



Food and Agriculture  
Organization of the  
United Nations

## **FIELD GUIDE FOR RAPID ASSESSMENT OF FOREST PROTECTIVE FUNCTION FOR SOIL AND WATER**



**A scientifically sound, cost effective  
and easy-to-apply method for collecting  
data to promote forest management  
for protection of soil and water**

## Definitions

### **Altitude**

Height above mean sea level

### **Basal area**

The area of a given unit of land occupied by the cross-section area of tree trunks and stems measured at breast height

### **Biome**

A regional ecosystem with a distinct assemblage of vegetation, animals, microbes, and physical environment often in a certain climate and soil

### **Canopy cover**

The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants; cannot exceed 100 percent (also called crown closure or crown cover)

### **Clinometer**

A surveying instrument for measuring angle of elevation or slope, or incline of a landform

### **Floor cover**

Vegetation or litter that covers the forest floor

### **Forest**

Land spanning more than 0.5 ha with trees higher than 5 m and canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*; does not include land that is predominantly under agricultural or urban land use

### **Forest cover**

Total cover of the forest area delineated by vertical projection

### **Gully**

A dry channel of 30 cm or more in both width and depth, left behind as a consequence of severe overland flow during precipitation; note that gullies are not smoothed by farm tillage, whereas rills (which are less than 30 cm in width and depth) are

### **Landform**

A specific geomorphic feature on the surface of the earth; can range from plains, plateaus and mountains to hills, valleys and alluvial fans

### **Litter**

Dead plant residue covering the forest floor

### **Parent material**

The geologic material (mineral or organic) from which soil develops

### **Plot**

An experimental unit, or a specific area in the forest established for the purpose of sampling

### **Quadrat**

A square or rectangular plot of land marked off for the study of plants and animals

### **Rill**

A dry channel of less than 30 cm in width and depth, left as a consequence of severe overland flow during precipitation; note that rills are smoothed by farm tillage, whereas gullies (which are more than 30 cm in width and depth) are not

### **Slope**

Gradient or steepness of terrain

### **Soil pillar**

Soil column capped by leaves, roots, pebbles, gravel or twigs, formed during overland flow scouring; used as an indicator of sheet erosion

### **Understorey**

An underlying layer of vegetation, especially the plants that grow beneath a forest canopy

### **Vegetation structure**

Physical arrangement of various physical and biological components of a forest

### **Vegetation type**

Vegetation in an assemblage where there is a characteristic dominant species or species, or a common aspect of the assemblage

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## INTRODUCTION

Forests have a significant role in soil and water protection. They protect soil from degradation and erosion and enhance water purity by acting as a filter. Increasing losses of life and property due to sediment-related disasters in developing countries underline the need to manage forest for the protection of soil and water. Such management involves addressing water supply, water quality, drainage, storm-water runoff, water rights, land degradation, erosion and the overall planning and use of watersheds. Forest management decisions made now will affect forests many decades into the future. Thus, it is important for managers to plan now for future disaster resilience and water security. Sustainable forest management is an important component in strategic planning for water security and sediment- and water-related disaster resilience, which is one of the prime objectives of FAO.

Reliable data on the soil and water protective function of forest will support forest managers in articulating specific soil and water related goals and objectives and incorporating them in management plans and practices for disaster resilience and water security. These data will also support awareness raising on the important protective functions of forest.

This publication presents a method for collecting reliable data on forest protective functions for soil and water. This method – the line-point transect forest cover and erosion assessment method – records forest canopy, floor cover and erosion evidence. The method was designed through an FAO study designed to identify the most scientifically valid and least expensive method for collection of these data in developing countries. The instrument used in this method, the GRS Densitometer™, is small, light and easy to carry and comparatively cost efficient.

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This guide is designed for forest inventory practitioners and researchers interested in evaluating forest protective functions. It will help to improve capacity for reporting to national inventories and national and global forest resource assessments, to support evidence-based decision- and policy-making for sustainable forest management in developing countries. The guide is complementary to the Global Forest Resources Assessment 2015 (FRA 2015), which sets out an approach for using evidence of forest resource change in national forest programmes to support sustainable forest management. Countries are invited to use the method and to adapt it, as necessary, to fit national and subnational circumstances.

### **How the data gathered using the recommended method can improve reporting on the protective function of forest for soil and water**

As the replication of sampling sites increases, it will be possible to answer the following questions with greater confidence.

- When does forest provide the protective function for soil and water?
- What forest indicator points out when forest management is necessary for the protection of soil and water?
- What is the critical topography for protection of soil and water?
- Can forest understorey cover be an indicator for the protection of soil and water? If yes, how? What percentage cover is critical under what topographic and hydrological conditions?
- What is/are the function(s) of the forest canopy for soil and water protection?
- What should be the critical level of forest canopy and ground cover for best management practices for soil and water protection?

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## HOW THE METHOD WAS DESIGNED

The method presented in this publication is the outcome of a field study carried out by FAO to identify the most scientifically valid and least expensive method for collecting data on soil and water protective function of forest in developing countries (detailed in *Testing field methods for assessing the forest protective function for soil and water*, Forest Resources Assessment Working Paper No. 185, FAO, 2015). The study compared four methods: visual forest floor cover assessment; forest canopy and floor cover assessment; line-point transect forest cover assessment; and forest floor cover biomass assessment. In collaboration with partner organizations in three pilot countries – Mexico, Nepal and Viet Nam – the methods were field tested during the summer of 2014. An international workshop with the pilot country counterparts in October 2014 then evaluated the methods for accuracy, time required, costs of gathering data and ease of use in the field.

Line-point transect forest cover assessment was ranked the best of the four methods. However, the study concluded that the method would be even more useful if it included information on soil erosion in addition to vegetation cover, and it was modified accordingly. The modified method, presented here, is recommended for use in developing countries to enhance data collection and reporting on forest protective function.

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## PREPARATION

### Site attributes

The term “site” refers here to the general location for the field test. The site should:

- be forest designated for soil and water protection;
- be covered under national forest inventory, with adequate descriptive data available including soil type, vegetation type, dominant species list and general forest structure;
- be easily accessible by those conducting the field test, e.g. close to a road and to the offices of field staff;
- be as diverse as possible, with an array of understorey densities, ideally ranging from sparse to dense forest floor cover.

### Site description

General information about the environment and forests of the survey sites is necessary in order to analyse the state of forests for the soil and water protective function. Record general information on landform, parent material, climate and vegetation on Form 1. If available, comprehensive data obtained from the national forest inventory can also be used to provide explanatory variables for evaluating the soil and water protective function.

**Landform.** Since landform affects erosion rates, record altitude, slope inclination and direction in the field. Measure altitude in metres using a GPS (geographic positioning system) receiver. Measure the downward water flow with a clinometer and use this as a reference point to establish the slope angle and slope direction.

**Parent material.** Parent material affects soil characteristics including erodibility (the susceptibility of soil to erosion).

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Refer to published data such as geological maps. Where such geological data cannot be obtained, a soil type from the site can be substituted. If a soil map has not been created for the area, soil types from the FAO Harmonized World Soil Database can be used ([www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12](http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12)).

***Climate.*** Climatic conditions are the driving forces of soil erosion. Wind erosion is a critical factor in dry countries and water erosion is severe in humid countries. Air temperature also affects the decomposition of organic material on the forest floor, which is useful for soil aggregation. Record annual precipitation, monthly average precipitation and mean annual temperature either from local weather station data or a global climate data set.

***Vegetation.*** Forest type and canopy and floor cover are key factors affecting soil and water. Of the natural factors affecting soil and water resource management, e.g. soil type, slope and climate, only vegetation can be manipulated. Thus, data on vegetation type and forest conditions are indispensable for managing forest for protective functions, and should be collected in an unbiased manner. Record the following information:

- biome: identify through reference to a local vegetation map or the world vegetation map (<http://en.wikipedia.org/wiki/File:Vegetation.png>);
- leaf type: broadleaf or needle leaf, and deciduous, evergreen or mixed;
- management: human-made/plantation or natural forest;
- basal area: measure using an angle gauge, with at least three replications.

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**FORM 1****General information on landform, climate and forest vegetation obtained from the field, weather bureau and forest inventories**

<b>Supervisor</b>	
<b>Date</b>	
<b>Landform (recorded or measured in the field)</b>	
Altitude	
Slope (°)	
Slope direction	
<b>Parent materials (from geo maps or database) or soil type (from soil map)</b>	
<b>Climate (from weather bureau)</b>	
Annual precipitation (mm)	
Monthly average precipitation (mm)	
Mean annual temperature (°C)	
Mean monthly temperature (°C)	

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<b>Vegetation (from national forest inventory)</b>	
Structure	
Composition	
Vegetation type	
Forest species	
Biome	
<b>Vegetation (recorded or measured in the field)</b>	
Leaf type	
Canopy cover	
Management type	
Basal area 1	
Basal area 2	
Basal area 3	
Average basal area	

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# Line-point transect forest cover and erosion assessment method

This method uses a GRS Densitometer™, available from Geographic Resource Solutions ([www.grsgis.com](http://www.grsgis.com)). The instrument uses a mirror to project a view of the sample location point in the canopy above to the person holding the instrument on the ground. The densitometer can be aligned to give an exact vertical line of sight up into the canopy or down to the ground. Mounted inside the viewing tube are two levelling vials. The surveyor simply sights through the unit until the vial's bubbles are both level, then records the characteristics of the feature centred on the instrument's sighting dot.

The data collection is best done by a team of three people, two persons taking the densitometer reading and the third recording the data.

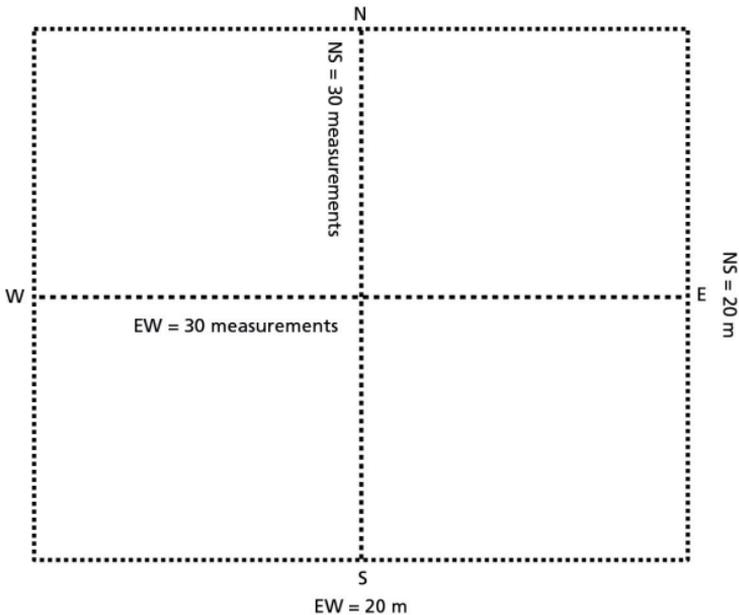
## Steps

1. Establish precision target 20 m × 20 m plots (see Figure) with two east-west and north-south imaginary orthogonal lines to ensure a uniform unbiased sampling.
2. Use the densitometer to determine the crown and floor cover of the forest, as follows. Adjust the densitometer to a horizontal position. Walk from one end of the imaginary east-west line to the other, stopping to take a canopy reading (sky or leaf/vegetation) and a ground cover reading (vegetation, roots, forest litter, stones/rocks, dead wood and bare soil) at every step. Repeat for the north-south line. Take 30 readings along each line.

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- The reader should announce the readings in a moderate voice, so as to allow the recorder to hear and transcribe the reading correctly. The recorder should make sure to fill in all the spaces in the data entry sheet (Form 2). To prevent data error, it is important to adjust the densitometer to a horizontal position for each and every reading.
  - While recording the canopy and ground cover, also record the presence of soil pillars as erosion evidence. Record the number of rills and gullies present along the lines and their width and depth. Also record the general slope of the sampling site.

**Quadrat with imaginary east-west and north-south lines along which 30 densitometer measurements each should be made**

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**FORM 2****Field data sheet for assessing forest canopy and ground cover and erosion**

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Plot No.:
Location:
Starting coordinates:
Topography (slope):
Supervisor:
Data recorder:
Vegetation type:

**Legend**

Canopy reading: L (leaf); S (sky)

Ground reading: 0 (vegetation); 1 (roots); 2 (forest litter); 3 (stones/rocks);  
4 (dead wood); 5 (bare soil)

Point	Canopy	Ground	Soil pillars
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			

Point	Canopy	Ground	Soil pillars
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			





Y. ADIKARI, FAO

*Use of the GRS Densitometer™ in the field*

### **Equipment required**

- GRS Densitometers™ (2 pieces)
- A compass (record latitude and longitude coordinates)
- Clinometer (slope of the field)
- Measuring tapes (measure width and depth of rills and gullies)
- Field data sheets, pens and pencils
- Camera (optional) and batteries

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## **DOS AND DON'TS**

- A team of three people is recommended. One person will record all the data in the field, and the other two will do the measurement.
- Do not change the team members. Developing experience in a stable team for a period of time fosters teamwork and harmony, leading to better efficiency.
- Before you leave for the field, check the list of equipment required in the field to be sure you have everything you need. Prepare all the necessary instruments so that once in the field you can start the sampling straight away.
- Choose a site as diverse as possible so that a great variety of information will be included in the data set.
- Do not go beyond a 35 or 40 degree slope, as it is dangerous to collect data on steeper slopes.
- Check that you have filled in all your data sheets before you leave the field.
- Always switch mobile phones to silent mode while at work.
- Always carry a first aid kit.

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