Forest Service

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Subject: Technical Guidance for Assessing and Monitoring Soil Quality in the Southwestern Region

To: Forest Supervisors and Staff Directors

The present direction for assessing and monitoring soil quality for National Forest System Lands at the National and Regional levels is currently undergoing review for the purpose of incorporating new science and technology. This subject was discussed at the Southwestern Region Watershed and Air workshop held April 24–27, 2012. Previous direction that was incorporated under R3 Forest Service Handbook (FSH 2509.18) will soon be migrated to a Regional supplement within FSM 2550.

However, in the interim, the definitions, procedures, and rating process for assessing and monitoring soil quality (soil condition) for the Southwestern Region will be accomplished with the enclosed technical guidance. This guidance is essential to assessing and evaluating the existing conditions of the soil resource for all Forest planning and project-level decisions. Soil quality assessment and monitoring (soil condition) is foundational to the determination of watershed condition and maintaining long-term soil productivity.

Questions regarding the technical guidance can be directed to Wayne Robbie, (505) 842-3253, or wrobbie@fs.fed.us.

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Enclosure

cc: Forest Soil Scientists

Technical Guidance for Soil Quality Monitoring in the Southwestern Region, USDA Forest Service

DEFINITIONS.

Bulk Density. The mass of dry soil per unit bulk volume. Soil Science Society of America. 1997. Glossary of soil science terms. p. 14.

Coarse Woody Material. Organic materials on the soil surface such as plant stems, branches and logs with a diameter greater than 7.6 cm (3 inches).

Litter. Organic materials on the soil surface that are at least 1.25 cm (0.5 inches) thickness. This includes needles, leaves and all woody material.

Nutrient Cycling. The ability of the soil to accept, hold and release nutrients.

Soil Condition. An evaluation of soil quality based on an interpretation of factors which affect vital soil functions.

Soil Hydrology. The ability of the soil to absorb, store, and transmit water, both vertically and horizontally. Changes in soil bulk density, soil chemistry, soil structure, soil pores and ground cover can alter soil hydrology.

Soil-loss Tolerance. The maximum rate of soil erosion at which plant productivity can be sustained indefinitely. It is dependent on the rate of soil formation and organic matter balance.

Soil Quality. The capacity of the soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality and promote plant and animal health. Doran, John W.; Parkin, Timothy B.. 1994. Defining and assessing soil quality. Defining soil quality for a sustainable environment. Soil Science Society of America, Madison, Wisconsin. Special Publication No. 35. p. 3-21.

Soil Stability. The ability of the soil to resist erosion. This is a function of both slope and inherent soil erodibility.

SOIL QUALITY STANDARDS. Soil quality standards are thresholds that indicate soil impairment. The phrase "soil condition objectives", as used throughout this supplement, is equivalent to "soil quality standards".

1. Soil Condition Evaluation. Management activities create various degrees of soil disturbance but ecologically sustainable land stewardship can minimize adverse impacts on soils. Soil condition objectives provide threshold values that indicate when changes in soil properties would result in significant change or impairment of soil condition.

Soil condition is primarily determined by evaluating surface soil properties. This is the critical area where plant and animal organic matter accumulate, begin to decompose and eventually become incorporated into soil. It is also the zone of maximum biological activity and nutrient release. The physical condition of this zone plays a significant role in soil stability, nutrient cycling, water infiltration and energy flows. The presence and distribution of the surface soil is critically important to productivity.

Soil condition objectives apply to lands where long-term soil productivity and satisfactory watershed condition are principle objectives. Management activities which may affect soil condition include timber or fuelwood harvesting, grazing, dispersed recreation and management prescribed fires.

While soil condition is an important element in determining general watershed condition, it is not intended to be a stand-alone process for evaluation of site specific conditions such as soil mass movement, stream channel health or sediment yield.

Soil condition is an evaluation of soil quality based on an interpretation of factors which affect three primary soil functions. The primary soil functions evaluated are: soil hydrology, soil stability and nutrient cycling. It is important to realize that these functions are interrelated.

a. Soil Hydrology. This function is assessed by evaluating or observing changes in surface structure, surface pore space, consistence, bulk density, infiltration or penetration resistance using appropriate methods. Increases in bulk density or decreases in porosity results in reduced water infiltration, permeability and plant available moisture.

b. Soil Stability. Erosion is the detachment, transport, and deposition of soil particles by water, wind or gravity. Vascular plants, soil biotic crusts, and litter cover are the greatest deterrent to surface soil erosion. Visual evidence of surface erosion may include rills, gullies, pedestalling, soil deposition, erosion pavement or loss of the surface "A " horizon. Erosion models are also used to predict on-site soil loss.

c. Nutrient Cycling. This function is assessed by evaluating the vegetative community composition, litter, coarse woody material, root distribution and soil biotic crusts. These indicators are directly related to soil organic matter, which is essential in sustaining long-term soil productivity. Soil organic matter provides a carbon and energy source for soil microbes and provides nutrients needed for plant growth. Soil organic matter also provides nutrient storage and capacity for cation and anion exchange.

2. Soil Condition Categories. Ecological land units are assigned a soil condition category which is an indication of the status of soil functions. Soil condition categories reflect soil disturbances resulting from both planned and unplanned events. Current management activities provide opportunities to maintain or improve soil functions that are critical in sustaining soil productivity.

Following is a brief description of each soil condition category:

a. Satisfactory - Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of soil to maintain resource values and sustain outputs is high.

b. Impaired - Indicators signify a reduction of soil function. The ability of soil to function properly has been reduced and/or there exists an increased vulnerability to degradation. An impaired category should signal land managers that there is a need to further investigate the ecosystem to determine causes and degrees of decline in soil functions. Changes in management practices or other preventative actions may be appropriate.

c. Unsatisfactory - Indicators signify that loss of soil function has occurred. Degradation of vital soil functions result in the inability of soil to maintain resource values, sustain outputs, and recover from impacts. Soils rated in the unsatisfactory category are candidates for improved management practices or restoration designed to recover soil functions.

MONITORING METHODS.

Qualitative methods are generally used to make initial evaluations of the effects of management activities on soils. The major objective of soil condition monitoring is to ensure that ecologically sustainable soil management practices are being applied. In most cases, qualitative estimates will be considered sufficient.

Measurements and detailed sampling are used to calibrate visual methods and to conduct investigations where qualitative methods are inadequate or where benchmark sampling is required for comparison purposes. Monitoring may be one-time or periodic, depending on the type or duration of the activity.

Soil Condition Evaluation Techniques.

Soil condition is evaluated by using the Soil Condition Field Evaluation Form and Rating Guide. Indicators of each soil function are assessed in order to place the soil into a soil condition category. Weighting of indicators is site specific and is based on professional experience and judgement of the watershed specialist.

Soil Condition Management Implications.

Soil condition evaluations describe existing conditions. Degradation of soil function may reflect past or current events. Management activities responsible for changes in soil condition should be identified. If necessary, corrective action should be taken to reverse unfavorable changes in soil condition.

A soil condition category of satisfactory indicates that past and current management activities have allowed the soil to function properly and retain its inherent productivity. If changes in management are planned, their effects on soil function should be evaluated.

A soil condition category of impaired indicates that past and/or current management activities have reduced the soil's ability to function properly and normally. Existing management practices need to be evaluated to determine if the current management activity is responsible for the decline in soil function. The effects of management activities on declining soil functions should be evaluated and monitored.

A soil condition category of unsatisfactory indicates that past and/or current management activities have resulted in a loss of soil function. These soils have degraded to the point that, for most ecosystems, rest alone is not likely to allow them to recover their function in a reasonable period of time. Unless intensive restoration projects are implemented, decades or centuries may be required before soil functions are fully restored.

Existing management activities need to be evaluated to determine if the current management activity is contributing to the loss of soil function. In some cases, current management activities may not have caused the loss of soil function, but may be preventing recovery of functions. Management activities that slow or prevent recovery of soil function should be avoided.

Table 1.

SOIL CONDITION FIELD EVALUATION FORM AND SOIL CONDITION RATING GUIDE

Map Symbol	State	County	Forest	District	By	Date
Watershed	Area	7 ½ Min. Quad	7 ½ Quad No.			
T. R. S. 1/4 1/4	Aerial Photo	Stop Number				
GPS File Name Latitude Longitude UTM						
Soil Taxon	Phase					
Vegetation Taxon	Climax Class	Climate Class				
Landform	Parent Material	Bedrock	Elevation			
Slope Gradient %	Length m	Aspect º	Complexity	Shape	Contour	

SURFACE SOIL DESCRIPTION

Horizon			Texture	Rock	Color	Structure	Consistence	Pores	Roots	Other
Symbol	Depth (cm)	Boundary	U.S.D.A. Texture and % clay	gr co st bd (% Vol)	p/d p/c p/m p/r	gr si sh	dr mo st pl	qu si lo	qu si lo	Accessory Properties

CANOPY COVER BY SPECIES

Trees	%	#1/	Shrubs	%	Forbs	%	Forbs	%	Graminoids	%	Graminoids	%
Total			Total				Total				Total	

SURFACE COMPONENTS 2/

Components	%
Graminoids (ba)	
Forbs (ba)	
Shrubs/trees (ba)	
Litter (>1.25 cm)	
Gravel (.2-2 cm)	
Gravel (2-7.5 cm)	
Cobble	
Stone	
Boulder	
Rock outcrop	
Bare soil	
Biotic crust	

Modeled Soil Loss	T/h/yr
Potential:	
Current:	
Natural:	
Tolerance:	

Notes:

OTHER OBSERVATIONS

Coarse woody material:	diameter
	number
Bulk density:	g/cc
Infiltration rate:	cm/hr
Penetration resistance (depth):	cm
Forage production:	lbs/ac/yr

1/ Number of regenerating trees (<5" dbh) in plot 2/ Sample area of 375 square meter circular plot

SOIL CONDITION RATING GUIDE

Function	Indicator	CONDITION CATEGORY		
		Satisfactory	**Impaired**	**Unsatisfactory**
HYDROLOGIC	Surface Structure [1]	Moderate/strong granular or single grained.	Sub-angular blocky or weak granular.	Massive or platy.
	Surface Pore Space [1]	Many/common tubular pores, high vertical continuity.	Common/few tubular pores.	Few tubular pores, low vertical continuity.
	Rupture Resistance [1]	Loose to slightly hard (dry) Loose to friable (moist).	----	Very hard to very rigid (dry), Extr. firm to very rigid (moist).
	Near Surface Subzones [1]	No surface crusting or subsurface compaction.	Water compacted or non-biotic surface crust present.	Mechanically compacted.
	Bulk Density	Bulk density not increased.	Moderate bulk density increases (5-15%).	Significant increase in bulk density (>15%).
	Infiltration	No decrease in infiltration.	Moderate decrease in infiltration. (10-50%).	Significant decrease in infiltration (>50%).
	Penetration Resistance	No increase in resistance.	Moderate increase in resistance (10-50%).	Significant increase in resistance (>50%).
STABILITY	Modeled Soil Loss	Current soil loss < tolerance.		Current soil loss > tolerance.
	Visible Sheet Rill & Gully Erosion	Sheets/rills/gullies not evident.	Rills/gullies are small, discontinuous, poorly defined & not connected into any pattern.	Rills/gullies actively expanding, well-defined, continuous & connected into a definite pattern.
	Pedestaling	No/slight pedestaling of plant, litter and rocks. No evidence of exposed roots.	Grasses, forbs and rock fragments are pedestaled. Small, fibrous root strands of forbs & grasses are exposed on the soil surface.	Trees and shrubs are pedestaled and may be hummocked. Shallow, lateral roots of trees and shrubs are exposed.
	Erosion Pavement [2]	None to slight. If erosion pavement exists it is discontinuous or localized.	-----	Erosion pavement is continuous or exists in interspaces between canopy cover of trees & shrubs.
	Soil Deposition	Not unusual or excessive.	Soil and/or litter deposition is present. Fine litter may be patterned as small debris accumulations.	Soil and/or litter is deposited on the uphill side of logs, brushpiles, etc. Soil may be moving offsite.
	Surface ("A") Horizon	"A" horizon is present, well distributed, not fragmented.	"A" horizon is present, but not evenly distributed. Changes in physical properties exist.	"A" horizon is absent or present in association with prominent plants. Properties are similar to those of the underlying subsoil.
NUTRIENT CYCLING	Vegetative Community Composition	Distribution of desirable, perennial plants reflects species by vegetative layer (i.e. trees, shrubs, forbs and graminoids) as identified in the potential plant community.	Changes in vegetation composition indicate a shift towards a drier, less productive plant community. There may also be an increase in annual plants, shallow-rooted grasses, taprooted woody perennials or invasive plants.	The perennial forb and/or graminoid vegetative layers are absent or sparse.
	Litter	Litter is distributed evenly across the soil surface and is associated with all vegetative layers.	-----	Litter is either absent or is associated only with prominent plants and not evenly distributed across the soil surface.
	Coarse Woody Material	Pipos/Quga-----5-10 t/ac. Pipos/Fear2-----7-14 t/ac. Abco/Fear2-----8-16 t/ac.	-----	Pipos/Quga-----<5 t/ac. Pipos/Fear2-----<7 t/ac. A bco/Fear2-----<8 t/ac.
	Root Distribution[1]	Many/common roots in surface horizons.	Moderately few roots in surface horizons.	Few/very few roots in surface horizons.

1/ Categories and/or descriptions defined in USDA Handbook No. 18, Soil Survey Manual, October, 1993.
2/ Certain soils within desert ecosystems inherently contain erosion pavement (desert pavement) surfaces. Desert pavements are not used to indicate soil condition.