Down Woody Materials: Simple Mass Estimation from a Complex Forest Service Database

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Introduction

Down woody materials (DWM; **Figure 1**) include

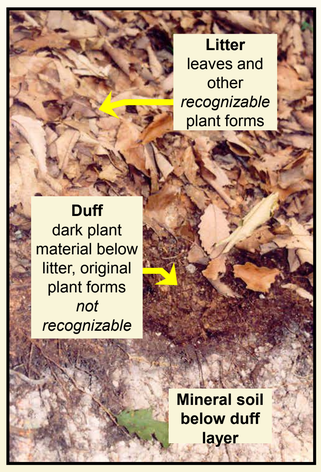
- soil organic layers of duff and litter
- dead and down fine and coarse woody detritus (FWD, CWD)
- live and dead understory vegetation

Accurate assessments of DWM are important because of their roles in carbon storage in the forest floor, organism habitat, nutrient cycling, fire risk, and fuel loading.

The Forest Inventory and Analysis (FIA) Program of the USDA Forest Service subsamples DWM in Phase 3 of its survey of all U.S. forest lands regardless of ownership (Bechtold and Patterson 2005):

- Phase 1 (P1): remote-sensing phase to determine forest area
- Phase 2 (P2): grid of about 120,000 field plots (1 per 2,400 ha) to measure trees
- Phase 3 (P3): 1/16th subsample of P2 plots to collect detailed forest health information, including DWM

We compiled DWM component measurements from FIA plots into mass estimates, for online posting and for simple use with key stand structure variables.



a. Duff and litter layers.

b. FWD size classes. Left to right: <6 mm, 6–25 mm, and 26–76 mm diameter.

c. CWD (> 76 mm small-end diameter) measured for diameter along transects.

Figure 1—Down woody material.

Data Collection and Compilation

We downloaded all DWM plots available in November 2010 (http://apps.fs.fed.us/fiadb-downloads/datamart.html) (**Figure 2**):

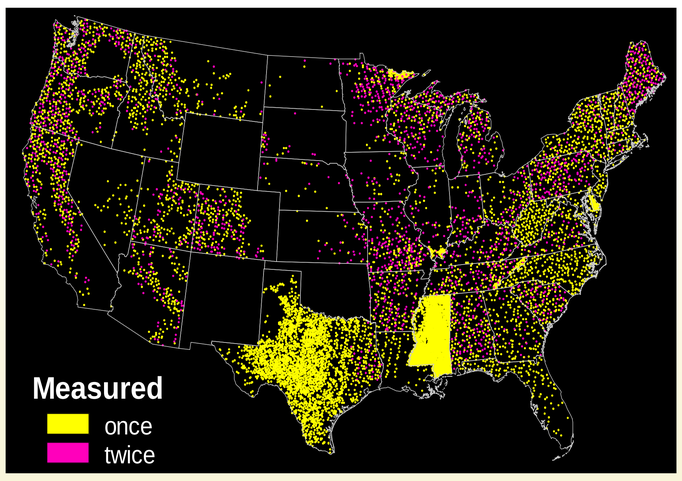


Figure 2—FIA measured DWM on 11,713 plots (134 in AK not shown) between 2001 and 2009 in all states except NM, WY, and OK. Most states were sampled at 1 plot per 38,000 ha forestland; but sampling was more intense for western TX and MS (after Hurricane Katrina), and sometimes for certain ownerships like national forests. Plots are remeasured on a 5- or 10-year cycle in respective East or West.

- FIA collected data for DWM components from transects radiating from centers of FIA plots (Woodall and Monleon 2008)
  - CWD, FWD sampled by measuring cross-section diameters at point of intersection along transects
  - Depth of duff and litter measured at points along transect (**Figure 3**)
  - Exact sample frames at each plot varied but averages were:
    - 58 m of total transect for CWD
    - 5–8 m of total transect for FWD (depending on material size)
    - 8 points for duff and litter DWM
    - 3 microplots (3.5-m^2) for percent understory cover

Figure 3—Litter and duff depths are measured at points along transects.

Over 10,000 lines of computer code were needed to synthesize more than 500 files. Why?

- FIA's DWM sampling was not fully integrated with its P1/P2 design, but an independent add-on (Brown 1974) —that required considerable end-user integration.
- FIA file structure was organized around field data collection, not end-product data use.
- FIA field plots can be uniquely split into "conditions" based on forest ownership, type, and stand structure variables—and splits can inconsistently reduce or omit P3 sample material.
- Calculation of dry-weight mass for DWM components (Chojnacky et al. 2004) required considerable auxiliary information, e.g., specific gravity, mean diameters of FWD classes, etc. Although FIA provided much auxiliary information, it contained gaps, uncertainty, and some publication errors that required much checking and adjustments.

Results and Discussion

Plot Scale: Online Database

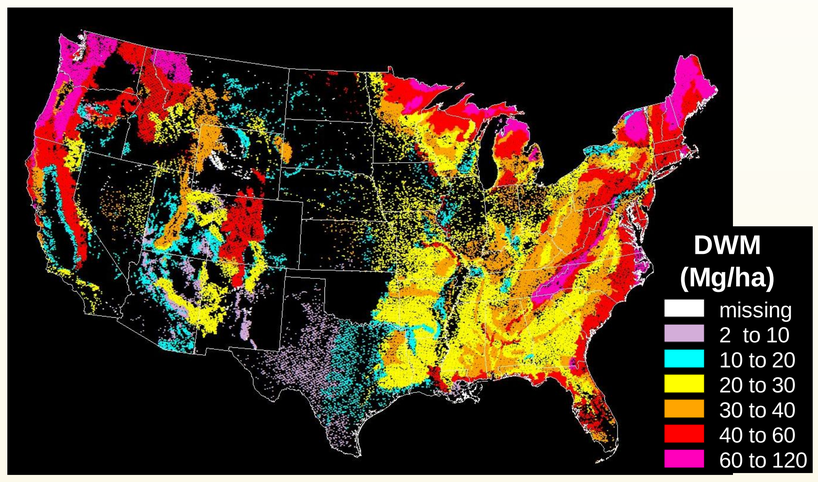
A Microsoft Excel® file of the 11,713 plots is being posted on a Virginia Tech website:

- All DWM components and accompanying P2 data on forest structure are in one convenient location.
- Users can manipulate these data using GIS or statistical software to pull out plots, summarize by ecoregion unit, or otherwise match DWM data with their needs.
- For ease of use, the "conditional" FIA plot splits have already been reverse-engineered back into whole plots.

Ecoregion Scale: DWM within Subsection or Section

- **Mean DWM within ecoregion subsection is a simple format for dissemination** of DWM data for use within the United States (**Figure 4**).
- Depending on number of plots available, subsection means could be further subdivided into means by forest type, stand size, or other available FIA variables.

Figure 4—Mean DWM mass within ecoregion subsection or section, mapped to corresponding forested FIA P2 plots. About 70% of plots correspond to subsection means based on 3 to 511 plots (median 8). When a subsection mean included 2 or fewer plots, the section mean was mapped. Hence, "section means" sometimes extrapolated into states not sampled (e.g., NM and WY; Figure 2).



State Scale: DWM Components and Comparison to Total Biomass

The database was designed to use at finer (e.g., ecoregion) scale, but 2 state-scale examples illustrate the relationships among DWM components and to total forest biomass.

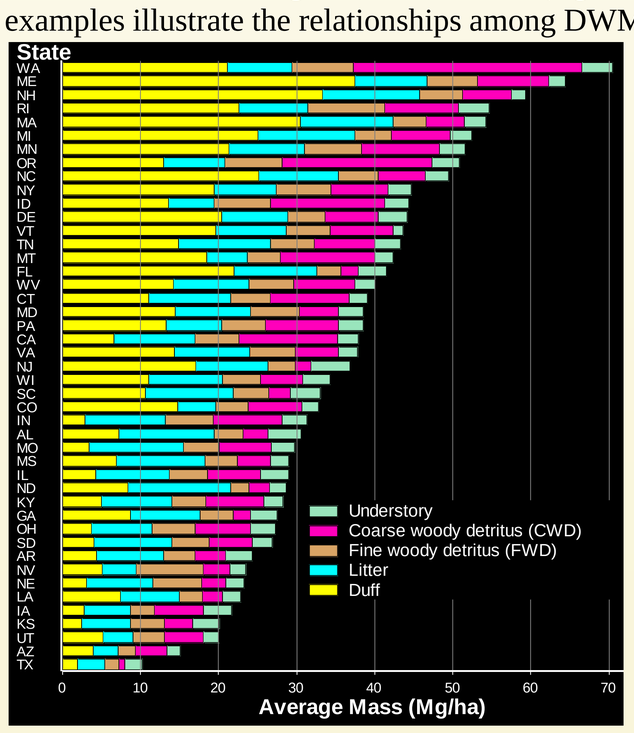


Figure 5—DWM components summarized to state scale. Separation of DWM into components would be useful for applications in the areas of fire fuels, soil productivity, wildlife habitat, etc.

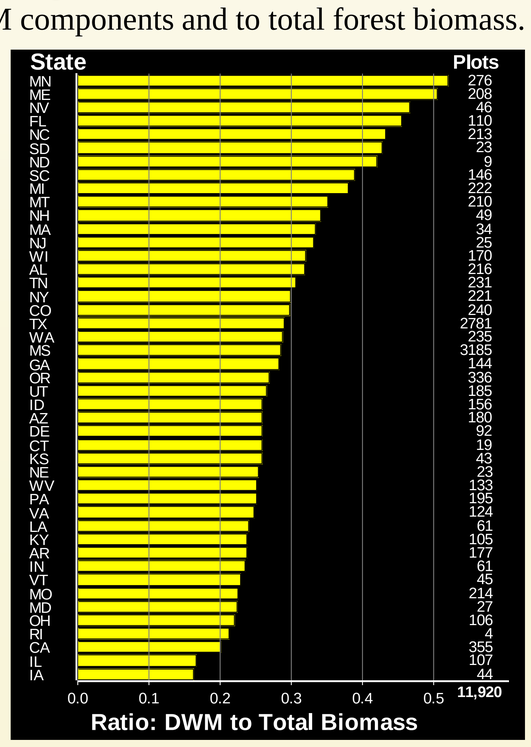


Figure 6—Ratio of DWM to total above- and belowground biomass. For most states DWM is 20% to 40% of total biomass.

Conclusion

- Current DWM component data from FIA plots was synthesized into a simple-to-use format that will be available online.
- The synthesis process was not simple because of FIA data complexity; for example, the ratio of compilation/development time to analysis time for producing the figures shown here was 50-to-1.

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