2001 and 2002 Down Woody Materials P3 Data for Eastern U.S. Forests

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Forest Floor Monitoring

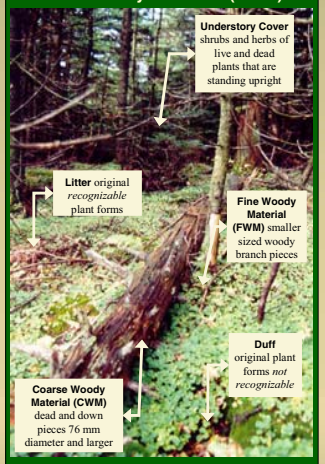
In addition to carbon mass in living and dead standing trees, forests include considerable carbon in plant material lying on the forest floor.

The U.S. Department of Agriculture (USDA) Forest Service, Forest Inventory and Analysis (FIA) program—which has monitored U.S. forests for more than 70 years—has added down woody material (DWM) to a subsample of its plots.

FIA started monitoring DWM in 2001. Methodology for compiling these data is under development. This poster overviews an initial compilation and summary for 2 years of data.

Figure 1—Coarse woody material (CWM) is greater than 76 mm diameter at the small end.

Major Components of Down Woody Materials (DWM)



Data Collection and Modeling Methods

The FIA inventory uses a 3-phase design to periodically monitor field plots across all land ownerships in the U.S.:

- **Phase 1** (P1) remote-sensing phase to determine forest area;
- **Phase 2** (P2) grid of 120,000 field plots at 5-km intervals to measure trees;
- **Phase 3** (P3) subsample of these plots to collect more detailed forest health information.
- P2 plots sample the nation's 302 million ha of forestland, with about 1 plot per 2,500 ha. P3 plots subsample 1/16th of the P2 plots.

In 2001 and 2002, FIA made DWM measurements on 1,531 P3 plots in the eastern U.S., including:

- diameters and transect lengths for CWM and FWM;
- layer depth for litter and duff, and cover for shrub and herbs **(Figure 2)**.

The measurements were combined with material density (specific gravity) values in linear equations to compile dry-weight mass (Mg/ha) for each DWM component **(Figure 3)**.

Because DWMs were subsampled from FIA plots, a method was needed to extend DWM data to all plots. This was done by developing regression models for each DWM component from P2 plot variables on forest structure and auxiliary climate variables **(Table 1).**

Figure 2—Fine woody material (FWM) is measured along transects in 3 diameter classes (<6, 6-25, 25-76 mm). Litter and duff depths are measured at points.

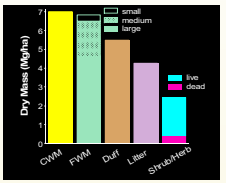


Figure 3—Mean mass for DWM estimates from 1,531 FIA plots in eastern U.S.

Table 1—Plot-level regression model for estimating down woody material:
Component $= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_9 X_9$
Model Coefficients

Component	β_0	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	R^2
CWM	-2.09	9.9536	0	0	0.091	0	0	0	-0.0044	0.0876	0.19
FWM (25-76 mm)	3.36	3.2936	0	-0.0009	0	0	0.0202	0.0651	0	0	0.02
FWM (6-25 mm)	-0.58	0	0	0	0	0.2028	0	0.0255	0	0.0101	0.06
FWM (< 6 mm)	0.55	0	0	0.0002	0	0.209	0.0135	0.0189	0	0	0.13
Litter	6.00	0	0	0.0013	0	0	0	-0.0173	0.0019	-0.0327	0.12
Duff	13.13	0	0	0	0	2.6721	0.2439	0.313	0	0	0.15
Shrub/ Herb	4.86	0	-0.0297	0	0	0.2924	0	0	0	-0.0202	0.16

$$\text{Component} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_9 X_9$$

where

Equation Variables Defined

Component = mass of down woody and understory components (Mg/ha)

X_1 = proportion of dead trees (≥ 5.0 dbh) tallied on FIA plot (value from 0 to 1)

X_2 = total basal area of live trees (≥ 5.0 dbh) on FIA plot (m^2/ha)

X_3 = number live trees (≥ 5.0 dbh) tallied on FIA plot (No./ha)

X_4 = quadratic mean diamter of live trees (≥ 5.0 dbh) tallied on FIA plot (cm)

$X_5 = \begin{cases} 1 & \text{if forest type is coniferous forest} \\ 0 & \text{otherwise} \end{cases}$

X_6 = longitude of county center for all FIA plots in that county (decimal degrees)

X_7 = latitude of county center for all FIA plots in that county (decimal degrees)

X_8 = average precipitation of county center for all FIA plots in that county (mm/yr)

X_9 = average number of days rain or snow fell in county center for all FIA plots in that county (No./yr)

Results for Eastern U.S.

Total forest carbon was estimated at about 11.2 Pg (10^{15} gm) for 33 eastern U.S. states. About 17%, or 1.9 Pg, was DWM **(Table 2)**.

The 17% DWM proportion of total carbon appears fairly constant across U.S. regions. However, variation in our estimates is probably somewhat "smoothed" by the regression methodology, because our low R^2 models essentially applied regional means to each FIA plot.

Amounts of CWM, FWM, and duff decrease from north to south across the eastern U.S., but litter and shrub/herb mass increase from north to south **(Figure 4)**.

Table 2—Carbon in eastern U.S. forests.

U.S. Region	Total Pg*	DWM	Dead tree	Live tree	No. of plots
		percent of total			
North Central	2.3	17	6	77	36,638
Northeast	3.2	17	5	78	15,570
South	5.7	16	4	80	47,104
Total	11.2	17	5	78	99,312

*Pg = 10^{15} gm; carbon is assumed 50% of dry mass

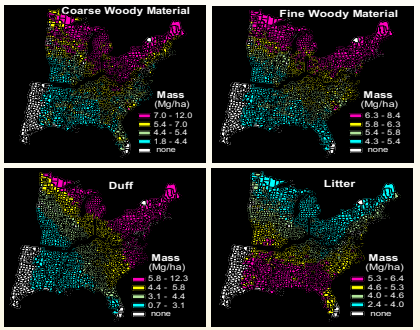


Figure 4—Average amount of DWM components in eastern U.S. counties. Estimates are based on 99,312 plots in the FIA database from 2000 Eastwide version. Legend is quartiles of distribution among counties.

Transect Sampling Variation

CWM and FWM were sampled on transects overlaid on a cluster of 4 subplots. However, some plots contained fewer than 4 subplots when a plot straddled more than one forest condition. These data provided opportunity to examine within-plot sampling variation by calculating the coefficient of variation (CV) for numbers of subplots per plot.

CVs ranged from about 20% to 70% depending on component. **(Figure 5).**

Some illogical patterns were observed. For example, CWM increased as number of subplots per plot increased, which causes concern that CWM may be too sparsely distributed for the FIA sample design.

Although CV for FWM decreased (as expected) as number of subplots increased, the larger material had the larger CV, which raises concern about too-short transect length.

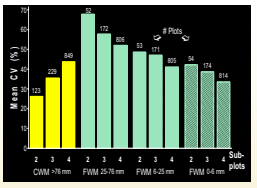


Figure 5—Mean coefficient of variation (CV) computed for CWM and FWM for varying numbers of subplots within FIA plot.

Conclusions

- The 1.9 Pg of DWM in eastern U.S. forests is a significant amount (17%) of 11.2 Pg total forest carbon (excluding soil).
- Although DWM measurements are being routinely collected, considerable effort is required for compiling these measurements into mass estimates. This raises questions for further study of sampling and compilation methods.
- Linkages established between the DWM model and the FIA database offer a method to monitor DWM, which will be beneficial for understanding global warming, measuring carbon credits, assessing wildlife habitat, managing fire fuels, and other forest health issues related to dead wood and the forest floor.

Future Plans

- Models in Table 1 will be refined to improve predictive capability by: (1) including 2003 data, (2) doing further analysis of P2 data associated with P3 plots, and (3) testing for regional differences.
- Duff and litter P3 soils data will be analyzed for new material density estimates to improve compilation of DWM duff and litter components for eastern U.S. forests.

Further Information:

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