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Specific Gravity of Coarse Woody Debris For Some Central Appalachian Hardwood Forest Species

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Abstract

Although coarse woody debris (CWD) may play an important role in nutrient cycling in eastern hardwood forests, it rarely is included in nutrient budgets for most ecosystems. Meaningful nutrient budgets require reliable estimates of biomass and nutrient concentrations. The CWD of 21 tree species was sampled in a central Appalachian forest within the Fernow Experimental Forest in West Virginia. The specific gravity of CWD was determined for three decay classes. Mean values ranged from 0.360 to 0.729 g cm^{-3} for decay class 1 (least decayed wood; coefficient of variation = 22.2 percent), 0.286 to 0.560 g cm^{-3} for class 2 (CV = 22.7 percent), and 0.215 to 0.442 g cm^{-3} for class 3 (CV = 26.8 percent). Black locust and several oaks had the highest specific gravity; fire cherry, yellow-poplar, and basswood had the lowest densities across all decay classes. Specific gravity decreased by nearly 50 percent from class 1 to 3.

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Introduction

Coarse woody debris (CWD) may play an important role in nutrient cycling in forested ecosystems (Boddy 1983; Harmon et al. 1986), but it is rarely included in nutrient budgets for most ecosystems. Meaningful nutrient budgets require reliable estimates of biomass and nutrient concentrations. For CWD, these estimates often are not based on species-specific measurements of specific gravity at various stages of decay but on fresh, solid wood, or on values averaged across species and thus may not accurately represent CWD. There are few specific gravity values for hardwood tree species by decay class (Idol et al. 1999), and they are lacking for many of the tree species found in Appalachian hardwood forests.

We sampled CWD of 21 tree species commonly found in Appalachian hardwood forests (Table 1). Our objective was to obtain estimates of specific gravity for three wood-decay classes for these species, so that survey data (volume or amount of wood) can be more accurately converted to biomass in constructing nutrient budgets for entire ecosystems. This research was part of a larger study evaluating the productivity and nutrient cycling in Appalachian hardwood forests (Adams 1999).

Methods

Samples of dead wood (> 10 cm diameter) were collected from 21 tree species from each of the three decay classes. Part of a larger system for describing CWD of species on the Fernow Experimental Forest (L. Thomasma, unpublished), the classes are:

1. Wood is uniformly firm along the bole length; bark is mostly intact.

2. Wood is soft in some places but not uniformly so; bark is loose and may be absent.

3. Wood is soft throughout and can be crushed or broken easily; little or no bark remains.

Downed wood on untreated areas of the Fernow was identified as to species and decay class for sampling. A single crew was used to collect and assess samples. Disks were removed from 20 pieces of CWD for each species and decay class. These samples were returned to the lab where they were subsampled. We used only wood for which the species could be determined positively. Dead wood that is so decayed that the species cannot be recognized is comparable to Class IV and V wood in other systems, and was not included in this study (Maser et al. 1988).

Each sample was weighed immediately after being brought into the lab. The green volume of the CWD sample was determined by water displacement. Samples were then dried in a forced-air oven at 65°C, until constant weight was achieved (about 5 days) and then reweighed. A lower oven temperature was used to reduce potential nitrogen losses so that future nutrient analyses would not be compromised. However, to assure comparability with standard procedures, a subset of CWD samples were dried at 65°C and then at 102°C for another 3 to 5 days and the difference in mass determined. At the higher temperature, oven-dry mass changed less than 1 percent (generally less than 0.5 percent), so we believe that our mass estimates are accurate and comparable. Specific gravity was calculated as dry weight (in grams) divided by the green volume (in mL or cm^3).

Unbalanced, one-way analysis of variance was used to evaluate the effect of species on specific gravity for the three decay classes; Duncan's multiple range was used to compare species means within decay classes. A paired t-test was used to test the hypothesis that specific gravity values for freshly dead wood (class 1) did not differ from published values (U.S. Dep. Agric. 1974). All comparisons were evaluated for statistical significance at p=0.05 unless otherwise indicated.

Results and Discussion

Mean specific gravity ranged from 0.360 to 0.729 g cm^{-3} for decay class 1, (coefficient of variation = 22.2 percent), 0.286 to 0.560 g cm^{-3} (CV = 22.7 percent) for class 2, and 0.215 to 0.442 g cm^{-3} (CV = 26.8 percent) for class 3 (Table 1). Across all species, mean specific gravity decreased by nearly 50 percent from class 1 to 3 (Fig. 1, Table 1).

Mean specific gravity differed significantly among species within decay classes (p=.0001). For the least decayed wood (class 1), chestnut oak and black locust had significantly higher specific gravity than other species (Fig. 2). The specific gravity of black locust also was significantly higher than all other species in class 2. We could not locate black locust that fit the definition of decay class 3, probably because of the even age of the forest (approximately 90 years) and the strong decay resistance of black locust wood. Additionally, there were no white oak in class 3 and only one

Table 1.—Mean specific gravity (g cm^{-3}) of dead wood of 21 tree species on the Fernow Experimental Forest, by species and decay class (standard deviation in parentheses; N = 20 unless indicated otherwise)

		Decay class		
Species	Scientific name	1	2	3
Red maple	*Acer rubrum*	0.602 (.045)	0.441 (.067)	0.317 (.037)
Sugar maple	*A. saccharum*	0.679 (.040)	0.392 (.086)	0.276 (.058)
Sweet birch	*Betula. lenta*	0.635 (.069)	0.420 (.099)	0.283 (.085)
Yellow birch	*B. lutea*	0.636 (.043)	0.385 (.058)	0.234 (.045)
American chestnut	*Castanea dentata*	0.360 (.046)	0.348 (.038)	0.255 (.056)
Bitternut hickory	*Carya cordiformis*	0.610 (.074)	0.367 (.074)	0.249 (.050)
Shagbark hickory	*C. ovata*	0.551 (.071)	0.479 (.087)	0.308 (.065)
American beech	*Fagus grandifolia*	0.598 (.070)	0.372 (.042)	0.245 (.042)
White ash	*Fraxinus americana*	0.475 (.070)	0.286 (.070)	0.317 (.048)
Yellow-poplar	*Liriodendron tulipifera*	0.458 (.046)	0.353 (.055)	0.215 (.024)
Cucumbertree	*Magnolia acuminata*	0.425 (.028)	0.399 (.084)	0.250 (.059)
Sourwood	*Oxydendrum arboreum*	0.524 (.103)	0.406 (.034)	0.337 (.057)
Fire cherry	*Prunus pensylvanica*	0.401 (.029)	0.337 (.026)	0.216 (.026)
Black cherry	*P. serotina*	0.577 (.072)	0.499 (.049)	0.346 (.097)
White oak	*Quercus alba*	0.644 (.036)	0.508 (n=1)	(n=0)
Scarlet oak	*Q. coccinea*	0.571 (.053)	0.502 (.041)	0.442 (.033)
Chestnut oak	*Q. prinus*	0.729 (.078)	0.489 (.093)	0.294 (.042)
Northern red oak	*Q. rubra*	0.650 (.057)	0.495 (.121)	0.368 (.098)
Black locust	*Robinia pseudoacacia*	0.725 (.031)	0.560 (.053)	(n=0)
Sassafras	*Sassafras albidum*	0.432 (.028)	0.388 (.042)	0.338 (.025)
American basswood	*Tilia Americana*	0.406 (.024)	0.333 (.032)	0.256 (.019)

value for this species in class 2, i.e., it is difficult to distinguish between white oak and other oaks at later stages of decay. Except for scarlet oak, all class 3 values for specific gravity ranged from 0.215 to 0.368 g cm^{-3} (Table 1, Fig. 2). Fire cherry, basswood, and yellow-poplar consistently had the lowest specific gravity for all decay classes. Generally, species of CWD with the highest class 1 values showed the greatest change from class 1 to 3 (Fig. 2).

Of the tree species found in mixed hardwood forests, those rated as the most decay resistant are black cherry, American chestnut, chestnut oak, white oak, and sassafras. Black locust showed exceptionally high decay resistance (U.S. Dep. Agric. 1974). It is important to note that all of the chestnut CWD that we sampled had been dead for approximately 60 years, which attests to its decay resistance. There was relatively little salvage of chestnut killed by blight in these control areas, so the wood available for sampling was large in diameter. The wood in decay class 1 was sampled from the outer portion of these large stems. Thus, while the wood met our requirements for class 1, it cannot be considered as “freshly dead.”

Our study did not directly address decay rates or resistance. Many factors contribute to decay rates of wood (Harmon et al. 1986). Decomposition rates may reflect qualitative differences among log substrates rather than simple quantitative relationships (Showalter 1992). The rate and progression of decay also are important in understanding the roles of deadwood in nutrient cycling, as wildlife habitat and food sources, and in carbon sequestration and release. For example, American chestnut decays from the inside (heartwood) out, resulting in valuable habitat for wildlife but has different nutrient release rates than a species like fire cherry, which decays quickly and uniformly.

We do not know when most of this deadwood originated, so we could not calculate decay rates. Such information would be useful in determining nutrient loss rates over time and the longevity of dead woody debris. We are currently analyzing the nutrient content of the samples of dead wood collected in this study for a future publication. In addition, a study to evaluate decay rates has begun on the Fernow Experimental Forest, where we have tagged CWD originating from two windstorms in 1993 and 1998. Logs will be resampled over time to estimate rates of mass and nutrient loss.

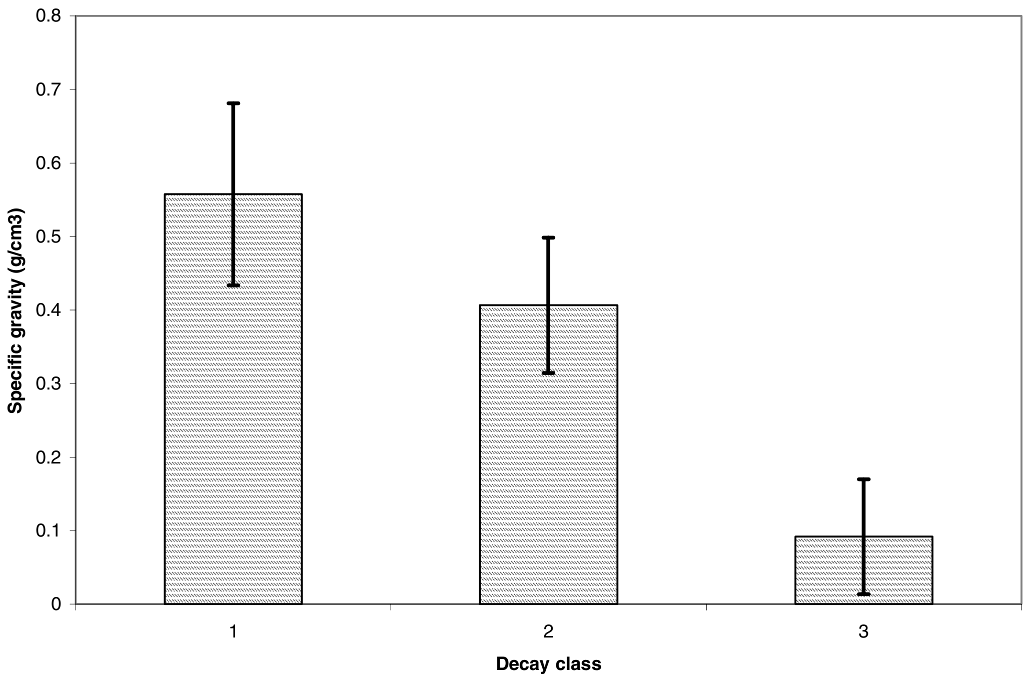

Figure 1.—Mean CWD specific gravity by decay class; vertical bars are standard errors.

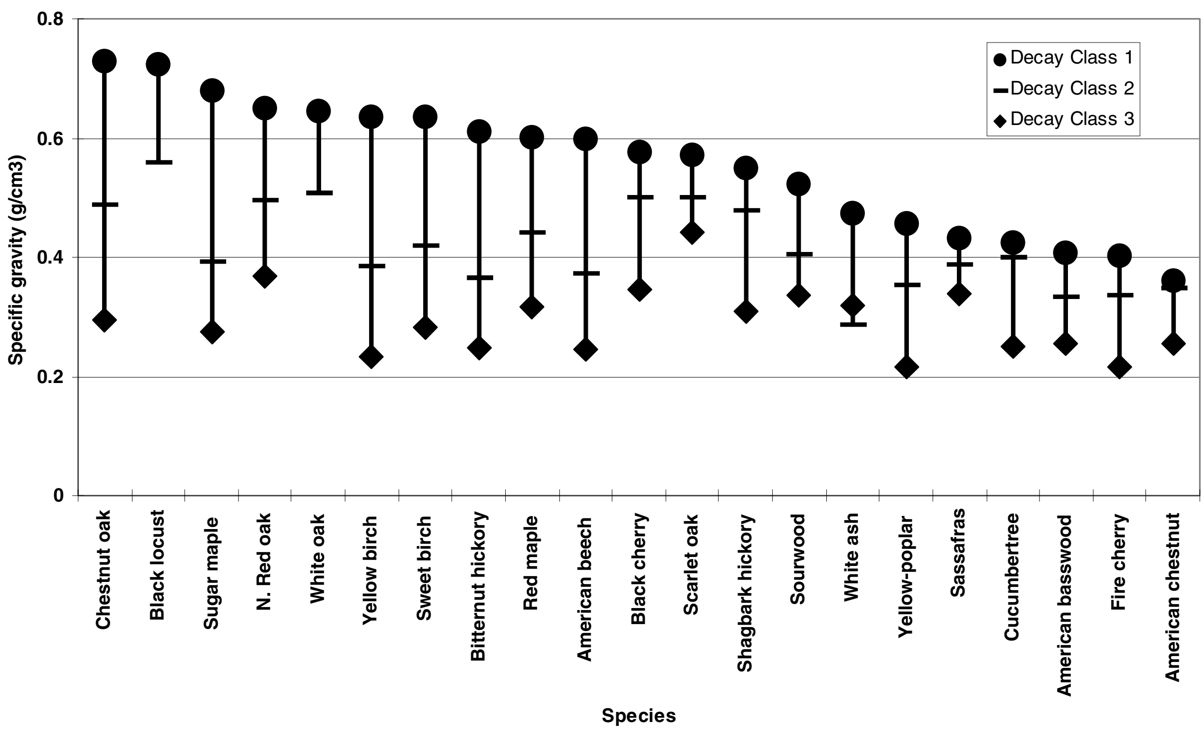

Figure 2.—Mean CWD specific gravity for 21 tree species for three decay classes.

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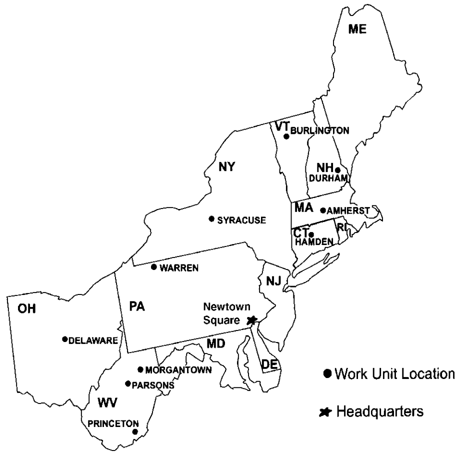
Keywords: down dead wood, decay class, wood density



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