Estimating Carbon in Forest-floor Duff and Litter from FIA Data

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Introduction

The forest floor is an important part of forest management for carbon storage, biodiversity, nutrient cycling, and fire fuel hazard. Foresters commonly separate forest floor into 3 successive layers: (1) branches and logs (fine and coarse woody materials), (2) litter; and (3) duff (Fig. 1). The focus of this study is on duff and litter layers for eastern U.S. forests.

Data Collection and Modeling Methods

The 3rd phase of the FIA inventory includes soil and other forest floor measurements. This phase consists of about 1/16 of FIA’s 120,000 forest plots, which are monitored nationwide over a 5- to 10-year cycle (FIA 2005b). At each plot, generally 3 duff and litter samples were collected (Fig. 3); layers were combined during collection. We measured depth of litter and duff layers separately at 4 points within each 30.5-cm (12-in) diameter sample before the sample was collected. Duff and litter samples were then sent to lab where dry weight and carbon content were determined for both layers combined.

Data were summarized for each plot, and regression analysis was used to predict carbon content (Mg/ha) from available predictor variables. Graphical analysis was used to select variables and devise modeling strategy. Carbon was used for the dependent variable because it was better correlated with layer depth measures than was mass. Hoefl’s function (Daniel and Wood 1971) was used as the base model equation to allow considerable flexibility in fitting data. Final model predictor variables included duff and litter depth (Dd, Dl) and some 0.1 indicator (dummy) variables. The model now permits prediction of duff and litter carbon simply by measuring depths at a few points along transects (Fig. 4).

Some of the unexplained variation is due to regional spatial distribution of the plots, where forest floor is subjected to different climates that affect decomposition. To capture some of that spatial component, indicator variables (nc and so) were included to separate FIA regions. Remaining indicator variables separated organic soils from the rest. Duff and litter depth were included in 2 forms as direct measurement and as ratio of duff to total. The final regression model explained 54% of the variation (R²=0.54, log units):

\[ FFC_c = \exp \left( 0.39967 + 1.13322 \ln (D_d) + 0.07126 D_l + 0.73143 D_d \right) - 0.12994 nc - 0.39935 so - 0.41555 p \]

Where:

- FFCc = forest floor carbon of duff and litter combined (Mg/ha)
- Dd = depth of duff (cm)
- Dl = depth of litter (cm)
- nc = 1 if plot located in North Central FIA region, 0 otherwise
- so = 1 if plot located in Southern FIA region, 0 otherwise
- or = 1 if plot from an organic soil type, 0 otherwise

Conclusions

- Combined duff and litter carbon can be modeled (R²=0.54) from simple forest floor depth measurement.
- The model can likely be improved with greater availability of FIA data for describing regional spatial dimensions in data (particularly more measurements from phase-2 plots).
- Separate estimates of duff and litter are available from the model process but further study and better models could be developed if duff and litter were kept separate for lab processing.
- Mass of duff and litter is about 50% carbon for organic soils but close to 30% carbon for all other soil types.

References

- FIA, 2005 a. 10-year forest floor depth measurement. USDA Forest Service, Forest Inventory Analysis (FIA) program currently measures variables related to duff and litter on a subsample of plots covering all U.S. forests regardless of ownership. We use FIA field and lab soils data (FIA 2005a) to test a model of duff and litter carbon storage based on simple measurements of forest floor depth. The objective is to provide a simple field technique for estimating forest floor carbon (Fig. 2).

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