

TITLE: Multi-scale modeling and mapping coarse woody debris
(THIS REQUEST IS FOR RENEWAL FUNDING: Year 2 of 2)

LOCATION: North Central Region

DURATION: 2 years

FUNDING SOURCE: Fire Plan EM

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PROJECT OBJECTIVES:

1. Develop generalized plot-level and stand-level statistical/computer models to quantify coarse woody debris (CWD) using plot and site factors.
2. Develop a system of predictive models applicable for multiple spatial scales (from 1 ha up to approximately 100 ha in extent) and identify estimation/prediction accuracy associated with each spatial scale. (Note: See *Background* material below. For forest components such as CWD that are highly variable among plots, models predicting CWD on areas larger than a single plot or stand can perform better than models based on individual plots and often have other advantages.)
3. Evaluate the use of ensembles of models to predict CWD.
4. Apply the models in conjunction with FIA/FHM plots and other sources of data to map CWD for selected subregions in Missouri. Missouri sites serve as a prototype to calibrate and test a general approach suitable for eastern forests.
5. Compare data and predictions to values for other published CWD inventories in the Midwest.

JUSTIFICATION: Coarse woody debris is a key component in fuel loading and fire modeling as well as for wildlife habitat evaluation. The ability to use modeling to extend the utility of the limited amount of available coarse woody debris data will aid in the management of fire, fuels and wildlife habitat.

DESCRIPTION:

a. Background: FIA/FHM programs provide important data that have been used to map dead and down woody material for multi-state regions (McRoberts et al. 2004). The dead and down woody material maps generated based on FIA/FHM plots are too coarse to describe variation at small spatial scales because of the low sampling intensity (about 1 Phase 2 and Phase 3 plot per 2,500 and 40,000 ha, respectively). The resultant maps are, therefore, insufficient for regional resource management and planning to evaluate fire risk or wildlife habitat suitability (e.g., at the scale of a national forest or other sub-state region). Generally, dead and down woody material is relatively scarce and varies dramatically at small spatial scales such as plots/stands, even when the plots/stands are similar in many other respects (Shifley and Schlesinger 1994). This is due to the spatially stochastic nature of disturbance agents (Shifley et al. 2000) and the resultant tree mortality and decay process. Research on other rare components of the forest such as cavity trees have indicated rare forest components are predictable within a tolerable range of errors at relatively small spatial scales (e.g. 20 ha blocks) using stand and site factors, and the prediction/estimation error may be reduced significantly by employing an ensemble of related models rather individual component models (e.g., simple linear regression models) (Hensen and Salamon 1990, Breiman 1996, Lee 1999, Fan et al. 2004a, 2004b). The scale-dependent statistical/computer models and ensembles of predictive models can be developed by using boot-strapping techniques to combine groups of FHM plots and create virtual landscapes of various sizes where the CWD characteristics are known. These can be linked with other data sources such as remote sensed imagery, GIS layers, or other sources of existing data (e.g., Shifley and Brookshire 2000) to map dead and down woody material at finer scales than previously reported for the Midwest. Other sources of CWD data for the region (Shifley et al. 1997, Spetich et al. 1999) serve as an additional benchmark against which to compare findings from FHM data.

b. Methods: 1. Use classification and regression tree (CART) and other machine learning tools to identify the hierarchical relation of dead and down woody material to the associated stand/site factors based on FIA/FHM and intensive monitoring plots (phase 3 plots).

2. Construct a statistical/computer model (e.g., probability density model) to quantify and characterize change of dead and down woody material stratified by stand and site factors identified in step 1 above.

3. Use resampling (e.g., bootstrap), ensemble modeling, and computer simulation to aggregate model results across different spatial scales (one to many hectares) to construct scale-dependent models and ensembles and evaluate the effect of scales on prediction/estimation accuracy and statistical power.

4. Integrate intensive monitoring and FIA/FHM plots to map dead and down woody material based on models applied at scales larger than the individual plot. Initial applications will be in Missouri where CWD data are relatively abundant from multiple sources. The process is generic and should be applicable throughout the eastern United States.

c. Products: 1. An identified set of hierarchical stand and site factors and/or computed composite variables statistically associated with dead and down woody material. (year 1)

2. A set of statistical/computer models applicable for estimating CWD at multiple spatial scales. (year 1)

3. Dead and down woody material maps for Missouri based on models or ensembles applied at different scales. These also serve as prototypes for extension of the methods to other geographic regions. (year 2)

d. Schedule of Activities: (Based on elapsed time from date of award)

Year 1: Month 1 to 6: Exploratory data analysis to identify down and dead woody material pattern and associated stand/site factors.

Month 7 to 10: Develop confirmatory statistical/computer models.

Month 11 to 12: Model evaluation and quantify prediction accuracy across scales

Year 2: Month 1 to 6: GIS work and generate dead and down woody material maps at appropriate scales based on current FIA/FHM and intensive monitoring plots

Month 7 to 9 Simulate down and dead woody material change under management alternatives

e. Progress/Accomplishments: We analyzed dead woody material (DWM) data from 103 FIA/FHM plots in Missouri. We compared findings for the CWD component with data from 548 inventory plots from the Missouri Ozark Forest Ecosystem Project (MOFEP). We also examined snag density for a wide range of Missouri forests conditions. Snags are a source of wildfire fuel and wildlife habit; when they fall they make large additions to the DWM on the forest floor and they provide habitat to alternative species of wildlife.

Total dead woody materials (DWM) averaged 19 tons, and CWD averaged 518 cubic feet per acre on Missouri forests (Table 1). The great variability in the sampled values was notable. Standard deviations of totals and of individual components were typically twice as large as the means (i.e., coefficient of variation approx. 200%). This has important implications for sampling and mapping DWM in the next phase of the study.

Table 1. Summary statistics of by components of dead woody materials in Missouri FHM plots.

DWMComponent	plot #	mean	Std. dev.	Min.	Max.
Total (tons) DWM	103	18.94	38.99	0	329.11
FWD (tons)	103	1.60	2.01	0	18.72
CWD (tons)	103	4.42	10.99	0	85.41
Litter (tons)	103	0.87	1.88	0	12.83
Slash (tons)	103	6.96	37.50	0	328.64
Duff (tons)	103	5.09	8.13	0	43.48
FWD(%)	103	22.83	23.29	0	100.00
CWD (%)	103	24.80	30.46	0	100.00
Litter (%)	103	8.17	12.62	0	72.59
Slash (%)	103	8.81	24.38	0	99.85
Duff (%)	103	35.37	32.18	0	99.22
CWD (cuft)	103	517.99	1244.20	0	7288.96

We learned that silvicultural treatments had a measurable effect on CWD ≥ 2 inches in diameter. The volume of CWD increased significantly with increasing intensity of harvest disturbance at the MOFEP sites (Figure 1).

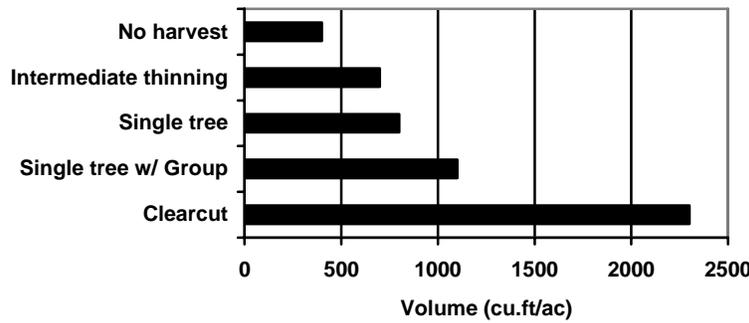


Figure 1. Volume of CWD (2 inches in diameter and larger) by harvest treatment.

Snag density (number per acre) increased up to stand age 40 years, but the number of large snags continued to increase with increasing stand age beyond age 40 (Table 2).

Table 2. Snag density (number/ha) by size class in Missouri second-growth forests (FIA plots) and the old-growth forests in Missouri, Indiana and Illinois

Age class (year)	# of FIA plots	Mean / Standard deviation			
		total	dbh ≤ 25 cm	26cm<dbh≤48 cm	dbh > 48 cm
1-10	244	8.7 / 31.9	5.8 / 24.8	2.7 / 9.8	0.2 / 1.4
11-20	726	10.6 / 40.1	8.3 / 36.0	2.1 / 7.7	0.2 / 1.0
21-30	203	11.1 / 37.1	9.4 / 30.7	1.6 / 10.1	0.1 / 0.7
31-40	395	19.9 / 53.3	17.4 / 49.2	2.3 / 7.6	0.2 / 1.1
41-50	574	19.9 / 45.8	16.1 / 40.7	3.5 / 11.2	0.3 / 1.6
51-60	438	20.7 / 47.7	17.5 / 42.7	3.0 / 8.7	0.3 / 1.0
61-70	427	21.3 / 42.7	16.6 / 37.0	4.3 / 10.1	0.4 / 1.5
71-80	358	19.7 / 36.6	15.3 / 33.1	4.0 / 8.3	0.3 / 1.3
81-90	270	15.7 / 35.8	12.1 / 32.6	3.2 / 6.7	0.4 / 1.6
91-100*	417	22.6 / 42.0	16.5 / 35.4	5.4 / 11.5	0.7 / 2.0
Old-growth	303	24.2 / 19.0	13.1 / 15.6	6.6 / 9.2	4.4 / 6.3

* including plots > 100 years.

We also learned that the volume of CWD was significantly related to the volume of live trees on an inventory plot. But the variation in regression estimates of CWD as a function of live tree volume was quite large for individual plots. However when 6 or more plots were combined (based on proximity) and used to regress CWD against live tree volume, the standard error of regression decreased sharply. This has implications for sampling and mapping CWD volume. We will explore those implications in detail during the coming year.

COSTS (renewal request for Year 2 of 2)

	Item	Requested FHM EM Funding	Other-Source Funding	Source
YEAR 1				
Administration	Salary & Benefits	\$45,000	\$25,000	Cooperators (in kind)
	Travel	\$800	\$2,000	Cooperators (in kind)
Procurements	Contracting			
	Equipment			
	Supplies	\$ 300		
Year 1 Total	Received FY 2005	\$46,100		
YEAR 2				
Administration	Salary & Benefits (Fan)	\$39,000	\$27,000	Cooperators (in kind)
	Travel	\$1,000	\$2,000	Cooperators (in kind)
Procurements	Overhead Univ of MO (25%)	\$13,500		
	NCRS (5%)	\$2,842		
	Supplies	\$500		
YEAR 2 Request	Requested for FY 2006	\$56,842		
Total project (2 years)		\$102,942		

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