental Research
Department of Forest and Park Services
Bhutan
2018

Lab Manual

Laboratory Protocol for Drying of Aboveground Tree Biomass Sample

Forestry Laboratory, CFRSC, Yusipang
Ugyen Wangchuck Institute for
Conservation and Environmental Research
Department of Forest and Park Services
Bhutan

Lab Manual

2018

Prepared by:

Yog Raj Chhetri, UWICER
Kaka Tshering, UWICER
Dorji Wangdi, FRMD
Younten Phuntsho, FRMD

Suggested citation:

Citation: UWICER (2018). Laboratory Protocols for Drying of Tree Biomass Sample. Forestry Laboratory, CFRSC, Yusipang, Ugyen Wangchuck Institute for Conservation and Environmental Research, Department of Forests and Park Services. UWICER Press. Lamai Goempa, Bumpthang, Bhutan.

Intra-Agency Collaborator:

Forest Resource Management Division

ISBN: 978-99980-812-6-0

ACRONYMS AND ABBREVIATION

MoAF:	Ministry of Agriculture and Forest
DoFPS:	Department of Forest and Park Services
UWICER:	Ugyen Wangchuck Institute for Conservation and Environmental Research.
CFRSC:	Conifer Forest Research Sub-Centre
FRMD:	Forest Resources Management Division
BTFEC:	Bhutan Trust Fund for Environmental Conservation
REDD:	Reducing Emissions from Deforestation and Degradation
ICIMOD:	International Centre for Integrated Mountain Development
FAO:	Food and Agriculture Organization

TABLE OF CONTENTS

What is total aboveground tree biomass?

Total aboveground tree biomass is the total constant dry weight of all aboveground components of the tree including stem, branches, foliage, fruits and deadwoods. This dry weight is further used to estimate and quantify the total aboveground tree carbon. In general fifty percent of this biomass constitutes aboveground tree carbons.

1. Introduction.

Forest plays an important role in global carbon cycle and sequestering atmospheric carbon (Djomo, Knohl, & Gravenhorst, 2011). The stored carbon in the forest and trees are manifested as biomass of tree or a stand. The aboveground biomass including herbs and shrubs constitutes the major carbon pool amongst the five terrestrial carbon pools and litter, below ground, woody debris and soil organic matter are other pools (IPPC, 2006). In the context of Bhutan, estimating the tree and forest biomass is important for quantifying the national carbon stock besides its potential application in the monitoring and estimation of carbon flux. This manual describes only the drying process of the samples collected from field using the randomized branch sampling procedure which is described in a separate manual (Randomized Branch Sampling for Aboveground Tree Biomass Estimation) (FRMD, 2012).

Figure 1: Field sampling

Figure 2: Tree disc samples

The lab drying process is vital for measuring the accurate dry weight of the tree sample. In order to minimize the errors, certain standardized procedure has to be followed in the laboratory while storing and drying the samples collected from the field. Uniform measurement across samples is required for accurate estimation of biomass content. The sample that come to the laboratory for drying consists of different species collected from different sampling regions of the country and are tagged with unique identity code such as SWWC-01(*Schima wallichii,* tree number 1); S1Ø1(Stratum 1 theta

1); P1N1(Path one node one). The samples should be transferred to the laboratory as soon as possible for oven drying. In case of large numbers of sample where immediate drying is not possible, samples should be stored in the dry condition and should not be exposed to rain or humidity. All samples undergoing drying process in the oven are recorded into the log book (Annex.1). Details such as name of the tree, sample id, component, date and weight have to be correctly and systematically entered. Correct packaging and labeling is very important for accurate biomass estimation. The accurate measurements and recordings of dry weights of samples in the laboratory reduce potential measurement biases and generate better biomass models/equations.

2. Laboratory equipment

2.1. Oven (Drying oven)

Drying oven is an electronic machine which is used for drying the sample of the trees like stem disc, path way (branch sample), Terminal, leaves etc. (Fig. 3). The machine used can either be manual or preferably fully automatic where by you can pre-set the required temperature and duration for the sample to be dried. Immediate drying of samples is highly recommended if possible, if not, the samples have to be stored in a ventilated and dry condition.

Figure 3: Electronic drying oven

2.2. Weighing balance

The digital weighing balance is used to measure the dry weight of the samples after every prescribed interval (Fig. 4). For dry weight measurement, digital balance with precision level up to 1 gram is suitable for measuring the weight of the samples. The samples are dried at prescribed temperature in oven until it reaches constant dry weight.

Figure 4: Electronic weighing balance

2.3. Sample Tray

Figure 5: Oven tray

Sample/Oven tray is a tray made out of high temperature resistant materials (Fig 5), which is used for drying and measuring the smaller size samples of the trees such as foliage, twigs, cones etc. The weight of the tray is premeasured and will be deducted from the sum of weight of the tray and samples to get the weight of the samples only.

NOTE:-

(TAGTBM: Total Aboveground Tree Biomass); (S1Ø1: Stratum one Theta One); (P1N1: Path one Node one); (SWWC: First two letter represents trees scientific name & second two letter sampling region (Example: Schima wallichii, West Central)); (BCWC: Bombax ceiba, West Centra); (QLW: Quercus lanata, Western); (WC: West Cental); (EC:East Central); (DW:Dead Wood); (ID No: Identification number)

3. Flow chart showing the lab drying process of tree biomass

Field Sampling	Carry out biomass field sampling using the randomized branch sampling procedure
Sample Labeling	Label the collected samples with correct identity numbers
Sample Segregation	Once samples reached to the lab, segregate the samples according to category and components and correct the missing labels
Sample Drying	Oven-dry the samples as per the prescribed temperature systematically
Sample Weighing	Weight the samples in prescribed intervals and record it in the Lab register
Total Biomass Computation	Use the constant dry weight of the representative samples of tree components to calculate the total aboveground biomass of the tree

4. Laboratory Process

4.1. Verification of samples identity number in the laboratory

The samples brought from the field will be given a unique sample identification number. The sample id number will be given according to different components of the tree such as for disc samples S1Ø1, S1Ø2; Path ways P1N1, P2N1 (Fig.6 & 8) and dead wood DW, and so on. The sample id will be later used to calculate the total weight of the individual trees from which the samples were collected from. The different components of the tree are:

a) BBM:- Bole/Stem disc biomass
b) TBM:- Terminal shoot/foliage biomass
c) DBM:- Dead/Dry wood biomass
d) PWBM:- Pathway/Branch biomass
e) CBM:- Cone/fruit biomass
f) EBM: - Epicormic branch biomass.

Figure 6: Writing sample id number in the field

Figure 7: Disc sample arranged

Figure 8: Disc sample arranged

Therefore it is important to carry out the following steps before starting the drying process in the oven.

1. Segregate the samples collected according to the tree identification number. For example if the sample id is (pwwc01, S1Ø1) then it should be grouped under tree id no. pwwc01 (*Pinus wallichiana,* west central region, tree number one) (Fig.7 & 8).
2. Find out if there are any missing id numbers in the samples during transportation and identify the numbers and re-label it.
3. If the sample ids on the disc written with marker pen are faded as a result of water and sap flow, re-write them to make legible.
4. In case of duplicate sample id, verify with field data collection template and correct accordingly.
5. Carefully handle and pack sample so that its barks and other broken parts are not detached or misplaced.
6. Once the verification is completed the sample is ready to undergo the drying process.

4.2. Drying process for different tree components

Once the segregation is completed, it should undergo drying process until it reaches the constant dry weight. The drying should begin with foliage and terminal samples so as to avoid decay and loss of the samples. The following drying steps are followed:-

4.2.1. Terminal sample

The terminal sample and foliage samples should be put in the tray or drying bags for drying (Fig. 9, 10 & 11). The sample of the terminal shoots should be labeled with the sample code, tree id, path number such as P1/P2/P3 and node number N1/N2/N3 for every sample. For example: (*Bombax ceiba, tree number one, west central region;* BCWC-O1, P1N6) If the sample size is too large to fit in one bag, use separate bag with the correct sample identification number. Then follow the following drying steps:-

Figure 9: Terminal and foliage samples

Figure 10: Terminal sample

Figure 11: Foliage sample

1. The weight of the terminal shoot/foliage sample should be minimum of 500g or more.
2. Put tray or bags containing the terminal sample into the drying oven to its optimum capacity.
3. Set the temperature between/in the range of 70-80° C.
4. Dry the samples for 48 to 72 hours before first measurement is taken.
5. After 48–72 hours drying hours, measure the weight of the samples and record the readings in the laboratory register/ log book or digital sheet.
6. Thereafter, measure the weight of the samples every 24 hours until constant weight is obtained.
7. Repeat the entire process for all the samples, measure and record the measurements.

4.2.2. Disc and Path way samples

1. The thickness/width of the stem disc sample and pathway sample should be 5cm or more.
2. Put the disc and pathway sample into the drying oven according to sample id numbers in sequence, for example: (ACWC-01, S1Ø1), (ACWC-01, S1Ø2), (ACWC-01, S2Ø1), (ACWC-01, S2Ø2) etc. (Fig. 10), to its optimum capacity (Fig. 12, 13 & 14).
3. Set the oven temperature in the range of 80-100°c.
4. Dry the samples for 48 to 72 hours before first measurement is taken.
5. After 48 to 72 hours measure the weight of the sample and record the readings in the laboratory register/log book or digital sheet.
6. Thereafter measure the weight of the samples every 24 hours until constant weight is obtained.
7. Repeat entire process for all other samples, measure and record the measurements. The moisture content of the samples would reach to 0% when the weight reaches to constant.

Figure 12: Disc and pathway sample

Figure 13: Two pathway samples

Figure 14: Drying of disc samples

4.2.3. Dead wood and cones

As done in case of terminal shoots, the sample of the dead wood and cone should be labeled correctly with the name and identification number of the particular tree in tray or drying bags (Fig.15, 16 & 17). The dead wood is collected from the dead branches and given the name as for example: (*Bombax ceiba,* west central region, tree number one; BCWC-01, DW;

BCWC-02, DW). The trays and drying bags are used to dry the samples of deadwood and cones in the oven (Fig 16 & 17). The following drying steps are followed:-

1. The weight of the deadwood sample should be minimum of 500g or more.
2. Put the trays or bags containing dead wood and cones sample into the oven to its optimum capacity.
3. Set the temperature to 70° C.
4. Dry the samples for 48-72 hours before first measurement is taken.
5. After 48-72 hours of drying, measure the weight of the samples and record the readings in the laboratory register/ log book or digital sheet.
6. Thereafter, measure the weight of the samples every 24 hours until constant weight is obtained.
7. Repeat entire process for the remaining samples, measure and record the measurements.

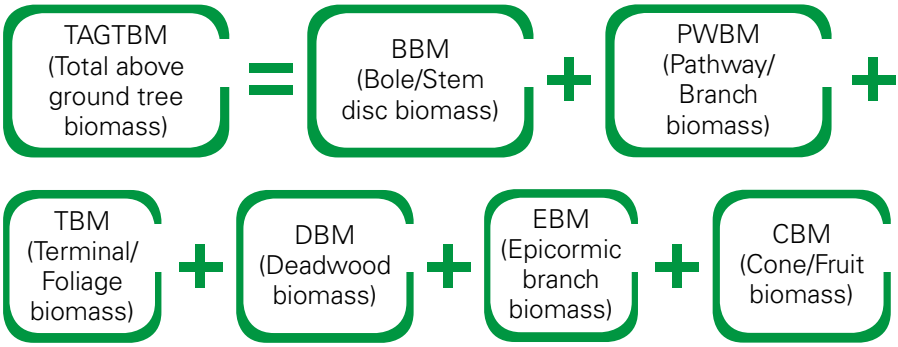
Figure 15: Deadwood samples

Figure 16: Deadwood sample

Figure 17: Deadwood sample in tray

5. Compute the total weight of the tree

The recorded constant dry weight of the samples in the laboratory are transferred to the excel sheet in the computer for further computation and digital record. The representative samples collected for different components of the tree are used to estimate the total weight of particular component of individual trees following the randomized sampling method (Gregoire, Valentine, & Furnival, 2008). For example the total component weight are the total branch weight, total dead wood weight, total foliage weight, total bole weight, total cone weight and any other components. At the end all these total components weight is sum up to find the total aboveground biomass of the particular tree. The sum of the total weights is the total aboveground dry weight or biomass of the particular tree.



6. Biomass allometric equation development

Biomass equation can be developed as a function of diameter at breast height (D), basal area (BA), tree height (h), or product of D and h (Dh), product of BA and h (Bah) or any other measured tree parameter during data collection using regression approach. The total biomass or constant dry weight for each component or their sum is response variable, while D, BA, h, Dh, BAh etc are the predictor variable for each component as well as their sum (total tree biomass). The best fit model is chosen as a model for particular species based on model selection criteria chosen by modeler. The statistical package used for biomass modeling in Bhutan is R-Statistics.

ACKNOWLEDGEMENT

We would like to express our gratitude and appreciation to the Department of Forest and Park Services, MoAF, Bhutan for bestowing this biomass responsibility to the UWICER for implementation since the inception of the National Forest Inventory. We also would llike to express our gratitude to Professor Tim Gregorie of Yale University USA for extending his technical guidance and support in implementing the biomass activity in Bhutan.

We are also obligated to the Director, UWICER and the Program Director, Conifer Forest Research Sub-Centre, UWICER for their technical inputs and moral support in the success of this biomass project.

We would also like to thank the entire biomass team working in the field as well as in the laboratory for rendering their kind cooperation in shouldering the responsibility with utmost dedication.

Finally, the UWICER and FRMD would like to thank the BMUB supported GIZ-ICIMOD REDD+ Himalayas project, Bhutan Trust Fund for Environment Conservation(BTFEC), FAO under UN-REDD-TS, EU, Forest Carbon Facility (FCPF) supported REDD Readiness project for their generous fund support to carry out the biomass activity and coming out with this biomass lab manual effectively and efficiently.

REFERENCES

Djomo, A. N., Knohl, A., & Gravenhorst, G. (2011). Estimations of total ecosystem carbon pools distribution and carbon biomass current annual increment of a moist tropical forest. *Forest Ecology and Management,* 261(8), 1448–1459. http://doi.org/10.1016/j.foreco.2011.01.031

FRMD. (2012). Randomized Branch Sampling Field Protocol for Aboveground Tree Biomass Estimation.

Gregoire, T. G., Valentine, H. T., & Furnival, G. M. (2008). Sampling Methods to Estimate Foliage and Other Characteristics of Individual Trees Published. *Ecological Society of America,* 76(4), 1181–1194.

IPPC. (2006). IPCC Guidelines for National Greenhouse Gas Inventories, prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Miwa K., Ngara T., and Tanabe K (eds). Published: IGES, Japan.

ANNEX:-1: LABORATORY RECORD FORMAT SAMPLE

Tree species: ..... Recorded by…..……

Tree Id no.	Sample Id no.	Start date (48 hrs)	1st Record weight (24 hrs)	2nd Record weight (24 hrs)	3rd Record weight (24 hrs)	4th Record weight (24 hrs)
SWWC-01	S1Ø1…	20/11/2018	15.00kg	14.4kg	14.2kg	14.2kg
SWWC-01	S1Ø2….	-	-	-	-	-
SWWC-01	S2Ø1					
SWWC-01	S2Ø2					
SWWC-01	P1N1….					
SWWC-01	P1N2					
SWWC-01	P1N3					
SWWC-01	P2N1					
SWWC-01	P2N2…					