October 2024

Soil Health
Technical Note No. 470-08

Forestland In-Field Soil Health Assessment (FIFSHA) Guide

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family or parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at How to File a Program Discrimination Complaint and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by mail to U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, DC 20250-9410; by fax to (202) 690-7442; or by email to program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.

Acknowledgments

Cover Photos:

Tom Sauer, ACES.

Other Photo Credits:

Figure 1: U. S. Department of Agriculture, Forest Service.

Figure 2: U. S. Department of Agriculture, Natural Resources Conservation Service.

Figures 3-7: Tom Sauer, ACES.

Figure 8: U. S. Department of Agriculture, Forest Service.

Figure 9 a & b: Tom Sauer, ACES c: Dennis Landwehr, U. S. Department of Agriculture, Forest Service, retired.

Figure 10: Tom Sauer, ACES.

Figure 11: U. S. Department of Interior, Bureau of Land Management.

Figure 12 & 13: Tom Sauer, ACES.

Contributions:

Early versions of the FIFSHA were developed by Laura Starr and Joe Williams of the Soil Health Division (SHD). NRCS field staff tested and provided feedback during pilot testing of the tool. Loretta Metz, Candiss Williams, Candy Thomas, and others with the SHD and Ecological Sciences Division (ESD) provided valuable suggestions for improvement of the tool and this technical note.

Citation:

USDA-NRCS. Soil Health Division. 2024. Forestland In-Field Soil Health Assessment (FIFSHA) Guide. Soil Health Division Tech. Note No. 470-08.

Table of Contents

Introduction

The Forestland In-Field Soil Health Assessment (FIFSHA) was developed by the Soil Health Division to assist NRCS planners with evaluating the health of private non-industrial forestland soils. Soil health is defined by NRCS as "The continued capacity of the soil to function as a vital living ecosystem that sustains plants, animals and humans". Soil health is maintained or achieved through application of four principles which are: 1) maximize presence of living roots, 2) minimize disturbance, 3) maximize soil cover, and 4) maximize biodiversity.

Historically, most attention on forest soils has focused on relationships between soil properties and forest productivity or health, often through interpretations of site quality (Carmean, 1975; O'Neill et al., 2005b; Amacher et al., 2007; Page-Dumroese et al., 2021a). Soil properties were often considered as one element of forest site quality or site index (Carmean, et al., 1989; Morris and Campbell 1991), primarily from the perspective of their effect on tree growth and timber production. The FIFSHA is intended to complement silvicultural and forest inventory activities by identifying potential soil health resource concerns (RCs) while contributing more detail on the soil component of site quality.

The FIFSHA is designed to be broadly applicable and readily adaptable to local conditions and practices. It uses eight indicators (Soil Cover, Woody Debris, Soil Burn Severity, Soil Disturbance Intensity, Soil Structure, Water Stable Aggregates, Soil Fauna/Biological Diversity, and Roots) to establish whether a site has any of four potential soil health RCs. Those RCs are: AGG - Aggregate Instability, CPT - Compaction, HAB - Soil Organism Habitat Loss or Degradation, and SOM - Soil Organic Matter Depletion). Basic soil information and site details are also collected before or during the assessment including information on site management history (Appendix 1, page 26).

For each indicator, a description is provided to aid in assigning one of three ratings at the site: 1) **Meets Assessment and CART Criteria**, 2) **Potential Resource Concern for Assessment and CART**, or 3) **Does Not Meet Assessment or CART Criteria**. Soil health RCs related to each indicator are identified and the scores for the indicators are summed and given unique preference to identify whether each RC **Meets** or **Does Not Meet** the CART (Conservation Assessment and Ranking Tool) threshold, and whether any conservation practices should be considered. A table of common conservation practices for forestlands is provided in Appendix 2 and indexed to the four soil health RCs to assist with the selection of potential conservation practices to address the identified soil health RC.

Development of the FIFSHA relied heavily on previous efforts on forest soil quality and soil health primarily by the U.S. Forest Service (Powers et al., 1998; O'Neill et al., 2005a, 2005b; Page-Dumroese et al., 2009ab, 2021b). These authors acknowledged the challenge of developing a soil health assessment for national forests with their wide variation in climate, soils, topography, tree species, and land use histories. Their goal was a system that was "operationally practicable and open to continuous revision" which may need to rely on "best professional judgement" (Powers et al., 1998). These efforts were focused on national forests, which often have different characteristics, management objectives, and silvicultural practices than private non-industrial forests (Butler et al., 2016). Development of the FIFSHA, therefore, involved modifying selected principles of soil quality and soil health developed primarily for national forest lands for application to private non-industrial forestlands that are assessed by NRCS planners.

Where to Apply the Forestland In-Field Soil Health Assessment (FIFSHA)

The goal of a Forestland In-Field Soil Health Assessment (FIFSHA) assessment is to identify soil health resource concerns (RCs) on private non-industrial forestland agroecosystems. One of the challenges of developing this assessment tool is the great diversity of site conditions, stand types, and management practices of private non-industrial forestlands in the U.S and affiliated territories (Oswalt et al., 2019; Perry et al., 2022). Feedback from extensive pilot testing was used to ensure that the FIFSHA is both informative and broadly applicable, although it is acknowledged that some local adjustments may be necessary to achieve optimal results with the tool.

The choice of where to make assessments will depend on multiple factors including the size of the stand, field, or Conservation Management Unit (CMU), the uniformity of soil characteristics, site disturbance history, variation in stand characteristics, and landowner objectives. Any assessment should be made at the stand level with sampling at rates appropriate for the stand size. An assessment site should be clear of any anomalous features and visually representative of the surrounding area. How large of an area to consider and the number of sites selected for an assessment will be affected by site conditions, i.e. whether there is clear line of sight that is not obstructed by understory or forest floor vegetation or low branches. In a forest plantation, the assessment area may be the alley between adjacent rows, or it could extend to additional alleys. The area under assessment may also be considered in terms of the spatial scale of potential conservation practices likely to be applied. For forest inventories of uniform stands, the percentage of the area to be sampled ranges from 20% for 20 to 40 acres and 5% for areas larger than 80 acres (Natural Resources Conservation Service, 2004). If each FIFSHA assessment focuses on a circular area 52.6 ft in diameter (1/20 of an acre) and is representative of an area of 1/2 to 2 acres, 4 to 16 sites would need to be assessed on a uniform 40-acre stand to sample at a density comparable to forest inventories.

Plantation forests are likely to be more accessible than many natural forests and more likely to have a known site history. The regular tree spacing and some accommodation for equipment travel may also facilitate implementation of conservation practices. Natural forests are likely to be more challenging for soil health assessment due to variation in site conditions and variability in forest stand characteristics. Nonetheless, terrain (slope and aspect) and elevation (especially in mountainous regions) are likely to create distinct stand characteristics that present discrete areas for assessment of soil health.

Another strategy involves recognizing areas that are or may be prone to soil degradation and targeting them for soil health assessment. Forest roads, skid trails (for dragging logs), and landings (areas where logs are processed for transport) are areas dedicated to the movement of harvested timber and woody material and the equipment used during harvest and other operations (thinning, pest control, fire suppression, etc.). These areas may be subject to compaction and rutting from heavy equipment traffic and loss of cover from processing and loading of woody material. Poorly constructed or maintained roads and trails can also contribute to higher rates of erosion and water quality concerns. Some forests are grazed and compaction from livestock trailing may occur along trails, near water sources, and in supplemental feeding areas. In these cases, targeting representative areas may mean targeting areas that may not be representative of a forest stand in its entirety but are representative of areas of specialized use or impact.

Page-Dumroese et al. (2009ab) describe a protocol for rapid assessment of disturbance of forest soils that includes recommendations for sampling transects that may be useful for application of the FIFSHA. Two of these options that may be appropriate for the FIFSHA are: 1) randomly oriented transects that are selected prior to visiting the site and 2) systematic grid points (Figure 1). The greater the number of sites that are assessed improves the accuracy of the assessment, but the number of sites to be assessed must be balanced against the required time commitment. The distance between assessment sites on a transect or the number of transects can be adjusted as needed to meet the assessment goals.

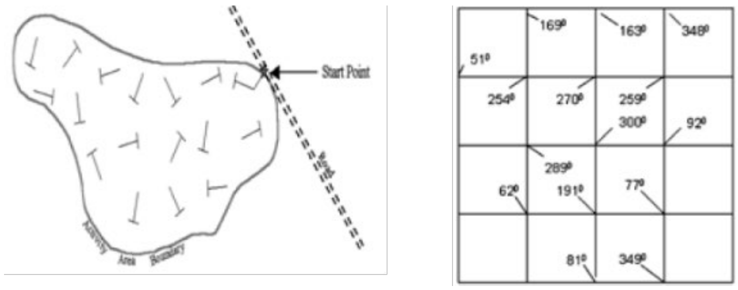

Figure 1. Examples of possible sampling strategies for forest soil disturbance proposed by Page-Dumroese et al. (2009a) that could be used for FIFSHA site selection. Randomly oriented transects (left) and systematic grid points (right).

A preferred option for FIFSHA site selection would be to incorporate the soil health assessment into forest stand inventory procedures as described in the National Forestry Handbook (Natural Resources Conservation Service, 2004). The handbook is currently under revision and the new version will recommend three sampling strategies: 1) strip sampling, 2) fixed plot sampling, and 3) variable plot or point sampling (Figure 2). Each of the sampling techniques has recommendations for the number of trees or plots to include in the inventory and suggested adjustments for plantation forests. One advantage of conducting FIFSHA assessments as part of the stand inventory would be to obtain both soil health and stand characteristic information at the same sites and at the same time. Soil health assessments could be included concurrent with forest inventories on a proportion of inventory sites or selected sites considered representative of sections of the stand.

The sampling strategies from Figures 1 and 2 are examples of sampling strategies taken from other inventory procedures. The number and location of FIFSHA assessment locations may fit some modified form of one of these examples or may be determined based on local experience and knowledge.

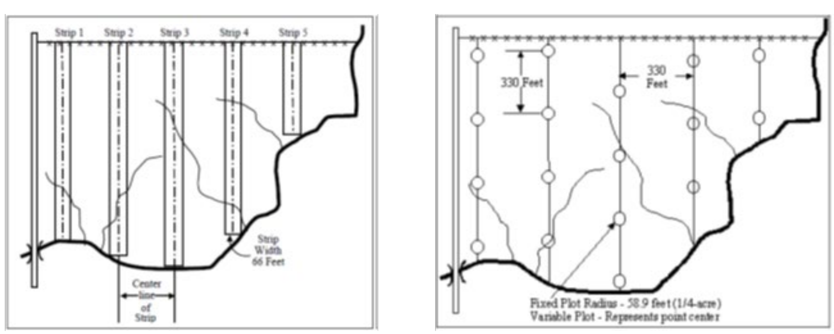

Figure 2. Examples of strip sampling (left) and fixed and variable plot sampling (right) forest inventory sampling techniques (Natural Resources Conservation Service, 2004).

When to Apply the FIFSHA

Ratings of some soil health indicators in the FIFSHA will not change significantly over a growing season, while others, especially Soil Fauna/Biological Diversity and Soil Cover, may change appreciably. Hot, dry weather in the summer may inhibit biological activity near the surface as soil fauna seek cooler temperatures and more moist soil deeper in the profile. For deciduous forests, leaf drop in the fall will provide a fresh layer of litter to the forest floor that may largely be absent by the following summer. Ratings for most indicators will change following disturbances such as planting, thinning, harvest, or prescribed burning treatment. Weather events or disease or insect outbreaks may result in significant increases in woody debris, which may present a higher risk of an intense wildfire on the forest floor.

A strategic approach to application of the FIFSHA should be used, when possible, to identify and address RCs at critical periods in the forest growth cycle or following disturbance events. However, a soil health assessment may not always be achievable at the optimal period to capture important changes in soil health indicators. Another application of the FIFSHA would be following the application of conservation practices to determine whether those practices have alleviated the targeted RCs or if additional practice implementation is needed.

How to Complete the FIFSHA

Appendix 1 contains brief instructions and worksheets for the FIFSHA that are intended to be taken to the field for completion of a forest soil health assessment. Prior to proceeding to the field, background information on the field or CMU to be assessed should be collected and reviewed. Details of the soil series, their slope, and the aspect and elevation (i.e. the topography) of the area will assist in site selection. An ecological site description (ESD) if available, or official series description (OSD) of the relevant soil series will provide greater detail on the reference state, which would supplement the **Meets Assessment and CART Criteria** rating descriptions for each indicator. Discussion with the landowner should take place to provide important information on the site history, their management objectives, and any recent site disturbances (e.g., harvest, pruning, grazing, etc.). In addition to the FIFSHA worksheets, maps for the fields or CMUs to be assessed, a shovel or spade, and a tape measure should be taken into the field. A GPS unit and digital camera are recommended to record assessment site locations and create images to document the assessment results for later reference.

A brief overview of the assessment procedure is presented here with greater detail provided below for interpreting each indicator.

Indicators Assessed Visually on Forest Floor

The first four FIFSHA indicators can be assessed by rotating 360º and scoring the RCs based on visual observation of conditions of the forest floor within a 1/20th acre plot area (26.3 ft.-radius). If there is significant variation in the observations within the assessment area, completing assessments on multiple sites may be necessary. Scores for RCs associated with the Soil Cover, Woody Debris, Soil Burn Severity, and Soil Disturbance Intensity indicators are assigned based on the indicator descriptions for the **Meets Assessment and CART Criteria**, **Potential Resource Concern for Assessment and CART**, **Does Not Meet Assessment or CART Criteria** classes on the worksheets. Visually assess the amount of soil cover and prevalence of woody debris. Look for evidence of damage to the forest floor from fire (loss of litter or presence of ash) and for tracks or rutting from equipment of animal trailing. Record notes on the FIFSHA form to document observations or provide additional detail on the observations. If photos are taken, denote the photo file name/number in the notes area on the FIFSHA.

Some Examples

Figure 3 shows a photo of a pine plantation (left) and a natural broadleaf stand (right). Both photos were taken in the spring. The pine plantation had recent mechanical brush control leaving shredded wood from mastication of invasive shrubs on the forest floor along with some fallen branches, and pine needles. The broadleaf site also had near complete soil cover by a thick leaf litter layer and a large amount of coarse woody debris (CWD) that, although common in a natural forest setting, may be approaching amounts that could be a wildfire hazard concern. Neither site has evidence of fire damage. Although there had been mechanical brush control in the pine plantation, there were no visible wheel tracks or ruts. The broadleaf site also had no evidence of recent physical disturbance. There is no understory or low branches to obscure observation of the forest floor in the 52.6 ft-diameter assessment area.

These examples illustrate sites where visual assessment of the forest floor is not obstructed and there are no readily apparent significant RCs relating to the Soil Cover, Woody Debris, Soil Burn Severity, and Soil Disturbance Intensity indicators.

Figure 3. Photo of pine plantation (left) and natural broadleaf stand (right).

The sites shown in Figure 3 are examples of sites that should be relatively straightforward to assess the visual indicators of forest floor condition. Figure 4 shows a more challenging case of a broadleaf forest several months after a prescribed burn treatment. The photos were taken in summer. It is difficult to visually

Figure 4. Photo of hardwood forest several months after a prescribed burn (left) and a closeup of the soil surface (right).

assess the forest floor over a 52.6 ft.-diameter area due to the presence of burned brambles and herbaceous vegetation. For these types of sites, planners may need to walk in a small circle to gain a better view of the surface conditions and brush aside the litter (Figure 4, right) at multiple sites to observe the surface conditions. In this example, the prescribed fire consumed some of the litter but there is still good ground cover from recent leaf drop and regrowth of herbaceous vegetation. Some CWD is charred but was not consumed by the prescribed fire. There is no evidence of disturbance by equipment traffic or animal treading.

Indicators Assessed from Exposed Soil

The remaining indicators, Soil Structure, Water Stable Aggregates, Soil Fauna/Biological Diversity, and Roots are assessed by removing or exposing some of the surface soil. Identify 1 to 3 points within the 26.3 ft.-diameter assessment area. Push a shovel or spade straight downward into the ground (Figure 5a). Note how difficult it is to insert the shovel as this may indicate the degree of soil compaction. A heavy textured soil is generally going to offer more resistance than most other soils, especially when dry. Try to push the shovel or spade all the way into a depth of 10 or more inches. Repeat three more times in a square pattern and then remove the block of soil (Figure 5b).

Note the thickness of the litter layer on the block of soil and on the sidewalls of the excavation (Figure 5c). The litter layer may consist of fresh needles on the surface and grade to fine, dark, nearly fully decomposed duff on the mineral soil surface. Litter layers can also be described as “mull” or “mor” types, with mull types exhibiting a mixing of the organic and mineral layers and mor types typically found beneath pine forests that are acidic, matted layers with an abrupt boundary with the mineral soil.

Check for a compacted surface layer and determine the soil structure (Schoeneberger et al., 2012). Granular or subangular blocky structure is generally the preferred structure. Platy or massive soil structure is indicative of poor structure and/or compaction. Look for evidence of ponding nearby (no vegetation or moisture-indicating plants), especially in areas where you wouldn’t expect water to pond as low infiltration may indicate impaired structure or surface sealing. In a well-structured soil, one wouldn’t expect small depressions to show signs of standing water for long periods.

If the soil is dry, conduct a soil stability bottle cap test or wet aggregate stability (“sink strainer”) test on 2 to 4 soil aggregates taken from different depths of the exposed soil block. Alternatively, if the soil is moist, transport intact soil aggregates to the office/lab and allow to air dry before completing an aggregate stability test.

When breaking apart the soil to determine soil structure, observe any soil fauna and the amount and distribution of live roots. Note any dead or diseased roots. Additional soil fauna may be found in the litter layer or beneath CWD. Look for other evidence of faunal activity such as earthworm midden piles, biopores and ant burrows.

Repeat the same procedure for additional points within the 26.3 ft.-diameter assessment area, documenting any variation in the observed indicators. Variation in observations should not be considered “error” but rather capturing the range of properties within the assessment area. Experience will help determine the optimal number of sampling points within the assessment area as more sampling points are warranted when there is a larger range of indicator ratings.

Figure 5. Photo of shovel in soil in a pine planting (a), the soil removed (b) and a closeup of the litter layer and roots in the soil (c).

FIFSHA Indicators

Each of the eight FIFSHA indicators are presented in detail below with a description of their relevance to soil health, details regarding their assessment, and a list of potential Conservation Practice Standards for use on forestlands to address the identified RCs (Appendix 2). Note that the discussion and interpretations are intentionally general. A comprehensive treatment of details specific to forest types, local forestry practices, or soil characteristics is not practical and "best professional judgement" may need to be applied with practice for local conditions. State guidance may also influence both the interpretation of indicators and the selection of appropriate conservation practices to address the soil health RCs identified.

As the tree canopy, understory, and ground vegetation are routinely evaluated during forest inventories, the FIFSHA focuses on the forest floor (branches, twigs, leaf litter, and unincorporated humus or duff) and the soil beneath it. Nonetheless, observation of stand characteristics including species, tree age, stand density, and vigor may influence overall interpretation on the soil health indicators in terms of relating forest health to soil health.

Soil Cover

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Cover	Mineral soil surface is > 75% covered by leaf litter, O horizon, woody debris, moss, or exposed stones/rocks.	Soil is < 75% but > 50% covered; **Or**, evidence of seasonal soil cover > 50% such as insect midden piles, leaf fragments, or litter displacement; **Or**, > 50% cover of slash from harvest or thinnings on ground but not well distributed.	Soil is <50% covered; Or, less than 75% cover on slopes greater than 25%; Or, loss of litter layer and O horizon (organic surface layer) from > 15% of area.	**AGG CPT HAB SOM**	

<u>Importance</u>: Soil cover has multiple benefits for soil health including providing a repository of organic inputs from the woody and herbaceous vegetation, habitat for burrowing soil organisms, protection of the mineral soil surface from raindrop impact to prevent or reduce soil detachment and movement, and moderating soil temperature and moisture extremes. A thick litter layer also helps absorb some of the loads from vehicle traffic and animal treading, reducing soil compaction.

Ideally, the woody and herbaceous vegetative cover is provided by native or desirable species, however, invasive or undesirable species are prevalent in many forest ecosystems. While invasive and undesirable woody and herbaceous vegetation often have known negative impacts on forest health, the negative impacts on soil health may not be as direct. For example, invasive woody understory species may reduce ground cover by shading out herbaceous species, through allelopathic effects, or by producing leaf litter with properties that result in it being quickly decomposed. A holistic perspective of balancing soil health with overall forest health is warranted.

The biotic and abiotic effects of the litter layer are integral to maintaining vigorous faunal activity that contribute to litter incorporation and the mixing of organic and mineral constituents of the soil. Decomposition of organic inputs and incorporation of residues into the soil helps sustain and build soil organic matter (SOM). Biopores created by soil fauna enhance water and air exchange at the soil surface and within surface soil layers.

Unlike most crop fields, the forest litter layer represents the net balance of years of accumulation and decomposition with new and fresh litter on the surface grading to older, finer, and more decomposed material near the mineral soil interface. Another important difference is that some forest soils may have exposed bedrock and stones or moss cover that provide stable surface conditions.

Assessment: Ratings of RCs for the Soil Cover indicator, as for the Cropland In-Field Soil Health Assessment (CIFSHA), are based on visual estimation of the percent cover of the mineral soil surface. The assessment of soil cover can be made by rotating 360º or walking in a small circle to obtain clear view of the exposed forest floor in the 26.3 ft.-diameter assessment area. Soil cover is beneficial for soil health in all situations however, the percent coverage and depth of the litter indicative of a healthy soil will vary with forest type and climate; this is where referring to the ecological site description (if available) may be helpful. Maintaining protective soil cover on steep slopes is important but made more difficult due to litter transport downslope by wind or surface runoff. Litter layer thickness can be recorded as a useful measure of the quality of the litter layer in terms of its protective ability and to enable comparison with future assessments.

Figure 6 shows examples of different amounts of broadleaf and pine litter cover. Soil cover may not be uniform, especially in areas with appreciable slope and movement by water or wind may result in accumulation of litter on downed trees and limbs, exposed bedrock or stones, and roots.

Figure 6. Examples of forest soil cover: broadleaf cover of near 100% (a), broadleaf litter and moss < 50% cover (b), pine litter of 100% cover (c), and pine litter of ~75% cover (d).

NRCS Conservation Practice Standards to Address RCs: Practice Codes 314, 383, 384, 484, 528, 612, & 666.

Woody Debris

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Woody Debris	Downed trees and limbs and stumps well distributed and in various states of decomposition.	Some woody debris of similar age or poorly distributed accumulations of debris from machine or water disturbance.	Woody debris largely absent or large accumulations of concentrated debris from machine, storm, insect, disease or water disturbance.	AGG HAB SOM	

<u>Importance</u>: Another component of the forest floor is the coarse woody debris (CWD) or down woody material (DWM). In a natural, uneven-aged forest, broken or sloughed limbs and fallen trees at varying stages of decomposition may be found lying on the forest floor. In plantation forests, there may be CWD from pre-commercial thinning, pruning, or slash from thinning or recent harvests lying on the forest floor. Large slash piles are often burned or, if left to decompose, provide less benefit to soil health as more evenly distributed CWD. Disease, insect outbreaks, fire and other occurrences may result in standing dead trees (snags) and high winds produce windthrows that may result in large amounts of CWD on the forest floor.

CWD is another source of organic inputs for decomposition and potential incorporation into SOM, provides habitat for wildlife and soil fauna, and may help reduce litter movement, especially on slopes. Slash can be used in high traffic areas such as skid trails and landings to reduce compaction or rutting by heavy equipment.

Like Soil Cover, Woody Debris is a "Goldilocks" indicator in that having too much or too little woody debris may lead to soil health RCs. Too much litter or woody debris, especially if dry, represents a wildfire hazard and the risk of an intense fire that consumes the forest floor and damages the surface soil layer. Too little litter or woody debris leaves the soil surface vulnerable to erosion and exposed to extremes in temperature and moisture content that are less desirable for soil biological activity.

<u>Assessment</u>: The Woody Debris indicator can be assessed as for the Soil Cover indicator by rotating 360º or walking in a small circle to obtain clear view of the exposed forest floor within the 26.3 ft.-diameter assessment area. There is an interplay between the two indicators in that a site with good soil cover but without significant CWD may not necessarily lead to a significant soil health RC. The opposite condition

Figure 7. Examples of coarse woody debris (CWD): very limited CWD in a pine plantation (a), distributed, moderate amounts of pine CWD (b), and slash from pine harvest, poorly distributed (c).

(moderate amount of well-distributed CWD but low Soil Cover) may not be as desirable but also may not justify a **Does Not Meet** Resource Concern rating. Figure 7 shows examples of different amounts and distribution of CWD in pine plantations.

NRCS Conservation Practice Standards to Address RCs: 314, 338, 384, 561, 654, 655, 660, & 666.

Soil Burn Severity

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Burn Severity	Forest floor (litter layer and O horizon) may be charred but are intact.	Forest floor is partially consumed; some black ash present; mineral soil is not visibly altered; some water repellency at or below soil surface.	Forest floor is largely consumed; white ash present; mineral soil is exposed; fine roots absent in surface soil; strong water repellency; parts of exposed soil are orange.	AGG HAB SOM	

<u>Importance</u>: Wildfires, especially if intense (hot and for long residence time), can cause serious soil health RCs due to the loss of soil cover, physical and chemical damage to the surface mineral soil layer, and destruction of soil biota (Agbeshie et al., 2022). Intense fire can kill plant roots and microorganisms, consume SOM, destroy soil structure, and even fuse soil clays.

Prescribed burning is a specialized conservation practice that uses carefully controlled, lower intensity burning to manage undesirable vegetation like invasive brush, reduce risks associated with wildfire (i.e. fuel reduction), improve terrestrial habitat for wildlife and pollinators, and improve plant and seed production. Prescribed burning can be used to enhance forage productivity and the distribution of grazing livestock and browsing wildlife. Low intensity fire, when used as a conservation tool, can improve soil health by enhancing productivity of the forest understory, which will increase organic inputs to the forest floor and support larger and more diverse soil biota communities. Reducing fuel loads under controlled burning also reduces the risk of a large, catastrophic wildfire that can severely damage the forest resource and soil health.

<u>Assessment</u>: Rating of the RCs under the Soil Burn Severity indicator will be aided by knowledge of the fire history of the site, but an assessment is still necessary to document any fire effects. The same procedure used for the Soil Cover and Woody Residue indicators can be used to observe charring of the forest floor, presence of ash, and whether excessive amounts of mineral soil are exposed within the assessment area. Water repellency can be assessed by adding water to the mineral soil surface and observing whether any beading occurs or if the water infiltrates readily. When available, a reference, unburned site would be helpful to compare with the site(s) under assessment as pre-fire conditions may be difficult to determine. Parsons et al. (2010) provides a detailed, comprehensive field guide for assessing post-wildfire soil burn severity. Figure 8 shows examples of different levels of soil burn severity.

The FIFSHA is not intended to penalize for any short-term effects of prescribed burning like the loss of some soil cover. It should be assumed that any such short-term detrimental effects of prescribed burning will be more than offset by the long-term improvement in overall forest health and conditions of the forest floor.

Figure 8. Examples of low burn severity with charred needles that are still intact (a), moderate burn severity with majority of litter consumed (b), and high burn severity with thick ash layer and oxidized soil (c). Photo credits: Parsons et al., 2010.

NRCS Conservation Practice Standards to Address RCs: 342, 484, & 612.

Soil Disturbance Intensity

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Disturbance Intensity	Site is stable without visible signs of significant disturbance or active erosion (excluding established roads and trails).	Dispersed, faint wheel tracks/ ruts less than 4 inches deep, and/or evidence of some soil displacement (sheet or rill erosion, sediment movement, topsoil/subsoil mixing).	Highly visible wheel tracks/ruts greater than 4 inches deep, and/or significant soil displacement (rill or gully erosion, sediment movement, topsoil/subsoil mixing).	**AGG CPT**	

Importance: Where cropping systems routinely have multiple field operations each growing season, equipment traffic in forest systems is generally much less frequent but can cause significant disturbance with potentially long-term impacts. Heavy equipment operations on steep slopes or on wet soils can reduce soil cover and cause severe rutting and compaction. Significant advancements in tree harvest machinery to improve load distribution and optimized harvest strategies to avoid wet soils (e.g., harvest when soils are dry enough or completely frozen) and better slash distribution can greatly reduce the impacts of forest operations on soil health. Skid trails, landings, and roads are high-traffic areas that, if not well-designed and maintained, can become areas of severe soil degradation with significant soil health RCs.

Assessment: Like the Soil Burn Severity indicator, details of the site history will help inform assessment of the Soil Disturbance Intensity indicator. However, even if the disturbance history is known, evaluation of the soil health effects is still necessary. Wheel tracks and ruts are areas of potentially severe compaction, where soil structure and aggregation have likely been impacted.

Unlike some indicators, assessment of the Soil Disturbance Intensity indicator may focus primarily on areas of vehicle/equipment traffic (Figure 9) although even aerial harvesting may result in disturbance due to dragging of felled trees across the soil surface. Targeting of these areas that have been impacted by disturbance may be needed for evaluation of the Soil Disturbance Intensity indicator. For these areas, the recommended 26.3 ft.-diameter area with 1 to 3 soil excavations may not be appropriate. Instead, as many of these disturbance features are linear (i.e. tracks or trails), the FIFSHA assessment could be conducted on a 26.3 ft. length of the track or trail with 1 to 3 soil excavations. Multiple assessments may be necessary for long tracks/trails or those that cross different soils or landscape positions.

Figure 9. Examples of low disturbance intensity with faint tracks following mastication of invasive understory woody species with a tracked skid steer (a), moderate disturbance intensity of shallow wheel tracks (b), and deep ruts from harvest equipment indicating severe disturbance (c).

NRCS Conservation Practice Standards to Address RCs: 384, 472, 484, 560, 561, 654, & 655.

Soil Structure

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Structure [1/]	Strong granular or subangular blocky or as expected for site; resistance to probe or spade similar to natural condition.	Weak platy or massive structure and/or increased resistance to probe or spade to 10 cm; evidence of ponding; some visual evidence of mechanical and/or animal traffic.	Strong platy or massive structure and increased resistance to probe or spade to 30 cm; widespread evidence of ponding; clear visual evidence of compaction from mechanical and/or animal traffic.	AGG CPT	

[1/] **Soil Structure Indicator note:** If the soil survey confirms a natural platy structure anywhere within the upper 30cm (12in), and there is no other indication of human-induced compaction, please enter a FIFSHA Score of 5 for this indicator.

Importance: Soil structure types are based on the shape of the aggregates or peds that are composed of individual soil particles and how strongly they are held together. Soils are typically ~50% pore space and the size and connectivity of those pores affect the transport of water and air and the ease of root extension and soil fauna movement. Exudates from roots coat the surfaces of the soil particles and aggregates creating ideal habitat for soil microbes with access to partially decomposed plant tissues and fecal materials from soil fauna. Soils with strong structure will drain more readily when wet, avoiding long periods of anaerobic conditions detrimental to many soil organisms and plant roots.

Sandy soils can have weak structure or can even be structureless, i.e. single grained. Soil particles may not cohere to each other at all, which most often occurs in sandy soils with little SOM. At the other extreme, soil particles can be compressed so tightly that there is no definite arrangement of particles or natural lines of weakness, a condition referred to as massive. Platy soil structure can be natural but can also be associated with compaction. Consulting the OSD will help determine whether platy structure is natural for the soil series under consideration. Compacted soils can be so dense as to retard or completely prevent root penetration, limiting the soil volume available for plant uptake of water and nutrients.

Assessment: Push a shovel or spade straight downward into the ground (Figure 5a) at 1 to 3 points within the 26.3 ft.-diameter assessment area used for the previous indicators. Note how difficult it is to insert the shovel or spade with depth until it is fully inserted (10 or more inches), or a point of refusal is reached. Repeat three more times making a square pattern and then remove each block of soil (Figure 5b). A heavy textured or dry soil is generally going to offer more resistance than a medium or coarse textured or a wet soil. Break off some of the soil from the surface and from deeper in the excavated block to observe the soil structure (Schoeneberger et al., 2012). Soil structure should be granular or subangular blocky, especially near the surface (Figure 10). Structure grading from weak to strong platy or to massive, especially if associated with mechanical traffic or animal treading is indicative of a **Potential** or **Does Not Meet** RC for AGG, CPT or both.

Measurement of soil penetration resistance with a portable penetrometer may provide another indicator of soil structure and density, as it relates to potential root elongation. Readings of 2 MPa (290 psi) or above indicate likely restriction of root growth while root growth is likely to cease at values above 3 MPa (435 psi) (Sinnett et al., 2008). Note that penetrometer measurements should be made in wet soil. The utility of penetrometer measurements in forest soils may be limited by the presence of many and/or large stones and large tree roots that obstruct the penetrometer probe. The readings also only assess vertical resistance while tree roots grow in all directions.

Figure 10. Granular soil structure (a), subangular blocky soil structure (b), and weak platy structure (c). All photos are of soil taken from the A horizon of a hardwood forest soil.

NRCS Conservation Practice Standards to Address RCs: 327, 484, 561, 654, & 655.

Water Stable Aggregates

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Water Stable Aggregates	Unless single grained, soil aggregates are stable and don't disintegrate when submerged in water.	Unless single grained, soil aggregates begin to partially disintegrate when submerged in water.	Unless single grained, soil aggregates completely disintegrate after submersion in water.	AGG CPT HAB SOM	

Importance: Soil aggregates are formed from soil particles that adhere more strongly to each other than to any surrounding particles. Soil aggregates are held together by substances derived from microbial activity and root exudates. Aggregates should be distinct in undisturbed soil, separating cleanly when a large sample is broken apart. Soils with strong aggregate stability are more able to retain their structure and maintain water and air flow when wet and resist soil loss by wind erosion under dry conditions.

While soil structure is a classification based on the shape of the soil aggregates that is affected by soil forming processes, texture, and management, aggregate stability is a measure of how soil aggregates resist crumbling or disintegrating. Coarse-textured soils, e.g. loamy sands, may not have stable aggregates due to the lack of significant clay content to help bind particles together and the naturally low SOM content of these soils. The stability of soil aggregates is a key indicator of soil physical health with links to soil biological health as it is primarily organic substances from microbes and roots that helps adhere soil particles together. Soils with stable aggregates are better able to support soil biological function and lead to SOM accumulation. Soils with higher clay content are likely to have more stable soil aggregates than coarse textured soils, which naturally have weaker aggregation.

Assessment: Collect 2 to 4 soil aggregates from different depths of the exposed soil to capture the variation in aggregation. Three different tests are options based on regional practices and planner experience. If the soil is dry, conduct a soil stability bottle cap test (Pellant et al., 2020), which is a semiquantitative variant of the soil stability test of Herrick et al., 2021 adapted for the FIFSHA assessment criteria classes (Figure 11). Alternatively, the wet aggregate stability "sink strainer" test (USDA, 2020) could be used with no slaking after 5 minutes as the **Meets** criteria, some slaking as the **Potential** criteria, and complete slaking after 5 minutes as indicating a **Does Not Meet** RC. If the soil is moist, intact aggregates can be transported to the office/lab and allowed to air dry before completing the slake test as described in the Soil Quality Test Kit Guide (USDA, 2001) where stability classes 0-2 indicate a **Does Not Meet** RC, classes 3-4 indicate a **Potential** RC, and classes 5-6 represent a **Meets** criteria for the FIFSHA.


Figure 11. Soil aggregate that disintegrated after placing in water (left) and an aggregate that remained stable (right). Photo credits: Pellant et al., 2020.

NRCS Conservation Practice Standards to Address RCs: 327, 336, 342, 484, 561, 654, & 655.

Soil Fauna/Biological Diversity

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Fauna/ Biological Diversity	Presence or evidence of multiple beneficial soil organisms present in forest floor, mineral soil, and under logs, etc.	Limited numbers of visible beneficial soil organisms; some evidence of soil faunal activity including burrows, biopores, or fecal matter.	Absence of visible beneficial soil organisms or evidence of their activity; Or, visible presence of or evidence of activity by invasive or harmful species.	**AGG HAB SOM**	

<u>Importance</u>: The forest floor, with its leaf litter, small branches, and CWD provides a range of habitats and organic inputs to support a large and diverse faunal community. Plants and animals living in the various components of the forest floor and soil are connected within intricate food webs with cycles of growth, death, and decay. Small mammals like moles and mice feed on litter and roots, burrowing in the soil and mixing the organic and mineral components. Invertebrates like earthworms, ants, and termites break apart fresh organic material enabling smaller invertebrates like springtails and mites to consume and degrade the materials further.

This biological activity is key to the decomposition of organic material, building SOM, and recycling nutrients. Soils with higher SOM are more likely to have stable aggregates that improve soil aeration and store more plant-available water, making the soils and the plant communities they support more resilient to extremes in precipitation (flood and drought).

<u>Assessment</u>: When breaking apart the soil to assess soil structure, look for living soil fauna. Biopores, burrows, and fecal deposits are easier to identify and won't disappear quickly if there hasn't been any recent activity. Earthworm middens are another indirect indicator of invertebrate activity. Turn over some CWD and search within the litter layer for invertebrates like millipedes, centipedes, woodlice, and ground beetles (Figure 12). The number and diversity of organisms will likely depend on local conditions so evaluation of multiple sites may be needed to determine what are typical populations and diversity of soil biota.

This indicator is one of the more challenging ones to assess as identifying and quantifying beneficial versus harmful or invasive soil biota can be complex and require specialized knowledge or training. A more detailed assessment of forest soil biota may be obtained through sampling methods like pitfall traps or Berlese funnels. Xerces Society for Invertebrate Conservation (2022) and Soil and Water Conservation Society (2000) are resources that provide greater details on soil biota, their roles, and aids in identification.

Invasive invertebrates or any species harmful to forest health that is soil borne or has a reproductive phase in the soil may or may not necessarily be detrimental to soil health. A holistic approach should focus on soil health but should also acknowledge that some invasive species that do not present a direct soil health RC may still be harmful to overall forest health.

Figure 12. A ground beetle (a), earthworm midden piles (b), woodlouse (c), and ant burrow (d).

NRCS Conservation Practice Standards to Address RCs: 314, 336, 384, 490, & 666.

Roots

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Roots	Healthy, living roots present in significant numbers; no evidence of restricted growth.	Numerous living roots present; some evidence of disease; root architecture may be altered or a lack of fine root penetration in a restrictive soil layer.	Few or no living roots present or disease prevalent; root growth severely restricted by restrictive soil layer, excessive dryness, or wetness (shallow groundwater).	**AGG CPT HAB SOM**	

Importance: One of the primary connections between soil health and forest health are the root systems of the trees and other woody and non-woody plants in the forest. Although tree roots may penetrate to great depths, most tree roots are within ~ 18 inches of the soil surface. Different species have different rooting patterns like taproot, heartroot, and flatroot, however, restrictive soil layers can modify these general patterns. Compaction by equipment traffic or animal treading can damage surface roots or restrict root growth through compacted layers. Shallow groundwater or bedrock may also restrict deeper rooting and may be evident by a high number of windthrown trees.

The largest tree roots provide physical strength to anchor the tree in the ground while water and nutrient uptake are primarily through fine roots and associated mycorrhizal fungal hyphae. A common rule-of-thumb is that the root uptake is most active near the drip line (vertical line down from the exterior edge of a tree's crown), although roots may extend much farther from the tree trunk.

Secretions from roots (exudates) and fungal mycorrhizae enhance litter decomposition and the plant-soil connection facilitating nutrient and water uptake, especially during periods of stress like drought and extreme nutrient deficiency. Turnover of fine roots, along with root exudates, are significant sources of organic material that feed soil biota and are processed to form SOM.

Assessment: Break apart the exposed soil and inspect the sidewalls of the excavation for living roots (Figure 13). The presence of dead roots, although possibly due to natural turnover, may also be an indicator of the presence of pathogens or other stressors like insect damage, drought, or fire. Like the Soil Fauna/Biological Diversity indicator, the Roots indicator may be one of the more challenging indicators to assess as identifying healthy, live roots or the cause of root death may require specialized knowledge or training. Again, evaluation of multiple sites may be needed to establish typical root densities and distribution.

Figure 13. Tree roots exposed by loss of soil cover and soil movement (a), root mass of a pine tree windthrow (b), and prolific fines roots near the soil surface (c).

While the presence of roots of invasive woody species like honeysuckle, buckthorn, and tree-of-heaven are not necessarily detrimental to soil health, invasive shrubs are known to shade out native plants or have allelopathic properties, reducing soil cover. There is a strong linkage between forest health, including characteristics of understory species, both invasive and native, and competition with tree roots and desirable understory species. So again, a holistic perspective of balancing soil health with overall forest health is warranted.

NRCS Conservation Practice Standards to Address RCs: 314, 336, 384, 484, 528, 655, & 666.

Final Scoring and Interpretation

The FIFSHA has been added as an assessment method in the Conservation Assessment and Ranking Tool (CART) for fiscal year 2025 and beyond. Because of that, there are three important items to note when it comes to the final scores and interpretations for each Resource Concern. First, the Assessment has a simple "FIFSHA Sum" (column 3 in Table 1). Then there is a slightly more complicated "CART Sum" (column 4 in Table 1). Finally, there is the actual "CART Threshold Value" (column 1 in Table 1). Let's go through each of those important columns.

1. **FIFSHA Sum** - The FIFSHA Sum is the sum of all Indicators that contribute to the Resource Concern. In the assessment spreadsheet, this is an automatic calculation.

2. **CART Sum** - The CART Sum adds up the appropriate Indicator values, giving preference to those that are essential for the Resource Concern to achieve the CART threshold for Soil Health. Those essential Indicators are listed below for each Resource Concern and are further explained in Appendix 3. The CART Sum column contains the RC values the planner enters into CART. In the assessment spreadsheet, this is an automatic calculation.

a. If the AGG Resource Concern scores < 5 on any of the following indicators, the CART Score will always be "Does Not Meet": Water Stable Aggregates; Soil Structure; Soil Disturbance Intensity; Soil Burn Severity.
b. If the CPT Resource Concern scores <3 for Soil Cover AND <15 for the sum of all other CPT Indicators, the CART Score will be "Does Not Meet". **However -** If the soil surface layer (and/or depth to 30cm (12in)) has a natural platy soil structure as documented by the soil survey, the planner may choose to override this rating by following footnote 1/, giving the Soil Structure indicator a score of 5, while considering the other CPT Indicator ratings.
c. If the HAB Resource Concern scores < 5 on either of the following indicators, the CART Score will be "Does Not Meet": Woody Debris; Soil Fauna/Biological Diversity.
d. If the SOM Resource Concern scores < 5 on either of the following indicators, the CART Score will be "Does Not Meet": Soil Cover; Woody Debris.

3. **CART Threshold Value** – This is the unique numeric threshold that must be met or exceeded in the CART Sum column in order for the RC to Meet Assessment and CART Criteria. This was determined by specialists in the Soil Health Division.

Appendix 3 provides further guidance for interpretation of final RC scores to determine whether a soil health RC is identified or not and the relation to CART.

Table 1. Example of the scoring breakdown by soil health RC based on sum of scores for indicators associated with each resource concern (RC). Note that the FIFSHA Sum differs from the CART Sum, as described above.

CART Threshold Value	Resource Concern (RC)	FIFSHA Sum 1/	CART Sum 1/	Final CART RC Ranking 1/
35	Aggregate Instability (AGG)	32	18	Does Not Meet (RC)
17	Compaction (CPT)	18	18	Meets (No RC)
25	Soil Organism Habitat Loss or Degradation (HAB)	26	13	Does Not Meet (RC)
25	Soil Organic Matter (SOM)	26	18	Does Not Meet (RC)

For ease of use and interpretation, two bar charts have been provided in the spreadsheet assessment tool (Figures 14 and 15). These charts will automatically change to reflect any new FIFSHA Scores that are entered into column G of the spreadsheet.

Figure 14 shows the individual Indicator scores. Where an Indicator scores a 1 or 2, that Indicator "does not meet" CART or FIFSHA Assessment Criteria. Indicators scoring a 5 do "meet" CART and Assessment Criteria. For Indicators with a value of 3 or 4, there may or may not be a concern, so those should be interpreted as having a "potential resource concern" for CART and the FIFSHA Assessment, although that is not included on the bar chart.

Figure 15 shows the final CART scores and whether or not each RC "meets" or "does not meet" the CART threshold for conservation planning purposes. The numerical values shown within each RC bar on the chart reflects the total CART score for that RC and is the same as the value shown in the CART Sum column of the spreadsheet for each RC.

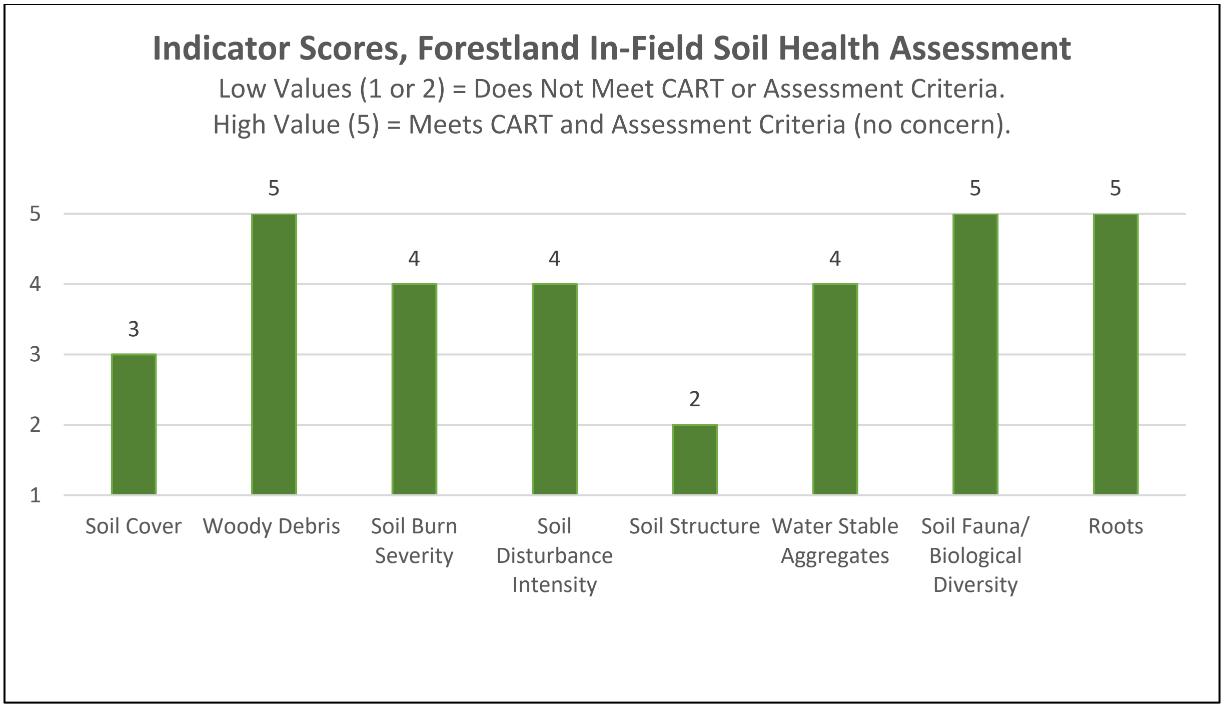

Figure 14. Example of FIFSHA Indicator Scores.

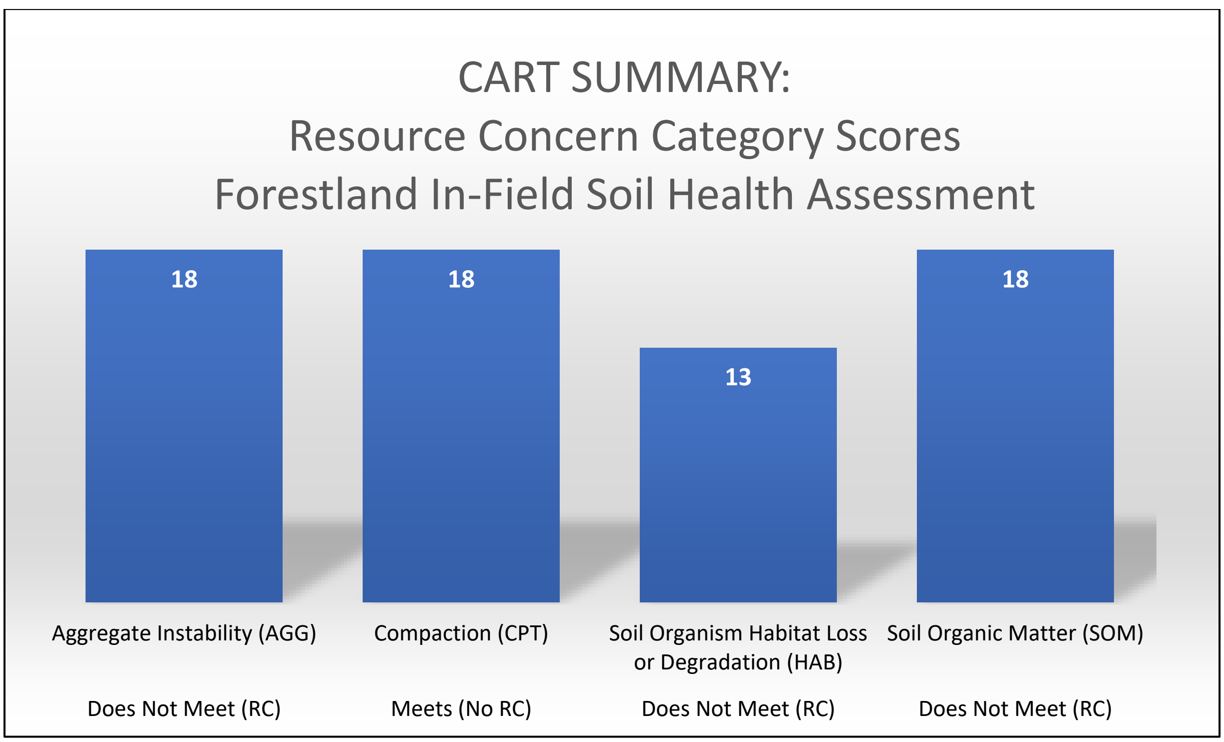

Figure 15. Example of the CART Summary for each RC category, their total CART score, and whether or not the RC "Meets" or "Does Not Meet" the CART Threshold.

If a **Potential RC** or **Does Not Meet RC** is identified, appropriate conservation practice(s) should then be considered to address the Indicator and/or RC(s). Appendix 2 contains a table of potential conservation practices for forestlands organized by the four soil health RCs. Note that this table is not inclusive as there may be additional practices that are available and appropriate, and the suite of potential practices may vary by region. In natural forests, the judicious use of conservation practices in conjunction with allowing sufficient time for the soil to stabilize, recover, and restore its below ground processes is essential.

APPENDIX 1. FIFSHA cover sheet and worksheets.

USDA United States Department of Agriculture

Forestland In-Field Soil Health Assessment: Instruction Overview

1

This assessment is designed to identify potential resource concerns related to soil health in private, non-industrial forestlands. This assessment should be used in conjunction with client input/objectives and site observations. Each indicator has associated resource concerns identified that could arise from deteriorating soil health. Enter a numerical score from 1 to 5 associated with the appropriate observed condition of each indicator.
Potential Resource Concerns (RC): **AGG**: Aggregate Instability; **CPT**: Compaction; **HAB**: Soil Organism Habitat Loss or Degradation; **SOM**: Soil Organic Matter Depletion.

Preparation

- Review site history and landowner objectives.
- Collect site information (soil series, slope, aspect, etc…).
- Assemble materials (maps, shovel, tape measure, camera).

Where

- Multiple sites in each CMU or field; total number and location determined by field size and variation in soil properties.
- Choose sites representative of distinctive features (tree type, site conditions).
- Or, incorporate assessments into forest stand inventory activity.

When

- Avoid extreme conditions (drought, flood, extreme heat or cold) as soil biological activity may be reduced/absent.
- Following site disturbance activities like tree thinning or harvest or the application of a conservation practice.

How

- Make a visual estimate of soil cover and woody debris.
- Assess the severity of any fire damage or other disturbance.
- Monitor resistance while pushing a shovel into the soil.
- Remove shovelful of soil, measure thickness of litter layer, determine structure type, aggregate stability, and texture of surface layer.
- Observe amount and distribution of live roots.
- Observe presence of soil organisms or evidence of their recent activity like burrows.

Date
Client Name
Planner
Location
Field, CMU, or Stand
Soil Map Unit(s)
Ecological Site Description (If Available)
Slope, Aspect, Elevation
O Horizon Thickness
Mineral Surface Soil Texture

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Cover	Mineral soil surface is > 75% covered by leaf litter, O horizon, woody debris, moss, or exposed stones/rocks.	Soil is < 75% but > 50% covered; **Or**, evidence of seasonal soil cover > 50% such as insect midden piles, leaf fragments, or litter displacement; **Or**, > 50% cover of slash from harvest or thinnings on ground but not well distributed.	Soil is <50% covered; Or, less than 75% cover on slopes greater than 25%; Or, loss of litter layer and O horizon (organic surface layer) from > 15% of area.	**AGG CPT HAB SOM**	
Woody Debris	Downed trees and limbs and stumps well distributed and in various states of decomposition.	Some woody debris of similar age or poorly distributed accumulations of debris from machine or water disturbance.	Woody debris largely absent or large accumulations of concentrated debris from machine, storm, insect, disease or water disturbance.	**AGG HAB SOM**	
Soil Burn Severity	Forest floor (litter layer and O horizon) may be charred but are intact.	Forest floor is partially consumed; some black ash present; mineral soil is not visibly altered; some water repellency at or below soil surface.	Forest floor is largely consumed; white ash present; mineral soil is exposed; fine roots absent in surface soil; strong water repellency; parts of exposed soil are orange.	**AGG HAB SOM**	
Soil Disturbance Intensity	Site is stable without visible signs of significant disturbance or active erosion (excluding established roads and trails).	Dispersed, faint wheel tracks/ ruts less than 4 inches deep, and/or evidence of some soil displacement (sheet or rill erosion, sediment movement, topsoil/subsoil mixing).	Highly visible wheel tracks/ruts greater than 4 inches deep, and/or significant soil displacement (rill or gully erosion, sediment movement, topsoil/subsoil mixing).	**AGG CPT**	

USDA United States Department of Agriculture

Forestland In-Field Soil Health Assessment: Worksheet

3

Indicator	Meets Assessment and CART Criteria Score = 5	Potential Resource Concern for Assessment and CART Score = 4 or 3	Does Not Meet Assessment or CART Criteria Score = 2 or 1	RC	FIFSHA Score *(Enter values from observations)*
Soil Structure [1/]	Strong granular or subangular blocky or as expected for site; resistance to probe or spade similar to natural condition.	Weak platy or massive structure and/or increased resistance to probe or spade to 10 cm; evidence of ponding; some visual evidence of mechanical and/or animal traffic.	Strong platy or massive structure and increased resistance to probe or spade to 30 cm; widespread evidence of ponding; clear visual evidence of compaction from mechanical and/or animal traffic.	AGG CPT	
Water Stable Aggregates	Unless single grained, soil aggregates are stable and don't disintegrate when submerged in water.	Unless single grained, soil aggregates begin to partially disintegrate when submerged in water.	Unless single grained, soil aggregates completely disintegrate after submersion in water.	AGG CPT HAB SOM	
Soil Fauna/ Biological Diversity	Presence or evidence of multiple beneficial soil organisms present in forest floor, mineral soil, and under logs, etc.	Limited numbers of visible beneficial soil organisms; some evidence of soil faunal activity including burrows, biopores, or fecal matter.	Absence of visible beneficial soil organisms or evidence of their activity; Or, visible presence of or evidence of activity by invasive or harmful species.	AGG HAB SOM	
Roots	Healthy, living roots present in significant numbers; no evidence of restricted growth.	Numerous living roots present; some evidence of disease; root architecture may be altered or a lack of fine root penetration in a restrictive soil layer.	Few or no living roots present or disease prevalent; root growth severely restricted by restrictive soil layer, excessive dryness, or wetness (shallow groundwater).	AGG CPT HAB SOM	

[1/] **Soil Structure Indicator note:** If the soil survey confirms a natural platy structure anywhere within the upper 30cm (12in), and there is no other indication of human-induced compaction, please enter a FIFSHA Score of 5 for this indicator.

USDA United States Department of Agriculture

Forestland In-Field Soil Health Assessment: Worksheet

4

CART Threshold Value	Resource Concern (RC)	FIFSHA Sum [2/]	CART Sum [2/]	Final CART RC Ranking [2/]
35	Aggregate Instability (AGG)			
17	Compaction (CPT)			
25	Soil Organism Habitat Loss or			
25	Soil Organic Matter (SOM)			

[2/] FIFSHA Sum, CART Sum, and Scoring Notes:

The CART Sum differs from the FIFSHA Sum. The FIFSHA Sum is the sum of all Indicators that contribute to the Resource Concern. The **CART Sum adds up the appropriate Indicator values giving preference to those that are essential for the Resource Concern to achieve the CART threshold for Soil Health.** Those essential Indicators are listed below for each Resource Concern. **The values to enter into CART are shown in the CART Sum column.**

1. If the AGG Resource Concern scores < 5 on any of the following indicators, the CART Score will always be "Does Not Meet": Water Stable Aggregates; Soil Structure; Soil Disturbance Intensity; Soil Burn Severity.
2. If the CPT Resource Concern scores <3 for Soil Cover AND <15 for the sum of all other CPT Indicators, the CART Score will be "Does Not Meet". However - If the soil surface layer (and/or depth to 30cm (12in)) has a natural platy soil structure as documented by the soil survey, the planner may choose to override this rating by following footnote [1/], giving the Soil Structure indicator a score of 5, while considering the other CPT Indicator ratings.
3. If the HAB Resource Concern scores < 5 on either of the following indicators, the CART Score will be "Does Not Meet": Soil Cover; Woody Debris; Soil Fauna/Biological Diversity.
4. If the SOM Resource Concern scores < 5 on either of the following indicators, the CART Score will be "Does Not Meet": Soil Cover; Woody Debris.

Moss Soil Cover

Soil Aggregate

Stone Soil Cover

APPENDIX 2. Table of potential conservation practices to address soil health resource concerns.

Potential conservation practices for private, non-industrial forestlands and their relationship to the four resource concerns (RCs). This list can be adjusted for local conditions and multiple practices can address soil health resource concerns depending on landowner goals and site conditions.					
Practice Number	**Practice Name**	**AGG**	**CPT**	**HAB**	**SOM**
314	Brush Management			X	X
315	Herbaceous Weed Treatment			X	
327	Conservation Cover	X	X		
336	Soil Carbon Amendment				X
338	Prescribed Burning			X	
342	Critical Area Planting	X			X
379	Forest Farming			X	
382	Fence		X		
383	Fuel Break			X	X
384	Woody Residue Treatment				X
410	Grade Stabilization Structure				X
420	Wildlife Habitat Planting			X	
468	Lined Waterway Outlet				X
472	Access Control		X		
484	Mulching	X	X	X	X
490	Tree/Shrub Site Preparation		X	X	X
528	Prescribed Grazing		X		X
560	Access Road	X	X		
561	Heavy Use Area Protection		X		
590	Nutrient Management				X
595	Pest Management Conservation System			X	
612	Tree/Shrub Establishment			X	X
654	Road/Trail/Landing Closure and Treatment	X	X	X	X
655	Forest Trails and Landings	X	X		
660	Tree-Shrub Pruning			X	X
666	Forest Stand Improvement				X

APPENDIX 3. Guidance for further interpretation of Potential RCs and relation to CART.

1) Resource Concern: Aggregate Instability (AGG)

Eight (8) Indicators: Soil Cover, Woody Debris, Soil Burn Severity, Soil Disturbance Intensity, Soil Structure, Water Stable Aggregates, Soil Fauna/Biological Diversity, and Roots.

RC or No RC: A score of 5 for these four indicators is required: Soil Burn Severity, Soil Disturbance Intensity, Soil Structure and Water Stable Aggregates. If those four indicators each score a 5, **and** the total score for all AGG indicators is ≥ 35, then there is no Aggregate Instability RC. If the Total score < 35, then Aggregate Instability is a RC.

2) Resource Concern: Compaction (CPT)

Five (5) Indicators: Soil Cover, Soil Disturbance Intensity, Soil Structure, Water Stable Aggregates, and Roots

RC or No RC: A score of ≥ 3 for Soil Cover is required. If the total score for all CPT indicators is ≥ 15 and Soil Cover is ≥ 3, then there is not a Compaction RC. If the Total score < 15, or if Soil Cover scores < 3, then Compaction is a RC.

However - If the soil surface layer (and/or depth to 30cm (12in)) has a natural platy soil structure as documented by the soil survey, the planner may chose to override this rating by following footnote [1/], giving the Soil Structure indicator a score of 5, while considering the other CPT Indicator ratings.

[1/] Soil Structure Indicator note related to the Compaction RC: If the soil survey confirms a natural platy structure anywhere within the upper 30cm (12in), and there is no other indication of human-induced compaction, please enter a FIFSHA Score of 5 for this indicator.

3) Resource Concern: Soil Organism Habitat Loss or Degradation (HAB)

Six (6) Indicators: Soil Cover, Woody Debris, Soil Burn Severity, Water Stable Aggregates, Soil Fauna/Biological Diversity, and Roots.

RC/No RC: A score of 5 for Soil Cover, Woody Debris and Soil Fauna/Biological Diversity indicators are required, and the total score for all HAB indicators is ≥ 25, then there is no Soil Organism Habitat Loss or Degradation RC. If the Total score < 25, and/or if one or more of the Soil Cover, Woody Debris or Soil Fauna/Biological Diversity indicators score < 5, then HAB is a RC.

4) Resource Concern: Soil Organic Matter Depletion (SOM)

Six (6) Indicators: Soil Cover, Woody Debris, Soil Burn Severity, Water Stable Aggregates, Soil Fauna/Biological Diversity, and Roots.

RC/No RC: A score of 5 on Soil Cover and Woody Debris; other indicators score ≥ 4 and total score for all SOM indicators is ≥ 25, then there is no Soil Organic Matter RC. If the Total score < 25, and/or if one or both of the Soil Cover or Woody Debris indicators score < 5, then SOM is a RC.

APPENDIX 4. FIFSHA Worksheet for Field Use.

The following two pages contain a blank worksheet for field use.

It is highly recommended that all Indicator scores are entered onto the accompanying FIFSHA Spreadsheet tool (hotlinked as an attachment to the eDirectives release), so that final calculations and scoring are performed automatically. If scoring in the field is necessary, follow guidance in the **Final Scoring and Interpretation** section of this Guide.

Indicator	Meets Assessment and CART Criteria	Potential Resource Concern for Assessment and CART	Does Not Meet Assessment or CART Criteria	RC	FIFSHA Score *(Enter values from observations)*
	Score = 5	Score = 4 or 3	Score = 2 or 1		
Soil Cover	Mineral soil surface is > 75% covered by leaf litter, O horizon, woody debris, moss, or exposed stones/rocks.	Soil is < 75% but > 50% covered; **Or**, evidence of seasonal soil cover > 50% such as insect midden piles, leaf fragments, or litter displacement; **Or**, > 50% cover of slash from harvest or thinnings on ground but not well distributed.	Soil is <50% covered; Or, less than 75% cover on slopes greater than 25%; Or, loss of litter layer and O horizon (organic surface layer) from > 15% of area.	**AGG CPT HAB SOM**	
Woody Debris	Downed trees and limbs and stumps well distributed and in various states of decomposition.	Some woody debris of similar age or poorly distributed accumulations of debris from machine or water disturbance.	Woody debris largely absent or large accumulations of concentrated debris from machine, storm, insect, disease or water disturbance.	**AGG HAB SOM**	
Soil Burn Severity	Forest floor (litter layer and O horizon) may be charred but are intact.	Forest floor is partially consumed; some black ash present; mineral soil is not visibly altered; some water repellency at or below soil surface.	Forest floor is largely consumed; white ash present; mineral soil is exposed; fine roots absent in surface soil; strong water repellency; parts of exposed soil are orange.	**AGG HAB SOM**	
Soil Disturbance Intensity	Site is stable without visible signs of significant disturbance or active erosion (excluding established roads and trails).	Dispersed, faint wheel tracks/ ruts less than 4 inches deep, and/or evidence of some soil displacement (sheet or rill erosion, sediment movement, topsoil/subsoil mixing).	Highly visible wheel tracks/ruts greater than 4 inches deep, and/or significant soil displacement (rill or gully erosion, sediment movement, topsoil/subsoil mixing).	**AGG CPT**	
Soil Structure [1/]	Strong granular or subangular blocky or as expected for site; resistance to probe or spade similar to natural condition.	Weak platy or massive structure and/or increased resistance to probe or spade to 10 cm; evidence of ponding; some visual evidence of mechanical and/or animal traffic.	Strong platy or massive structure and increased resistance to probe or spade to 30 cm; widespread evidence of ponding; clear visual evidence of compaction from mechanical and/or animal traffic.	**AGG CPT**	
Water Stable Aggregates	Unless single grained, soil aggregates are stable and don't disintegrate when submerged in water.	Unless single grained, soil aggregates begin to partially disintegrate when submerged in water.	Unless single grained, soil aggregates completely disintegrate after submersion in water.	**AGG CPT HAB SOM**	
Soil Fauna/ Biological Diversity	Presence or evidence of multiple beneficial soil organisms present in forest floor, mineral soil, and under logs, etc.	Limited numbers of visible beneficial soil organisms; some evidence of soil faunal activity including burrows, biopores, or fecal matter.	Absence of visible beneficial soil organisms or evidence of their activity; Or, visible presence of or evidence of activity by invasive or harmful species.	**AGG HAB SOM**	
Roots	Healthy, living roots present in significant numbers; no evidence of restricted growth.	Numerous living roots present; some evidence of disease; root architecture may be altered or a lack of fine root penetration in a restrictive soil layer.	Few or no living roots present or disease prevalent; root growth severely restricted by restrictive soil layer, excessive dryness, or wetness (shallow groundwater).	**AGG CPT HAB SOM**	

[1/] **Soil Structure Indicator note:** If the soil survey confirms a natural platy structure anywhere within the upper 30cm (12in), and there is no other indication of human-induced compaction, please enter a FIFSHA Score of 5 for this indicator.

CART Threshold Value	Resource Concern (RC)	FIFSHA Sum [2/]	CART Sum [2/]	Final CART RC Ranking [2/]
35	Aggregate Instability (AGG)			
17	Compaction (CPT)			
25	Soil Organism Habitat Loss or			
25	Soil Organic Matter (SOM)			

[2/] FIFSHA Sum, CART Sum, and Scoring Notes:

The CART Sum differs from the FIFSHA Sum. The FIFSHA Sum is the sum of all Indicators that contribute to the Resource Concern. The **CART Sum adds up the appropriate Indicator values giving preference to those that are essential for the Resource Concern to achieve the CART threshold for Soil Health.** Those essential Indicators are listed below for each Resource Concern. **The values to enter into CART are shown in the CART Sum column.**

1. If the AGG Resource Concern scores < 5 on any of the following indicators, the CART Score will always be "Does Not Meet": Water Stable Aggregates; Soil Structure; Soil Disturbance Intensity; Soil Burn Severity.
2. If the CPT Resource Concern scores <3 for Soil Cover AND <15 for the sum of all other CPT Indicators, the CART Score will be "Does Not Meet". However - If the soil surface layer (and/or depth to 30cm (12in)) has a natural platy soil structure as documented by the soil survey, the planner may choose to override this rating by following footnote [1/], giving the Soil Structure indicator a score of 5, while considering the other CPT Indicator ratings.
3. If the HAB Resource Concern scores < 5 on either of the following indicators, the CART Score will be "Does Not Meet": Soil Cover; Woody Debris; Soil Fauna/Biological Diversity.
4. If the SOM Resource Concern scores < 5 on either of the following indicators, the CART Score will be "Does Not Meet": Soil Cover; Woody Debris.

REFERENCES

Agbeshie, A. A., S. Abugre, T. Atta-Darkwa, and R. Awuah. 2022. A review of the effects of forest fire on soil properties. J. For. Res. (2022) 33:1419–1441 https://doi.org/10.1007/s11676-022-01475-4

Amacher, M. C., K. P. O'Neil, and C. H. Perry. 2007. Soil vital signs: A new Soil Quality Index (SQI) for assessing forest soil health. Res. Pap. RMRS-RP-65WWW. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 12 p. www.fs.usda.gov/rm/pubs/rmrs_rp065.pdf

Burger, J. A., and D. L. Kelting. 1998. Soil quality monitoring for assessing sustainable forest management. pp. 17-52 In: The Contribution of Soil Science to the Development of and Implementation of Criteria and Indicators of Sustainable Forest Management SSSA Special Publication No. 53. https://forest.moscowfsl.wsu.edu/smp/docs/docs/Page-D_ForEcol138.html

Butler, B. J., J. H. Hewes, B. J. Dickinson, K. Andrejczyk, S. M. Butler, and M. Markowski-Lindsay. 2016. Family forest ownerships of the United States, 2013: Findings from the USDA Forest Service's National Woodland Owner Survey. Journal of Forestry 114(6):638–647 http://dx.doi.org/10.5849/jof.15-099

Carmean, W. H. 1975. Forest site quality evaluation in the United States. Advances in Agronomy. 27: 209-269. https://doi.org/10.1016/S0065-2113(08)70011-7

Carmean, W. H., J. T. Hahn, and R. D. Jacobs. 1989. Site index curves for forest species in the eastern United States. Gen. Tech. Rep. NC-128. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 142 p. https://doi.org/10.2737/NC-GTR-128

Herrick, J. E., J. W. Van Zee, S. E. McCord, R. M. Courtright, J. W. Karl, and L. M. Burkett. 2021. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. Volume I: Core Methods. 2nd Edition. USDA-ARS Jornada Experimental Range, Las Cruces, New Mexico. 76 p. https://www.blm.gov/noc/blm-library/technical-reference/monitoring-manual-grassland-shrubland-and-savanna-ecosystems

Morris, L. A., and R. G. Campbell. 1991. Soil and Site Potential. pp. 183-206 in M. L. Duryea and P. M. Dougherty (Eds.) Forest Regeneration Manual. Kluwer Academic Publishers. Boston. 433 p.

Natural Resources Conservation Service, National Forestry Handbook, title 190, February 2004.

Natural Resources Conservation Service, National Forestry Manual, September 1998.

O'Neill, K. P., M. C. Amacher, and C. J. Palmer. 2005a. Developing a national indicator of soil quality on U.S. Forestlands: Methods and initial results. Environmental Monitoring and Assessment 107: 59–80 DOI: 10.1007/s10661-005-2144-0 https://link.springer.com/article/10.1007/s10661-005-2144-0

O'Neill, K. P., M. C. Amacher, and C. H. Perry. 2005b. Soils as an indicator of forest health: a guide to the collection, analysis, and interpretation of soil indicator data in the Forest Inventory and Analysis program. Gen. Tech. Rep. NC-258. U.S. Department of Agriculture, Forest Service, North Central Research Station. 53 p. https://doi.org/10.2737/NC-GTR-258

Oswalt, S. N., W. B. Smith, P. D. Miles, and S. A. Pugh. (Coords.) 2019. Forest Resources of the United States, 2017: a technical document supporting the Forest Service 2020 RPA Assessment. Gen. Tech. Rep. WO-97. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 223 p. https://doi.org/10.2737/WO-GTR-97

Page-Dumroese, D. S., A. M. Abbott, M. P. Curran, and M. F. Jurgensen. 2012. Validating visual disturbance types and classes used for forest soil monitoring protocols. Gen. Tech. Rep. RMRS-GTR-267. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 17 p. https://doi.org/10.2737/RMRS-GTR-267

Page-Dumroese, D. S., A. M. Abbott, and T. M. Rice. 2009a. Forest soil disturbance monitoring protocol volume I: rapid assessment. U. S. Department of Agriculture, Forest Service. Gen. Tech. Report WO-82a. 31 p. https://doi.org/10.2737/WO-GTR-82A

Page-Dumroese, D. S., A. M. Abbott, and T. M. Rice. 2009b. Forest soil disturbance monitoring protocol volume II: supplementary methods, statistics, and data collection. U. S. Department of Agriculture, Forest Service Gen. Tech. Report WO-82b. 64 p. https://doi.org/10.2737/WO-GTR-82B

Page-Dumroese, D. S., M. D. Busse, M. F. Jurgensen, and E. J. Jokela. 2021a. Sustaining forest soil quality and productivity. pp. 63-93 In: J. S. Stanturf and M. A. Callaham, Jr. (Eds) Soils and Landscape Restoration. Academic Press. https://doi.org/10.1016/B978-0-12-813193-0.00003-5

Page-Dumroese, D. S., F. G. Sanchez, R. P. Udawata, C. Perry, and G. Gonzalez. 2021b. Soil health assessment of forest soils. pp. 100-138 In: D. L. Karlen, D. E. Stott, and M. M. Mikha (Eds.) Soil Health Series Volume 1: Approaches to Soil Health Analysis. Soil Science Society of America, Madison, WI.

Parsons, A., P. R. Robichaud, S. A. Lewis, C. Napper, and J. T. Clark. 2010. Field guide for mapping post-fire soil burn severity. Gen. Tech. Rep. RMRS-GTR-243. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 49 p. https://doi.org/10.2737/RMRS-GTR-243

Pellant, M., P. L. Shaver, D. A. Pyke, J. E. Herrick, N. Lepak, G. Riegel, E. Kachergis, B. A. Newingham, D. Toledo, and F. E. Busby. 2020. Interpreting Indicators of Rangeland Health, Version 5. Tech Ref 1734-6. U.S. Department of the Interior, Bureau of Land Management, National Operations Center, Denver, CO. https://pubs.er.usgs.gov/publication/70215720

Perry, C. H., M. V. Finco, and B. T. Wilson. (Eds.) 2022. Forest Atlas of the United States. FS-1172. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 54 p. https://doi.org/10.2737/FS-1172

Powers, R. F., A. E. Tiarks, and J. R. Boyle. 1998. Assessing soil quality: practicable standards for sustainable forest productivity in the United States. pp. 53-80 In: The Contribution of Soil Science to the Development of and Implementation of Criteria and Indicators of Sustainable Forest Management SSSA Special Publication No. 53. https://doi.org/10.2136/sssaspecpub53.c3

Schoeneberger, P. J., D. A. Wysocki, E. C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE. https://www.nrcs.usda.gov/resources/guides-and-instructions/field-book-for-describing-and-sampling-soils

Sinnett, D., G. Morgan, M. Williams, and T. R. Hutchings. 2008. Soil penetration resistance and tree root development. Soil Use and Management 24:273-280. https://doi.org/10.1111/j.1475-2743.2008.00164.x

Soil and Water Conservation Society. 2000. Soil biology primer. Ankeny, IA. 48 pp.

USDA, 2001. Soil Quality Test Kit Guide. U.S. Department of Agriculture, Natural Resources Conservation Service. Washington, D.C.

USDA, 2020. Cropland In-Field Soil Health Assessment Guide. Soil Health Technical Note No. 450-06. U.S. Department of Agriculture, Natural Resources Conservation Service. Washington, D.C.

Xerces Society for Invertebrate Conservation. 2022. Pocket guide to soil invertebrates as bioindicators. https://xerces.org/publications/identification-monitoring-guides/pocket-guide-to-soil-invertebrates-as-bioindicators