Coarse Woody Debris in Relation to Forest Types at the University of Notre Dame Environmental Research Center, MI

BIOS 569: Practicum in Field Biology

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Abstract

The amount, structure, and dynamics of coarse woody debris (CWD), standing or fallen dead wood, can influence species composition, nutrient cycling, and productivity of a forest for centuries. Information on the structure and dynamics of CWD in different types of ecosystems is, therefore, very useful in the management of forests. This study tested the hypothesis that different types of stands found in northern Michigan would contain different volumes of CWD. Several studies have shown that the amount of CWD is highest in old-growth forests, intermediate in young, and lowest in mature forests. Other studies have shown that mixed and deciduous forests have a higher volume of CWD than coniferous forests. Therefore, I hypothesized that the volume of CWD would be greater in aspen-sugar maple (*Populus tremuloides, Populus grandidentata, Acer saccharum*) stands, as aspen is a young pioneer species, than in mixed hardwood and coniferous stands or sugar maple stands. The total volume of CWD, the volume per piece, the number of pieces, and the mean decay class were compared between the 3 types of stands. There was no significant difference in the volume of CWD, the volume per piece, the number of pieces, or the decay class among the 3 stand types. These results suggest that stand type does not affect CWD found there. Because all stands in the study were approximately the same age, the results are consistent with other studies suggesting that volume of CWD is a function of stand age.

Introduction

Coarse woody debris (CWD) plays an important part in the ecological and physical processes of forest ecosystems (Harmon et al. 1986). The presence of CWD is critical to many plant and animal groups (McGee et al. 1999 and Spetich et al. 1999) and serves as sites for seed germination as well as long term storage for moisture and nutrients (Harmon et al. 1986). The effects of the abundance, structure, and dynamics of CWD on species composition, nutrient cycling, productivity, and geomorphology of a forest can last for centuries (Spies et al. 1988). Depending on the forest type, stage of succession, land-use history, and management practices, the pool of CWD may contain significant portions of carbon and nutrient stocks (Clark et al. 2002). In addition, CWD in later stages of decay promotes favorable soil structure for the forest (Harmon et al. 1986). A description of CWD structure and dynamics in a variety of forest ecosystems is necessary to illustrate its importance in ecosystem function and this information can be useful to forest land managers in maintaining the biological diversity and productivity of ecosystems (Spies et al. 1988).

In the last few decades, many studies have been done on the dynamics of CWD in stands of different ages and regions, some contradicting each other. In several studies, old-growth stands have been found to contain the highest volumes of CWD (McGee et al. 1999, Vasiliauskas et al. 2004, Lee et al. 1997, McMinn and Hardt 1996). However, a few studies have found the highest volume of CWD to be present in young forests (Krankina et al 2002). Clark et al. (2002) found the volume of CWD to be highest in old growth forests, intermediate in young, and lowest in mature forests. Studies by Pedlar et al. (2002) and Lee et al. (1997) in boreal forests of Canada both showed that mixed and deciduous forests had a higher volume of CWD than coniferous forests. Because the volume of CWD in mature forests is known to be proportional to the biomass of living trees, the lower volumes of CWD in conifer stands found in these studies were thought to be a result of relatively lower volumes of living trees found there. The volume of CWD has also been found to increase at sites with increasing moisture (Vasiliauskas et al. 2004).

Another important component of CWD is its degree of decomposition. As CWD decomposes, its nutrients become more readily available to the ecosystem (W.P. Carson, personal communication). Several studies have shown that decay class does not differ among stand type (Pedlar et al. 2002, Lee et al. 1997, and McGee et al. 1999) and McGee et al. (1999) found the highest volume of CWD to be in the middle decay classes.

In this study, I tested the volume of fallen CWD in three types of forest stands: aspen-sugar maple stands, sugar maple stands, and mixed hardwood and coniferous stands. I hypothesized the volume of fallen coarse woody debris to be significantly different among the three types of forests. I predicted the volume of

CWD to be the greatest in aspen-sugar maple stands, followed by sugar maple stands, and finally mixed stands.

Methods

This study was conducted in the forests of the University of Notre Dame Environmental Research Center in the western part of the Upper Peninsula of Michigan. Five aspen-sugar maple stands, 5 sugar maple stands, and 5 mixed hardwood and coniferous stands were chosen throughout the UNDERC property in a way to represent the whole area (Fig. 1). Aspen-sugar maple stands were dominated by quaking aspen (*Populus tremuloides*), big-toothed aspen (*Populus grandidentata*), and sugar maple (*Acer saccharum*); sugar maple stands were dominated by sugar maple; and mixed stands mostly contained balsam fir (*Abies balsamea*), sugar maple, quaking and big-toothed aspen, and white ash (*Fraxinus americana*), and some contained paper birch (*Betula papyifera*), black spruce (*Picea mariana*), and eastern hemlock (*Tsuga canadensis*, Table 1).

Following Whitman et al., unpublished data, CWD was classified into five decay classes as follows: class 1: intact bark, very hard wood, original color; class 2: bark beginning to fall off, wood still hard, grayish color; class 3: bark falling off (parts gone), log starts to sag, wood separates into hard chunks; class 4: no bark left, log sags a lot, very soft wood that separates into small pieces, reddish color; class 5: no bark, powdery (almost soil). A 100 m x 10 m (1000m^2) plot was randomly chosen at each site and was located at least 10 m from a road and 10 m from another stand type. All CWD >8 cm in diameter and >100 cm in total length that was found inside the plot area was considered for this study. Pieces that were tipped must have had an angle of <45° with the ground to qualify (Bate et al. 2004). The average diameter (taken at the midpoint of the log), the length of the log inside the plot, the decay stage, the species (if possible), and the source and part were recorded for each piece of CWD. CWD volume was calculated using the equation for the volume of a cylinder ($V = (L)(\pi r^2)$). The volume of CWD in each site was calculated and the data at each type of stand was pooled. ANOVA tests were used to determine statistical significance of volume of CWD among the three types of forest stands.

Results

The volume of coarse woody debris was not significantly different (ANOVA, p=0.412, f=0.957, df=2) between the aspen-sugar maple, sugar maple, and mixed forest stands (Fig. 2). The volume of CWD per piece and the total number of pieces of CWD also showed no difference (ANOVA, p=0.606, f=0.523, df=2 and p=0.376, f=1.063, df=2, respectively) between the 3 types of stands (Figs. 3 and 4, respectively). Although not significantly different, the total volume of CWD, volume per piece, and number of pieces were all greatest in the mixed stands and lowest in the sugar maple stands. The mean decay class was not significantly different (ANOVA, p=0.627, f=0.485, df=2) between the 3 types of stands, although the mean decay class was slightly higher in the sugar maple stands (Fig. 5). Mean decay classes for all three types of stands fell between 2.5 and 3. The amount of CWD consisting of entire trees was significantly different (ANOVA, p=0.023, f=5.258, df=2) among the 3 types of stands (Fig. 6). The mixed stands had a significantly higher number of CWD consisting of entire trees (Bonferroni, p=0.022) than sugar maple stands. However, the test showed that the amount of CWD consisting of entire trees was not significantly different (Bonferroni, p=0.547) between aspen-sugar maple stands and sugar maple stands nor was it significantly different (Bonferroni, p=0.282) between aspen-sugar maple stands and mixed stands.

Discussion

The volume of coarse woody debris was not found to be different among the 3 types of stands (aspen-sugar maple, sugar maple, and mixed). Although not measured in this study, the ground in mixed forest stands contained more moisture than the other 2 types of stands, sometimes even containing sphagnum moss and freshly dried up vernal ponds. The CWD volume in wetter mixed stands was slightly higher than in the other 2 types of stands, similar to the findings of Vasiliauskas et al. (2004) that CWD increased as moisture increased. However, CWD volume in mixed stands was not significantly different from the drier hardwood stands. The sugar maple stands were found to have a slightly lower volume of CWD than the other 2 stand types, possibly due to the relatively dry conditions found in maple stands.

The volume of CWD in a forest stand has been shown to be related to stand age (McGee et al. 1999, Vasiliauskas et al. 2004, Lee et al. 1997, McMinn and Hardt 1996, and Clark et al. 2002). The forests on the UNDERC property are probably of approximately the same age (G. Belovsky, personal communication), which could account for the insignificant results of volumes of CWD in different stand types on property. This result could also be due to the extensive logging that occurred in the early decades of the twentieth century (K.E. Francl, personal communication), which removed potential CWD and possibly masked any differences in CWD volumes among forest types.

The average decay classes for all 3 types of stands fell within the middle decay classes, which is consistent with the findings of McGee et al. (1999) that most CWD fell into decay classes 2 and 3 throughout different stand types. It is possible that stand types in this study are showing the same CWD average decay classes if they are the same age and were logged at the same time.

The mixed forest stands contained the highest percentage of entire trees found within the CWD, while sugar maple stands contained the lowest percentage. The moisture content on the ground may account for this finding. Because the ground of mixed forest stands tends to have a higher moisture content than the other stands, the trees may have been more likely to uproot and fall over as a result of strong winds compared to trees in dryer stands with more solid ground, which may be more likely to snap at the top or middle during strong winds. Also, the smallest percentage of entire trees found in CWD content in sugar maple stands could be due to a closer canopy in which trees protect each other from strong wind and as a result, entire trees are less likely to fall.

A measure of the volume of living trees in each stand would have provided a ratio of CWD volume to live tree volume and would have allowed CWD comparisons with respect to relative productivity at each site. This additional factor would have corrected for the bias that some plots contained less trees than other plots, making relative CWD comparisons somewhat skewed. Also, including stumps in the study would have provided data on the history of sawn trees in the stands, which directly affects the amounts of CWD found there. A preliminary survey of stand ages by coring several trees in each type of stand before selecting them would have more accurately shown the age differences among stand types and allowed for further conclusions on the relationship between stand age and CWD. Another helpful addition to this study would have included measurements of moisture in the soil at each site so that definite conclusions could have been drawn involving the relationship of CWD volume and wetness of the ground. Dominant conifer stands and old-growth stands were excluded from this study because they are either too small or absent on the UNDERC property in the case of old-growth stands. Further studies on the relationship between stand type and CWD volume might be expanded to the surrounding Ottawa National Forest to include these types of stand.

Studies involving the dynamics of CWD in unmanaged forests of different ages, types, and histories provide very important information for current and future forest management. Because CWD is now known to be critical to physical and ecological forest processes, any future forest management at UNDERC should take into account the dynamics of CWD found there in order to preserve the physical quality and ecological biodiversity provided by CWD.

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Table 1. Dominant vegetation of each study site.

Sites	Dominant Canopy Species	Dominant Understory Species
Aspen-Sugar Maple		
1	*Populus grandidentata* *Populus tremuloides* *Acer saccharum*	*Abies balsamea* *Acer saccharum*
2	*Populus grandidentata* *Populus tremuloides* *Acer saccharum*	*Abies balsamea* *Acer saccharum*
3	*Populus grandidentata* *Populus tremuloides* *Acer saccharum*	*Acer saccharum*
4	*Populus grandidentata* *Populus tremuloides* *Acer saccharum*	*Abies balsamea*
5	*Populus grandidentata* *Populus tremuloides* *Acer saccharum*	*Abies balsamea*
Mature Maple		
1	*Acer saccharum*	*Acer saccharum*
2	*Acer saccharum*	*Acer saccharum*
3	*Acer saccharum*	*Acer saccharum*
4	*Acer saccharum*	*Acer saccharum*
5	*Acer saccharum*	*Acer saccharum* *Fraxinus americana*
Mixed		
1	*Acer saccharum* *Fraxinus americana* *Populus tremuloides* *Abies balsamea* *Betula papyifera*	*Abies balsamea*
2	*Acer saccharum* *Populus tremuloides* *Abies balsamea*	*Abies balsamea*
3	*Acer saccharum* *Populus tremuloides* *Abies balsamea*	*Abies balsamea* *Acer saccharum*
4	*Acer saccharum* *Populus tremuloides* *Abies balsamea* *Picea mariana*	*Acer saccharum* *Abies balsamea* *Picea mariana*
5	*Acer saccharum* *Tsuga Canadensis*	*Abies balsamea* *Acer saccharum*

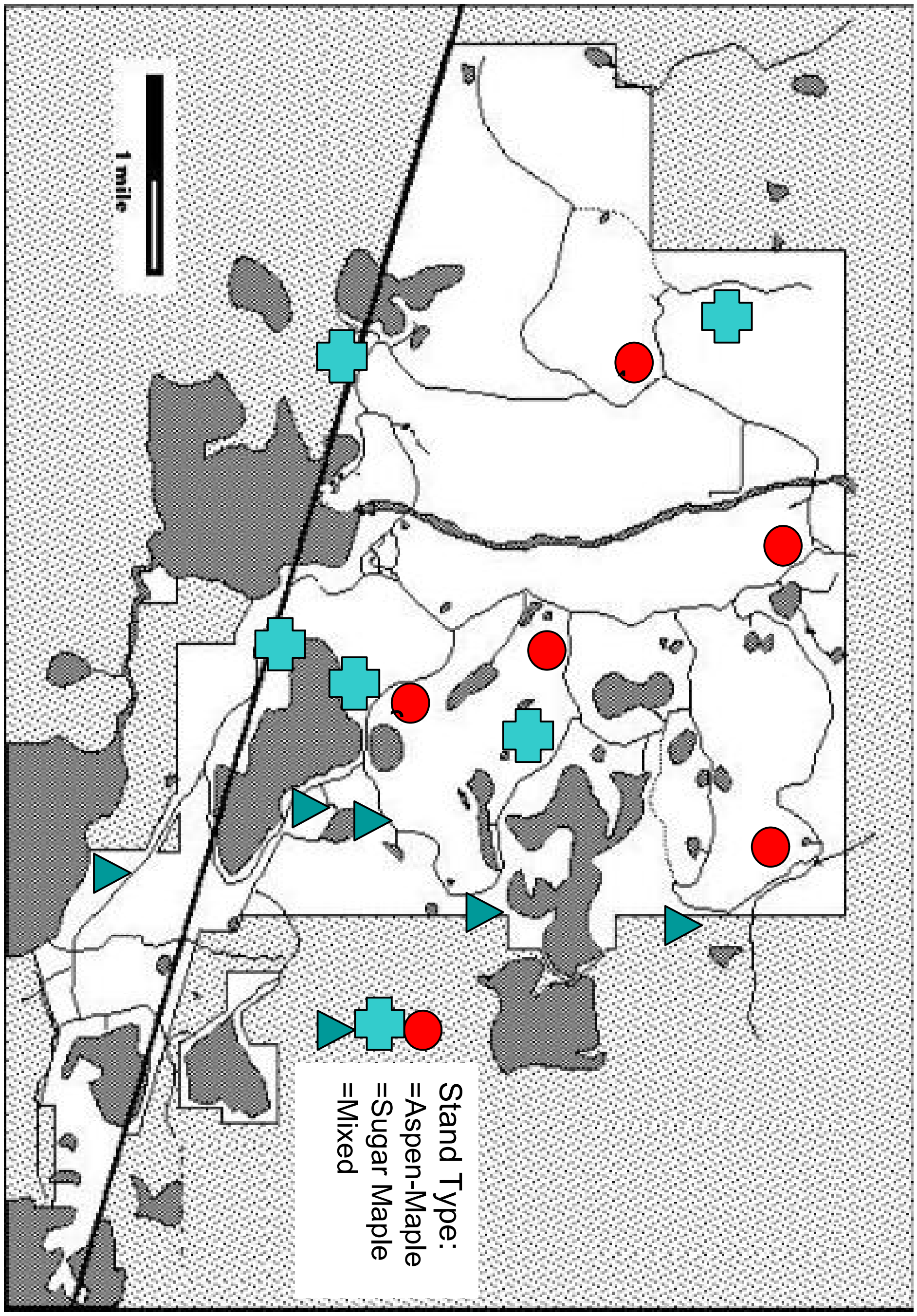

Figure 1. Study sites at University of Notre Dame Environmental Research Center, Gogebic County, Michigan.

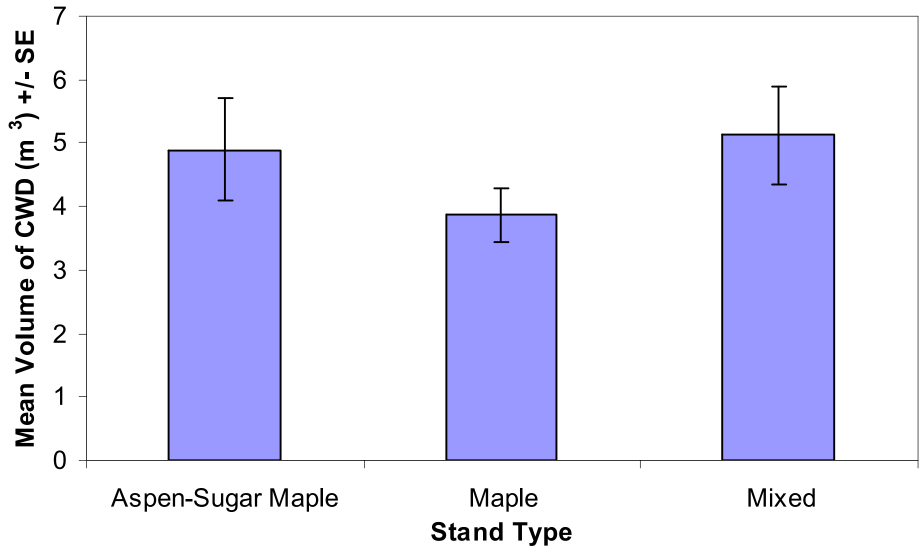

Figure 2. Mean volume of CWD per stand type. For each stand type, n=5. Error bars represent standard error.

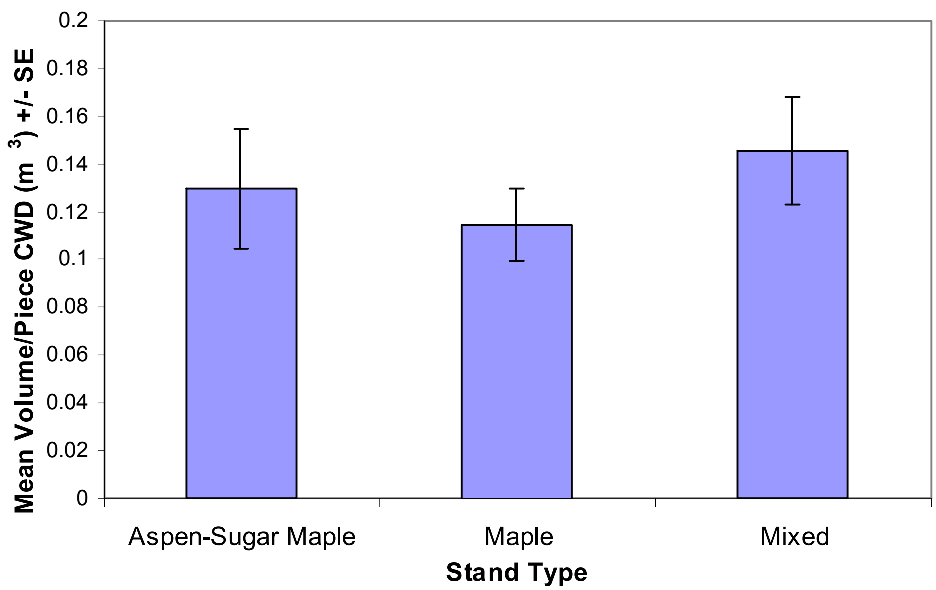

Figure 3. Mean volume per piece of CWD in different stand types. For each stand type, n=5. Error bars represent standard error.

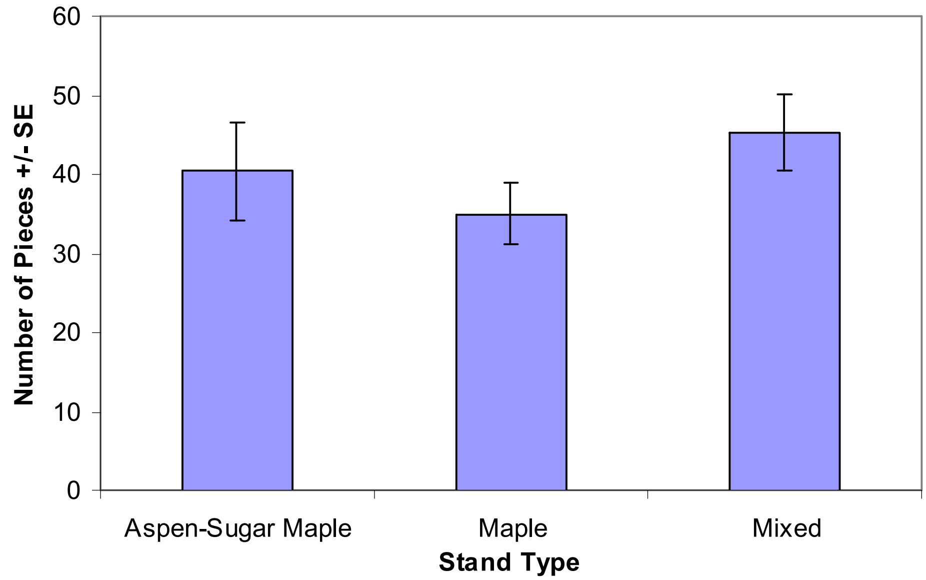

Figure 4. Mean number of CWD pieces per stand type. For each stand type, n=5. Error bars represent standard error.

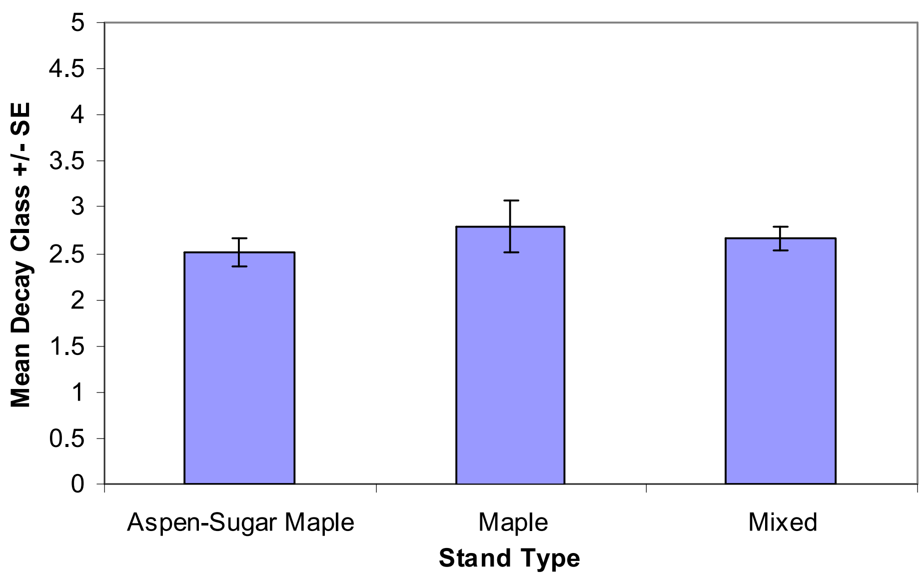

Figure 5. Mean decay class per stand. For each stand type, n=5. Error bars represent standard error.

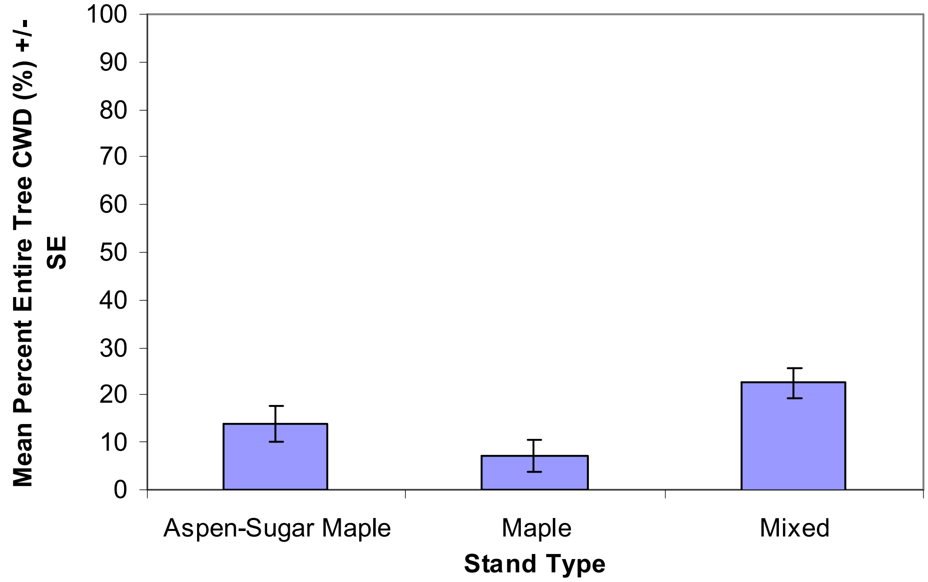

Figure 6. Percent CWD consisting of entire tree. For each stand type, n=5. Error bars represent standard error.