LDSF

Guide to Field Sampling and Measurement Procedures

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Before you go into the field

There are five main things you should do or consider before going into field:

I. Assemble pre-existing information about the area, where this is available. Particularly important are items like topographical, geological, soils and/or vegetation maps, satellite images and/or historical aerial photographs, long-term weather station data, government statistics, census data etc. This help will help you conduct the field survey, for example you can use topographical maps for orienteering and navigation, but also later in interpreting the data.

II. Make sure that everyone in the field team knows what they are doing, this includes navigation and orienteering (you don't want anyone getting lost in a remote area), as well as knowing all the relevant field procedures. Some initial practice runs with a team may be needed to accomplish this.

III. Obtain a set of random coordinates for laying out sampling locations on the ground and record these in the GPS units. The randomization procedures are described in **Section 2**.

IV. Do a thorough equipment check against the table in Appendix II. Ideally, each 5 person field team should have this equipment. In cases where 2 or more field teams are working in close proximity to one another, it may be possible to share things like GPS units and soil augers.

V. Obtain permission from the land owner(s) to sample a given area, and make sure that he/she understands what you are doing. Informing local government officers and community leaders about your activities is also a good idea. In remote areas without cellular phone access make sure that someone knows where you are going to be on any given day.

Note!

1. **Definitely avoid any areas where you might be placing your field team at any risk of harm or injury**.
2. **Always carry an emergency first aid kit**.
3. **Make sure you have the necessary equipment listed in Appendix II.**

Table 1: Spreadsheet formulae for calculating random coordinates located in a 1 km^2 circular area.

	A	B	C	D	E	F
1	Area	Angle	Distance	Heading	+X	+Y
2	=RANDBETWEEN(1,1,000,000)	=RANDBETWEEN(-180,180)	=SQRT(A2/PI())	=IF(B2<0,B2+360,B2)	=C2*COS(RADIANS(B2))	=C2*SIN(RADIANS(B2))

Cluster-level sampling plan

The LDSF is built around the use of "Sentinel Sites" or "Blocks", 10 x 10 km in size. The basic sampling unit used in the LDSF is called a "Cluster". A Cluster consists of 10 "Plots" (described on page 3). The centre-point of each cluster in LDSF is randomly placed within a "tile" in each Sentinel Site (see figure on the right). The sampling plots are then randomized around each cluster centre-point, resulting in a spatially stratified, randomized sampling design

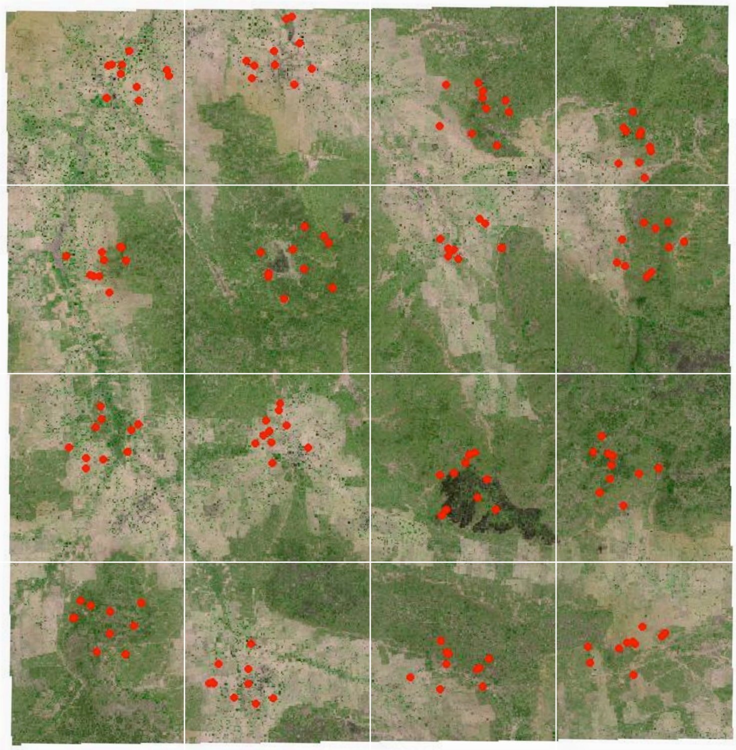
Both the number of plots per cluster and the cluster size may be adjusted depending on the specific purpose of the survey being conducted. For example, 1 km^2 clusters are useful for large-area reconnaissance surveys; whereas, 10 ha clusters may be more appropriate for more detailed project-level surveys.

Whatever the cluster size and sampling intensity, randomizing the plots in the cluster is extremely important as you will want to minimize any local biases that might arise from convenience sampling.

The randomization procedures are done using customized programs or scripts. Send an e-mail to t.vagen@cgiar.org giving either the center or the four corners of your sampling block (in Lat/Lon or UTM coordinates). A file is generated containing the plot location coordinates and labels (based on a name that you give). This file can then be loaded to your GPS unit and you can navigate to the various plots in your Sentinel Site, completing the sampling procedures and field observations described in the next sections of this guide. Alternatively you may do the randomization for each cluster in an Excel spreadsheet using the formulas in Table 1 (previous page).

A team of five people should generally be able to complete all the field measurements in a "standard" 1 km^2 cluster on one day.

Abandoning and replacing plots:



10x10 km sentinel site (block) with sampling clusters

To achieve a sample that is representative of the cluster area and statistically valid, every plot identified for measurement within the cluster should be measured at its mapped location. For example, if a plot point falls in a part of the cluster containing a school yard, a house or a road, the plot should still form part of the sample and should not be abandoned or moved to a new location. While you will not take any measurements in these situations, the presence of these types of areas should be noted and GPS coordinates should be recorded.

There are some limited circumstances in which a plot can be abandoned. These are unlikely and include situations where:

1. The plot coordinates overlap in part with another plot. You can evaluate this possibility in the office.
2. The plot point falls in a stream, lake, cliff or other completely inaccessible place.
3. There are safety concerns in completing the plot.

Where a plot cannot be completed for one of the above reasons, an alternate plot should be selected instead. Randomly choose the alternate plot using the procedures outlined above. Note the alternate plot used and the reason for abandoning the original plot on the field recording sheet.

Plot layout

The figure on the right shows the radial arm plots used in the LDSF. The plots are designed to sample a 1000 m² area, but you may have to apply slope corrections to the center point distances and sub-plot radii to achieve this.

1. To lay out the plots you will need: a Field recording sheet (Annex III), a slope correction table (Annex), a GPS, a 30 meter tape measure, or for dense vegetation, a pre-marked chain, a clinometer, a compass and two, 2 meter range poles.

2. Initially GPS the point by averaging position fixes for at least 5 minutes. Store this as a waypoint on your GPS, and record the Easting, Northing, Elevation and Position error on the field recording sheet Annex III).

3. While the GPS is averaging, complete the slope measurements. To measure the slope, stand in the centre of the plot. Take a sighting along the steepest part to a point on the up-slope plot boundary using the clinometer. Ensure that you sight to a location that is at the same height as the observer's eye-level. A marked range pole is useful for this, or alternatively a point on another person may be used. Also remember to look at the scale in degrees, rather than in percent.

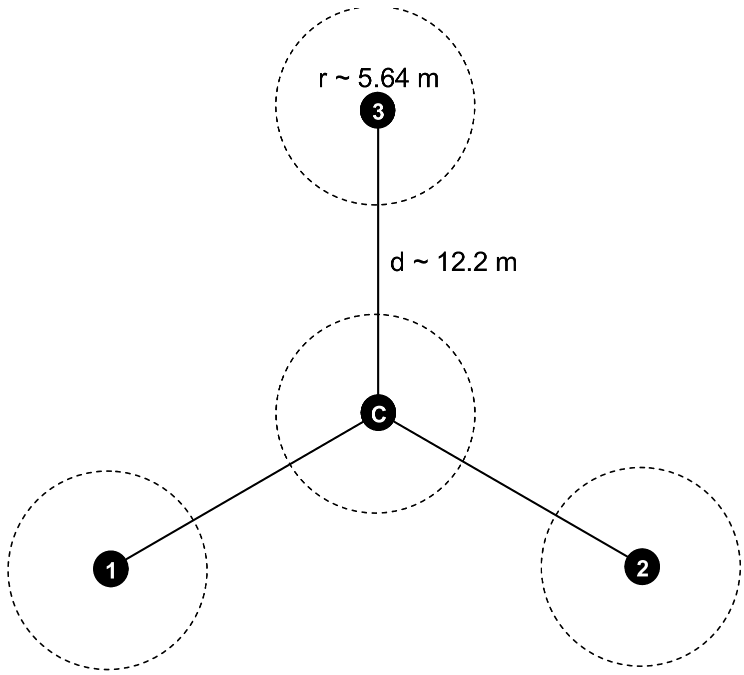
4. Rotate 180 degrees and repeat the process in the down-slope direction. Record both the up-slope and down-slope measurements on the field recording sheet. Then average the two figures, and use the slope correction table to determine the correct center-point distances

$$Slope\ distance = \frac{Horizontal\ distance}{cos(Slope)}$$

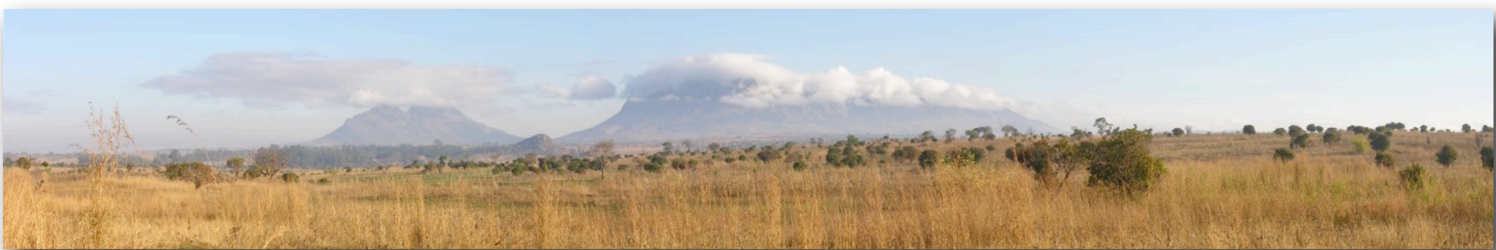
   and subplot radii. Alternatively use the following slope correction formula:

Note: that the Slope must be measured in degrees

5. Using a measuring tape or a pre-marked chain, measure out the center-point distance from the plot center to the center of the up-slope sub-plot. Mark this point for soil sampling. The second and third soil sampling points should be offset 120 and 240 degrees (use the compass to determine this) from the up-slope point, respectively, on the plot boundary.



0.1 ha radial-arm plot layout and sampling locations. The black dots indicate soil (0-20 and 20-50 cm) sampling locations. Georeferencing and infiltration measurements should be completed in the center of the plot. The larger (dashed) circles represent 0.01 ha sub-plots in which soil surface and vegetation observations should be carried out. r is the subplot radius, d is the center-point distance. Note that the distances are for a flat plot. In instances where slope is >10 deg. the radii and center-point distances of the subplots should be slope corrected



Measuring soil infiltration capacity

The soil infiltration measurements will be the most time consuming aspect of the field measurements, so these should be set as soon as possible. The easiest way to do this is to use the first three plots in the cluster sequence (see Fig. 1). However time allowing, it is generally desirable to obtain more than three (as many as possible) infiltration measurements, particularly in large clusters. So, should you be able complete more than three infiltration measurements per day, allocate these randomly to the different plots in the cluster.

1. To complete the infiltration measurements you will need: three, 12 inch diameter infiltration rings per cluster, a sledge hammer, approximately 25 liters of water per ring, and an infiltration field recording sheet (Annex).

2. The infiltration ring should be placed at the center of the plot (see Fig. 2). To ensure that the ring does not leak, drive it at least 2 cm into the soil with a sledge hammer. Under some circumstances it may be necessary to seal the ring with clay on its inside edge.

3. Remove any vegetation, litter and large stones from inside the ring, but make sure not to disturb the soil surface by digging out large stones or uprooting vegetation. If the soil surface is accidentally disturbed, reset the ring at another location.

4. Pre-wet the soil with 2-3 liters of water. Let this soak in for at least 15-20 minutes. Then slowly pour water into ring to a level of 20 cm, again making sure not to disturb the soil surface.

5. The infiltration rates at the beginning of the test will be quite variable. So for the first half-hour of the test record at 1-5 minute intervals. Note that it will be easier to process the data if you record time in minutes since initiation of the test rather than as clock time.

6. After each recording top up the water level to 20 cm. After the first half hour record at 10-20 minute intervals for an additional 2.5 hours, or until the infiltration rates have stabilized. Top-up the water level to 20 cm after each reading.

Land form and land cover classification

The land cover of all plots should be recorded using the FAO Land Cover Classification System (LCCS), which has been developed in the context of the FAO-AFRICOVER project
(also see www.africover.org).

The "binary phase" of LCCS recognizes 8 primary land cover types, only 5 of which should be sampled including:

- cultivated and managed terrestrial areas,
- natural and semi-natural vegetation,
- cultivated aquatic or regularly flooded areas,
- natural or semi-natural aquatic or regularly flooded vegetation, and
- bare areas.

Artificial surfaces and associated areas, natural and artificial waterbodies, and surfaces covered by snow, or ice should not be formally surveyed under the LDSF, though their presence within a cluster should be noted and georeferenced.

The "modular-hierarchical phase" of LCSS further differentiates primary land cover systems on the basis of dominant vegetation life form (tree, shrub, herbaceous), cover, leaf phenology and morphology, and spatial and floristic aspect. All the associated features are assessed visually and are generally coded on either categorical or ordinal rating scales. The ratings can subsequently be converted to unique hierarchical identifiers representing different land cover types. The questions in the field recording sheet are designed to guide you through the classification process.

Initially complete the section describing landform and topographic position. To do this, visually inspect the area surrounding the plot and select the appropriate categories provided on the field recording sheet and the major landform designation table (Annex). Skip the section on topographic position if the Major Landform is "Level Land".

Continue through the form completing the "plot-level" information before moving to sub-plots.

Soil surface characterization

To sample soils, you will need 2 buckets, an appropriate (hard soil, sand or general purpose) soil auger marked at 20 and 50 cm, 2 buckets, sturdy plastic bags, a mixing trowel, a permanent marker, labels, a torvane, and the provided soil texture table (Annex).

Soil sampling:

1. Top-soil (0-20 cm) and sub-soil (20-50 cm) samples should be collected from the four soil sampling positions (Fig. 2) and pooled into separate plastic buckets, one for topsoil, one for subsoil. Record the depth (to the nearest 5 cm) to any restriction at any one of the four sampling locations on the field sheet.

2. When augering, make sure that you avoid overfilling the auger or collapsing the hole. So, take small, steady bites, empty the auger frequently, and do not lever the auger against the side of the hole when removing it. Should the hole collapse, reset the auger at another location within 50 cm of the original position.

3. Mix the samples thoroughly in the buckets using the mixing trowel. Then, take a ~250 g sub-sample and place it in a plastic bag. Note that there should be one bag of topsoil and one bag of subsoil for each plot.

4. Labeling is critical. The cluster and plot ID's should be legibly recorded with a permanent marker on the outside of the plastic bag. Additionally, a paper label containing the same information should be placed inside the bag.

After getting back from the field the samples should be air-dried for at least 3 days.

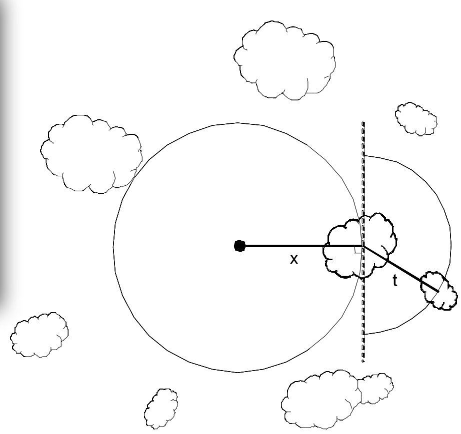
Visual soil surface characterization

Examine the plot and note down visible erosion and/or soil conservation measured in the field recording sheet.

Soil texture determination

Follow the procedure outlined in Annex IV for determining field texture, and note down the results on the field recording sheet.

Measuring woody vegetation



The T-square sampling procedure. x is the Point-to-nearest-plant distance, t is the Plant-to-nearest-plant distance constrained to lie in the hemisphere of the dashed line perpendicular to x (after Krebs, C. J. 1989. Ecological Methodology. Harper & Row Pub., New York).

The "**T-square**" method is one of the most robust distance methods for sampling woody plant communities, particularly in forests, but also in rangelands. It can be used to estimate stand parameters such as density, basal area, bio-volume, and depending on the availability of suitable allometric equations, also biomass. The advantage of this method, over other commonly used distance methods such as the point-centered quarter (PCQ) method, is that it is less prone to bias where plants are not randomly distributed.

<u>Under the LDSF protocol shrubs and trees are sampled separately.</u>

To complete the T-square measurements for trees and shrubs you will need, the field recording sheet (Annex), a 15+ meter measuring tape, a diameter tape, a height pole and/or a clinometer and a calculator.

1. Standing at the center of each subplot record the distance from the subplot center point to the nearest tree and shrub (x) (see figure). Measure this either to the center of the tree trunk, or to the central portion of the shrub. Record this figure in the appropriate space on the field recording sheet.

2. Next measure the distance to the nearest neighboring plant (t). Note, however that the angle of the measurement must be constrained to lie in the hemisphere of a line that lies perpendicular to x. This is the T-square distance. Also record this measurement.

3. For both trees and shrubs measure and record the height using either the height pole or clinometer methods described further below. Measure only the 2nd plant identified (i.e. the tree and/or shrub identified by the plant-to-nearest-plant measurement).

4. For trees measure the diameter at breast height (DBH) of the 2nd tree. The DBH should be measured 1.3 meters above ground level. In instances where a tree branches below this level, measure the diameters of all of the branches at 1.3 meters above ground level and sum these. For trees that are tilted determine the 1.3 meter level from the down-slope direction.

5. For shrubs, measure their width, length and height (at centre).

   Fill the above recordings into the field recording sheet in Annex III.

Appendices

I

Landform designations

Level land	Sloping land	Steep land	Land with composite forms
Plain	Medium gradient mountain	High gradient mountain	Valley
Plateau	Medium gradient hill	High gradient hill	Narrow plateau
Major depression	Med. gradient escarp-ment	High gradient escarpment	Major depression
Low gradient footslope	Ridges	High gradient valley	
Valley floor	Mountainous highland		
	Dissected plain		

II

LDSF - equipment required for land cover classification, soil and vegetation inventory.

Activity	Equipment required	People required
Cluster and Plot layout	Cluster cover sheet Field recording sheets Random coordinates Digital camera GPS Calculator Clinometer Compass	1 Person
Landcover classification & vegetation inventory	Field recording sheet 15+ meter measuring tape Diameter tape Height pole	2 People
Soil inventory	Field recording sheet Infiltration recording sheet Soil texture table Watch or stop watch 3 × 12″ inside diameter infiltration rings 4 × 20 liter jerry cans Sledge hammer Hard soil auger Sand auger General purpose auger Electrical tape Torvane 2 × 20 liter buckets Mixing trowel Sturdy plastic bags Permanent marker Paper or cardboard labels Electrical tape	1 Person for infiltration measurement 1 Person for soil collection
Other	First aid kit	

III

Country: Name of data recorder:

LDSF Data-Entry Form

Block Name		**UTM zone**	
Cluster No		**Northing**	
Plot No		**Easting**	
Date (dd/mm/yyyy)		**Elevation**	
Photo ID		**Pos. Error** (m)	

PLOT

Slope (degrees)	Up:	Down:			
Major landform	Level	Sloping	Steep	Composite	
Landform designation (see table)					
Position in topographic sequence	Upland	Ridge/Crest	Midslope	Footslope	Bottomland
Artificial surface?	Yes	No			
Vegetation cover < 4% for 10 mo yr^{-1}	Yes	No	Don't know		
Plot regularly flooded	Yes	No	Don't know		
Plot cultivated or managed	Yes	No	Don't know		
Vegetation types present	Trees	Shrubs	Graminoids	Forbs	Other
Woody leaf type	Broadleaf	Needleleaf	Allophytic	Evergreen	Deciduous
Herbaceous height (m)	0.8 – 3	0.3 – 3	0.3 – 0.8	0.03 – 0.3	
Herbaceous annual	Yes	No	Mixed	Don't know	
Vegetation strata description (include dominant species where known) - use keywords where possible					
Same land cover / use since 1990	Yes	No	Don't know		
Land ownership	Private	Communal	Government	Don't know	
Primary current use	Food / Beverage	Forage	Timber / Fuelwood	Other	
Describe land cover / use history (where known – use back of sheet if necessary)					
Rock / stone / gravel cover	< 5%	5 – 40%	> 40%		
Visible erosion	None	Sheet	Rill	Gully / Mass	
Conservation structures	None	Vegetative	Structural	Description:	
Number of structures					

Woody & Herbaceous cover ratings: **0** = absent, **1** = < 4%, **2** = 4 – 15%, **3** = 15 – 40%, **4** = 40 – 65%, **5** = >65%

SUB-PLOT

	1		2		3		4	
Woody cover rating								
Herbaceous cover rating								
Auger depth restriction (cm)								
Topsoil ribbon (mm) / Texture grade								
Subsoil ribbon (mm) / Texture grade								
Shear strength (2 per subplot)								
	Shrubs				**Trees**			
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Subplot plant density (count)								
Point – plant distance (m)								
Plant – plant distance (m)								
Height (m)								
Length (m, Shrubs) / Circumference (cm, Trees)								
Width (m)					©LDSF, World Agroforestry Centre			

Notes:

IV

Soil texture table.

Soil texture grade	Soil texture class	Behavior of moist bolus	Approximate clay content
K	Coarse sand	Obviously coarse to touch, cannot be molded. Sand grains are readily seen with the naked eye.	< 5 %
S	Sand	Coherence nil to very slight, cannot be molded; sand grains of medium size. Commonly single sand grains adhere to fingers.	< 5 %
F	Fine sand	Fine sand can be felt and often heard when manipulated, cannot be molded.	< 5 %
LS	Loamy sand	Slight coherence; sand grains of medium size; can be sheared between thumb and forefinger to form **minimal ribbon of about 5 mm.**	~5 %
CS	Clayey sand	Slight coherence, sand grains of medium size, sticky when wet. Sand grains stick to fingers. Will form **minimal ribbon of 5–15 mm.** Discolours fingers with clay stain.	5-10 %
SL	Sandy loam	Bolus coherent but very sandy to touch. Will form **ribbon of 15–25m**. Sand grains are of medium size and are readily visible.	10-20 %
L	Loam	Bolus coherent and rather spongy. Smooth feel when manipulated but with no obvious sandiness or silkiness. May be somewhat greasy to the touch if much organic matter present. Will form **ribbon of about 25 mm.**	~25 %
ZL	Silty loam	Coherent bolus; very smooth, often silky when manipulated. Will form **ribbon of about 25 mm.**	~25%, 25%+ silt
SCL	Sandy clay loam	Strongly coherent bolus, sandy to touch; medium size sand grains visible in clay loam finer matrix. Will form **ribbon of 25–40 mm.**	20 – 30 %
CL	Clay loam	Coherent plastic bolus, smooth to manipulate. Will form **ribbon 40–50 mm.**	30 – 35 %
CLS	Sandy clay loam	Coherent plastic bolus; medium size sand grains visible in finer matrix. Will form **ribbon of 40–50 mm.**	30 – 35 %
ZCL	Silty clay loam	Coherent smooth bolus, plastic and often silky to the touch. Will form **ribbon of 40–50mm.**	30 – 35 %, 25%+ silt
LC	Light clay	Plastic bolus; smooth to touch; slight resistance to shearing between thumb and forefinger; will form **ribbon of 50–75 mm.**	35 – 45%
LMC	Light medium clay	Plastic bolus; smooth to touch; slight to moderate resistance to ribboning shear; will from **ribbon about 75 mm.**	40 – 45 %
MC	Medium clay	Smooth plastic bolus; handles like plasticine and can be molded into rods without fracture; has moderate resistance to ribboning shear; will form **ribbon of 75 mm or more.**	45 – 55 %
MHC	Medium heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has moderate to firm resistance to ribboning shear; will form **ribbon of 75 mm or more.**	> 50 %
HC	Heavy clay	Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has firm resistance to ribboning shear; will form **ribbon of 75 mm or more.**	> 50 %

V

LDSF Infiltration Sheet

Block Name: ____

Cluster No: ____

Plot No: ____

Start minute	End minute	Start level (cm)	End level (cm)
0			