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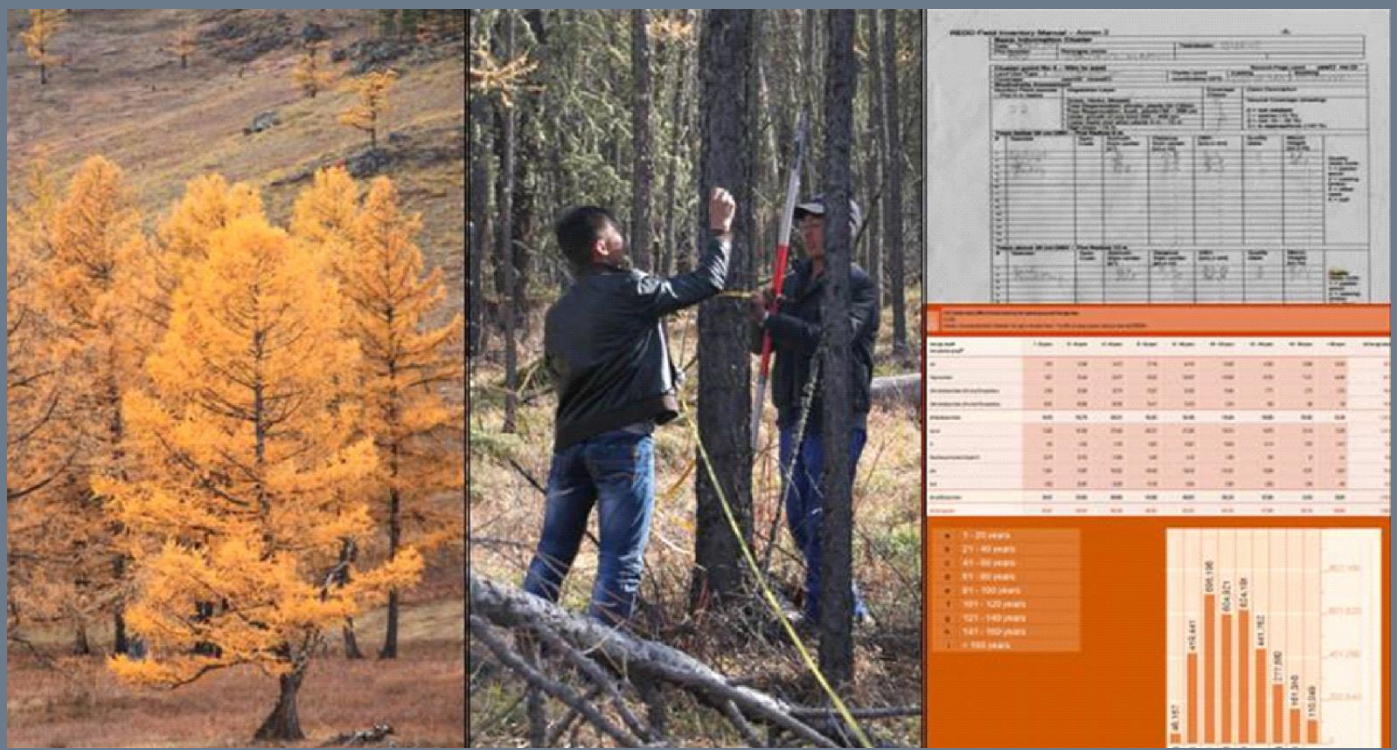
In cooperation with

GOVERNMENT OF MONGOLIA
MINISTRY OF ENVIRONMENT AND GREEN DEVELOPMENT

MANUAL FOR MULTIPURPOSE NATIONAL FOREST INVENTORY FIELD ASSESSMENT



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ABBREVIATIONS AND DEFINITIONS

AFOLU	Agriculture, Forestry and Other Land Use Sector
DFS	DFS Deutsche Forstservice GmbH
LULUCF	Land Use, Land-Use Change and Forestry (LULUCF)
REDD+	Reducing Emissions from Deforestation and Degradation
IPCC	Intergovernmental Panel on Climate Change
AGB	Above Ground Biomass
BGB	Below Ground Biomass
(UN)FCCC	United Nations Framework Convention on Climate Change (UNFCCC)
GiZ	GesellschaftfürInternationaleZusammenarbeit
MRV	Measurement, Reporting, and Verification (MRV)
NMFRI	National Multipurpose Forest Resources Inventory
CCCO	CCCO Climate Change Coordination Office, Mongolia
MEGD	Ministry of Environment and Green Development
DBH	Diameter at Breast Height (1.3m above ground)
Sampling Unit	Cluster of sampling plots to be treated as one unit in the data processing, per ha averages from the sampling unit
Sampling Plot	Plot of nested, concentric sampling circles of different sizes for different sized trees
Sampling Circle	Circle of defined radius to select sampling trees
ha	Hectare, area of 10 000 m²
m	Meter, 100 cm
GPS	Geographic Positioning System
Pixel	Picture element, is a physical point in a raster image, or the smallest addressable element in a display device (in LandSat imagery 20x30 m on the ground)

1. INTRODUCTION

This manual summarizes and describes the proposed method for field assessment of sampling units in the frame of the National Multi Purpose Forest Inventory. During a workshopon Friday 15th of November 2013 the design and possible measurement and observations were discussed with Mongolian forestry experts from the different research institutes (Academy of Sciences – Institutes for Geo-Ecology and Geo-Botanic) and Teaching Institutions (Technical University and National University of Mongolia in UlaanBaatar) and the Forest Department in the Ministry of Environment and Green Development. A final decision on type and procedures of assessment for all technical items for observation and measurement and the details of the sampling design was agreed amongst the assembly of experts.

2. ALLOCATION OF SAMPLING UNITS

2.1 Number of Sampling Units

The National Multipurpose Forest Resources Inventory of Mongolia will cover the assessment of a total of 3500 sampling units, allocated over the national forest (excluding the Saxaul Forest in the south) as detailed in the table below. The allocation of the sampling units is based on two grids, a national grid of 9x9 km grid line distance and a 4x4 km grid for intensified assessment in major forest areas.

Table 1: Sampling Units – Number and Allocation

	Sampling Units	Total Area (ha)	Representation area (ha)
National Grid (9x9 km)			
All Forest	1.100	9.237.000	8.397
1. Forest Region (Khenti)	298	2.500.000	8.397
2. Forest Region (Khuvsgul)	298	2.500.000	8.397
3. Forest Region (Khnagai)	298	2.500.000	8.397
RemainingForest outside Regions	206	1.737.000	8.397
Intensified Grid in 3 Regions (4x4 km)			
	Additional Sampling Units		
1. Forest Region (Khenti)	802	2.500.000	2273
2. Forest Region (Khuvsgul)	802	2.500.000	2273
3. Forest Region (Khnagai)	802	2.500.000	2273
Total Sampling in Mongolia			
1. Forest Region	1100	2.500.000	2273
2. Forest Region	1100	2.500.000	2273
3. Forest Region	1100	2.500.000	2273
RemainingForest outside Regions	206	1.700.000	8252
Total	**3506**	**9.200.000**	

2.2 Definition of Forest

The purpose of the inventory is the production of average stocks of volume and biomass of trees on a per ha basis for the National Forest and for forests of 3 regions. The identification of forest for the allocation of forest sampling units inside the forest is based on the interpretation of LandSat 8 TM satellite image data. The spatial resolution of the data is 30m per pixel in the multispectral bands and 15 m in the panchromatic band. The general identification of forest is related to the FAO definition of forest, but adjusted to the local conditions of Mongolia with minimum tree canopy coverage of 10% and a minimum in situ height of the tree species of 2 m at the location site.

Minimum size for a forest to be included in the forest map is 15 pixel in the 30 m resolution multispectral image, which is on the ground a size of 1.35 ha. Similarly the minimum size of a non-forest area inside a forest is also 1.35 ha or 15 pixel. Smaller areas without tree coverage surrounded by forests are considered to be part of the forest.

The identification of the inventory unit location is based primarily on the forest map. The field teams will have to confirm for questionable locations the forest boundary and the size of the forest or non-forest area. The inventory of forest carbon stocks and other forest related data is supposed to be undertaken only in forest, which is part of the identified mapped and accounted for by area forest of the national forest mask from the LandSat Images. The field assessment thus has to control at the location that the inventory units determination point, which is the centre of plot number 1, when identified by GPS approach is located inside forest as was assumed from the mapping. Inventory units that are located on non-forest area will have to be abandoned.

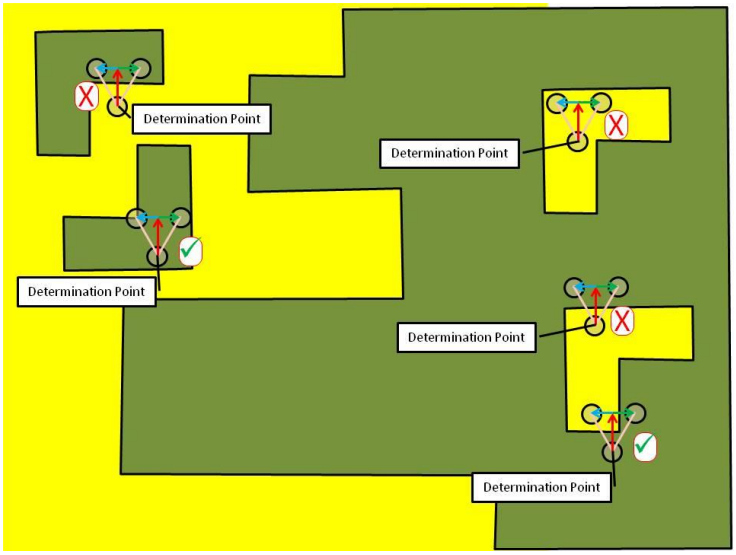


Figure 1: Inventory Sampling Units Inside and Outside of Forest

The definition of forest for the purpose of NMFRI cannot follow the national legal definition for forest, since the mapping procedure can only identify the forest by its vegetation characteristics. Areas after clear cut felling operations, that are not yet re-stocked

with forest trees and areas that don't have for other reasons no or insufficient (below 10% canopy coverage) forest tree coverage and of a size of more than 1.35 ha interrelated surface are not part of the forest vegetation for the inventory, even though they would be part of the forest fund, or they might be recovered into forest through plantation and natural succession and be part of the forest in future.

For the cases where the sampling unit is identified by the location of its determination point to be part of the inventory but parts of the unit are found to be outside the forest a procedure to deal with the outside located parts is described in the sampling unit design chapter below. For all those cases the forest edge has to be identified in the field following the instructions/definitions used in the satellite image interpretation. The forest ends where a vegetation starts, that does not have forest trees (which can grow higher than 2 m) covering at least 10% of the ground with their crowns and leafs. The non-forest vegetation should have at least a size of 1.35 ha. Smaller openings or unstocked parts of the forest are still parts of the forest and will be sampled in the designed procedure, even when no trees will be recorded on these parts.

3. SAMPLING UNIT DESIGN

The design of the sampling units isguided by the need to cover the variation of density variations at one location, the need to limit the statistical coefficient of variation, the limitation of labour input and time constraints during the field works and the aim to reduce the possibility of measurement and assessment errors during the field works.

3.1 Clustering to Sampling Units

To cover the variety of vegetation density changes on small distances in order to improve the coefficient of variation in the statistical analysis the design of a sampling unit is a cluster of 3 sampling plots. The design of the sampling unit is laid out in the figure below. The sampling plots are composed of nested circles. The centres of the circles are 111.8 m apart from each other in an equilateral triangle. For easy approach the accessing procedure is made in a straight line to north from the centre of plot 1 and after a length of exactly 100 m a turn of 90° to East and to West to locate in a distance of 50 m the centres of plot 2 and 3.

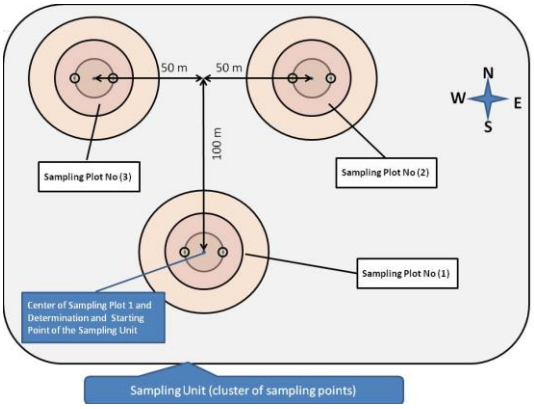


Figure 2: Inventory Sampling Unit Design

3.2 Nested Circles and Measurements

The assessment at the plots is done in circles of different radius. The size of each circle is defined by its radius. The radius is assigned to measurement of tree in a specific size and DBH range. The different measurements and assessments to be carried out in the different circular plots are listed in the table below.

Table 2: Circle Sizes and Measurements

Plot Radius	Assessments and Measurements
2 meter	Regeneration counted in 3 Classes, 10 – 50 cm height, 50 – 150 cm height, 150 cm height to 5.99 cm DBH 2 circles will be established and assessed
6 meter	Trees 6 – 15.99 cm DBH, Bio-Diversity counting
12 meter	Trees 15 – 29.99 cm DBH
20 meter	Trees >30 cm DBH, Slope and Landscape, Grazing, Stand Structure, Stand Condition, Forest Function, Forest Fire, Erosion

The lay-out and design of the sampling plots is shown in the figure below. All general information and forest assessments without specific measurements or counts will have to be referred to as the conditions found in the biggest circle (20 m). The assessment for biodiversity, the count of species occurrence for the bio-diversity, the layer structure and Red-List species identification should be done in a 6 m radius circle.

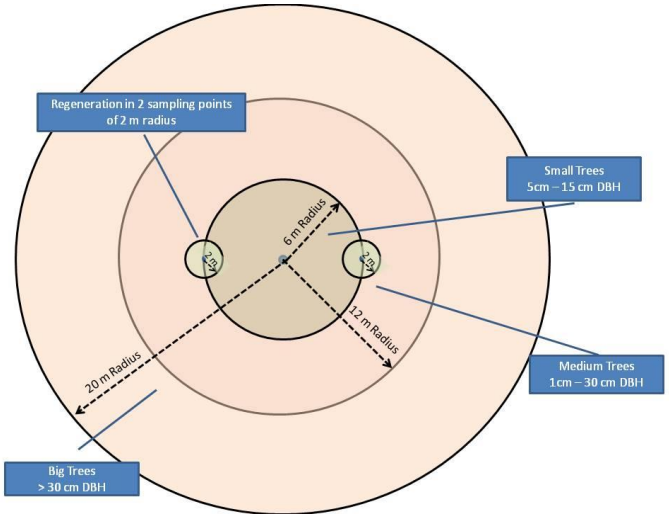


Figure 3: Inventory Sampling Plot Design - nested Circles

3.3 Location and Approach to Sampling Units and Circles

The sampling unit identification points are approached with simple handheld GPS (proposed Garmin GPS 62) according to the coordinates provided from the inventory base map and the point location list, derived thereof.

Figure 4: Proposed GPS Instrument

Basic settings needed for the inventory should be done to the instrument following the below instructions:

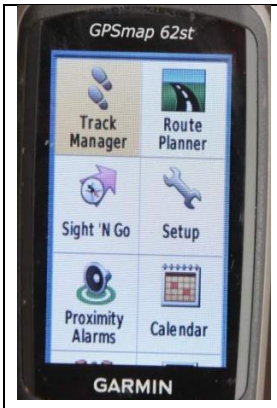
			
Open Main Menu	Select Units and open next window with high light and enter button	Select position format and open the list of possible formats with enter	Select hddd.dddd° and confirm with enter, return to main menu with page

Figure 5: Basic Settings GPS Instrument – Position Format

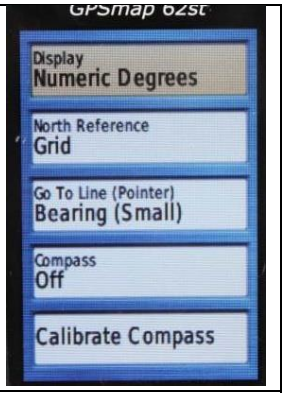
			
Select Units from Main Menu and set units to metric	With highlight and enter in each field a list of possibilities opens, select the metric types and confirm with enter	Select Heading to adjust the heading displays in the GPS	Set the display to numeric degrees and the north reference to grid form the list of choices. Set compass off.

Figure 6: Basic Settings GPS Instrument – Units and Heading

The steps to use of the GPS instrument for navigation to the sampling point, which should be stored onto the GPS as waypoint are lined out in the table below.

The last 10 meters should be accessed with compass and distance tape, using to the reading for distance and bearing on the GPS. This distance could be greater, when reception of satellite signals is a problem in closer vicinity of the sampling unit centre. The GPS' inaccuracy will not allow locating the final point by only using the GPS instrument.

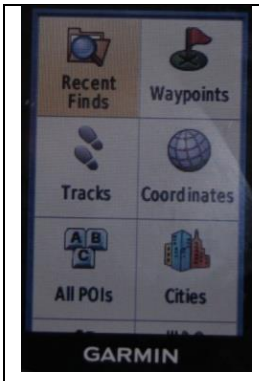
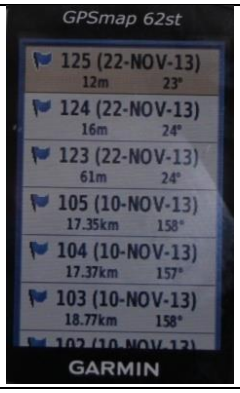
			
Having pushed the "Find" key -> this screen appears Select waypoints and push the "Enter" key -> the next screen appears	Select waypoint you intend to view or to be navigated to and push the "Enter" key -> the next screen appears	Select Go and push the "Enter" key -> the next screen appears	The red arrow indicates the walking direction when moving, the field information show Distance and Bearing to the waypoint. The Field information content may be changed when pushing the "Menu" key and then highlighting the intended field and confirming with "Enter" key will open the edit mode.

Figure 7: Steps to Use GPS for Navigation

Plot 2 and 3 are then approached by measuring a distance of 100 m to north (0°) (a temporal beacon should mark that place) and from there the plot 2 is accessed in a distance of 50 m towards east (90°) and the plot 3 is accessed in a distance of 50 m towards west (270°). The distance measurements are to be horizontal distances and not slope distances. In case of obstacles the broken chain procedure outlined in the graph below could be used. In step terrain the maximum distance for a distance step (chain) can only be 10m, in very step terrain only 5 m. The team leader has to make sure that the lower ranging rod is held straight vertically and the measuring tape is tightened ahd straight horizontal for the measurement.

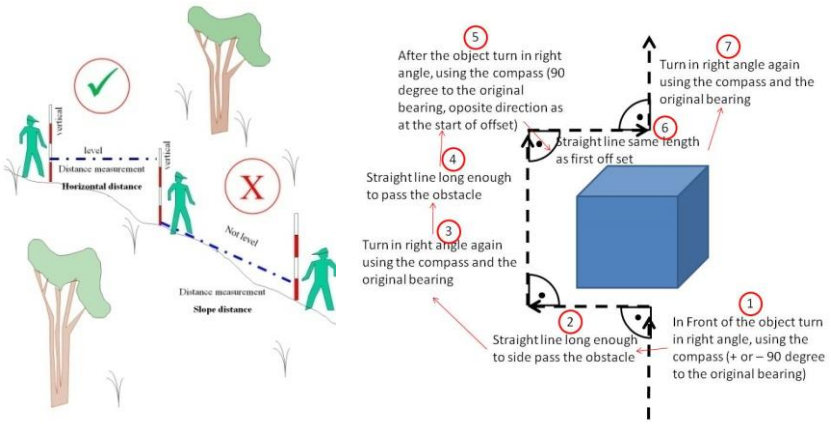


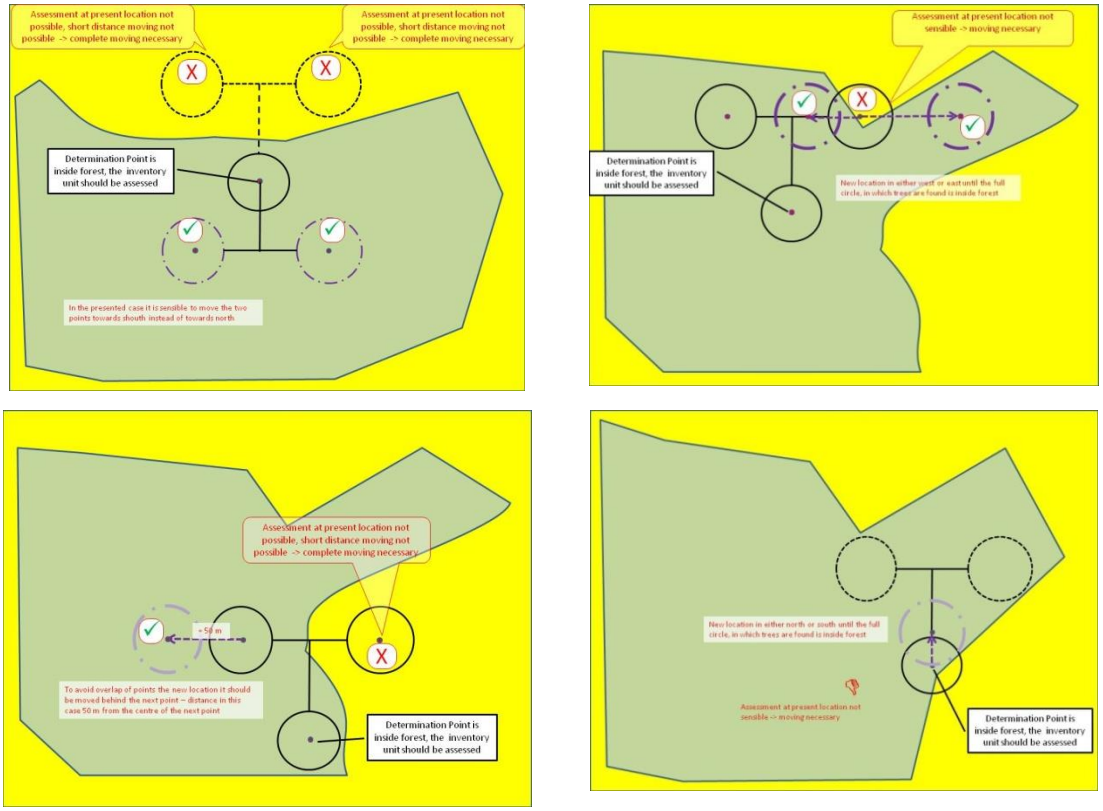
Figure 8: Procedures for Distance Measurements

For demarcation of each sampling plot centre (for the plot 1 the centre is also the smapling unit determination point)should be marked with an iron stick (cut construction steel piece) which is hammered to invisibility in the ground at the plot centre. The sampling plotsare permanently marked for monitoring, quality assurance and re-measurement.

3.4 Procedures for Re-Location of Sampling Circles

The next graph explains the relocation of cluster points. The full assessment circle has to be located inside the forest, since the results will be considered to be the description of the forest situation and not of a mix of forest and non forest. To make sure only forest is sampled, the centre point may have to be shifted until the full circle is inside the forest. The new location in either west or east, or north or south until the forest edge is tangential to the circle, in which trees are found. In cases the shift would lead to an overlap of circles, the moved circles has to be moved beyond the neighbouring circle to a distance of 50 m from centre to centre of the circles.

In the rare case of a point hitting into a stretch of riverine forest with non forest land use left and right of the forest along the river a non directed (no compass bearing) relocation with only fixed distance measurement is to be applied. The relocation should be done by measuring a distance of 111 m along the riverine forest. The location of the circle has to be chosen to ensure that the circle for the biggest trees found at the location (6, 12 or 20m) is located inside the forest.



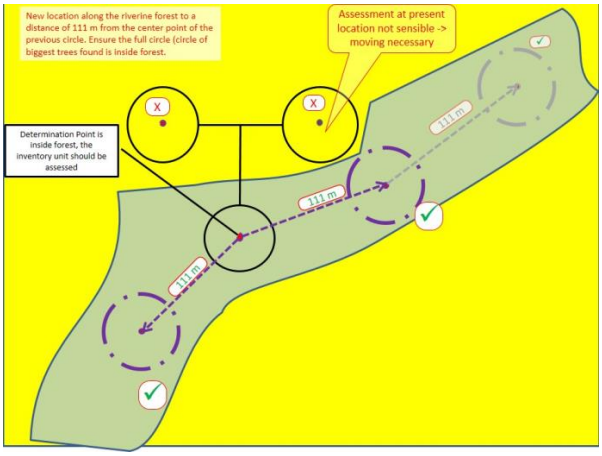


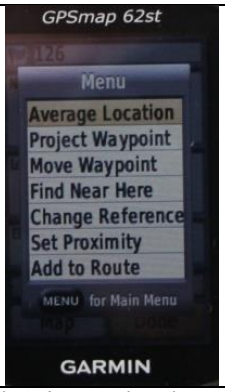
Figure 9: Procedures for Re-Location of Sampling Plots

4. GENERAL OBSERVATIONS

4.1 Location Coordinates of Sampling Circles

The target coordinates of the sampling point are to be filled under the GPS coordinates (list). These are the coordinates from the inventory map, which were used to access the point with the GPS instrument. Those are only available and filled for the plot N° 1 of each sampling unit.

The actual location of the sampling plot will be measured at the centre of the nested circles using the averaging function of the GPS. For improved accuracy the averaging function of the GPS has to be used (see figure below). The coordinates are to be recorded on the field record sheet under GPS Coordinates (Field). For the cases where the plot had to be re-located the relocation has to be indicated with YES in the respective field in the header. Not relocated plots will be marked with NO.

			
In this window with the present location data are shown, push the “Mark” key -> the next screen appears to save the present location as waypoint	Push “Menu” key -> the next screen appears with options on actions	Select Average Location and push “Enter” key -> the next screen appears to start with averag location measurments	Select Start and push “Enter” key -> the next screen appears

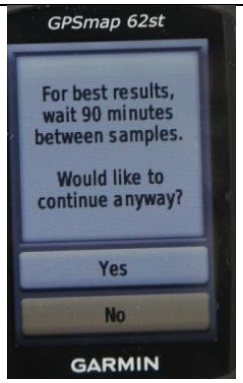
			
Select yes and push "Enter" key -> the next screen appears and the averaging measurements will start	Select save when the bar in center has been filled completely with green or at least 07:00 minutes are shown in the "Averaging Time" window. and push "Enter" key the next screen appears	Push "Enter" key the next screen appears with the "Done" button highlighted and the next window will appear	Select done and push the "Enter" key to save the waypoint. Its details may be viewed in the waypoint manager or by pressing the "Find" key

Figure 10: Averaging on GPS for Improved Location Reading

The location of the sampling plot centres is marked with an iron rod (construction steel piece of at least 12 mm diameter and 30 cm length) hammered almost completely into the ground.

4.2 Forest Location Description

The forest location description will cover 4 Details. The administration unit is the name of the Aimac, under Sume will the Sume name be recorded. Two more fields are reserved for the forest administration responsibilities. Under the forest unit the name of the responsible forest administration station will be recorded. The sub-compartment name is the identification of the location on the forest planning (taxation) map.

4.3 Forest Type

The forest type will have to taken as information from the forest map. The forest type is encoded in a two digit code. The types are listed in the "taxation instruction". The assessment will then confirm or not confirm if the forest type actually found in the field is conform with the map indications with a tick on YES or NO. To determine the forest type the teams have to use the table 1.1.1. "Dominant Forest Types of Mongolia" from the new "Forest Mensuration Handbook of Mongolia" to be guided by the description of the forest types. To use the table the forest vegetation growth region and the sub-region has to be determined, then the elevation, the aspect and the landscape type will be used to narrow the possible of forest to a selection types which will then be assessed for the final selection of forest type based on soil and water regime conditions. The table then also provides a detailed description of the dominant vegetation found in this forest type.

4.4 Elevation

The elevation should be read from the GPS instrument in the main window, where position and elevation is displayed. The elevation will be recorded in full meters.

4.5 Team Leader, Date and other Records

The identification of the Team, the date of assessment and all other records will have to be confirmed by the Team Leader with his signature. He will have to fill the Header of each field record sheet to ensure the ID of the sampling unit (4 digit number) and the respective ID for the sampling plot (only 1, 2 or 3 are possible). He will also have to fill and confirm which sheet number of the total record sheets for a sampling plot he has signed. It will be necessary to use a second field sheet for the same sampling plot in cases where not all records (more trees or regeneration species than available lines in the respective table) can be accommodated on one sheet.

5. TREE MEASUREMENTS

5.1 Identification of Sample Trees

The sample trees for each circular plot are selected without the need to establish a circle boundary line. The assessing engineer moves in the circle to measure and assess the tree, which are within the required distance of the sampling plot radius. This assessment will start in the north and follow a clockwise circluar sweep. Before assessing the tree, the distance distance from circle plot centre to tree centre is measured. The control distance to check for border trees if they are part of the sample, the distance has to be measured as horizontal distance. For distance measurement the VERTEX instrument can be used. The standard DEM function will measure slope distance. For horizontal distance measurement in steep terrain the first step of the height measurement with sighting from the tree to the central 360° reflector has to be used. In doubtful cases the tree distance is to be established with two measurements, the distance from plot centre to tree surface at DBH height and half of the Diameter at Breastheight (DBH). The tree distance is the addition of both measurements (see also Graph below).

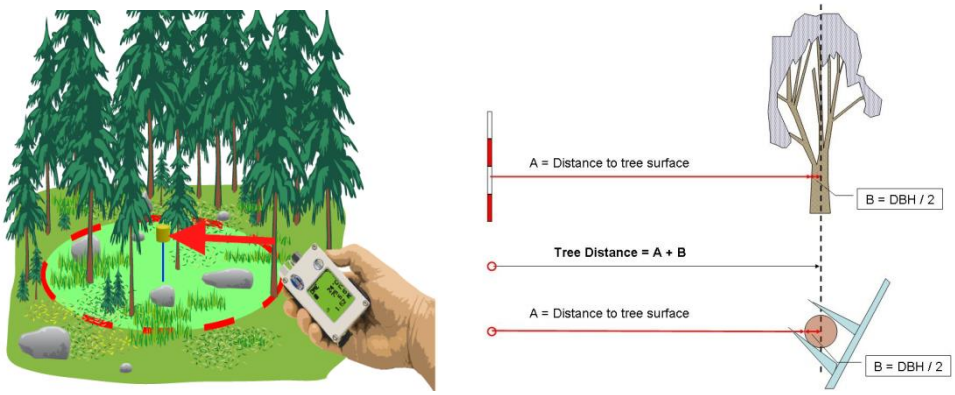


Figure 11: Distance Measurement for Selection of Sample Trees

5.2 Species Identification

The identification of tree species has to follow the list of tree species possible in Mongolia, following the tree species list in the attachment. Name and Code need to be recorded.

5.3 DBH Measurement

The Diameter at breast height (DBH) has to be taken in 1.3 m above the ground. In case of uncertainty for the measuring point, refers should be taken to the graph below, indicating the appropriate DBH measuring point. The measurement point for cases with difficult decision on where to measure the DBH should be selected on the basis of best fit with the displayed examples in the figure below. The DBH is measured with diameter tape. The Diameter is recorded in centimetres with one digit for millimetres.

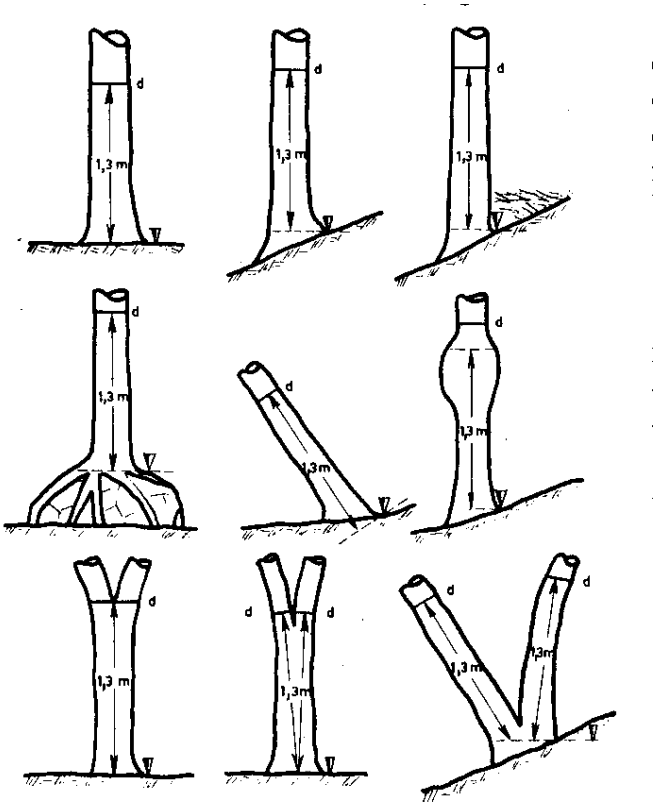


Figure 12: DBH Measurement

5.4 Tree Distance and Bearingfrom Circle Centre

Bearing and distance from plot centre to the centre of the tree has to be measured and recorded to facilitate control and re-measurement and to document the quality of the assessment. The distance from plot centre to tree centre has to be checked for selection of sample trees, border tree (border trees are trees located in a distance of ± 2 m of the reference circle of their DBH) to centre distance has to be measured as horizontal distance. The Bearing is measured with a handheld compass, records are at 1 degree. The Compass should have a 360 degree scale. The distance from plot centre is measured with Vertex using the DEM function as slope distance (except border trees). The distance is recorded in meters at accuracy of 2 digits for centimetres.

5.5 Tree Height Measurement

The tree height is measured with the clinometer based instrument Vertex. The measurement is based on a distance and angle measurement. The distance is measured from the point of the engineer to the tree, by using the inbuilt ultra sound infrared distance measurement system and the transponder which has to be placed to the tree.

The measurement is done with the following steps:

1. Start the transponder T3 and place it on/towards the object to measure. Note that the transponder should be placed at the T.HEIGHT (transponder height) that has been set in the SETUP menu (best is 1.3 m). Walk a suitable distance from the object – for optimal result accuracy, a distance equal to the approximate height.
2. Press ON to start the Vertex 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.
3. Aim at the height to measure with the sight cross blinking. Press ON until the cross hair disappears. The first height is locked and displayed.

Tree height measurement is done for 2 trees per species in each assessment circle (6m, 12 m and 20m) where trees are at that point are found and measured.

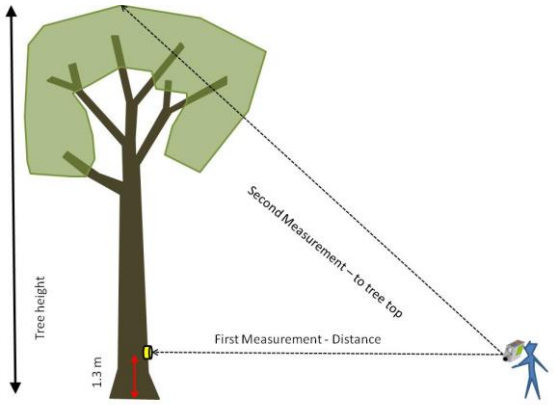


Figure 13: Tree Height Measurement with Vertex

5.6 Tree Age Estimation

The age of the tree needs to estimated in categories. There are 6categories to classify the trees, each tree need be recorded with its age category.

(1) Up to 20 years – young stand from natural regeneration or plantation
(2) 20 to 50 years – young stand
(3) 50 to 100 years – middle age stand
(4) 100 to 200 years – old to mature stand (depending on species)
(5) 200 to 300 years – mature stand to over mature stand (depending on species)
(6) Over 300 years – over mature stand

Teams may need to adjust their estimates for different growth regions and growths conditions by extracting and counting a bore span from one tree in a sampling unit.

5.7 Tree Health and Cause of Damage

Classification in health and damage classes is done in two steps. The first classification will look at the general health of the tree and have only 4 classes

(1) Fit and strong tree, fully vital tree, no visible health affecting damages
(2) Healthy tree with some visible reduction in vitality (reduced crown volume, some loss of green biomass, few visible health affecting signs of damage)
(3) Sick tree with substantial loss of crown and green biomass and visible health affecting signs of damage
(4) Dead tree

Dead trees Health Class 4 need to be assessed for decay but not for damage cause, and quality.

The second assessment will indicate the cause of damageaffecting the health status of the tree, if the tree is considered not fit, but not caused by any of the below damage causes no damage cause is registered

(1) Snow and ice damage (tree bent, top broken, major branches broken by heavy snow or ice)
(2) Insect damage (bark beetle, other beetle damaging bark or wood, beetle or larvae removing or damaging leafs or needles)
(3) Fungus damage (any fungus damage affecting wood, bark or leafs)
(4) Lightning damage (bark or leaf damage)
(5) Fire damage (bark or leaf damage by fire)
(6) Human induced damage, often from harvesting neighbouring trees, harvesting other products from the tree or for marking boundaries, etc.

Standing dead trees will have to be assessed for the amount of biomass already lost to decay or broken off. The recording should only be done in classes. The graph below may be used to estimate the loss of biomass in classes. As a reference class 1 indicates a live tree with 100% of biomass in place and no loss, 2 suffering slight losses of 10% and 90% of the tree biomass still in place (the tree only recently died and dried leafs / needles are still in place), class 2 shows a tree with 20 % of biomass lost and only 80% remaining and so on. The loss of biomass is estimated in 10% steps. Decay classification of dead tree starts with class 2, class 1 is only for reference.

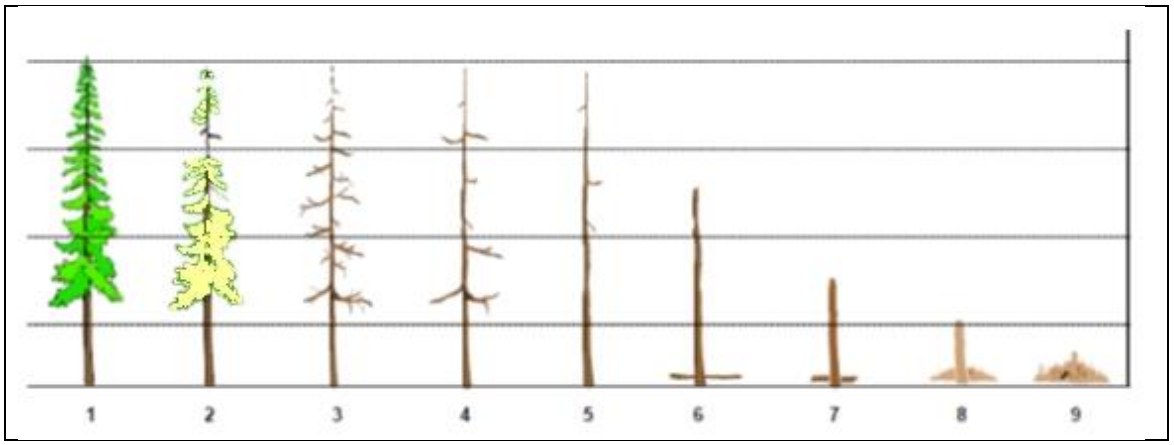
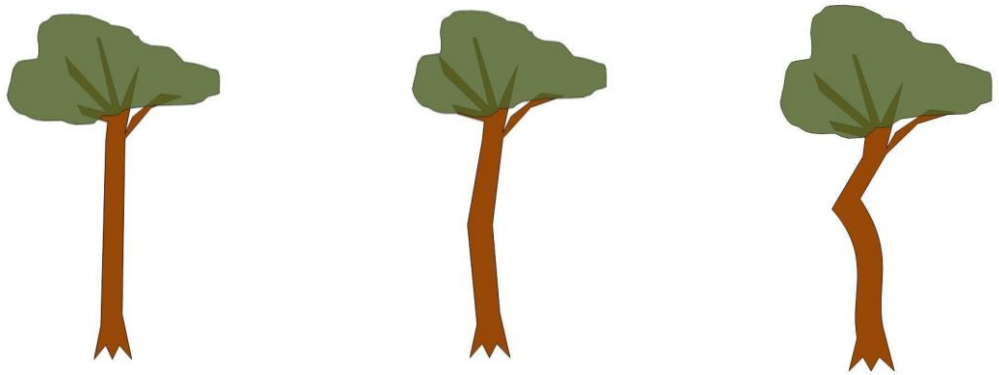


Figure 14: Biomass Loss Estimation Guide

5.8 Tree Quality

Classification in quality classes will follow only 3 classes, mainly criteria are only regarding the shape of the stem and visible defects on the stem:

(1) Straight bole without visible defects,
(2) slightly curved bole with few or little visible defects,
(3) multiple curved or crooked bole or with large visible defects



Straight bole without visible defects

Slightly curved bole with few or little visible defects

Multiple curved or crooked bole or with large visible defects

Figure 15: Stem Form Quality Assessment

5.9 Tree Biomass Increment Estimation

The tree age and the increment estimation will be done in a scientific study using samples from 10 % of all trees. The assessment will follow a separate instruction on volume increment estimation. The samples will be taken be the quality control team, which is supposed to visit and check 10 % of all sampling units. From those at random selected sampling units the samplings will be taken from the sampled trees with an increment borer and the samples will be marked with sampling unit number, sampling

plot number, tree number and tree diameter and stored in a special container to be transported for analysis to the laboratory at the National University in UlaanBaatar. The tree record on the record sheet should be marked with Y when a sample has been taken.

6. OTHER OBSERVATIONS AT SAMPLING UNITS

6.1 Dead Wood on the Ground

Dead Wood on the ground will be measured in the smallest sampling circle, the 6 m radius circle. It is measured by the mid diameter and the length of the log, as far as it is inside the circle. Dead wood logs that lay across the circle boundary are only measured with the part that is inside the circle (see examples below). Diameter measurements are done with the calliper. The records for length are in meter to the nearest decimetre (1 digit after the dot, example 3.4 m). The records for mid diameter are rounded to full centimetres.Standing dead trees are selected and measuredwith the same proceduresas live trees.

A decay percentage has to be estimated for each log. The percentage should be given 5 % steps. The estimation has to describe the loss of biomass / weight of the log against fresh log of the same size. The losses can be caused by moulding, insects and fungus, by the stem being hollow or else damaged and parts of it removed.

Stumps are included in the measurement and treated the same way. The mid diameter of the stump will be estimated by reducing the top diameter according to the estimated tapering. The height of the stump will be measured with tape and recorded the same way as logs on the ground. The decay will also be estimated. Stumps are recorded in the same table as the dead logs on the ground.

Stumps need to be assessed and recorded in the same procedure as logs with measuring the height of the stump and its mid diameter. The stumps need to be marked in the column S/L with S. Logs will be marked with L. For stumps that are partly out and partly in the circle the estimation of decay has to consider the parts outside of the circle and deduct that part as well from the estimated biomass remaining.

Measurement should start in north and follow a sweep around the circle starting towards east. Logs are recorded when the diameter is above 5 cm.

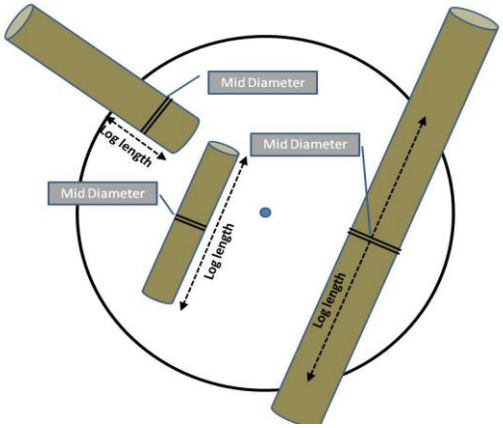


Figure 16: Dead Wood on the Ground Assessment

6.2 Forest Structure Type

The stand structure is described in 4 types of forest structure. The observations have to be made to identify how many layers of trees are found, following the examples in the graph below. There are four types of forest structure to choose from:

(1) Single layer forest stand – only one obvious major layer can be identified
(2) Two layer forest stand – two distinct major layers can be identified
(3) Three layer forest stand – all three possible layers can be identified as distinct from each other
(4) Multi Layer stand – there are several layers of trees existing but the cannot be separated from each other, because trees grow in a mix of heights

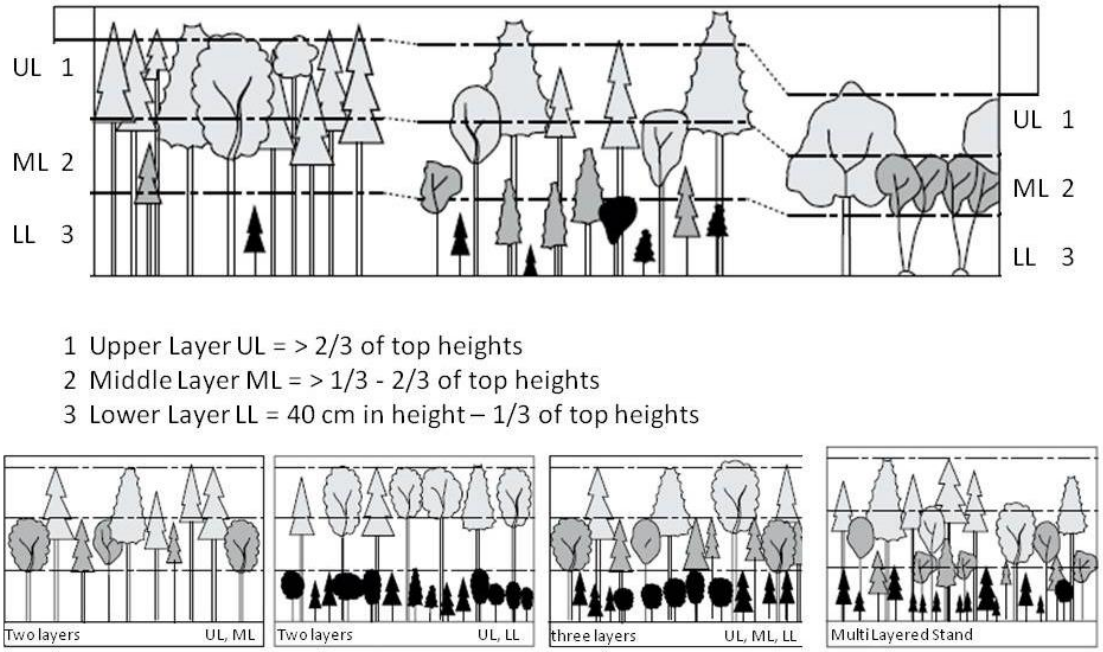


Figure 17: Stand Structure

6.3 Shrub and Ground Vegetation

To describe the shrub layer and ground vegetation, the thickness of the ground cover in sample circle r = 6 m is estimated and indicated in four stages for the following 14 morphological plant groups:

1 = lichen
2 = mosses
3 = bracken/fern
4 = herbaceous seed plants (non-woody or onlywoody at the base of the shoot)
5 = grasses
6 = large liana (ivy, clematis
7 = dwarf shrubs (fine-leaved heath, bilberries)
8 = subshrubs with 1-2 year-old suckers (raspberries, blackberries)
9 = shrubs <0.5 m high
10 = shrubs 0.5 to 2 m high
11 = shrubs >2 m high
12 = trees < 0.5 m high
13 = trees 0.5 to 2 m high
14 = trees > 2 m and < 4 m high

The four stages of coverage are described as
1 = non-existent
2 = sparse (up to 10%coverage)
3 = rich (>10% to 50%coverage)
4 = in aggregations (> 50% coverage)

6.4 Landscape Type, Slope and Soil Type

The landscape description should identify the location of the sampling unit in the landscape following the graph below. There is to choose from 9 locations.

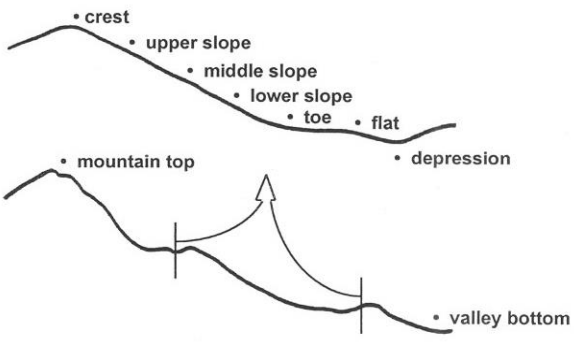
Code	Description	Definition
1	Mountain Top	
2	Crest	
3	Upper Slope	
4	Mid Slope	
5	Lower Slope	
6	Toe	
7	Flat (level)	
8	Depression	
9	Valley Bottom	

Figure 18: Location in the Landscape

The landscape description has to include the measurement of the slope. It will be measured with the clinometer and recorded in full degrees. The measurement with clinometer has to be done with two persons to ensure the measuring is not including the height difference of the measurer's eye height. See also the graph below.

The slope aspect is identified as a general direction for the area of the sampling plot with a compass. It is recorded in general directions according to the table below. If aspect cannot be identified (flat) it is marked with NN.

Table 3: Slope Aspect

N	NE	E	SE	S	SW	W	NW
337.5°-22.5°	22.5°-67.5°	67.5° - 112.5°	112.5° - 157.5°	157.5° - 202.5°	202.5° - 247.5°	247.5° – 292.5°	292.5° – 337.5°

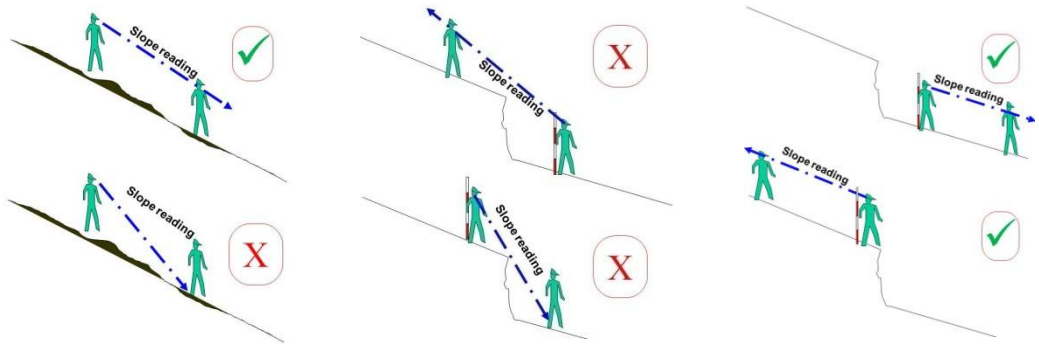


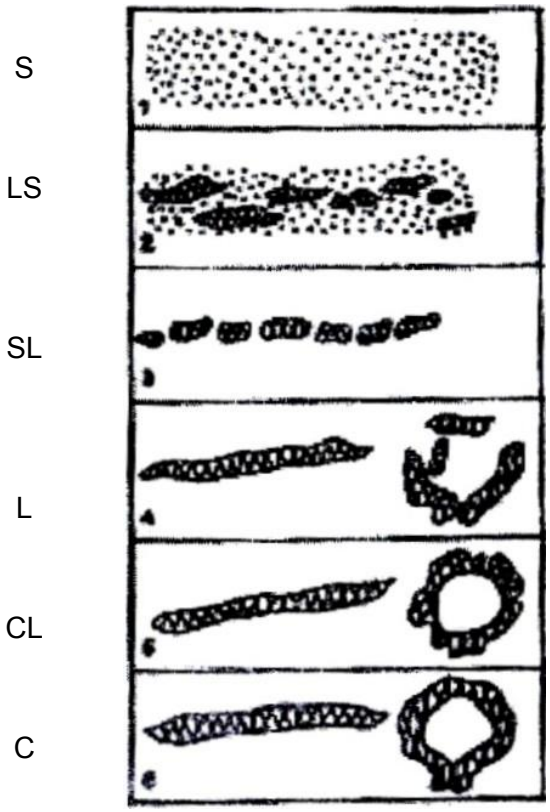
Figure 19: Slope Gradient Measurement

The soil type refers to the soil texture and should be recorded with the below abbreviations for the texture types listed. The soil texture can be confirmed with the finger test. A small soil sample will have to be tested by squeezing and rolling it between thump and fingers. In general some features can be identified already by just squeezing the sample. The more the finger prints can be visible on the sample, the higher must the clay part in the soil sample.

Table 4: Soil Texture Types

S	sand	If a small ball cannot be formed, soil does not stick together
LS	loamy sand	If the soil sample can be formed to a ball of 3 cm radius and the ball only falls apart when tried to roll out to a small roll
SL	sandy loam	If the ball can be rolled out to a small roll of 3 mm diameter but the roll falls apart in small pieces when tried to form a smaller roll
L	Loam	If the ball can be rolled out to a small roll of 3 mm diame-

		ter but falls apart into bigger pieces when tried to roll out to thinner roll
CL	clay loam	If the roll can be formed into a ring, which does not stick together well and tends to fall apart
C	Clay	If a ring can be formed from the roll that does not fall apart easy



(Extracted from:Mongolian Introduction to Soil Science from the Geo-Ecological Institute of Mongolia from 2002 (page 45))

Figure 20: Guide for Soil Texture Assessment by Feel

6.5 Soil Horizon Measurement

To allow the calculation of soil carbon amounts at a plot the depth to the different soil horizons has to be measured. The horizons to measured are the A, B and C Horizon.

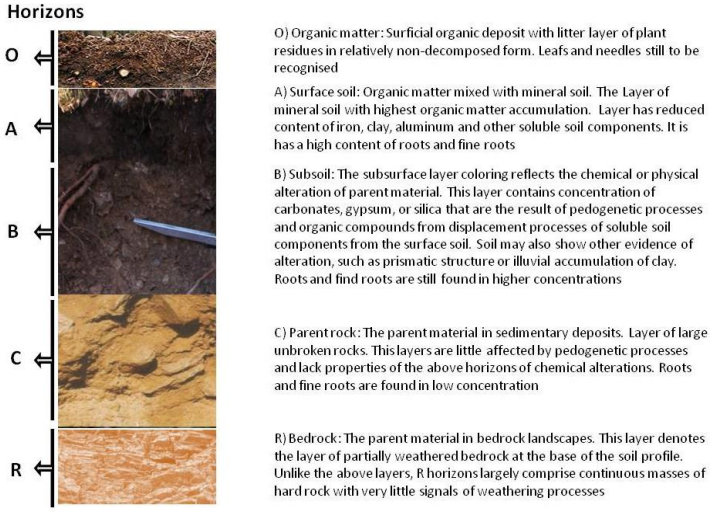


Figure 21: Soil Horizon Identification

The measurements are taken with a soil sample borer, which is hammered into the ground and with turnings extracted. Care has to be take to not let parts of the soil sample fall out of the grove of the soil sample borer when extracting the borer. The soil displayed in the grove will then be assessed for colouring and changes of colour to identify the horizons. Once identified the depth of the horizons will be measured with a ruler.

6.6 Litter Layer and Litter Moisture

The litter layer is defined as thesurficial organic deposit with litter layer of plant residues in relatively non-decomposed form which is not mixed with soil. It may be also formed by peat or duff in moist conditions. The depths of this layer need to be measured by opening a small soil pit to allow measurement of an undisturbed litter layer. In case of peat and duff the soil sample borer may be use to extract a sample. Measurements are taken with a ruler.

The moisture of the litter layer has to be estimated to allow differentiation of dry litter layers from moist and wet peat layers. The classification is done in 3 classes:

(1) dry litter –
(2) moist litter / peat – thicker layers (< 50 cm) of organic materials, partly alive in depression or flat terrain with tendency but not yet established bog or fen
(3) wet and deep peat / duff layers in sites which have developed into a bog, fen or swamp area.

6.7 Soil Erosion Assessment

The occurrence of erosion events caused by water erosion within the 20 m radius circle will have to be classified into 3 classes:

(1) No erosion events visible, litter layer and top soil undisturbed

(2) Smaller erosion events (< 10% of the sample plot) visible and litter layer in parts removed, top soil only slightly removed by erosion
(3) Erosion events of substantial size (> 10% of the sample plot) visible with litter layer and top soil removed

6.8 Forest Fire Assessment

Bush and forest fires should be identified by the damage to trees and shrubs and for recent fires by the ashes and burnt remnants of the vegetation.The Question Fire Damage should be responded with the assessment of the area being burned in last 3 years (20 m Radius) or not and should be answered with Yes or No.

6.9 Grazing in Forest

Grazing is assessed in the 20 radius circle for its presence and the intensity. Presence of grazing to be identified by the presence of animal droppings tracks and traces or sighting of the grazing animal itself by answering the question. The intensity will be classified in 4 classes as described below.

Table 5: Grazing Intensity Classes

Code	Description
1	No traces of grazing animals found
2	Only little use for grazing – few old trace, no damage to regeneration of trees and bushes, few grasses bitten.
3	Medium use for grazing – traces and droppings clearly present, little damages to tree and shrub regeneration, grass and herbs visibly browsed
4	Intensive use for grazing – traces and droppings plentiful and damages to tree and shrub regeneration substantial, grass and herbs heavily browsed.

6.10 Bio-Diversity Assessment

As a factor of biodiversity the number of different plant species, including the tree speciesis recorded. Within the 6 m radius circleall found plant species of all layers including the trees are counted. The count is done through collecting samples of all species and compare and count them at the end in order to not miss or double count any.

6.11 Identification of Red-List Plant Species

The team should assess the 6 m radius circle also for the occurrence of red list plant species. The list is reproduced in the annex. The identification will be done whilst doing the bio diversity counting. The red list species need to be identified and recorded with their scientific name. Care should be taken to not damage those plants.

6.12 Protection Status

The protection status of the plot location should be identified from the Forest Planning Map and notified with Yes or No. The team should then asses if the subject of protection (in case of special reserves, protection zones, etc. for specific plants, plant societies, animals, wells or water ponds, etc.) is still in place and refer to their assessment with Yes or No. And finally in those cases where no protection is in place, they should evaluate the location for its worth as a protected area with a special protection purpose, such as being a habitat for specific plants, plant societies, animals or a zone around wells or water ponds, etc. which may required special protection.

7. TEAM ORGANIZATION AND WORKSTEPS

7.1 Team Composition and Tasks

An inventory field team needs to have a well trained Team Leader who will be responsible for all assessments and measurements at the sampling plot as well as for its proper location. He needs to be assisted by a forest technician with skills in tree mensuration and tree and plant species identification. The team then needs to be completed with labour assistance to help carry equipment, hold instruments and to do the soil sample extraction. A job description for the team is listed in the table below.

Table 6: Team Composition and Job Description

Position	Qualification	Job description
Team leader	forest engineer with field inventory experience	Head of a field assessment team, responsible for identification and assessment of sampling units in required quality and accuracy 1) programming and using GPS instrument for location of sampling unit 2) using of compass and distance instrument for final approach and location of sampling unit and sampling points 3) supervision of tree measurements - DBH, height, distance and azimuth, vegetation assessments and soil measurements 4) recording of measurements on field record sheet (responsible for completeness and accuracy of records) 5) work organisation (during field work and for its preparation)
Assistant Team Leader	forest technician, literate, species knowledge, high school	Assistant Team Leader 1) assisting the team leader in all organisational and work preparatory matters 2) conducting all tree measurements - DBH, height, distance, azimuth 3) conducting the vegetation assessment and soil measurements 4) demarcation of sampling unit location
Assistants	n/a	1) helping the Team Leader and his Assistant in all labour matters 2) carrying equipment and gear 3) brushing and clearing approach way and plots to facilitate measurements

7.2 Equipment Needed

The field working teams need to be furnished with the measuring instruments, tools and other equipment listed in the table below to ensure the measurements are conducted in the expected and described standards. Not listed is personal equipment for transport, hiking and camping in the field.

Table 7: Equipment for Field Working Teams

Item Description	needed per team
GPS Receiver (Garmin 62s)	1
Distance Tape (carbon, 25m)	1
Diameter Tape (steel, 5 m)	1
Caliper	1
Compass/ Boussole (Suunto, Alu)	1
Clinometer (Silva, Alu)	1
Ranging poles	3
Dendrometer (Vertex IV) Including transponder + circular reflector	1
Wooden reference stick 1.3 m for DBH	1
Axe	1
Cutlass	1
Pürckhauer Soil Borer with Handle	1
Special Soil Borer Hammer	1
Writing board, Pencil and Eraser	1
Steel bars for demarcation of points	“
Paint, chalk for tree marking	1
Paper (copies of field record sheet) and stationary	“

7.3 Securing Assessment Quality

Independent forestry institutions are performingthe quality control of the field works. 10 % of all inventory points should be re-measured. The records of the re-measurementare then compared to the original data to assure the work quality as well to identify needs and work details for re-training of field teams. The quality control has to be conducted during the field works to timely identify errors and re-training needs and to allow the forest administration to act correspondingly.

The acceptable measurement tolerances for the different measurements are listed in the table below. The deviations found can be classified into tolerated deviations, errors and grave errors. The Contract for the field team will have to specify the consequences for the amounts of errors and grave errors occurring at one sampling unit.

Table 8: Acceptable Measurement Tolerances

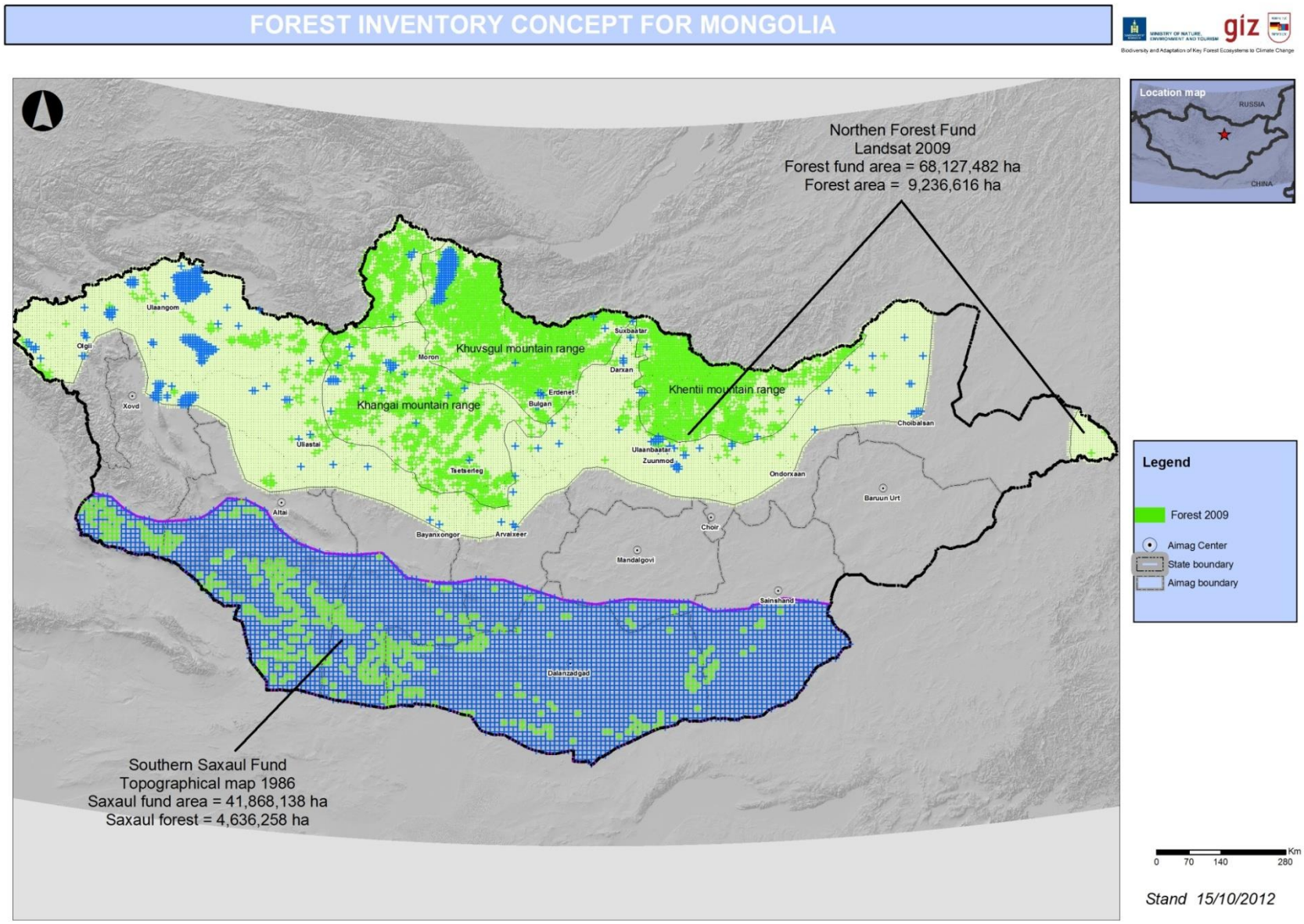
Type of Measurement	Unit of Measure	Tolerated deviation	Error	Grave Error
Regeneration count	count	3 %		
Tree species identification		none	Wrong species	Wrong family
DBH measurement	(xxx.x) cm	3%	3-5%	>5%
Height measurement	(xx.x) m	3%	3-6%	>6%
Quality, Damage class	classes	1 class	>1 class	forgotten
Health class	classes	1 class	>1 class	Dead not recognized
Decay classification of dead wood	10 % steps	1 step	1-2 steps	>2 steps
Length measurement of dead log	(xx.x) m	2%	2-5%	>5%
Diameter measurement of dead log	(xxx.x) cm	3%	3-5%	>5%
Vegetation layer classification	4 classes	1 class	>1class	forgotten
Erosion, fire, grazing	classes	1 class	>1 class	Forgotten, not recognized
Slope measurement	degree	3%	3-5%	>5%
Aspect	Cardinal direction	1 step	>1 step	forgotten
Soil measurements, horizon and layer thickness	(xx) cm	3%	3-5%	>5%
Biodiversity plan count	count	3%	3-5%	>5%

The quality control team will at the same time extract the samples for age determination and increment assessment from the sample trees of the re-sampled inventory units. The extraction of the samples and the marking and boxing of them for analysis in the laboratory of NUM is described in a separate manual.

Important for quality control is also a proper tracing of the process of field work and further processing of data and field record sheets.To ensure and document the overall quality and completeness of records the process of data recording and treatment will have to be documented in processing records. The records treatment is composed of three parts, the first is concerned with the recording and completeness check by the field team, another part is the random field controls of 10% of the and the third part is data encoding into the computer with follow up of data with plausibility checks. To document the procedure of data acquisition and to be able to trace the whereabouts of data and to monitor the progress a records tracer table similar to the below examples is recommended to be used.

Table 9: Example Record Tracer Table

SampleUnit No	Date field assessment	Date received in office	Check and Acceptance of completeness of records	Selected for Quality Control re-measurement	Date of remeasurement	Acceptance after Field Check	Date of Information of Field Team for Improvement	Date improved records received in office	Date data encoding	Date Conduct of Plausibility Check	Acceptance of Plausibility Check	Date of possible improvement request to FieldTeam	Date of delivery of improved data	Acceptance of improvement
			[Y /N]	[Y /N]		[Y /N]					[Y /N]			[Y /N]


FOREST INVENTORY CONCEPT FOR MONGOLIA
Northen Forest Fund
Landsat 2009
Forest fund area = 68,127,482 ha
Forest area = 9,236,616 ha
Location map
RUSSIA
CHINA
Khuvsgul mountain range
Khangai mountain range
Khentii mountain range
Ulaangom
Olgii
Xovd
Moron
Suxbaatar
Darxan
Erdenet
Bulgan
Choibalsan
Ulaanbaatar
Zuunmod
Ulaastai
Tsetserleg
Ondorxaan
Baruun Urt
Altai
Bayanxongor
Arvaixeer
Choir
Mandalgovi
Sainshand
Dalanzadgad
Southern Saxaul Fund
Topographical map 1986
Saxaul fund area = 41,868,138 ha
Saxaul forest = 4,636,258 ha
Legend
Forest 2009
Aimag Center
State boundary
Aimag boundary
Km
0 70 140 280
Stand 15/10/2012

Annex A:

Tree Species and Code List

Code	Зүйлийн нэр	Scientific name	Common name
1	Сибирийн шинэс	Larix sibirica	Siberian Larch
2	Эгэл нарс	Pinus sylvestris	Scotch Pine
3	Сибирь хуш	Pinus sibirica	Siberian Pine (Cedar)
4	Гацуур	Picea obovata	Siberian Spruce
5	Жодоо	Abies sibirica	Siberian Fir
6	Хавтаг навчит хус	Betula platyphylla	White Birch
7	Налчигар хус	Betula humilis	
8	Төгрөг навчит хус	Betula rotundifolia	
9	Лавр навчит улиас	Populus laurifolia	Poplar
10	Анхилуун улиас	Populus suaveolens	Mongolian Poplar
11	Улиангар	Populus tremula	Aspen
12	Хайлаас	Ulmus pumila	Elm
13	Заг	Haloxylon ammodendron	Saxaul
14	Тоорой	Populus diversifolia	Poplar
15	Тошлогонцор бургас	Salix berberifolia	Willow
16	Саарал бургас	Salix glauca	Gray Willow
17	Торлог бургас	Salix reticulata	Net-leaved Willow
18	Монос	Padus asiatica	Black Cherry
19	Тэс	Sorbus sibirica	Service Tree

Annex B:

List of endangered plant species (Red-List – separate book)

Annex C:

MPFRI Field Record Sheet (separate file)

Record Sheet for Multi Purpose Forest Inventory of Mongolia

Administration Unit	Village	Forest Unit	Sub Compartment	Page No		Total Pages	
				Elevation (m)		Relocation	Yes☐ No☐

Forest Type	Forest Type in Field	GPS Coordinates (List)		GPS Coordinates (Field)		Date
	Same as Map: Yes☐ No☐	N	E	N	E	

Unit ID		Plot ID		Team Leader		Signature	

Regeneration

Small Regeneration (10-50 cm) R: 2 m/2 circles				Medium Regen. (50-150 cm) R: 2 m/2 circles				Big Regen. (150cm -5.9 cm DBH)R: 2 m/2 circles			
Species Name	Code	Tally	Total	Species Name	Code	Tally	Total	Species Name	Code	Tally	Total

Dead Wood on the ground R: 6 m

No	S/L	Length	Diamet.	Decay	No	S/L	Length	Diamet.	Decay	No	S/L	Length	Diamet.	Decay
		(xx.x m)	(xx.x cm)	(xx %)			(xx.x m)	(xx.x cm)	(xx %)			(xx.x m)	(xx.x cm)	(xx %)

Small Tree (DBH 6 – 14.99 cm) R: 6 m

Tree No	Bearing	Distance	Species Name	Code	DBH	Height	Age	Health	D.Cause	Quality	Decay	BorSp
	(xxx°)	(xx.xx m)			(xxx.x cm)	(xx.x m)	(Categ)	(xClass)	(xClass)	(xClass)	(class)	Y/N

MediumTree (DBH 15– 29.99 cm) R: 12 m

Tree No	Bearing	Distance	Species Name	Code	DBH	Height	Age	Health	D.Cause	Quality	Decay	BorSp
	(xxx°)	(xx.xx m)			(xxx.x cm)	(xx.x m)	(Categ)	(xClass)	(xClass)	(xClass)	(class)	Y/N

Big Tree (DBH > 30 cm) R: 20 m

Tree No	Bearing	Distance	Species Name	Code	DBH	Height	Age	Health	D.Cause	Quality	Decay	BorSp
	(xxx°)	(xx.xx m)			(xxx.x cm)	(xx.x m)	(Categ)	(xClass)	(xClass)	(xClass)	(class)	Y/N

Other Observations

Vegetation Layers				Landscape and Soil		Biodiversity and Protection	
Forest Stand Structure according to Layers		Structure Type		Landscape Type		Number of Plant Species	
Layer	Coverage (Class1-4)		Coverage (Class1-4)	Slope (xx°)		Names of Identified Red List Plants	
1) lichen		8) sub-shrubs		Aspect (Cardinal Direction)			
2) mosses		9) shrubs <0.5 m		Soil Texture Type		Insects	
3) bracken/fern		10) shrubs 0.5 to 2 m high		A Horizon (xx cm)		Reptiles	
4) herbaceous seed plants		11) shrubs >2 m high		B Horizon (xx cm)		Mammals	
5) grasses		12) trees < 0.5 m high		C Horizon (xx cm)		Protected Area	Yes☐ No☐
6) large liana (ivy, clematis)		13) trees 0.5 to 2 m high		Litter thickness (xx cm)		Subject of Protec-tion is protected	Yes☐ No☐
7) dwarf shrubs		14) trees > 2 m and < 4 m high		Moisture Classifi-cation for litter		Protection Proposed	Yes☐ No☐

Erosion Classification		Fire Damage	Yes☐ No☐	Grazing Intensity Class	

Annex D:

Forest Mensuration Handbook of Mongolia (separate book)

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GIZ-Program
„Biodiversity and Adaptation of Key Forest Ecosystems to Climate Change“

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Maps
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