

# The Down Woody Material Indicator on the Allegheny National Forest

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## Abstract

The Forest Inventory and Analysis Program (FIA) conducts a national inventory of all forestland in the US. A subset of the FIA inventory plots are sampled every year for numerous forest health indicators. Down woody material (DWM) is defined as dead material on the ground in various stages of decay and is an important component of forest ecosystems. DWM data helps to describe important factors within forests including: quality and structure of wildlife habitats, structural diversity, fuel loading and fire behavior, carbon sequestration, and storage and cycling of water. The DWM inventory began in 2001 and is currently implemented in 38 states. The intensified grid of 173 FIA plots on the Allegheny National Forest (ANF) provided a substantial amount of data for a forest-wide analysis of the DWM data. Loadings of different debris types were characterized and mapped to provide an assessment of DWM on the ANF.



## Introduction

The Allegheny National Forest (ANF) (Figure 1) is situated in the Allegheny Plateau in northwestern Pennsylvania. The ANF is dominated by mixed northern hardwoods including black cherry, red maple, sugar maple, beech, and oak species. It represents an important source of high quality veneer-grade logs, but it is also heavily used for recreation given its proximity to the densely populated mid-Atlantic region.

The National Forest Health Monitoring Program was implemented by the USDA Forest Service in 1990 to monitor, assess, and report upon the status and trends in forest health across the country. Forest managers on the ANF recognized the need for a comprehensive survey of forest health conditions. In collaboration with USDA Forest Service Forest Health Protection (FHP) and research staff an intensified grid of 173 Forest Health Monitoring (FHM) plots was established in 1998. Methods developed by the National Forest Health Monitoring Program include the measurement of the down woody material forest health indicator.



Figure 1. The Allegheny National Forest is located in northeastern Pennsylvania.

## Methods

Down woody material (DWM) is defined as dead material on the ground in various stages of decay and is an important component of forest ecosystems. DWM data helps to describe important factors within forests including: quality and structure of wildlife habitats, structural diversity, fuel loading and fire behavior, carbon sequestration, and storage and cycling of water (USDA For. Serv. 2002).

Components estimated by the DWM indicator include: coarse woody debris (CWD), fine woody debris (FWD), duff, litter, herbs/shrubs, and fuelbed depth. CWD is dead wood greater than 3 inches in diameter; FWD is dead wood from 0.1 to 2.9 inches in diameter. CWD and FWD are sampled using the line intersect sampling method. Transects are established on each subplot if the subplot center is accessible and forested. The depth of the duff and litter layers are important components of fire models used to estimate fire behavior, fire spread, fire effects, and smoke production. Litter is defined as the loose plant material found on the top of the forest floor where little decomposition has occurred. Duff is the layer just below the litter; it consists of decomposing leaves and other organic material. Litter and duff measurements were taken on microplots in 1999 and 2000 and at the 24-foot location on each transect in 2001 (USDA For. Serv. 2002). An alternative to reporting mean herb/shrub height and coverage is to incorporate them into a single measure of height termed integrated fuel depth (Woodall and Williams 2004). The DWD plot designs for each of the three years of data collection are shown in Figures 2-4.

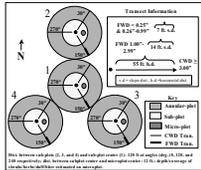


Figure 2. 1999 DWM plot layout.

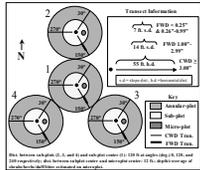


Figure 3. 2000 DWM plot layout.

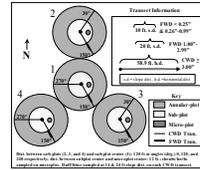


Figure 4. 2001 DWM plot layout.

## Results

Data from the DWM indicator was used to calculate variables that estimate fuel loadings and mass of CWD, FWD, and total DWD. Total tonnage of DWM broken down into duff, litter, 1-hr fuels, 10-hr fuels, and 1000-hr fuels (also called CWD) is shown in Figure 5. The majority of the tonnage per acre of DWM on the Allegheny National Forest was comprised of duff (64%).

A comparison of down woody material between plots within the ANF and plots in the rest of Pennsylvania (77 plots) is shown in Figure 6. The mean tonnage per acre of duff and 100-hr fuels were higher on plots in Pennsylvania outside of the ANF. In contrast, the mean tonnage per acre of 1000-hr fuels was higher on plots within the ANF. Mean tonnage per acre of litter, 1-hr fuels, and 10-hr fuels were similar on plots within and outside of the Allegheny National Forest.

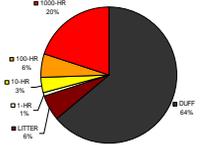


Figure 5. Total DWD broken down into debris categories.

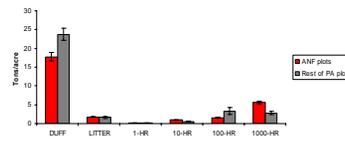


Figure 6. Mean values of DWM variables on the ANF versus the rest of Pennsylvania.

DWM loadings in tons per acre were broken down by FIA forest type (Table 1). Duff tons per acre were highest in the eastern hemlock forest type. Decomposition of litter may be slower in hemlock stands because they are generally darker and moister than hardwood stands. Litter and fine woody debris levels were similar among forest types. The largest amount of coarse woody debris was recorded in nonstocked stands possibly due to wood left from harvesting or other disturbance. Among forested stands, the sugar maple/beech/yellow birch forest type had the highest coarse woody debris levels.

Table 1. Mean values of DWM variables by FIA forest type.

FIA TYPE	N	DUFF	SE	LITTER	SE	FWD	SE	CWD	SE
Red maple/upland	60	15.1	1.7	1.9	0.1	2.8	0.2	5.7	0.3
Black cherry	51	17.8	1.7	1.7	0.1	2.9	0.2	6.0	0.8
Eastern hemlock	14	26.6	7.7	1.4	0.2	2.6	0.3	4.3	1.2
Mixed upland hardwoods	14	14.3	3.6	2.0	0.3	2.0	0.4	3.6	0.8
Sugar maple/beech/yellow birch	12	19.0	4.0	1.2	0.3	3.0	0.4	8.9	1.0
Other	12	17.0	3.1	2.0	0.2	3.6	0.5	5.8	1.2
White oak/red oak/hickory	7	12.3	2.2	2.4	0.4	2.9	0.4	3.2	0.9
Nonstocked	3	11.2	3.7	1.1	0.0	3.0	0.0	13.1	9.4

## Results Continued

Figures 7 and 8 show how DWM fuel components vary by density (basal area/acre) and stand age. Duff and litter tended to increase with stand age and, to some extent, basal area. As a stand ages and becomes more dense it follows that increasing litterfall would cause the duff layer to build up. In addition, the thicker overstory would shade the litter and duff causing decay to be slower. CWD appears to decrease with increasing stand basal area possibly due to CWD recruitment not by individual tree mortality but by larger stand disturbances. Litter and FWD levels were similar among age and density classes.

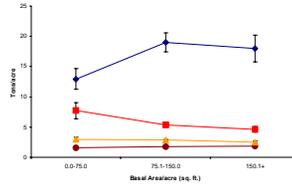


Figure 7. Mean values of DWM variables on the ANF in basal area/acre classes.

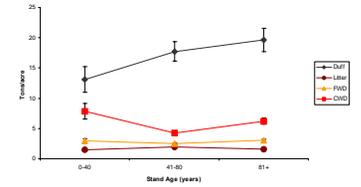


Figure 8. Mean values of DWM variables on the ANF in stand age classes.

As shown in Figure 9, integrated fuel depth tended to decrease with basal area/acre and stand age. A more developed herb and shrub layer would be expected in younger less dense stands due to a less developed overstory.

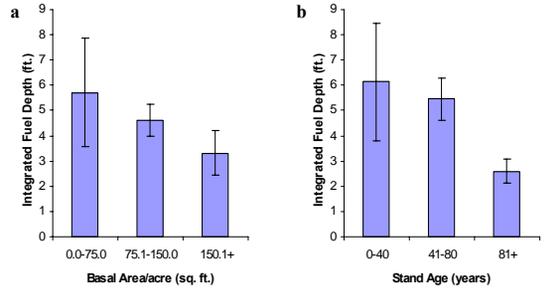


Figure 9. Mean values of integrated fuel depth on the ANF in: (a) basal area/acre classes and (b) stand age classes.

Kriged surfaces were generated to depict the spatial arrangement of fuels and debris (Fig. 10).

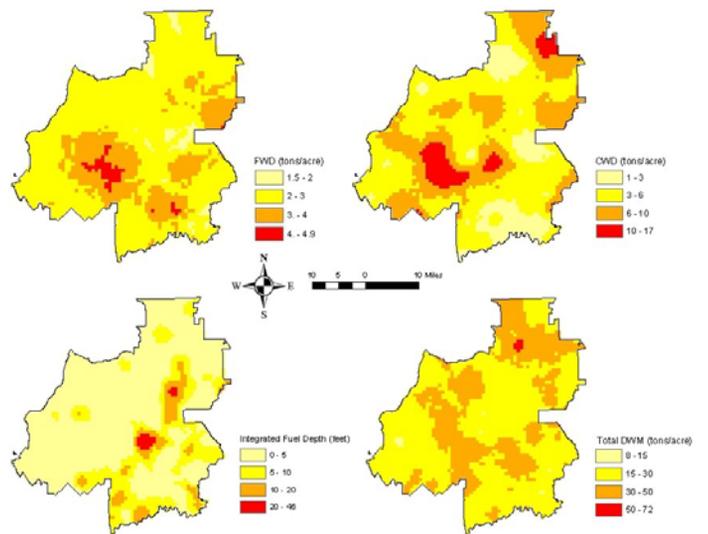


Figure 10. Kriged surfaces of DWM on the ANF.

## Literature Cited

U.S. Department of Agriculture, Forest Service. 2002. Forest inventory and analysis national core field guide, volume 2: field data collection procedures for phase 3 plots, version 1.6. U.S. Department of Agriculture, Forest Service, Washington Office. Internal report. On file with: USDA, For. Serv., Forest Inventory and Analysis, 2014th St., Washington, D.C., 20250.

Woodall, C.W. and M.S. Williams. 2004. Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program. USDA For. Serv. Gen. Tech. Rep. NC-xxxx. In press.