



Manual of Biomass Measurements
in plantation and in regenerated vegetation

Japan International Forestry
Promotion and Cooperation Center
(JIFPRO)

Japan Overseas Plantation
Center for Pulpwood
(JOPP)

breast height, the diameter of each branch must be measured at the breast height and noted in the field note.

Tools: diameter tape for DBH measurement.

I-3 Felling sample trees

Five to six trees shall be selected for sampling that would represent the whole plot. The DBH of the selected trees must, therefore, range from small to large DBH according to the DBH distribution data collected in the field note in the above.

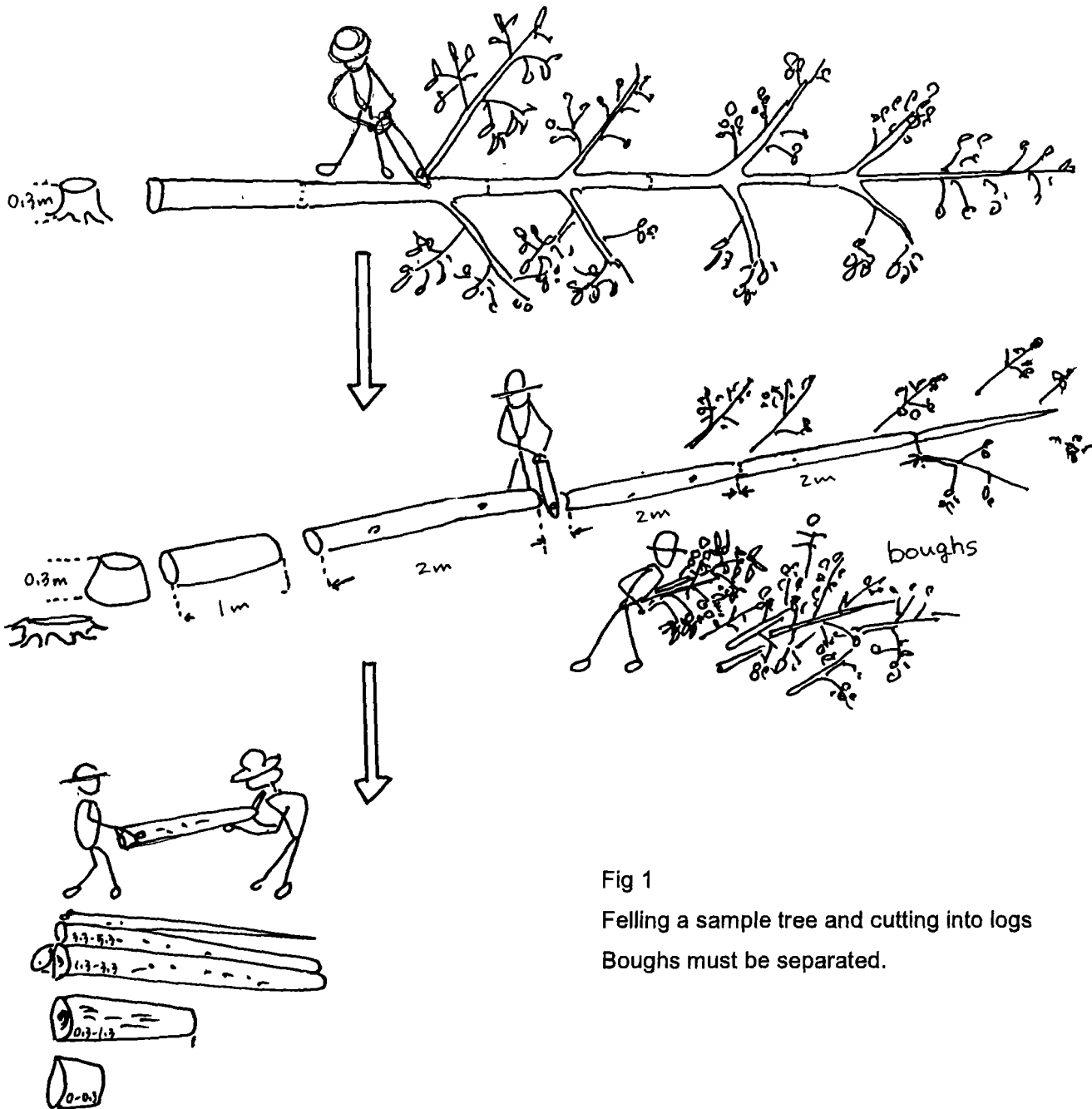


Fig 1
Felling a sample tree and cutting into logs
Boughs must be separated.

- 1) Chain saw can be applied for felling the sample trees. The tree must be felled at 0.3m from the ground (Fig1). The undercut from the felled tree must be set aside for weighing as the weight of which must be included in the total weight of the felled trunk.
- 2) The remaining stump must be cut off at the ground level that would make the log of 0.3m in length for weighing (Fig1). The weight must be included in the total weight of the felled trunk.
- 3) All the boughs must be cleared off the felled trunk and the stump and collected for weighing (Fig1).
- 4) The height of the felled tree must be measured before the trunk is being cut into logs.
- 5) The tree trunk must be cut into logs for the convenience of weighing (Fig1)

It is advisable to mark the felled trunk with cutting positions beforehand at the positions indicating, for example, 1.3m, 3.3m, 5.3m and so on from the ground ("1.3m" shall be marked at 1m from the cut bottom as the tree is felled at 0.3m from the ground)

It is also advisable to mark the position of each log on its surface to avoid errors in recording data. For example, to the log corresponding to the part of the trunk 0.3m to 1.3m from the ground mark "0.3-1.3", and the next log corresponding to 1.3m to 3.3m mark "1.3-3.3" and so on (Fig1)

<Note>

Each sample tree must be numbered and the logs cut out of it must bear the same number. The length of a log can be varied from one tree to another depending on the size of the tree.

- 6) When cutting, the trunk must be cross-cut at the marked positions so that the diameter of the bottom end of each log can be measured accurately. Two sets of two diameters of the longest and the shortest must be measured, one set with the bark and the other without it, and be noted in the field note (appendix 2).
- 7) Each log must be weighed and noted in the field note (appendix 3). Use of various spring scales according to the weight is advisable (Fig2).

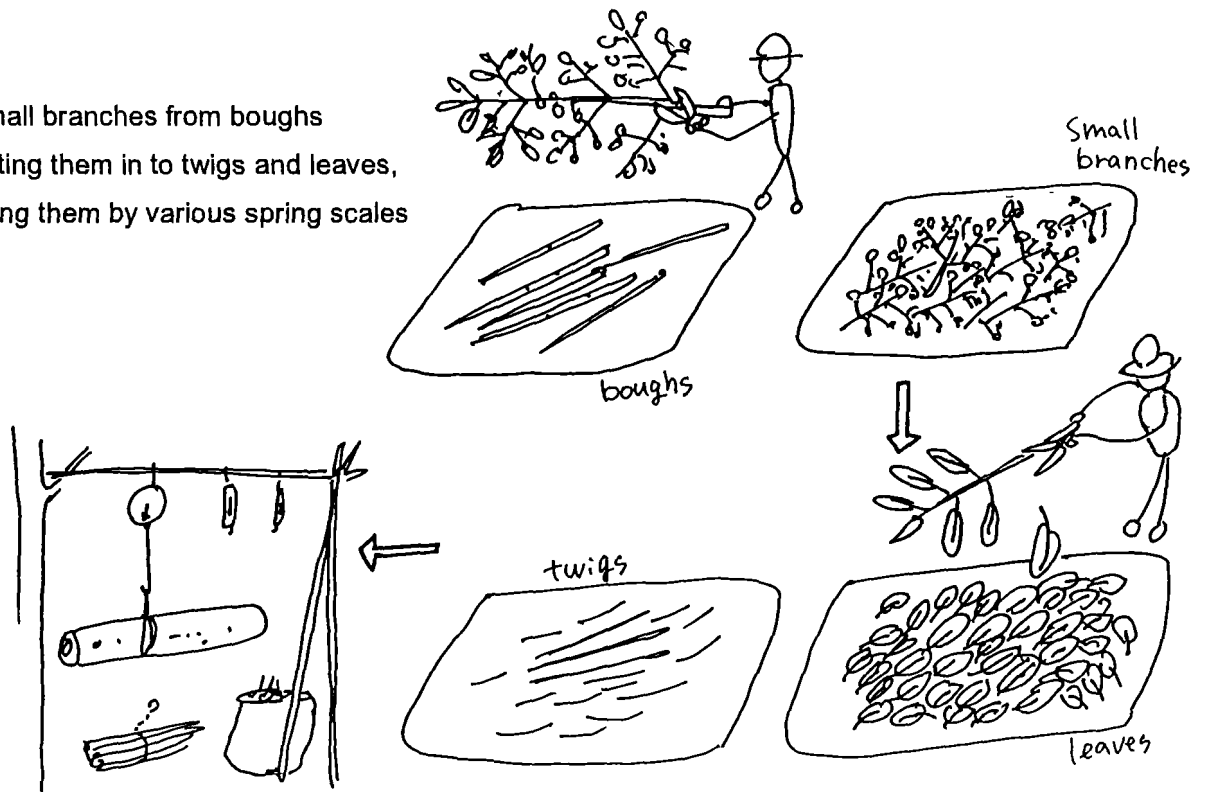
Tools: A saw or a chain saw, chalks, tape measures, and various spring balances.

I-4 Measuring fresh weight of each organ of a sample tree

- 1) Of all the boughs cleared off the trunk, the dead boughs must be separated from the live ones.
- 2) All the live boughs, then, shall be cleared off of all the small branches (twigs and leaves). The cleared boughs and the small branches shall each be collected onto a separate vinyl sheet (Fig2)
- 3) The small branches then shall be stripped off of all the leaves. The leaves and the twigs shall be collected separately on the vinyl sheets for weighing (Fig2).
- 4) The cleared boughs must be weighed, and noted in the field note (appendix 3). It is advisable to wrap the boughs in a vinyl sheet or bundle them with a rope for weighing by a spring scale. The tare such as the vinyl sheet or the rope must be weighed and noted in the field note as well.
- 5) The twigs shall be weighed. It is advisable to weigh them in appropriate vinyl bags or wrapped up in a vinyl sheet. The tare such as the bags or the sheet must be weighed and noted in the field note as in the above.
- 6) Lastly, all the leaves must be weighed, and noted in the field note. The leaves shall be weighted in appropriate bags or wrapped up in a sheet. The tare must be weighed and noted in the field note (appendix 3) as in the above.

Fig 2

Clearing small branches from boughs and separating them into twigs and leaves, then weighing them by various spring scales



If the quantity of small branches is large, estimation by samples can be made. Firstly, weigh the entire small branches of a sample tree. Then take 1/3 to 1/4 of the small branches as a sample that would represent the entire sample tree, and separate them to twigs and leaves. The weighing shall follow the same procedure as in the above.

The ratio of the weight of twigs and that of leaves can be calculated as follows. The entire weight of twigs and leaves of the tree can be estimated from this ratio and the weight of entire *small branches*

$$EW_{twig} = \frac{SW_{twig}}{SW_{leaf} + SW_{twig}} \times EW_{sbranch}$$

$$EW_{leaf} = \frac{SW_{leaf}}{SW_{leaf} + SW_{twig}} \times EW_{sbranch}$$

where,

EW_{twig} , EW_{leaf} , $EW_{sbranch}$ each stands respectively for the entire weight of twigs, that of leaves and of small branches of the sample tree. SW_{twig} and SW_{leaf} indicate the weight of the samples of twigs and of leaves respectively.

I-5 Collecting samples for dry weight estimate

Dry weight estimate, that is required to work out the volume of carbon estimate of biomass, can be made by samples

Samples for dry weight estimate shall be collected from the sample tree used for fresh weight measurement in the above I-4. The sample of the trunk, bark, boughs, twigs, and leaves shall be collected. It is advisable to collect each of them into separate paper bags for drying and weighing. The sample tree number and the organ name must be indicated on each bag. The samples collected in the bags must be weighed immediately for the fresh weight and be noted in the field note (appendix 4). The weight of the tare must be weighed and noted in the field note as well. It is strongly advisable to use a balance with high accuracy such as an electronic balance.

1) Boughs

Samples must be selected from boughs of various diameters and be cut into 10cm pieces in length. The cut pieces must be put into a paper bag with the sample tree number clearly indicated. The desirable weight of a sample is around 0.5kg to 1.0kg.

2) Twigs

Samples must be cut into 10cm pieces in length and be put into a paper bag. The desirable weight of the samples be around 0.3kg to 0.5kg

3) Leaves

The leaves must be put into paper bags. The desirable weight is 0.3kg to 0.5kg

4) Trunks and barks

A disk of 2.0cm to 4.0cm thickness must be cut out of each log marked with "0 3-1.3", "1 3-3.3" and so on indicating its position of the felled trunk. The barks must be removed from each disk. The disks without the barks and the barks must be put into different paper bags with the sample tree number and the log position clearly indicated

Tools: Small saws, pruning shears, ground sheets in vinyl, large and small paper bags, small plastic bags, spring scales, an electronic balance

Samples for **LAI (Leaf Area Index)** can be collected here. Around 10 leaves must be taken to the laboratory in plastic bags for working out the estimate of *Leaf Area Index (LAI)*. The leaves must be carried with care so that they will not be disfigured for working out the size of each leaf.

I-6 Drying samples

The samples must be dried in circulating oven. The samples of the trunks (the disks of the above item I-5-4) and of the boughs of the above item I-5-1) must be dried in a circulating oven at the temperature kept at 80 to 90 degrees centigrade for 4 days (96 hrs). The samples of the barks, twigs and leaves must be dried for two days (48 hrs). The dry weight of the samples must be weighed and noted in the field note (appendix 4) then calculate the moisture contents of the each organ.

II Estimating Biomass in Bush or in Regenerated Vegetation

II-1 Plot/Setting a plot for measurement

A four-sided plot is to be set in a given targeted bush (Fig3). The length of the shortest side of this plot must be longer than that of the mean height of the shrubs within the plot. In other words, for the mean shrub height of 2m, the length of the shortest side of the plot must be more than 2m, in other words, the size of the plot is larger than 2m x 2m.

To avoid overestimating the biomass of the plot by what is known as *edge effect*, two or three meters in distance from the edge of the bush or open-canopy site must be excluded from measuring. Because the shrub growth at such a location is usually better than the mean growth of the plot due to the better sun light conditions.

II-2 Measuring

All bushes above the ground in the plot must be cut and collected onto a vinyl sheet. The grasses must be separated from all the collected shrubs and the grasses must be collected into appropriate bags for weighing. The shrubs must be separated into stems and leaves if possible, and each must be put into separate bags (Fig3). The weight of each items and tare must be

noted in the field note (appendix 5)

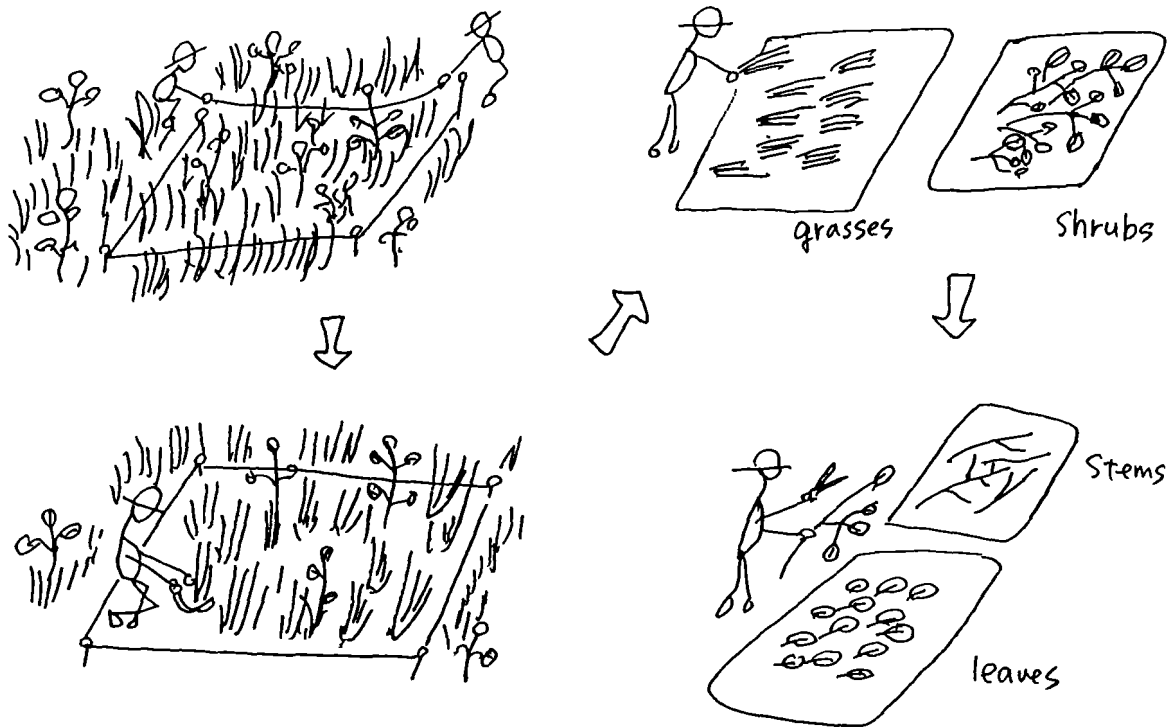
The same procedure as mentioned in the above applies here in sampling and drying of grasses, shrub leaves and shrub stems.

Tools: The same tools as used previously are required here

Fig 3

Setting a plot and cutting all plants in it.

Separating them into grasses, shrub leaves and shrub stems.



III. Estimating Biomass in plantation

III-1 Estimating Total Dry Weight of each sample tree

Total dry weight (TDW) of each organ of a sample tree can be calculated from its total fresh weight (TFW), the fresh weight of its organ sample (SFW) and its dry weight (SDW).

<Boughs, Leaves, Twigs>

$$TDW = \frac{SDW}{SFW} \times TFW$$

<Trunk, Bark>

$$TDW_{trunc} = \frac{SFW_{trunc}}{SFW_{trunc} + SFW_{bark}} \times TFW_{trunc + bark}$$

$$TDW_{bark} = \frac{SFW_{bark}}{SFW_{trunc} + SFW_{bark}} \times TFW_{trunc + bark}$$

III-2 Estimating Biomass using allometric relation

<Allometric relation>

Biomass by each organ in the site can be estimated from the allometric relations between DBH and the total dry weight (TDW) of each organ obtained from sample trees (Fig2). Allometric relation is expressed in the following equations;

$$TDW = a \cdot (DBH^2)^b$$

or

$$\ln TDW = \ln a + b \cdot \ln(DBH^2)$$

where a and b are coefficients. The coefficients can be applied to estimating biomass of other sites of the same species near the test site.

TDW of each organ of every standing tree in the site can be estimated, using the equations and DBH distribution data of the site.

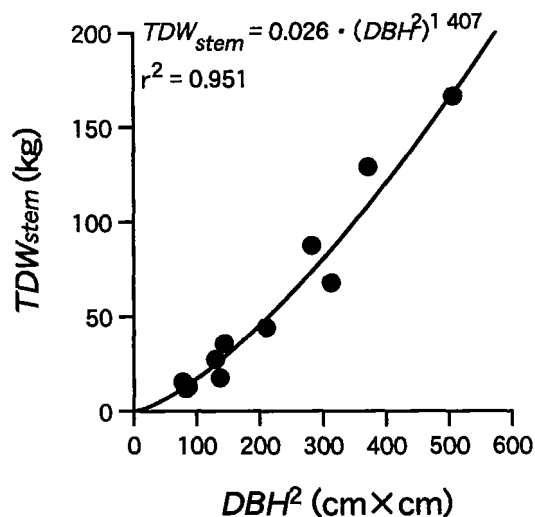


Fig 4
Example of the allometric relation between DBH and Total Dry Weight of stem (TDW_{stem}) obtained from sample trees.

<Biomass>

Biomass per unit area is calculated as follows;

$$BM = \frac{\text{sumTDW}}{\text{AREA}}$$

where,

sumTDW the sum of the total dry weight of every standing tree in the target site (t dry matter)

AREA : the area of the target site (ha=10000m²)

BM . the biomass of the target site (t dry matter/ha)

In converting the dry matter to carbon unit, 0.5 is generally used as a conversion coefficient

Mean annual increment (MAI , t dry matter/ha/year) is calculated as,

$$\text{MAI} = \frac{\text{BM}}{t}$$

where t is the age of the target site

III-4 Leaf Area Index (LAI)

LAI is calculated as follows;

$$\text{LAI} = \text{BM}_{\text{leaf}} \times \frac{\text{LA}_{\text{sample}}}{\text{DW}_{\text{sample}}} \times 0.01$$

where

BM_{leaf} Biomass of leaf of the site (t dry matter/ha)

$\text{LA}_{\text{sample}}$: Leaf area of the sample for LAI (cm²)

$\text{DW}_{\text{sample}}$: Dry weight of the sample for LAI (g dry matter)

<Note>

After the leaf area for LAI is measured and noted, the leaf samples must be dried in a circulating oven for two days before being weighed in the laboratory.

IV. Estimating Biomass in Bush or in Regenerated Vegetation

Total dry weight (TDW) of each organ can be calculated from total fresh weight (TFW), fresh weight of organ sample (SFW) and its dry weight of sample (SDW).

$$\text{TDW} = \frac{\text{SDW}}{\text{SFW}} \times \text{TFW}$$

Then each biomass (BM ; t dry matter/ha) is calculated as follows;

$$\text{BM} = \frac{\text{TDW} \times 10}{A}$$

where,

TDW : Total dry weight of each organ (kg)

A : Plot area (m²)

Diameter

date / / name

tree age tree NO Height m DBH cm

| Position (m) | Diameter with Bark Min | Diameter with Bark Max | Diameter without Bark Min | Diameter without Bark Max |
|--------------|------------------------|------------------------|---------------------------|---------------------------|
| 0 | | | | |
| 0.3 | | | | |
| 1.3 | | | | |
| 3.3 | | | | |
| 5.3 | | | | |
| 7.3 | | | | |
| 9.3 | | | | |
| 11.3 | | | | |
| 13.3 | | | | |
| 15.3 | | | | |
| 17.3 | | | | |
| 19.3 | | | | |
| 21.3 | | | | |
| 23.3 | | | | |
| 25.3 | | | | |
| 27.3 | | | | |
| 29.3 | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

Fresh Weight

date / / name

tree age tree NO Height m DBH cm

| Log | Weight | tare |
|------------|--------|------|
| 0-0.3m | | |
| 0.3-1.3m | | |
| 1.3-3.3m | | |
| 3.3-5.3m | | |
| 5.3-7.3m | | |
| 7.3-9.3m | | |
| 9.3-11.3m | | |
| 11.3-13.3m | | |
| 13.3-15.3m | | |
| 15.3-17.3m | | |
| 17.3-19.3m | | |
| 19.3-21.3m | | |
| 21.3-23.3m | | |
| 23.3-25.3m | | |
| 25.3-27.3m | | |
| 27.3-29.3m | | |
| 27.3-29.3m | | |
| | | |
| | | |
| | | |
| | | |
| | | |

| | Total Weight | tare |
|--------|--------------|------|
| Boughs | | |
| Twigs | | |
| Leaves | | |
| | | |

* if the small branches are large amount, fill the table below and estimate the weight of twigs and leaves

| | Total Weight | tare |
|-----------------------|--------------|------|
| Entire Small Branches | | |
| Sample Twigs | | |
| Sample Leaves | | |

note

Dry Weight

tree age tree NO date name
 year / /

| sample NO | | Fresh Weight with Paper Bag | Dry Weight with Paper Bag |
|-----------|--------|-----------------------------|---------------------------|
| | Trunk | | |
| | Bark | | |
| | Boughs | | |
| | Twigs | | |
| | Leaves | | |
| | | | |

Tare (paper bag)

| | |
|--------------|--|
| Fresh Weight | |
| Dry Weight | |

note

Biomass in Grassland

Plot No _____ Plot Area _____ date ____ / ____ / ____
 m X m

Total Fresh Weight

| | Total Fresh Weight | Tare |
|--------|--------------------|------|
| Grass | | |
| Stem | | |
| Leaves | | |
| | | |
| | | |
| | | |

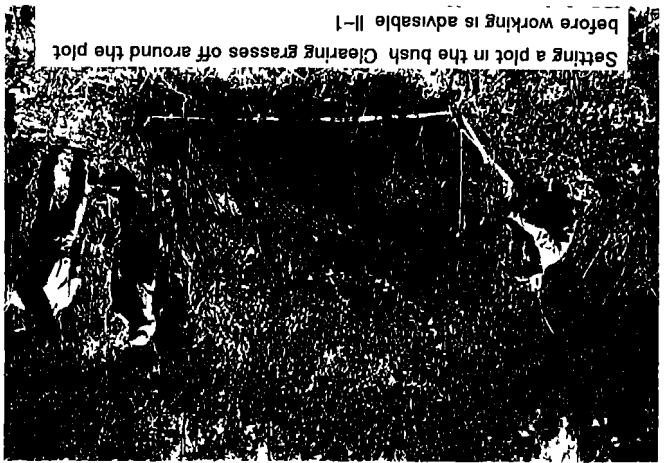
Drying samples

| sample NO | | Fresh Weight with Paper Bag | Dry Weight with Paper Bag |
|-----------|--------|-----------------------------|---------------------------|
| | Grass | | |
| | Stem | | |
| | Leaves | | |
| | | | |
| | | | |
| | | | |

Tare (paper bag)

| | |
|--------------|--|
| Fresh Weight | |
| Dry Weight | |

note



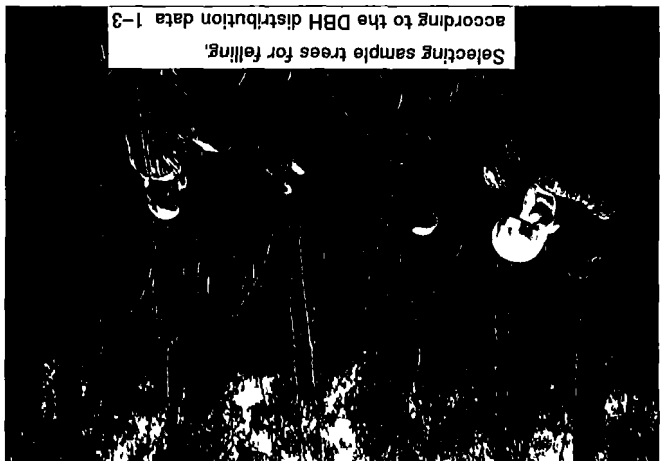
Setting a plot in the bush Clearing grasses off around the plot before working is advisable II-1



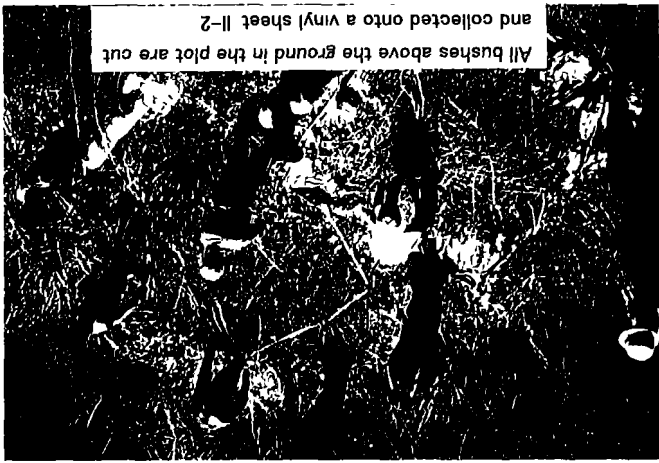
Cutting the trunk into logs at the marked position by chain saw I-3-5



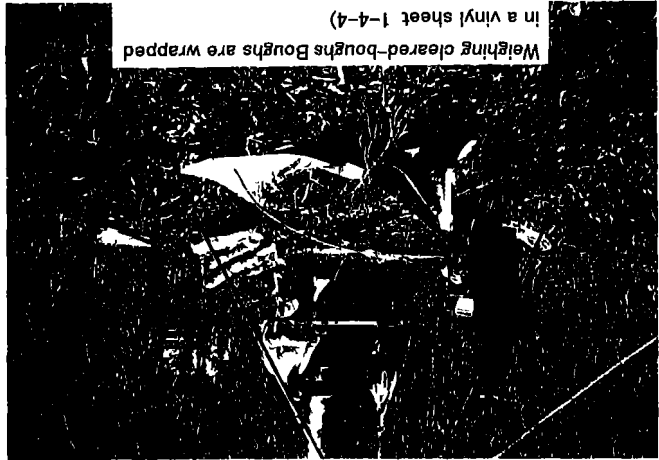
Clearing all boughs from the trunk with chain saw I-3-3



Selecting sample trees for falling, according to the DBH distribution data I-3



All bushes above the ground in the plot are cut and collected onto a vinyl sheet II-2



Weighing cleared-boughs Boughs are wrapped in a vinyl sheet I-4-4



Weighing a log with spring balance I-3-7



Stripping leaves from twigs I-4-3

