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Useful Tools for Identifying Surface Fuels and Biomass

Useful Tools for Identifying Surface Fuels and Biomass

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PREFACE

This publication presents issues, instructions, and protocols to determine the amount of surface fuels and biomass. The information and links provide the reader with an overview of the various protocols that will help to identify surface fuels and biomass. Fuels managers have used these protocols to estimate fuel loading for decades. The current emphasis on determining fuel loads for different fire effects models and other uses has created resurgence in the utility of the protocols. These same protocols are also useful to the soil scientist, watershed specialist, wildlife biologist, timber sale administrator, and contract inspector responsible for ensuring that soil cover components of both fine and coarse woody material are at the appropriate levels to provide effective soil cover and maintain long-term soil productivity.

INTRODUCTION

The recent emphasis to use down woody material, during timber harvest and fuels reduction as a source of biomass fuels, is a rapidly emerging issue on forests throughout the United States. The Healthy Forest Restoration Act of 2003 and the Cohesive Fuels Treatment Strategy emphasize the recovery and utilization of biomass from forest health treatments (Rummer 2008). In response, soil scientists are trying to identify soil prescriptions that maintain long-term soil productivity by ensuring adequate soil cover and providing nutrient sustainability. How much forest residue can and should be removed to meet treatment objectives varies from site to site and depends a great deal on treatment objectives. At this point not all the answers are known in terms of how much material should be removed. Maintenance of long-term soil productivity, wildlife habitat, and forest health are key considerations in developing treatment objectives. Decisions on how much woody biomass to remove should be determined by the overall soil nutrient budget in a stand, including which nutrients are limiting (Oregon Department of Forestry 2008).

Across the country overstocked stands are mechanically treated by removing stems, which are bundled, chipped, and transported to different plants for many uses including wood-energy electrical plants and thermal bioenergy systems (Nicholls et al. 2008). New and innovative equipment is now appearing on forests that efficiently and economically removes forest slash and litter. The equipment includes forest residue bundlers, successfully used in European forests, which can process 20 to 30 bales per hour. Once compacted, the bales can be burned in bioenergy systems. Waste salvage bins are another piece of equipment used to remove forest residues. The bins (that hold up to 15 tons of wood) are dropped off and left onsite, and retrieved when full (Nicholls et al. 2008). These are just a few of the forest residue removal methods currently in use. As other equipment and techniques are developed and tested the question of how much coarse and fine-woody material to leave onsite will continue to be asked but first there needs to be reliable protocols to determine existing fuel loads. The objective of this publication is to outline the measurement tools available to determine surface fuels and biomass onsite both before and after timber harvest or fuels reduction treatments.

PROTOCOLS FOR IDENTIFYING SURFACE FUELS AND BIOMASS

Inventory and sampling protocols to determine surface fuels and biomass are readily available. The majority of the protocols were developed for fuels specialists to assess fuel loads in natural stands to predict fire effects. Sampling methodologies have evolved over the years; they have become more sophisticated, and allow the fuels specialists to input data into models to predict fire effects. However, as national direction emphasizes management techniques to reduce hazardous fuels, protect forest health, and ensure ecosystem resilience (Kimbell 2009), resource specialists need to use these same protocols to ensure that soil resource objectives for cover and nutrient cycling are met.

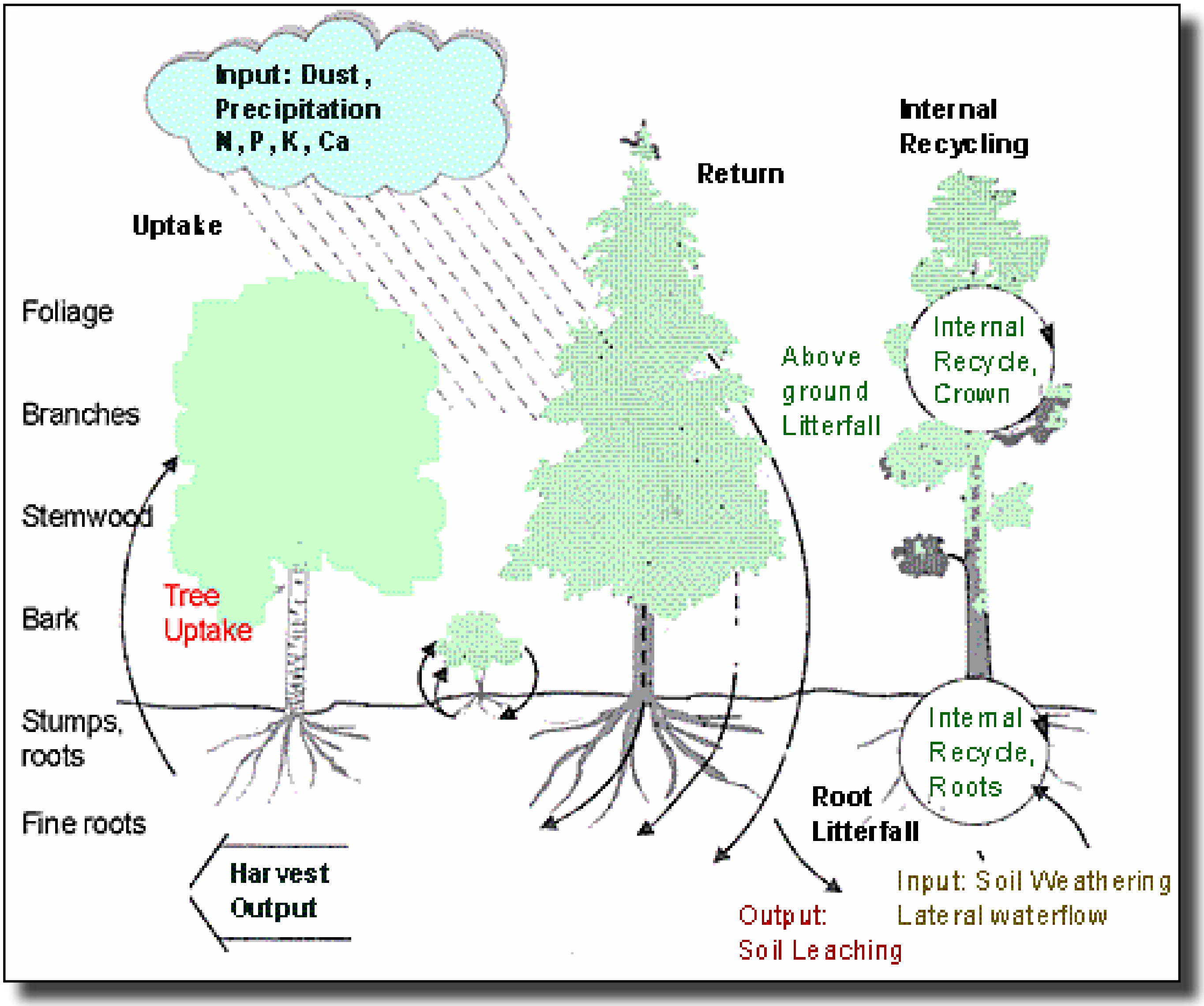

Figure 1. Soil resource objectives are achieved through an understanding of the nutrient requirements of each site.

Three surface fuels and biomass inventory methods commonly are available.

1. Line-intersect

The line-intersect or planar-intersect method uses a line transect to sample downed woody material including twigs, branches, stems, and tree boles in and above the litter (Brown 1974). The term planar-intersect is often used interchangeably with line intersect and it illustrates the height of the surface fuels included in the sampling plane. Not all surface fuel contacts the ground but may be supported by other down material. To get an accurate estimate of all the surface fuels it is important to capture each dead woody material class.

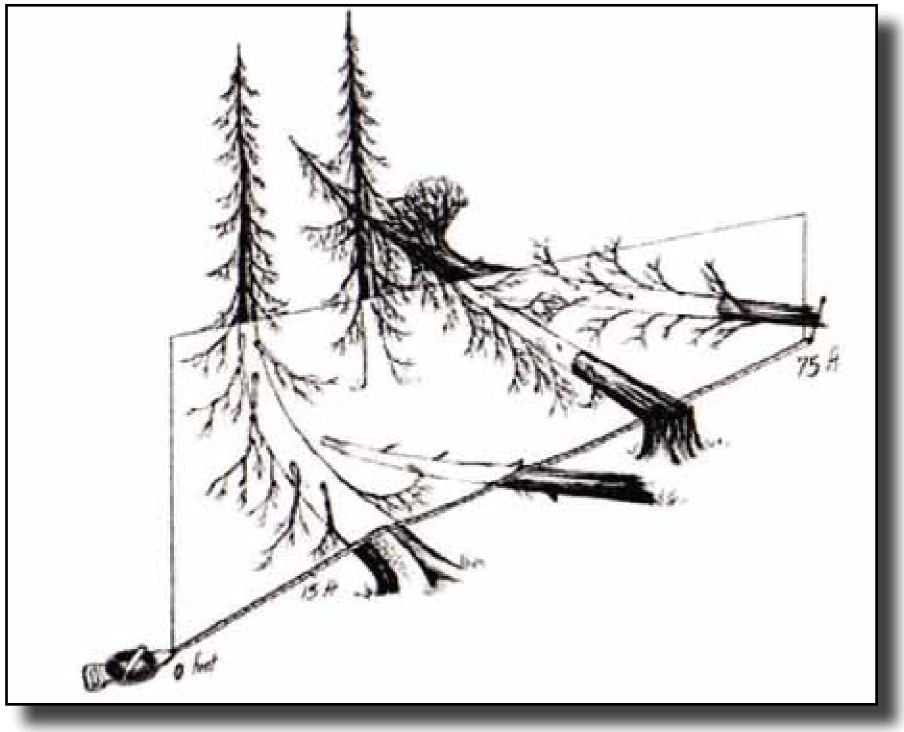

Figure 2. The line-intersect sampling plane. Modified from (FIREMON) fuel load.

The line-intersect method samples both fine and coarse woody material by diameter class. The diameter classes correspond to the 1-hour, 10-hour, 100-hour, and 1,000-hour fuel classes used in the U.S. National Fire Danger Rating System developed by Deeming. The inventory technique involves counting each intersection of woody pieces with the vertical sampling plane. First, volume is estimated, and then weight is calculated from the volume by applying estimates of the woody material's specific gravity. The line-intersect method is used to assess the downed woody material indicator in the Forest Inventory Analysis Program (FIA) and Fire Ecology Assessment Tool/ Fire Effects Monitoring and Inventory System (FEAT/FIREMON) Integrated (FFI).

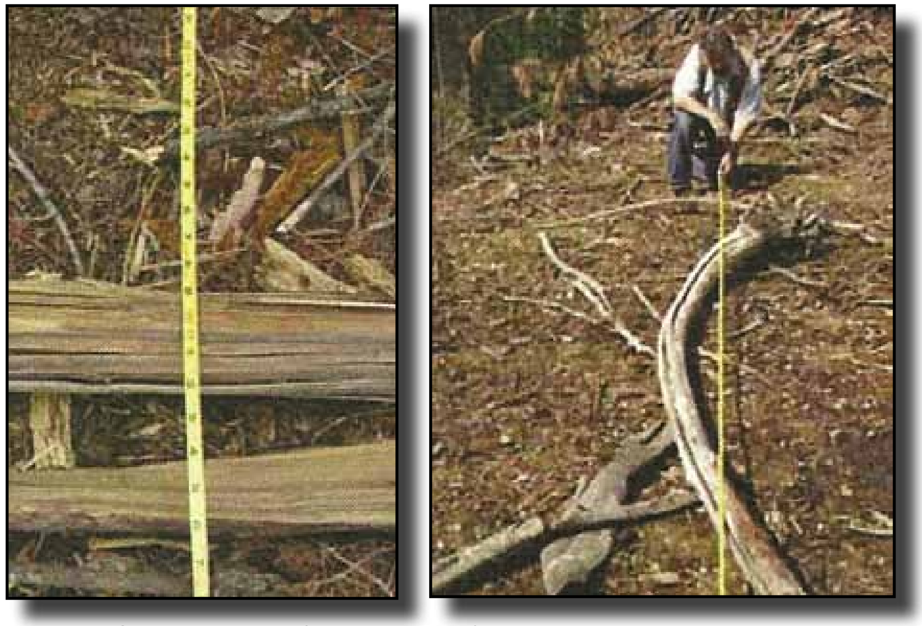

Figure 3. One must strictly follow the rules for measuring downed woody material volume.

Coarse Woody Debris Estimation - 100' Transects		Transect #1		Transect #2		Transect #3	
Diameter and soundness/rotteness	Tons per acre per piece[a]	# Pieces	Tons per acre per piece	# Pieces	Tons per acre per piece	# Pieces	Tons per acre per piece
3" sound	.4					1	.4
3" rotten	.3						
4" sound	.7					1	.7
4" rotten	.6						
5" sound	1.2						
5" rotten	.9						
6" sound	1.7						
6" rotten	1.3						
7" sound	2.3					1	2.3
7" rotten	1.7						
8" sound	3.0			2	6.0		
8" rotten	2.2			1	2.2		
9" sound	3.8						
9" rotten	2.8						
10" sound	4.7	1	4.7				
10" rotten	3.5						
12" sound	6.7						
12" rotten	5.0						
14" sound	9.1						
14" rotten	6.8						
16" sound	11.9						
16" rotten	8.9						
18" sound	15.1						
18" rotten	11.3						
20" sound	18.6						
20" rotten	14.0						
22" sound	22.5						
22 " rotten	16.9						
24" sound	26.8						
24" rotten	20.1						
26" sound	31.5						
26" rotten	23.6						
		Tons per acre: 4.7		Tons per acre: 8.2		Tons per acre: 3.4	
					Average tons per acre:	**5.4 tons/acre**	

Figure 4. The weight of the downed woody material is calculated from the volume counted.

2. Fixed Plot

The fixed plot or fixed-area plot is a sampling method to identify cover and height of shrubs and herbs and slash/residue piles.

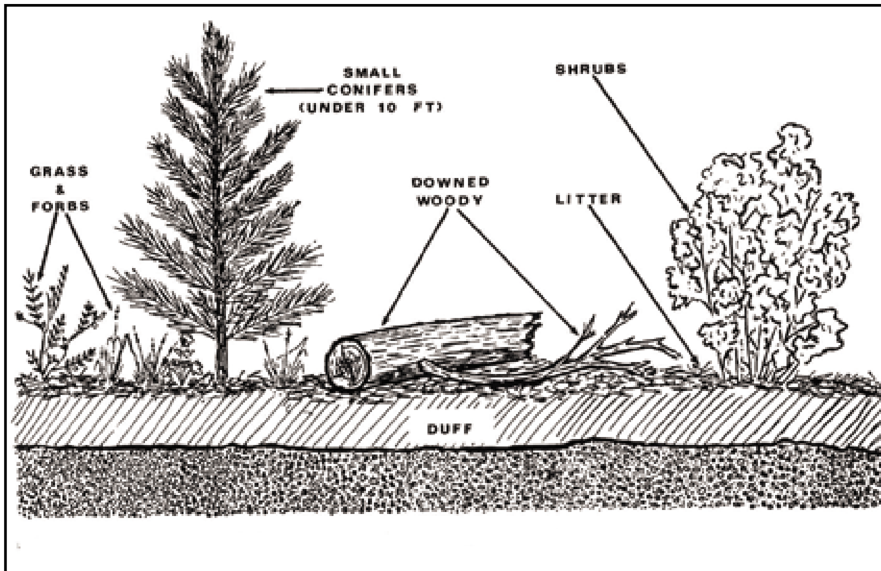

Figure 5. The sampling components that are collected in a fixed-plot sample.

Measurements are conducted within a fixed area (plot). The size of the plot varies depending on the type of information collected. Brown et al. (1982) recommend a different size fixed plot for different vegetative information. The technique includes a 1/300-acre plot size for trees, two ¼-milacre plots for shrubs, and four 0.98-by 1.97-foot plots for herbaceous material and litter.

The crew can collect different vegetation information in each plot systematically and efficiently. The fixed-plot technique is included as a component of Brown's (Brown et al. 1982) FIA and FFI.

In summary, the following protocols estimate surface fuel loadings using either the line-intersect or the fixed-plot method:

- Handbook for Inventorying Surface Fuels and •Biomass in the Interior West (Brown et al. 1982).
- FIA Program Down Woody Materials (DWM) Indicator (Woodall 2007).
- FEAT/FIREMON Integrated (FFI).

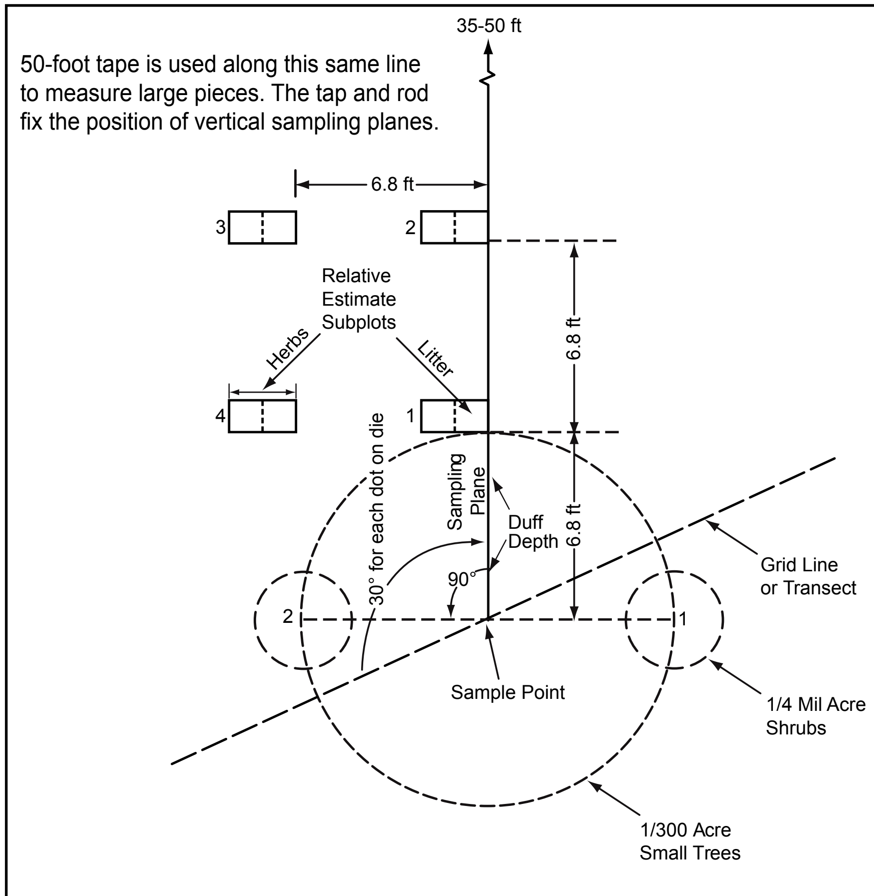

Figure 6. Plot layout at a sample point.

3. Visual Sampling

Visual sampling techniques were developed to reduce the time necessary to collect fuel load information. In the mid 1970s, photo series' were developed to provide an easy tool for quantifying natural fuels (Blonski 1981). The photo series still is used and has been refined and expanded to most every vegetation type and Forest Service region. The digital photo series includes a fuels database that users can search and browse to compare and format the output for other fire science software.

Figure 7. An example of the photo series.

Visual sampling techniques include observing each characteristic of the residue on the ground, including size and arrangement, and comparing it to the photo that most closely matches the residue. The photo series uses the same diameter size class for comparison as in the data collected for the line-intersect method.

The photoload sampling technique (Keane et al. 2007) is a new visual guide to estimate fuel loadings. As with the photo series, the user matches the conditions observed on the ground with a series of photoload sequences representing the six common surface fuel components (1-hour, 10-hour, 100-hour, 1,000-hour downed dead woody material, and shrubs and herbaceous fuels). The photos are a series of downward-looking and close-up oblique photos depicting fuel loadings of synthetic fuel beds for each of the six fuel components. The data gathered is used in the fire behavior and effects model and is an accurate assessment for quantifying the amount of live and dead carbon on the ground for a carbon budget.

Sikkink et al. (2009) use visual sampling to identify fuel loading models tied to different vegetative communities. This technique categorizes fuel beds into readily identifiable classes based on their predicted fire effects. The user quantifies the amount of downed woody material (1-hour, 10-hour, 100-hour and 1,000-hour fuel classes) using synthetic fuel loading photos modified from Keane (2007). Litter and duff measurements also are taken. These six components are needed for the first order fire effect model (FOFEM).

In summary, the visual sampling techniques have been updated over time but each protocol uses photographs to represent the six common surface fuel components. The current visual protocols are:

- Digital Photo Series.
- Natural Fuels Photo Series Publications.
- The Photoload Sampling Technique (Keane 2007).
- Field Guide for Identifying Fuel Loading Models (Sikkink et al. 2009).

SELECTING A SURFACE FUEL AND BIOMASS MONITORING PROTOCOL

Determining which protocol is best depends on the objective of the inventory and the scale at which the data needs to be collected. Factors to be considered when selecting a protocol include the amount of time available to conduct the sampling, accuracy of the data, and training required.

At the macro-scale, the FIA data may help assist land managers in prioritizing treatment areas. The national FIA program, phase 2 has one permanent inventory plot per 6,000 acres across the country. In 2001, the DWM inventory was started on phase 3 plots, which was applied to a subset of phase 2 plots, one plot per 96,000 acres. The widely spaced plots can provide a landscape-scale overview of fuel loading. Estimates of DWM, fuel loadings, and structural diversity are collected using line-intersect methods, point sampling, and fixed-radius sampling. The DWM inventory data can be mapped to display plot locations that are color coded according to the associated DWM component (Woodall 2007). Maps displaying estimates of coarse woody debris volumes for a given ecological province section also can be created. Additional sampling by a forest resource specialist at the project level can provide site-specific information and identify fuel load variation.

If the goal is to analyze treatment effects for a proposed timber sale or fuels reduction project, the resource specialist will need to identify the fuel-loading models used on the forest. Working with other

specialists they will determine if the forest has any data available using the line-intercept, fixed-plot, or a visual estimate using a photo series? If fuel loading data has been collected, can additional inventories be conducted to provide a more robust data set for soils interpretation? Does a photo series exist for the vegetation type in the area? If so, collect additional data on fuel loading with the photo series. Since all the methods use the same size classes that are equivalent to the lag-time fuel class system (1-hour, 10-hour, 100-hour, and 1,000-hour fuels) the inventory source can vary.

If a photo series is not available for the area and vegetation type, consider taking photos of areas with known fuel loads and begin building a quick reference set. Table 1 compares surface fuel and biomass sampling methods, and identifies the degree of difficulty in learning the method as well as the accuracy of the data collected.

Table 1—Comparison of surface fuel and biomass methods

Method	Degree of Difficulty - Training	National Application	Litter and Duff Measured	Slash Piles Measured	Precision Accuracy	Downed Woody Material Measured	Vegetation Biomass Measured
Handbook for Inventorying Surface Fuels and Biomass (Brown et al.)	Moderate	Yes[2]	Yes[3]	No	High	Yes	Yes
Forest Inventory Assessment (FIA)	Moderate	Yes	Yes	Yes	Moderate	Yes	Yes
FEAT/ FIREMON FFI	High	Yes[1]	Yes[4]	Yes	High	Yes	Yes
Photo Series	Low	Yes	No[5]	No	Low	Yes	No
Photo Load	Low	No	No		Low	Yes	Limited vegetation
Fuel Load Models FLM (Sikkink et al.)	Low	Yes	Yes	No	Low	Yes	No

[1] International application.
[2] Line-intercept works nationally but vegetation plot information is tiered to interior west.
[3] Litter and duff measurements are taken separately.
[4] Also collects information for Alaska duff and litter.
[5] Not distinguishable from the photos and requires additional sampling.

SUMMARY

The combination of new, innovative equipment and timber harvest prescriptions that emphasize increased use of biomass fuels requires an integrated approach to measuring fine and coarse woody material. Sampling techniques including the line intersect, fixed plot, and visual characterizations using photo series are readily available. These sampling techniques will help quantify the amount of forest residue onsite and enable soil scientists and contract administrators to determine if soil resource objectives have been met.

LINKS

Digital photo series Web site

The Digital Photo Series (DPS) is a Web-based application that provides access to the natural fuels photo series database and photographs. The DPS works through a user's Internet browser, but also has been designed to work as a stand-alone application when the computer is disconnected from the Internet. A user-friendly interface allows users to browse, query, and download photo series data and high-quality photographs. The digital photo series is intended to complement, not replace, the printed photo series volumes.

The Fuel Characteristic Classification System

The ongoing development of more sophisticated fire behavior and fire effects software along with the implementation of wildland fire emission inventory and large landscape fuel and carbon assessments has demonstrated the need for a comprehensive software system to build, characterize, and classify fuelbeds to accurately capture the structural complexity and geographical diversity of fuel components across landscapes and provide the ability to assess elements of human (e.g., logging slash) and natural (e.g., insect and disease) change.

The Fire and Environmental Research Applications team (FERA) of the Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory, U.S. Department of Agriculture, Forest Service, has developed a National System of Fuel Characteristic Classification (FCCS) to accommodate this need.

http://www.fs.fed.us/pnw/fera/fccs/index.shtml

FEAT/FIREMON Integrated

FFI (FEAT/FIREMON Integrated) is a monitoring software tool designed to assist managers with collection, storage, and analysis of ecological information. It was constructed through a complementary integration of the Fire Ecology Assessment Tool (FEAT) and FIREMON. FFI was funded by the National Interagency Fuels Coordination Group and developed in cooperation with the National Park Service, U.S. Forest Service, Systems for Environmental Management, and Spatial Dynamics. http://frames.nbii.gov/portal/server.pt?open=512&objID=483&&PageID=2216&mode=2&in_hi_userid=2&cached=true

Joint Fire Sciences Program Web site http://www.firescience.gov/

The Joint Fire Science Program:

- Provides credible research tailored to the needs of fire and fuel managers.
- Engages and listens to clients and then develops focused, strategic lines of new research responsive to those needs.
- Solicits proposals from scientists who compete for funding through a rigorous peer-review process designed to ensure the best projects are funded.
- Focuses on science delivery when research is completed with a suite of communication tools to ensure that managers are aware of, understand, and can use the information to make sound decisions and implement projects.

Forest Inventory and Analysis (FIA)

http://fia.fs.fed.us/program-features/indicators/

The forest monitoring component is the best-known component of the FIA program. This component consists of a three stage systematic sample of sites across all forested lands of the U.S. Phase 1 consists of remote sensing for stratification, to identify where the forested land is. Phase 2 consists of one field sample site for every 6,000 acres of forest, where field crews collect data on forest type, site attributes, tree species, tree size, and overall tree condition. Phase 3 consists of a subset of phase 2 sample plots, which are measured for a broader suite of forest health attributes including tree crown conditions, lichen community composition, understory vegetation, down woody debris, and soil attributes. Soil samples are sent to a laboratory for chemical analysis. Finally, an associated sample scheme exists to detect cases of ozone damage occurring to adjacent forest vegetation.

Line-Intercept Protocol References

http://www.ncrs.fs.fed.us/4801/national-programs/indicators/dwm/methods/references/

Down-woody material sampling protocols

http://www.ncrs.fs.fed.us/4801/national-programs/indicators/dwm/documents/dwm-field-manual-2004.pdf

The Photoload Sampling Technique

http://www.fs.fed.us/rm/pubs/rmrs_gtr190.pdf

Field Guide for Identifying Fuel Loading Models

http://www.fs.fed.us/rm/pubs/rmrs_gtr225.pdf

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