AN ANALYSIS OF THE ECOLOGY AND PUBLIC PERCEPTION OF COARSE WOODY DEBRIS IN VIRGINIA

By

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Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

FORESTRY

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June 30, 2004
Blacksburg, Virginia

Keywords: Coarse woody debris, Wildlife use, Perception of forestry

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(ABSTRACT)

Coarse woody debris (CWD) is an important habitat component for wildlife, fish, and plants and is important in nutrient cycling and soil formation. Knowledge of the volume, distribution, and use of CWD across Virginia would be useful to forest managers modeling nutrient budgets in southeastern forests and is important to wildlife management efforts. Knowledge of the effectiveness of informational brochures and cooperative learning activities/presentations at influencing public perception of CWD is important to program design and evaluation efforts in teaching and extension. The objectives of this study were to quantify the relationship between forest cover type and CWD volume, correlate CWD volume with small mammal and bird activity, distribute information on the advantages and disadvantages of CWD using informational brochures and cooperative learning activities/presentations, and compare the effectiveness of such teaching techniques at influencing public perception of CWD. The volume and wildlife use of CWD was assessed within 12 mature second-growth stands in Virginia. Volume of CWD was measured using fixed-area plots. Use of CWD by small mammals and birds was assessed by noting bodily, foraging, or movement evidence. Pre- and post-survey instruments were used to evaluate how perceptions were altered in first year college students who either reviewed an informational brochure or participated in a cooperative learning activity/presentation. Results suggested that the management of CWD for wildlife was most needed in southeastern Virginia where CWD volumes were lowest and that the value of CWD for wildlife was best conveyed through cooperative learning activities/presentations and may be important to landowner education efforts. Results suggested that management efforts to increase

CWD volumes in Virginia should focus on coniferous dominated stands where CWD volumes were lowest. Such a finding, combined with the knowledge that the value of CWD was best conveyed through presentations, suggests that landowners of coniferous woodlots could be effectively educated with presentations. Given that brochures were more effective for females than males, brochures addressing natural resource issues might be the most appropriate, cost effective method of education at events that target female audiences. Knowledge gained from this study that CWD management for wildlife would be most appropriate in western Virginia where CWD was most used by wildlife for travel and that presentations were most effective at reaching suburban participants may be important to outreach program design efforts. Regardless of academic major, presentations were more effective at generating positive attitudes toward CWD. The results of this study suggest that the choice between informational brochures and presentations for influencing public perceptions of CWD will likely be influenced by the demographics of the target audience and the relevance of the topic locally.

Acknowledgements

I would like to begin by thanking my family. This work would have been impossible without their ever continuing support and encouragement. First, I thank my Mom. Her confidence in me and "go wow 'em kid" support has kept a smile on my face in my most nervous moments. I thank my Dad ("Jerry"). It's been tough sometimes sitting at my desk knowing that he's on the bay catching the "beeekins" but he's quick to remind me that it'll all pay off. I thank my sister, Erin. It's hard to believe but she's just as goofy as I am and her phone calls while I've been away have kept me laughing. Finally, I thank my lovely girlfriend, Annie. I'll never know how we made it apart for so long. Her willingness to listen to me go on about school work on the phone at night, her overwhelming support for my dream, and personality have and will always astound me.

I would also like to thank my friends. I thank Nathan Smith, Michael ("Mikey") Tyson, and Noah Adams for their help with the fieldwork and the R.J. Reynolds Foundation for funding. I thank my dear friend Mr. Bob for his years of support and for giving me a refuge "on the ranch" when I needed it most. I thank Ranger Bill Trautman. Without this man's inspiration to pursue a career in natural resources, where would I be? To the Cheatham crew: John Peterson, Nathan King, Mike Tyree, and Kevin Kyle, you made the office "the place to be." I thank my committee members, Drs. Dolloff and Duncan. Thanks for providing your expertise Dr. Dolloff and thanks Dr. Duncan for your encouragement and smiles at every meeting. Finally, I give my most sincerest thanks to my major professor, Dr. Carolyn A. Copenheaver. She was a beyond excellent mentor and the caliber of scholarly guidance she gave me was incredible. In aspiring to become a university professor one day myself, I look at Dr. Copenheaver as a role model

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Chapter I:

Ecology of Coarse Woody Debris in Virginia

Introduction

Coarse woody debris (CWD) is an important component of forested ecosystems. Defined as woody detritus with a minimum diameter of 10 cm, CWD includes snags (standing dead trees), logs, broken treetops, branches, and stumps (Harmon et al. 1986). Coarse woody debris plays an important role in various ecological processes. Coarse woody debris provides wildlife and fish habitat, enhanced soil and slope stability, and a growing medium for plants. Coarse woody debris also plays a role in nutrient cycling and the formation of soil via decomposition.

Coarse woody debris: habitat component for wildlife and fish

Coarse woody debris is an important habitat component for wildlife and fish. Snags provide foraging sites, nesting cavities, hiding places, hibernation dens, and thermoneutral resting sites for various small mammals and birds (Hunter 1990). Logs, broken treetops, branches, and stumps create refuges and travel pathways for small mammals and birds and provide a moist microclimate for reptiles and amphibians. Coarse woody debris in streams and rivers disperses water energy, forming steps, bars, riffles, and pools (Bragg and Kershner 1999). Submerged CWD can create aquatic microhabitats and provide shade, protection, and structure for fish and other aquatic organisms.

Coarse woody debris: soil and slope stability

Coarse woody debris can promote soil and slope stability by decreasing the potential for erosion (Hagan and Grove 1999). Coarse woody debris serves as a natural obstacle that captures, retains, and stores eroding sediment. The quality and productivity of a riparian habitat can be associated with the presence of CWD. The removal of CWD in riparian zones has been linked to stream water quality degradation and may limit later recovery. Downstream CWD can accumulate into piles, causing deposition of sediments and the creation of new semi-terrestrial habitats.

Coarse woody debris: growing medium for plants

Coarse woody debris provides a growing medium for plants. The role of CWD as an active seedbed (e.g., nurse logs) is a function of decay state. Seedling establishment is often greater on decayed wood (moderate to advanced decay) because decaying CWD can provide enhanced moisture and nutrients and in exposed areas, shade provided by CWD can facilitate the establishment of conifer seedlings. Species richness and seedling abundance have been found to be highest on logs and stumps in advanced stages of decay. Seedlings established on CWD are elevated above the forest floor and have a competitive advantage over understory vegetation.

Coarse woody debris: nutrient cycling

Coarse woody debris plays an important role in nutrient cycling, often providing a stable, long-term source of nutrients (McComb and Lindenmayer 1999). A slow nutrient turnover rate is typically associated with larger sized CWD. Although species dependent, the slowest nutrient turnover rates are often associated with CWD of coniferous species because they generally decompose slower than deciduous species (Muller and Liu 1991). Topographic aspect and position also influence decomposition and nutrient cycling in CWD. In the northern hemisphere, CWD along warmer and drier northwestern and southwestern aspects has been found to decay slower than CWD on cooler and moister northeastern and southeastern aspects (Mattson et al. 1987). In addition to a slow nutrient turnover rate, CWD tends to store and accumulate nutrients as it decomposes and then slowly releases nutrients back into the soil.

Coarse woody debris: formation of organic soil

Coarse woody debris is an important component in the formation of the organic component of soil. Various factors influence the decomposition rate of CWD. Moisture and temperature conditions have been known to favor decay due to their direct affect on fungal activity (Harmon el al. 1986). In addition to climate, species, and size influences on decay, CWD position (standing vs. downed) also influences the rate of soil formation. Coarse woody debris in full contact with the ground will generally decompose faster than suspended or partially suspended CWD. Higher soil moisture levels under and around CWD with full ground contact increase the amount and quality of organic matter added to the soil during decay.

Study objectives

Knowledge of the volume and use of CWD is important to forest and wildlife management efforts. An understanding of the relationship between ecological setting and the amount and type of CWD present can help provide answers to landscape and habitat related questions. The objectives of this study were to: (1) quantify the relationship between forest cover type and CWD volume and (2) correlate CWD volume with small mammal and bird activity. The null hypothesis that there is no significant correlation between "use" of CWD by small mammals and birds and volume of CWD was tested against the alternative that there is a significant correlation between "use" of CWD by small mammals and birds and volume of CWD. A significance level of $P \leq 0.05$ was used to determine whether or not there is significant statistical evidence that there is a significant correlation between "use" of CWD by small mammals and birds and volume of CWD. The volume and wildlife use of CWD was assessed within 12 mature, second-growth forest stands in Virginia. Four stands were sampled within each of three major forest cover types. Cover types and associated Virginia physiographic provinces included the oak-hickory (Blue Ridge/Ridge and Valley), oak-pine (Piedmont), and pine-hardwood (Coastal Plain) forest types.

Literature Review

Forms of Coarse Woody Debris

Coarse woody debris (CWD) is an integral component of forest ecosystems, playing an important role in regulating various ecological processes and functions (Harmon et al. 1986). CWD can include snags (standing dead trees), dead and downed boles (logs), broken tops, branches, twigs, exposed root masses, and stumps (Hagan and Grove 1999, Payer and Harrison 2000, Rubino and McCarthy 2000). Coarse woody debris is most commonly defined as woody detritus with a minimum diameter of 10 cm (Harmon et al. 1986).

Coarse Woody Debris Use by Wildlife

Snags provide foraging sites, nesting cavities, hiding places (escape from predation), hibernation dens, and thermoneutral resting sites for a variety of forest dwelling small mammals and birds (Rosenberg et al. 1988, Hunter 1990, Hagan and Grove 1999, Payer and Harrison 2000, Lohr et al. 2002). Logs, broken tops, branches, twigs, and stumps create refuges for small mammals and birds and provide a moist microclimate for reptiles and amphibians (Harmon et al. 1986, Hunter 1990, Hagan and Grove 1999, Mengak and Guynn 2003). For reptiles and amphibians, woody debris serves as an important site for reproduction (nesting and mate attraction), food consumption, and thermoregulation (Whiles and Grubaugh 1993). For birds, CWD can provide roosting, drumming, and perching (for hunting and calling) sites (Lanham and Guynn 1993). For small mammals, downed woody debris may be used as travel routes (Fitzgerald and Wolff 1988, Barnum et al. 1992, Planz and Kirkland 1992, Roche et al. 1999, Loeb 1999, Zollner and Crane 2003). Woody debris may also be used as a refuge and resource for earthworms (*Lumbricus terrestris* L.), land snails, wood-feeding insects, and their predators, including reptiles, amphibians, small mammals, and birds (Caldwell 1993, Hanula 1993, Hendrix 1996).

Snag Density and Cavity Presence

Cavity presence in snags is directly related to snag diameter and height (Rosenberg et al. 1988, Goodburn and Lorimer 1998, Steeger and Hitchcock 1998, Haney and Lydic 1999). In young and old forest stands in southwest Virginia, use (as determined by foraging evidence) of snags by foraging birds was found to be positively correlated with higher snag densities and larger diameter (≥ 20 cm DBH) snags (Rosenberg et al. 1988). The presence of cavities was directly associated with snag diameter (Rosenberg et al. 1988). For northern hardwoods without a hemlock (*Tsuga canadensis* L. Carr.) component in Wisconsin and Michigan, total snag density (>10 cm DBH) in managed stands was found to be similar to the density measured in old-growth (Goodburn and Lorimer 1998). Although snags in old-growth northern hardwoods had a wide diameter range, 42% of the snags were >45 cm DBH (Goodburn and Lorimer 1998). In northern hardwood stands with a hemlock component, snag densities in old-growth stands were greater than snag densities in managed stands across all size classes

(10 cm to 60+ cm) (Goodburn and Lorimer 1998). The density of large snags was found to be more than 5-times greater in old-growth than in managed stands and an increase in cavities in live trees was found in managed stands due to a low abundance of snags (Goodburn and Lorimer 1998). Cavity-nesting birds in mature coniferous forests of southeastern British Columbia strongly preferred to nest in snags with greater height and diameter (Steeger and Hitchcock 1998). Nest-plots of red-breasted nuthatches (*Sitta canadensis* Linnaeus, 1766) in particular tended to contain more tall snags (avg ht 14.6 m) (Steeger and Hitchcock 1998). All snags on subplots of old-growth and young forest stands in a mixed pine-hardwood forest on the Cumberland Plateau, Tennessee were larger than 15 cm DBH with some snags exceeding 90 cm DBH (Haney and Lydic 1999).

The presence of cavity trees in old-growth and second-growth forests in the midwestern US is strongly related to tree diameter and whether a tree is alive or dead (Fan et al. 2003). In old-growth hardwood forests of Missouri, Illinois, and Indiana, inventories of cavity abundance found that 8-11% of snags had at least one visible cavity (Fan et al. 2003). Sites sampled in Missouri, Illinois, and Indiana averaged 18 cavity trees per ha for live and dead trees combined (Fan et al. 2003). The percentage of snags containing cavities was about twice the percentage for live trees containing cavities (Fan et al. 2003). In mature (≥110 years) second-growth stands in Missouri, 5% of live trees and snags had cavities, although snags typically accounted for no more than 10% of standing trees on any sites (Fan et al. 2003). Living trees accounted for 80-85% of cavity trees (Fan et al. 2003). In old-growth forests, a 30 cm DBH was considered a threshold size useful in distinguishing cavity trees from non-cavity trees (Fan et al. 2003). In mature second-growth forests, two diameter thresholds were found: an 18 cm and 44 cm

DBH (Fan et al. 2003). In southwest Virginia, young and old-growth oak-hickory stands contained more snags than were found in the midwestern US (Rosenberg et al. 1988). Stands in southwest Virginia 60-79 years old contained 164 snags per ha, stands 80-99 years old contained 146 snags per ha, and stands ≥ 100 years old contained 168 snags per ha (Rosenberg et al. 1988).

Snag Density and Stand Age

Snag and cavity tree densities increase with stand age (Rosenberg et al. 1988, Hardt and Swank 1997, Goodburn and Lorimer 1998). Forest stand structural and compositional characteristics of southern Appalachian old-growth, maturing second growth (previously selectively logged), and young second growth (previously clearcut) stands were examined to assess overall variability across age classes (Hardt and Swank 1997). The density of large live trees and large snags (≥ 75 cm DBH) was lowest in young stands (Hardt and Swank 1997). The range of tree sizes, wood density, and the density of snags was highest in old-growth stands and lowest in young second-growth stands (Rosenberg et al. 1988, Hardt and Swank 1997). Snags in both maturing and old-growth stands were in early stages of decay [based on Cline et al. (1980)] (Table 2), implying an increase in overstory mortality (Hardt and Swank 1997).

Log Density and Stage of Decay

Log densities and decay rates increase with stand age and depend on past disturbance events (Hardt and Swank 1997, Goodburn and Lorimer 1998, Loeb 1999). Greater total volumes of downed logs have been found in old-growth forests when compared to younger, managed stands (Goodburn and Lorimer 1998). Following a disturbance (natural or anthropogenic), the volume of existing logs depends on whether such material was salvaged or not (Loeb 1999). Logs in young second-growth stands have been found to be in more advanced stages of decay [based on Sollins (1982)] (Table 1), implying that these were the decaying remnants of debris created during harvesting (Hardt and Swank 1997). In maturing second-growth and old-growth stands, stand age was found to be positively related to evenness of CWD distribution across decay classes [Cline et al. (1980), Sollins (1982)], implying more regular inputs of woody debris to the forest floor (Hardt and Swank 1997). Speculations have been made that selective logging practices in maturing stands of the southern Appalachians may be a probable cause of the increase in densities of cavity trees, large snags, and large logs due to damage and subsequent structural weakening of trees that were not harvested (Hardt and Swank 1997).

Residual Logs and Geographic Location

The density and volume of residual logs is related to geographic location (Harmon 1982, Mattson et al. 1987, Muller and Liu 1991, Hardt and Swank 1997, Rubino and McCarthy 2000). Tree species, size, position (standing vs. downed), and elevation influence decay rates, specifically in southern Appalachian forests (Harmon 1982, Mattson et al. 1987, Muller and Liu 1991). The cooler temperatures of higher elevations tend to slow woody decomposition rates and result in higher CWD accumulations (Harmon 1982, Muller and Liu 1991). Such findings of site-related variability further verify that woody decay processes do not proceed at similar rates throughout a single forest (Rubino and McCarthy 2000).

The distribution of CWD is influenced by topography (Rubino and McCarthy 2003). In a mixed-oak forest of southern Ohio, total CWD density was significantly negatively correlated with slope position and percent slope (Rubino and McCarthy 2003). This relationship suggests that CWD may be lost from steep slopes and transported to lower-slope positions where it can often accumulate (Harmon et al. 1986, Rubino and McCarthy 2003). No significant relationship between CWD density or volume and slope aspect was found (Rubino and McCarthy 2003).

Decay Rate and Site Variability

Site variability impacts woody decay rates via vegetation type and climate related influences (Harmon 1982, Mattson et al. 1987, Muller and Liu 1991, Tainter and McMinn 1999, Harmon et al. 2000). A regional pattern of CWD accumulation in old-growth deciduous forests was suggested by Muller and Liu (1991) to be correlated with temperature. Old-growth deciduous forests in warmer regions were found to accumulate a CWD mass in the range of 22-32 Mg/ha, while CWD in similar forests of cooler ecosystems ranged from 34-49 Mg/ha (Muller and Liu 1991). An apparent trend was found for increasing amounts of CWD on drier, more exposed sites, dominated by chestnut oak (*Quercus prinus* L.) and red maple (*Acer rubrum* L.), although in cool temperate zone deciduous forests, larger accumulations of CWD occurred (Muller and Liu 1991).

Decay Rate and Woody Debris Size

Woody debris size also impacts associated decomposition rates (Abbott and Crossley 1982, Barber and Van Lear 1984, Mattson et al. 1987, Hagan and Grove 1999). In comparing mass losses in coarse (> 5cm diam) and fine (≤ 5cm diam) woody debris (FWD) in the southern Appalachians, the mass-loss of FWD was more than double that of CWD (Mattson et al. 1987). Evidence that small (< 2.5cm diam) loblolly pine (*Pinus* *taeda* L.) branches in the Piedmont of South Carolina decayed more slowly than medium (2.5-7.5cm diam) and large (>7.5cm diam) branches has been found (Barber and Van Lear 1984). Conversely, smaller branches of similar size to those defined by Barber and Van Lear (1984) were found to decay faster under similar conditions (Abbott and Crossley 1982).

Decomposition Stage, Salvaging Residual Material, and Small Mammals

The decomposition stage of snags and logs in forested plots following disturbance is related to whether efforts to salvage dead wood on those plots have been made (Mattson et al. 1987, Haney and Lydic 1999, Loeb 1999). Snags in un-salvaged plots were found to be in a more advanced stage of decay than snags in salvaged plots and thus potential cavity availability was increased in un-salvaged plots (Loeb 1999). The presence of logging and residual leave material following harvest or natural disturbance has been found to benefit small mammals during both breeding and non-breeding seasons (Loeb 1999, Moses and Boutin 2001). Downed and decaying logs in managed and old-growth forest stands enhance small mammal relative abundance year-round and improve habitat quality for small mammals (Carey and Johnson 1995, Loeb 1999, Bowman et al. 2000, Brannon 2000). The likelihood of small mammal residence in unmanaged and old-growth forests increases with greater abundance of CWD and downed and decaying logs (Carey and Johnson 1995, Bowman et al. 2000).

In managed southeastern pine forests following a tornado, more small mammals were found on un-salvaged forest plots because they had more downed and standing CWD than salvaged plots (Loeb 1999). Densities of snags and logs in un-salvaged plots were about three times greater than in salvaged plots (Loeb 1999). Snags in un-salvaged plots were found to be in a greater stage of decomposition than those in salvaged plots and 10% of snags in salvaged plots had cavities while only 2% of snags in un-salvaged plots had cavities (Loeb 1999). In terms of log size class, most logs in salvaged plots were in either the <20 cm diameter class or the 20-30 cm diameter class and most logs in un-salvaged plots were in the 20-30 cm class and the >30 cm class (Loeb 1999). A greater abundance of small mammals in un-salvaged forest plots following natural disturbance than in salvaged plots was also found (Loeb 1999). Specifically, cotton mice (*Peromyscus gossypinus* Le Conte, 1853) showed a strong positive response to abundant CWD, with almost twice as many cotton mice found on un-salvaged plots (Loeb 1999). The larger number of logs and snags in un-salvaged plots was speculated to improve the quality of the pine forest habitat for cotton mice by increasing the number of nest sites, amount of cover (from predators and elements), number of travel routes, and food supply (specifically invertebrates) (Loeb 1999).

In a study of small mammal microhabitat use within young *P. taeda* regeneration areas in the southern US, CWD was found to be an important microhabitat component for *P. gossypinus* (Mengak and Guynn 2003). Cotton mouse capture stations were characterized as having significantly shorter trees, smaller diameter stumps, greater CWD biomass (particularly logs), and shorter distances to the nearest log (Mengak and Guynn 2003). Management activities such as thinning and leaving residual material were expected to enhance small mammal habitat (Mengak and Guynn 2003).

Snag Volume, Disturbance, and Small Mammals

Snag volume increases following disturbance and the presence of disturbance-created snags has been found to benefit secondary cavity-nesting small mammals (Loeb

1999, Payer and Harrison 2000, Moses and Boutin 2001). For the American marten (*Martes americana* Turton, 1806) in the northeastern US, natural disturbances from the defoliating eastern spruce budworm (*Choristoneura fumiferana* Clem.) were found to be associated with greater volumes of snags that are preferred by the marten (Payer and Harrison 2000). Budworm defoliated stands were found to retain characteristics most associated with stand maturity, including more downed logs and root masses and taller trees that are most desirable for the marten (Payer and Harrison 2000). Most significantly, it has been suggested that the vertical structure provided by larger snags may substitute ecologically for structure provided by live trees (Gibbs et al. 1993, Payer and Harrison 2000). Such structure is often missing following even-aged silvicultural management (i.e., clearcuts) where a relative lack of snags was attributed to decreased marten use of such areas (Payer and Harrison 2000).

Snag Height and Wildlife Habitat Suitability

Snag height influences habitat suitability and likelihood of use in both small mammals and birds (Rosenberg et al. 1988, Herren et al. 1996, Steeger and Hitchcock 1998, Payer and Harrison 2000). Herren et al. (1996) studied boreal owl (*Aegolius funereus* Linnaeus, 1758) mating habitat in the Sierra Madre range of the Medicine Bow National Forest in Wyoming. They reported that all boreal owls were found in areas with old forest characteristics, including a high basal area of trees (avg 12.4 m^2/ha), large downed logs (length 7.7 m; diam >32 cm DBH), a tall overstory canopy (avg 27 m), and tall snags (12-31.8 m) with large diameters (>39 cm DBH) (Herren et al. 1996).

Natural Disturbance Events, Coarse Woody Debris, and Wildlife

Disease and insect infestation events influence forest structure and the habitat potential for various wildlife by creating an increase in snags and downed logs (Steeger and Hitchcock 1998, Loeb 1999, Payer and Harrison 2000, Moses and Boutin 2001, Showalter and Whitmore 2002). Cavity nesting bird populations have been found to be highly associated with snag abundance following defoliation by gypsy moths (*Lymantria dispar* (L.)) across Morgan and Berkeley counties in West Virginia (Showalter and Whitmore 2002). The abundance of all cavity nesting birds combined increased as snag abundance increased (Showalter and Whitmore 2002). Related snag abundance trends indicated that the abundance of snags >23 cm DBH increased 322% from an average of 75 snags/5 ha before gypsy moth outbreak to an average of 317 snags/5 ha after the outbreak (Showalter and Whitmore 2002).

Forest Gaps, Coarse Woody Debris, and Wildlife

Both anthropogenic and/or naturally created gaps in forest landscapes impact CWD loadings and thus have an effect on forest dwelling small mammal and bird habitat quality and reptile and amphibian community structure (Whiles and Grubaugh 1993, Loeb 1999, Menzel et al. 1999, Payer and Harrison 2000, Greenberg 2001, Greenberg and Lanham 2001, Moses and Boutin 2001). Mean CWD volumes have been found to be significantly higher in deep woods forest stands of the southern Appalachians compared to created wildlife openings, edges, and shallow and mid-woods stands (Menzel et al. 1999). Mean CWD volumes were lowest in wildlife openings (Menzel et al. 1999). Surprisingly, all small mammal species except for deer mice (*Peromyscus maniculatus* Wagner, 1845) were poorly correlated with CWD volumes across all study blocks

(Menzel et al. 1999). Deer mice were strongly positively correlated with CWD volumes and deer mice abundances were significantly greater in deep woods sites than in all other sites (Menzel et al. 1999). It has been suggested that deer mice abundances and distributions may be a function of edge type and origin, especially where CWD volumes are high (Menzel et al. 1999). Forest gaps created by a hurricane were found to have more CWD, shrub-cover, brushpiles, and pit and mound infrastructure (Greenberg and Lanham 2001). Associated total densities and species richness values of breeding birds were higher in hurricane created gaps than in undisturbed sites (Greenberg and Lanham 2001). Cavity-nesters, shrub-nesters, and canopy-nesters were more abundant in gaps than in controls and shrub and bark foragers were more abundant in gaps than in controls (Greenberg and Lanham 2001). Speculations have been reported that small gaps/patches are vital because they act to change the functional role of the forest habitat to accommodate a higher diversity of foraging and nesting niches (Greenberg and Lanham 2001).

Overstory Cover, Coarse Woody Debris, and Small Mammals

Canopy cover/closure influences small mammal use of CWD (Payer and Harrison 2003, Zollner and Crane 2003). Overstory features related to stand maturity were found to be most useful for distinguishing between areas of high, low, and no use by *M. americana* in the northeastern US (Payer and Harrison 2003). Areas of an extensively clearcut forest in Maine receiving use by *M. americana* had greater overhead cover and greater snag volume (Payer and Harrison 2003). Areas used most intensively by *M. americana* had larger (>22 cm) downed logs (Payer and Harrison 2003).

Canopy closure influences the use of CWD as a travel path by eastern chipmunks (*Tamias striatus* Linnaeus, 1758) (Zollner and Crane 2003). In the north central US, travel along CWD was found to be negatively associated with canopy closure and positively associated with both the percent of CWD available and the percentage of shrub cover (Zollner and Crane 2003). On average, 4.6% of chipmunk movements were along CWD greater than 5 cm in diameter. Chipmunk movement along woody debris as small as 2 cm in diameter was observed (Zollner and Crane 2003). Movement along fine woody debris (<5 cm) composed less than 5% of all chipmunk movements (Zollner and Crane 2003). These results suggest that CWD is more important to chipmunks in areas with open canopies so as to provide protection from predators (Zollner and Crane 2003).

Coarse Woody Debris and Cavity-Nesting Birds

Availability, use, and preference for nesting habitat of cavity-nesting forest birds have been shown to be strongly correlated with the presence of downed and standing CWD (Rosenberg et al. 1988, Steeger and Hitchcock 1998, Lohr et al. 2002). Forest dwelling bird species, including a variety of excavators (woodpeckers), secondary cavity nesters (owls), and Neotropical migrants benefit from the presence of downed and standing (snags) CWD. The establishment of avian breeding territories was proven to be positively correlated with downed CWD volume in *P. taeda* forests of the southeastern US (Lohr et al. 2002). Similar to the study by Goodburn and Lorimer (1998), Haney and Lydic (1999) tested whether differences could be detected in breeding bird communities and associated vegetative structure regimes in an old-growth mixed pine-hardwood forest on the Cumberland Plateau, TN versus generally similar, younger forests. All snags on sample subplots of old-growth and young forest stands were larger than 15 cm DBH with some snags exceeding 90 cm DBH (Haney and Lydic 1999). The heights of all measured snags in both forest types ranged from 8 to 13 m, of which 93% were shortleaf pine (*Pinus echinata* Mill.) (Haney and Lydic 1999). More than 80% of log CWD was found to be in the more advanced stages of decay (decayed or very decayed) (Haney and Lydic 1999). The authors of the study attribute the high densities and species richness of cavity-nesting birds found to the quantity and quality of snags and log CWD in the old-growth oak-pine forest (Haney and Lydic 1999).

Coarse Woody Debris and Riparian Areas

Studies have associated the quality and productivity of riparian habitats with the amount of CWD present (Harmon et al. 1986, Dobkin et al. 1995). Although the primary source of woody debris in streams, rivers, and lakes is the adjacent riparian zone, the effects of woody debris on riparian structure change with stream size (Harmon et al. 1986, McDade et al. 1990, Bragg and Kershner 1999). Snags >24 cm DBH in riparian woodlands of the northwestern Great Basin have been found to be favored disproportionately for use by birds as nesting sites while snags <18 cm DBH have been reported to be avoided almost entirely (Dobkin et al. 1995). Both live trees and snags with DBH >24 cm were favored as nest sites by all cavity nesting species found in riparian woodlands of the northwestern Great Basin (Dobkin et al. 1995).

Coarse Woody Debris Placement and Decomposition

Woody debris atop forest substrate can promote soil and slope stability by reducing the rate of run-off and erosion and can play an important role in nutrient cycling—storing and accumulating nutrients via decomposition (Barber and Van Lear 1984, Mattson et al. 1987, Muller and Liu 1991, Hagan and Grove 1999, Idol et al. 2001).

The decomposition rate of woody debris depends on its placement spatially—in contact with the ground or aerial (Barber and Van Lear 1984). *P. taeda* logging debris (slash) in contact with the ground decayed at a 50% higher rate than aerial slash (Barber and Van Lear 1984). Grounded slash has a more rapid decay rate versus aerial slash because temperature and moisture conditions are more conducive for decay when logging debris touches the ground (Barber and Van Lear 1984). Slash with ground contact was also more quickly leached and fungal hyphae had greater access to grounded debris, causing fungal colonization to occur faster than in suspended debris (Barber and Van Lear 1984).

Substrate Quality and Decomposition

In investigating how substrate quality and CWD nutrient content and concentration was related to Sollins (1982) decomposition classes at different stages of forest development in upland hardwood forest stands in southern Indiana, USA, the nutrient cycling processes of CWD in contact with various forest substrates were found to be affected (Idol et al. 2001). Specifically, the visual characteristics used to define Sollins (1982) decomposition classes that best corresponded to substrate quality indicators were log integrity and bark slippage (Idol et al. 2001). The best substrate quality indicators of decomposition class that best corresponded to visual differences in bark slippage and log integrity were the C:N and lignin:N ratios (Idol et al. 2001). The authors suggested that Sollins (1982) CWD Classes II and III should be combined into a single decay class (Idol et al. 2001). A large decrease in volume and mass of CWD from recently harvested to mature stands and a decomposition class shift from Class II to Classes III and IV with increasing stand age was also found and suggested to be indicative of substrate quality (Idol et al. 2001).

Table 1. Comparison of log decay classification schemes developed by various authors.

Log Decay Class

Sollins (1982); Muller & Liu (1991) |------Sound------|--Solid-Decayed--|-----Decayed-----|----Very Decayed----|
1 **2** **3** **4** **5**

|---------------Sound--------------|------------Solid-Decayed-------------|----------Very Decayed---------|

Pyle & Brown (1998)	**1**	**2**	**2a**	**3**	**4**	**5**
Characteristic						
Bark						
Sollins (1982)	Intact	Mostly intact	Mostly absent	Absent	Absent	---
Muller & Liu (1991)	Tight	Some slippage	Removed	Removed	---	---
Pyle & Brown (1998)	Firmly attached	Not firmly attached	Not firmly attached	Generally absent	Absent	Absent
Structural integrity						
Sollins (1982)	Sound	Sapwood rotting	Heartwood sound	Heartwood rotten	Heartwood rotten	---
Muller & Liu (1991)	---	Sound wood	Outer layers decaying	Some outer xylem layers missing	---	---
Pyle & Brown (1998)	Sound bark	Generally solid (surface does not flake off when kicked)	Does not crush with weight on it	Firm when kicked (some flaking)	Will crush into large pieces when kicked	>85% "powderwood"
Shape and form						
Sollins (1982)	All twigs	Larger twigs	Larger branches	Branch stubs	Appendages absent	---
Muller & Liu (1991)	---	---	---	---	---	---
Pyle & Brown (1998)	---	Driftwood-like	---	---	Oval/flattened	Flat/flat

Table 2. Comparison of snag decay classification schemes developed by various authors.

	Snag Decay Class				
	Sound	Sound-Decayed		Very Decayed	
	1	**2**	**3**	**4**	**5**
Characteristic					
Bark					
Sabin (1991)	Intact	Loose and sloughing	Decayed and sloughing sapwood	---	---
Limbs and branches					
Cline et al. (1980)	All present	Few limbs, no fine branches	Limb stubs only	Few or no stubs	None
Raphael and White (1984)	Intact	Intact	Mostly intact	Mostly broken	Gone
Sabin (1991)	Intact	Most broken	---	---	---
Twigs					
Raphael and White (1984)	Present	Present	Absent	Absent	Absent
Top					
Cline et al. (1980)	Pointed	Broken	---	---	---
Diameter at broken top					
Cline et al. (1980)	**Increasing at a decreasing rate** (→ from class 1 to class 5)				
Height					
Cline et al. (1980)	(← from class 5 to class 1) **Decreasing at a decreasing rate**				

Study Area

A total of 12 study sites were sampled throughout Virginia for CWD volume and wildlife use (Figure 1). Study sites were located in mature, second-growth forest stands owned primarily by state and federal agencies and ranged in elevation from 0 to 1067 m (Table 3). Study sites in western and central Virginia were dominated by *Quercus* spp. while sites in eastern Virginia were dominated by *Pinus* spp. and sweetgum (*Liquidambar styraciflua* L.) (Table 3).

Central Appalachian Broadleaf Forest

Sampling locations found within this ecoregion included Buffalo Mountain Natural Area Preserve (BUFF), Fishburn Forest (FISH), George Washington National Forest (GWNF), and Jefferson National Forest (JEFF) (Figure 1). This major forest cover type found throughout the southwestern portion of Virginia is located within the Ridge and Valley physiographic region (Daniels et al. 1973) (Figure 2). Bailey (1995) describes the land-surface form to be composed of subdued low mountains of crystalline rocks and more open low mountains with valleys of folded strata. Plateaus with mountainous topography are also dispersed throughout. Relief is generally high, upwards of 900 m in some localities. Elevations range from 90 to 1,800 m and higher towards the south.

The climate is temperate with distinct summer and winter seasons (Bailey 1995). All areas contained within the ecoregion are subject to frost. Average annual temperatures range from below 10°C in northern low areas to about 18°C at the southern-most end of the highlands. The frost-free period is about 100 days toward the northern

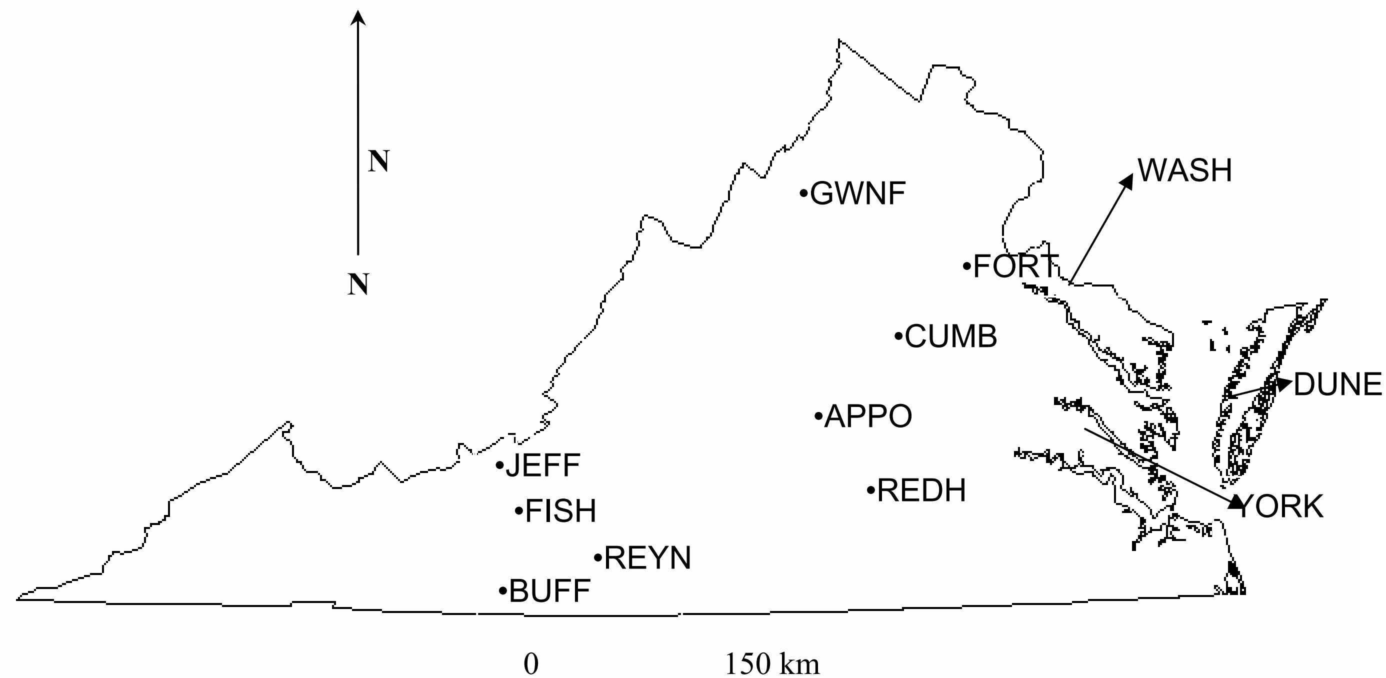

Figure 1. Locations of 12 study sites in Virginia sampled for CWD and wildlife use during the summer of 2003. APPO = Appomattox-Buckingham State Forest, BUFF = Buffalo Mountain Natural Area Preserve, CUMB = Cumberland State Forest, DUNE = Savage Neck Dunes Natural Area Preserve, FISH = Fishburn Forest, FORT = Fort A.P. Hill, GWNF = George Washington Nat'l Forest, JEFF = Jefferson Nat'l Forest, REDH = Red Hill, REYN = Reynold's Homestead, WASH = George Washington Nat'l Birthplace Monument, YORK = York River State Park.

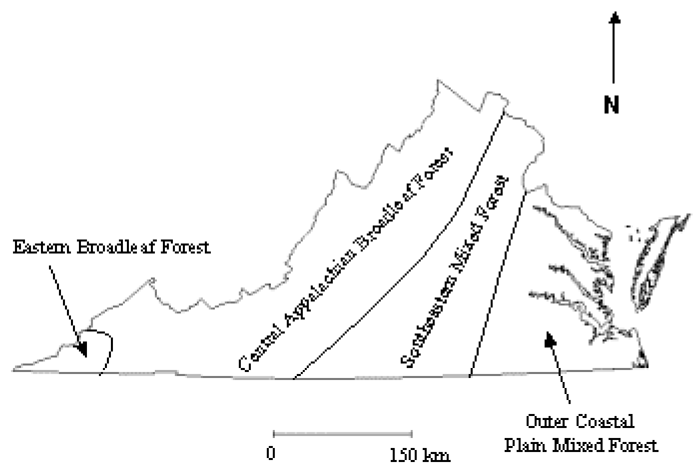

Figure 2. Ecoregions of Virginia (Bailey 1995). Study areas were located in the Central Appalachian Broadleaf Forest, Southeastern Mixed Forest, and Outer Coastal Plain Mixed Forest.

Table 3. Study area characteristics of 12 sampling locations in Virginia.

Location	Latitude	Longitude	Elevation (m)	Forest type	General soil type	Ownership
APPO	37º 23' 37"N	78º 43' 45"W	61	*Q. prinus/ Quercus alba*	Iredell/Mecklenburg/ Badin	VA Dept. of Forestry
BUFF	36º 47' 46"N	80º 28' 37"W	1067	*T. americana /Betula lenta*	Myersville-Chester-Glenelg association	VA Div. of Natural Heritage
CUMB	37º 30' 30"N	78º 17' 46"W	37	*Quercus coccinea/ Q. alba*	Appling-Enon-Cecil	VA Dept. of Forestry
DUNE	37º 19' 56"N	76º 00' 11"W	0	*P. taeda/ L. styraciflua*	Keyport fine sandy loam/ Sassafras fine sandy loam	VA Div. of Natural Heritage
FISH	37º 11' 14"N	80º 27' 41"W	661	*Q. coccinea/ Q. prinus*	Groseclose-Poplimento-Duffield	Virginia Tech
FORT	38º 07' 16"N	77º 19' 49"W	18	*Liriodendron tulipifera* L./ *Carya tomentosa* Nutt.	Savannah-Faceville-Varina assoc.	US Dept. of Defense
GWNF	38º 30' 01"N	79º 09' 59"W	168	*Q. prinus/ Q. alba*	Weikert-Berks-Laidig	USDA Forest Service
JEFF	37º 15' 01"N	80º 39' 59"W	220	*Q. alba/ Q. coccinea*	Berks-Weikert	USDA Forest Service

Table 3 (cont'd). Study area characteristics of 12 sampling locations in Virginia.

Location	Latitude	Longitude	Elevation (m)	Forest type	General soil type	Ownership
REDH	37º 01' 57"N	78º 53' 52"W	61	*Q. prinus/ Q. alba*	Cecil-Appling assoc.	Patrick Henry Memorial Foundation
REYN	36º 37' 48"N	80º 08' 41"W	345	*Q. alba/ Oxydendrum arboreum* (L.) DC.	Chester-Glenelg-Manor-Porters assoc.	Virginia Tech
WASH	38º 11' 33"N	76º 55' 38"W	0	*P. taeda/ L. styraciflua*	Lumbee-Leaf-Lenoir assoc.	USDI NPS
YORK	37º 24' 26"N	76º 42' 53"W	6	*A. rubrum/ L. tulipifera*	Emporia-Craven-Uchee	VA Dept. of Conserv. and Rec.

mountains and said to be about 220 days in the lower southern parts of the Appalachian Highlands. Average annual precipitation varies from 890 mm in low valley regions to about 2,040 mm along the higher ridges and peaks. Bailey (1995) describes the precipitation as fairly well distributed throughout the year. Southeast, southwest, and southern facing slopes in general are notably warmer and drier (facing the sun) compared to northwest and north facing slopes (Braun 1974).

The vegetation within the valleys of the Central Appalachian Broadleaf Forest—Coniferous Forest—Meadow Province is described by Braun (1974) and Bailey (1995) to be of mixed *Quercus* spp. and *Pinus* spp., including such evergreens as *P. taeda* and *P. echinata* and similar oaks as found in the Eastern Broadleaf Forest (Oceanic) Province. Common associations include hickory (*Carya* spp.), *L. styraciflua*, blackgum (*Nyssa sylvatica* Marsh.), and *A. rubrum*. The Appalachian oak-forest is found above the valleys, dominated by some dozen oak species in both the white oak (*Quercus alba* L.) and black oak (*Quercus velutina* Lam.) groups (Bailey 1995). Further north lies what Braun (1974) and Bailey (1995) describe as the northeastern hardwood forest, composed of various birch (*Betula* spp.), American beech (*Fagus grandifolia* Ehrh.), *A. rubrum* and sugar maple (*Acer saccharum* Marsh.), various elms (*Ulmus* spp.), northern red oak (*Quercus rubra* L.) and basswood (*Tilia americana* L.), with a mixture of *T. canadensis* and eastern white pine (*Pinus strobus* L.). *Quercus* spp. vegetation is said to predominate in the narrow valleys/coves of the southern Appalachians.

Soils that are characteristic of this forest cover type are described by Bailey (1995) as follows. Ultisols are found on ridge-tops, in areas of gentle/rolling topography, and within mountain basins. Inceptisols are found on steeper landforms. Kellogg (1936) describes a vast majority of the soils of this province to be of the gray-brown podzolic type. Such soils are well developed and moderately leached with incorporated humus.

Southeastern Mixed Forest

Sampling locations found within the Southeastern Mixed Forest included Appomattox-Buckingham State Forest (APPO), Cumberland State Forest (CUMB), Red Hill (REDH), and Reynold's Homestead (REYN) (Figure 1). This ecoregion is a major forest cover type found throughout central Virginia and located within the Piedmont physiographic region (Daniels et al. 1973) (Figure 2). Bailey (1995) describes the land-surface form of this province to be gently sloping throughout the Piedmont with local relief ranging from 90 to 300 m. Marshes, lakes, and swamps are dispersed throughout and support mesophytic thriving vegetation.

Climatic patterns are described as "roughly uniform" throughout the Piedmont and the greater province (Bailey 1995). Winters are mild and summers are hot and humid. The average annual temperature range is reported to be 15° to 21°C with a growing season of 200 to 300 days. Bailey (1995) reports frost occurring nearly every winter with snow falling rarely and melting quickly. Averages of precipitation are said to range from 1,020 to 1,530 mm annually with thunderstorms causing precipitation values to peak slightly in early spring and mid summer. Summer droughts occur and impact agricultural production and forestry operations.

Braun (1974) refers to Bailey's Southeastern Mixed Forest Province as the Oak-Pine Forest region and describes the vegetation of the region as predominantly *Quercus* spp. and *Carya* spp. *Q. alba* is described as the most abundant deciduous species in the oak-pine forest while *P. taeda* is said to be the most common coniferous variety, occupying secondary forests (Braun 1974). Bailey (1995) describes this major forest cover type as composed of medium-tall to tall broadleaf deciduous and needleleaf evergreen species. A minimum of 50% of the vegetation is in stands of *P. taeda* and *P. echinata*, with common associates including various *Quercus* spp., *Carya* spp., *L. styraciflua*, *N. sylvatica*, and *A. rubrum*. Flowering dogwood (*Cornus florida* L.), viburnum (*Viburnum* spp.), black haw (*Viburnum prunifolium* L.), blueberry bush (*Vaccinium* spp.), American beautyberry (*Callicarpa americana* L.), and various woody vines are common throughout the province (Bailey 1995).

Bailey (1995) describes the soils of the forest cover type to be dominated by Ultisols, "with locally conspicuous Vertisols formed from marls or soft limestone." Vertisols are the clayey type and commonly form wide, deep cracks when dry. Forest vegetation and agricultural crops are said to proliferate on the Inceptisols found throughout the floodplains of the major streams in the Virginia Piedmont. Braun (1974) describes the soils as podzolized and melanized lateritic, the first being the result of moderate leaching of lateritic soils (characteristic of warm, moist climates, with rapid chemical decomposition and accumulations of iron and aluminum oxides), where the horizon of incorporated humus is lacking/poorly developed. These soils are described as strongly acidic and infertile. The later implies a humus-enriched and much more fertile soil, supporting a variety of broad-leaved species (Braun 1974).

Outer Coastal Plain Mixed Forest

Sampling locations found within the Outer Coastal Plain Mixed Forest included Savage Neck Dunes Natural Area Preserve (DUNE), Fort A.P. Hill (FORT), George Washington National Birthplace Monument (WASH), and York River State Park

(YORK) (Figure 1). This ecoregion is a major forest cover type found throughout the eastern-quarter of Virginia, continuing to the Atlantic coast, and is located within the Coastal Plain physiographic region (Daniels et al. 1973) (Figure 2). The typical land-surface form comprising over 50% of the province is gently sloping, with local relief less than 90 m (Braun 1974, Bailey 1995). Streams, marshes, swamps, and lakes are numerous, however valley slopes adjacent to streams tend to be more abrupt than the average upland slope (Braun 1974, Bailey 1995).

The climate is stable with small to moderate variability in annual temperature. The average annual temperature ranges from 16° to 21°C (Bailey 1995). Precipitation is evenly distributed and ranges from 1,020 to 1,530 mm per year (Bailey 1995).

Bailey (1995) describes the vegetation as characteristic of a temperate rainforest with fewer species of trees and thus larger populations of individual species. Leaf canopies are low in density. Common species include evergreen oaks and members of the laurel (*Ericaceae*) and magnolia (*Magnoliaceae*) families. Along the Atlantic coast, interior marshes and swamps are described by Bailey (1995) to be dominated by *L. styraciflua* and cypress (*Taxodium* spp.). Upland areas are described as covered by sub-climax pine forests and shallow depressions may form bogs in which evergreen shrubs predominate. A well-developed lower stratum of vegetation is typical of this forest cover type and can include ferns, small palms, shrubs, and a variety of herbaceous plants. Lianas and epiphytes are said to be abundant, particularly at lower elevations [e.g., Spanish moss (*Tillandsia usneoides* (L.) L.)] (Bailey 1995).

Braun (1974) refers to Bailey's Outer Coastal Plain Mixed Forest as the Oak-Pine Forest region and describes the vegetation as predominantly *Quercus* spp. and *Carya* spp.

The Virginia portion of this province is also called the Coastal Plain or Embayed District within the Atlantic Slope section of the province (i.e., streams drain toward the Atlantic Ocean) (Braun 1974). Live oak (*Quercus virginiana* P. Mill.) and longleaf pine (*Pinus palustris* P. Mill.) are typically only found south of the James River (Braun 1974).

Soils characteristic of this forest cover type are mainly Ultisols, Spodosols, and Entisols (Bailey 1995). Soils tend to be wet, acidic, and low in plant nutrients (mainly Nitrogen and Phosphorus) and are typically derived from coastal plain sediments (Bailey 1995). Soil texture ranges from heavy clay to gravel with a predominance of sandy materials (Bailey 1995). More level expanses of the province are described by Bailey (1995) to contain silty soils while sandy soils are said to be more prevalent in hilly areas.

A soil boundary coincides with the James River of Virginia; soils of the Norfolk series of the red and yellow soils group are found south of the river while soils of the Sassafras series of the gray-brown or podzolic forest soils are found to the north (Braun 1974). Podzolic and melanized lateritic soils are common throughout the Outer Coastal Plain Mixed Forest (Braun 1974). Podzolic soils are described as moderately leached and are transitional between true podzols (produced by leaching) and weakly leached soils where the A_0 horizon is thin and the A_1 horizon is well developed with incorporated humus (Braun 1974).

Methods

Assessment of CWD Volume and Size Class within Three Forest Cover Types in Virginia

Coarse woody debris volume was assessed in 12 mature, second-growth forest stands within three major forest cover types (four stands per cover type). Major forest cover types and associated Virginia physiographic provinces included oak-hickory (Blue

Ridge/Ridge and Valley), oak-pine (Piedmont), and pine-hardwood (Coastal Plain) forests. Within each cover type, four mature, second-growth stands were sampled for volume of CWD. Within each stand, six 0.1-ha circular plots were randomly established. Circular plots were used to reduce the number of boundary line decisions and to ease plot establishment (Mueller-Dombois and Ellenberg 1974). Coarse woody debris was defined according to Harmon and Sexton (1996) as being downed or standing dead wood with the larger end of each piece being at least 7.5 cm in diameter.

Four forms of CWD were measured: (a) logs, (b) snags, (c) stumps, and (d) blobs. The latter was defined as a pile, variable in shape, of decomposed bark and wood that was unable to be distinguished as being a single log or stump, yet of significant size relative to stand characteristics. The volume of each piece of CWD was measured based on the following equations (Harmon and Sexton 1996):

<u>Log Volume:</u>

$$\text{Log volume} = L(A_b + 4A_m + A_t)/6$$

Where:

L = length of log

A_b = area at the base of the log

A_m = area at the middle of the log

A_t = area at the top of the log

The area at the base, middle, and top of each log was obtained by measuring the diameter and converting to area using the formula [πr^2]. Recording the diameter at both ends and at the midpoint of each log prevented the sampler from assuming any particular form to the log.

Snag Volume:

$$\text{Snag volume} = L(A_b + [A_bA_t]^{0.5} + A_t)/3$$

Where:

L = Length of snag

A_b = area at breast height (1.4 m)

A_t = area at top of snag (estimated)

Stump Volume:

$$\text{Stump volume} = L(A_b + [A_bA_t]^{0.5} + A_t)/3$$

Where:

L = Height of stump

A_b = area at base of stump

A_t = area at top of stump

Blob Volume:

$$\text{Blob volume} = L(A_b + A_t)/2$$

Where:

L = Length of blob

A_b = area (diameter) at base of blob

A_t = assume equal to zero (0)

Within each stand, the slope, aspect, elevation, general soil type, and any evidence of natural or anthropogenic disturbance (i.e., fire scars, insect damage, wind throw, or cut stumps) was also recorded.

Comparison of Fixed Area Plot and Line Transect Sampling Techniques

The use of fixed area plots was compared to line transect sampling in terms of CWD volume, variability, and sampling time (Appendix B). Within each 0.1 ha fixed area plot, two parallel 35.5 m line transects were established 17.8 m apart and the line intercept method was used to estimate CWD volume (Van Wagner 1968). The two parallel transects were combined to estimate CWD volume, variability, and estimated sampling time for one 71 m line transect per plot (Table B1). The diameter (m) of all pieces intersecting a transect was recorded at the point of intersection.

Volume (m^3/ha) was calculated as follows (Van Wagner 1968):

$$V = (\pi^2 \Sigma d^2 / 8L) * 10{,}000$$

where

V = volume of CWD per ha
d = piece diameter at point of intersection (m)
L = transect length (m)

Assessment of Vegetation within Three Major Forest Cover Types in Virginia

Forest composition and structure of live vegetation was sampled within each of the 12 stands (Figure 1). Species composition and structure was determined by recording the species and diameter of all trees (> 7 cm DBH) within a 300m^2 plot nested within each of six randomly established 0.1-hectare CWD plots per stand (4 stands per forest cover type, Figure 1). Canopy cover was measured at sample points within the 300m^2 vegetation plot using a point-intercept technique. This technique required the establishment of a sampling grid within the vegetation plot. Canopy cover was measured at increments along the sampling grid using a tally system.

Assessment of CWD Use by Small Mammals and Birds

Within each 0.1-ha fixed area plot, CWD use by small mammals and birds was assessed. "Use" was defined as the utilization of logs, snags, and stumps by small mammals and birds for daily survival activities, including hiding in/under (escape cover), feeding on/extracting food from, and/or using as "run-ways" for travel. Indirect methods of assessing small mammal and bird use included visually noting (a) fur or feathers in/around logs, (b) scat in/on CWD, and (c) foraging evidence such as beak-excavated holes and broken nut shells on logs and stumps within the plot. Snags were visually assessed for use by small mammals and birds from the ground. This included noting foraging evidence such as claw-marks, scaled bark, or use of excavated sites as den cavities (Rosenberg et al. 1988). Evidence of use by small mammals and birds was grouped into classes as follows (Table 4):

Table 4. Classification scheme used to categorize small mammal and bird use of CWD.

	Bodily evidence	Foraging evidence	Movement evidence	
Class	Fur/Feathers/Scat	Excavated holes/ Broken nut shells	Claw-marks/ Scaled bark	Total (# of yes)
High	YES	YES	YES	3
Medium	YES	YES	NO	2
Medium	NO	YES	YES	2
Medium	YES	NO	YES	2
Low	NO	NO	YES	1
Low	YES	NO	NO	1
Low	NO	YES	NO	1
None	NO	NO	NO	0

Data analysis

Within each plot (72 total), individual pieces of CWD were organized by type (log, snag, stump, or blob) and an average volume (m^3/ha) was calculated for each type by plot and stand. An average volume and associated variance of all CWD types was also calculated for each stand. Normality in the distribution of CWD volumes was examined using a Shapiro-Wilk goodness-of-fit test in the JMP IN 4 (SAS Institute Inc., Cary, NC) statistical software package. Log, snag, stump, and blob volumes were log-transformed to establish normality and meet the assumptions of analysis of variance. Levene's test was used to check for homogeneity in variance of the distribution of CWD volumes to meet the assumptions of analysis of variance. A chi-square test of homogeneity was used to examine if each study site had a different proportion of logs, snags, stumps, and blobs. The null hypothesis was that all sites had equal proportions of logs, snags, stumps, and blobs present. The alternative hypothesis was that study sites had different proportions of CWD.

One of the original goals of this study was to examine the relationship between CWD volume and ecoregion (Central Appalachian Broadleaf Forest, Southeastern Mixed Forest, and Outer Coastal Plain Mixed Forest) (Figure 1). The Eastern Broadleaf Forest was excluded from sampling due to its smaller size relative to the other three ecoregions and to increase power (Figure 1). A oneway analysis of variance (ANOVA) was used to test for differences in mean CWD volumes among ecoregions. The null hypothesis was that mean CWD volumes would be equal in each of the three ecoregions (Figure 1). The alternative hypothesis was that mean CWD volumes would differ between ecoregions.

CWD patterns and overstory data

Total basal area (BA) (m^2/ha) and density (trees/ha) were calculated at the plot level for coniferous and deciduous species. Total BA per plot and total BA with minor species excluded were examined across study sites for patterns in overstory composition and structure using detrended correspondence analysis (DCA). Minor species were species occupying less than 1% of the plot BA. Density in overstory vegetation per plot was also examined across study sites for patterns in overstory composition and structure using DCA. Detrended correspondence analysis is an eigenvector ordination technique often used in vegetative community analysis and is based on reciprocal averaging that produces uniform axis scaling, eliminating the arch distortion common to correspondence analysis that may fail to effectively reveal minor community gradients (Gauch 1982).

Cluster analysis was used to identify community types within the overstory vegetation data. Jaccard similarity indices were calculated and used to examine similarities in overstory vegetative communities across study sites. The Jaccard index is based on the presence-absence relationship between the number of species common to two communities and the total number of species. The index is calculated as:

$$JI = [c / a + b + c] *100$$

where c is the number of common species, a is the number of species unique to the first community, and b is the number of species unique to the second community (Mueller-Dombois and Ellenberg 1974). A dendrogram was created from the similarity indices to examine similarities in overstory species across locations.

Simpson's diversity indices were calculated and used to assess overstory diversity across study sites. Simpson's index reflects dominance and is sensitive to dominant species over rare species (Barbour et al. 1999) and was used rather than Shannon-Wiener's index because dominant species will influence CWD more than rare species.

CWD and wildlife use

Wildlife use of CWD was categorized using a use classification decision table (Table 4) and each plot was given a wildlife use score (low, medium, or high). Oneway ANOVA was used to test for differences in mean snag, stump, and log volumes (m^3/ha) across low, medium, and high wildlife use classes at each plot ($\alpha = 0.05$). Blobs were excluded because of a low number of occurrences. When significant differences were detected, Tukey-Kramer HSD means separation was performed on all pairs of means.

Vegetation and wildlife use

Simpson's diversity index for overstory vegetation was examined with wildlife use class at the plot level using oneway ANOVA. This identified differences in overstory vegetative diversity between low, medium, and high wildlife use classes ($\alpha = 0.05$). Oneway ANOVA was used to test for differences in percent canopy cover and wildlife use class ($\alpha = 0.05$). Levene's test was used to check for homogeneity in variance across wildlife use classes using JMP IN 4 software to meet the assumptions of analysis of variance. Oneway ANOVA was also used to test for differences in BA (m^2/ha) of large mast producing species between low, medium, and high wildlife use classes ($\alpha = 0.05$). Large mast producing species included *Carya* spp., *F. grandifolia*, black walnut (*Juglans nigra* L.), *P. echinata*, *P. taeda*, and *Quercus* spp.

CWD and environmental variables

Aspect, elevation (m), percent slope, and coniferous and deciduous BA were compared to CWD volume using JMP IN 4 software. Numeric aspect data was classified by cardinal direction (northeast, northwest, southeast, southwest) and analyzed as the independent variable against CWD volume in a oneway ANOVA conducted at the plot level ($\alpha = 0.05$). Homogeneity in variance was varified using Levene's test. Elevation was averaged across plots at each study site and compared to mean CWD volume at each site using Pearson's correlation ($\alpha = 0.05$). Percent slope within each plot was log-transformed to stabilize variance, assessed graphically to ensure normality, and compared to CWD volume at the plot level using Pearson's correlation ($\alpha = 0.05$). Coniferous and deciduous BA's were summed at each plot and compared separately to CWD volume at the plot level using Pearson's correlation ($\alpha = 0.05$).

Results

CWD patterns and overstory data

Detrended correspondence analysis of total BA per plot and total BA with minor species excluded showed no distinctive communities based on overstory vegetation (Figure 3). The calculation of Jaccard's similarity indices and display of indices as a dendrogram revealed two relatively similar communities of overstory vegetation (Figure 4). Two or more communities were classified as similar in overstory vegetation if their Jaccard's similarity index was greater than 50. The first vegetative community included APPO, GWNF, FISH, REDH, and REYN (Figure 4). The second community included CUMB and FORT (Figure 4). The locations DUNE and WASH were least similar to the other 10 locations and were not regarded as members of overstory vegetation communities (Figure 4).

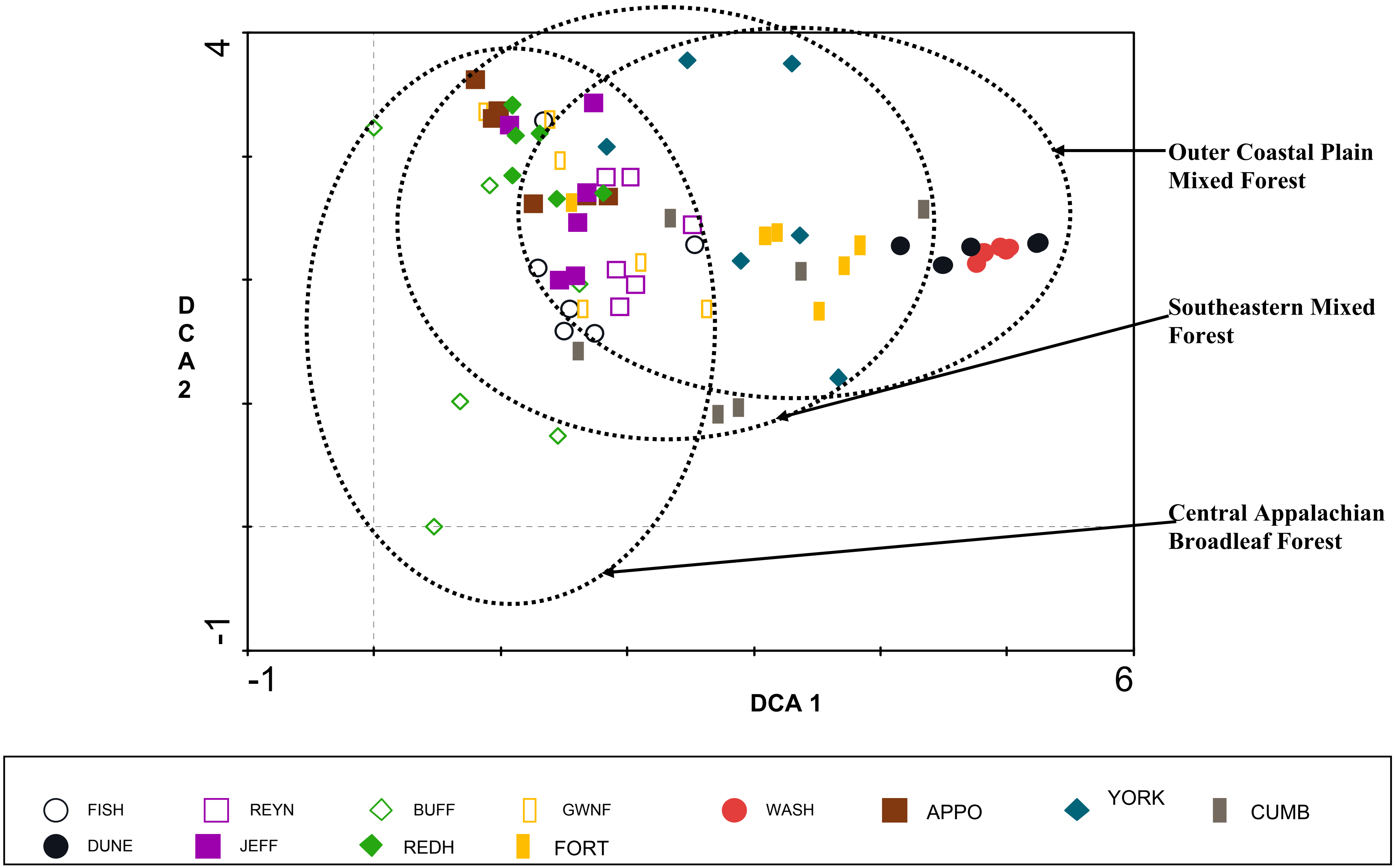

Figure 3. Detrended correspondence analysis of total basal area (BA) of overstory vegetation with minor species excluded from 12 sites in Virginia sampled in the summer of 2003. Minor species included species occupying less than 1% of the plot BA. Symbols within circles represent plots sampled in each of three ecoregions in Virginia.

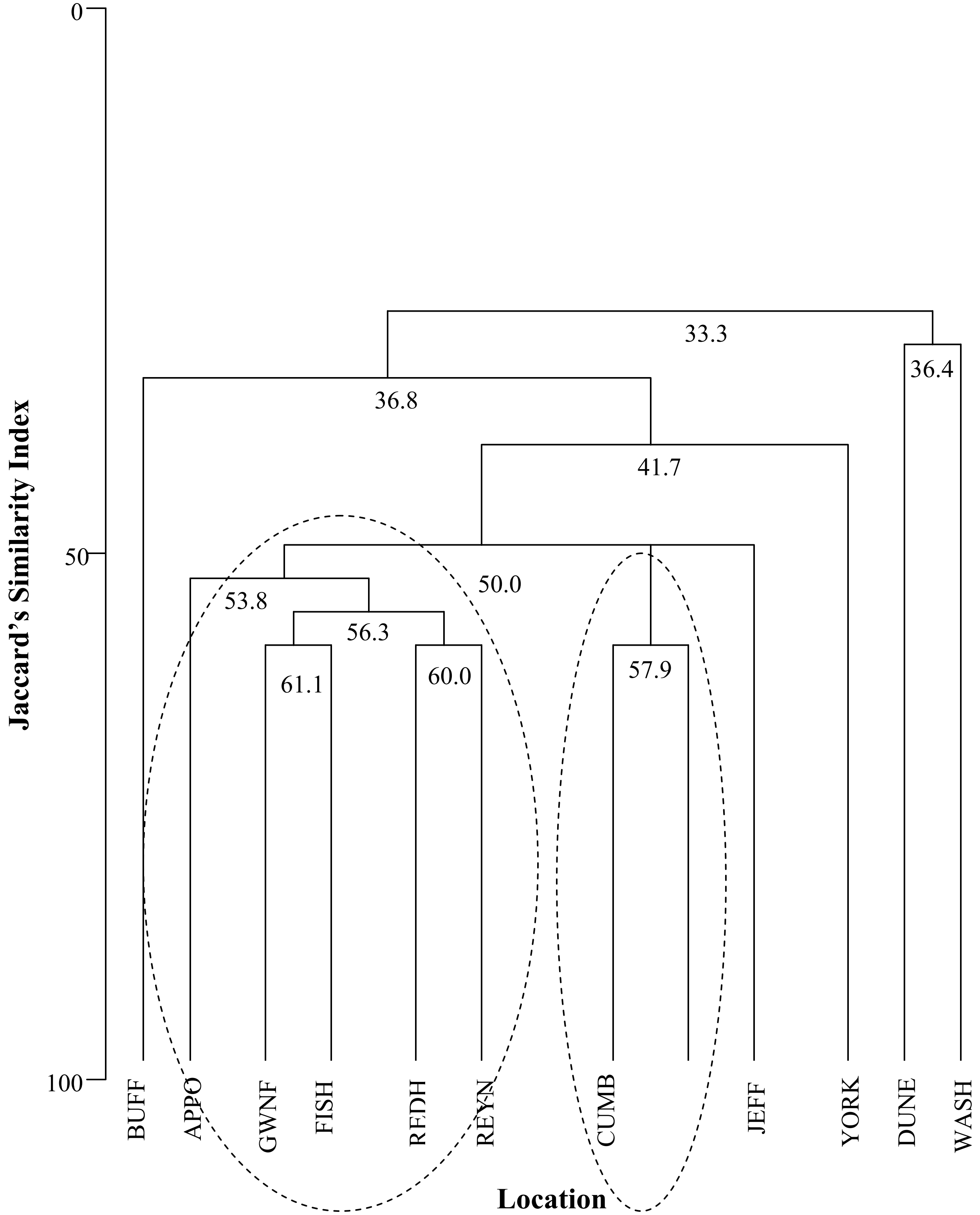

Figure 4. Dendrogram of Jaccard similarity indices for overstory vegetation by study site sampled across Virginia in the summer of 2003. Values between lines are the similarity indices for overstory species. Ovals represent locations that are similar (have similarity indices greater than 50).

Appomattox-Buckingham State Forest

At APPO, the mean volume of CWD was 18.0 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 10.99, 5.57, and 1.50 m^3/ha, respectively (Table 6). Of 195 pieces of CWD measured, 78% were logs, 11% were snags, and 11% were stumps (Table 5). The stand contained an average of 35 snags per ha. Of the 21 snags sampled, 57% were ≥ 15 cm DBH and 24% were ≥ 25 cm DBH. Slopes ranged from 5% to 30% with an average slope of 13%. The mean elevation was 61 m (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by bodily. Evidence of natural or human-caused disturbance included cut stumps, old flagging, and beverage cans. The three most dominant overstory species were *Q. prinus*, *Q. alba*, and *A. rubrum* and their importance values were 37%, 20%, and 15%, respectively (Appendix A). Mean canopy cover was 60% and was occupied by deciduous species; no coniferous species were sampled in the canopy (Table 7). Of the 12 sampling locations, the second highest Simpson's diversity index (0.16) was found in this stand (Table 7).

Buffalo Mountain Natural Area Preserve

At BUFF, the mean volume of CWD was 36.5 m^3/ha, the highest volume of the 12 sampling locations (Figure 5). Mean log, snag, and stump volumes were 21.83, 12.44, and 2.05 m^3/ha, respectively (Table 6). Of the 12 sampling locations, the second highest log volume and the highest variability in snag volume were found in this stand (Table 6).

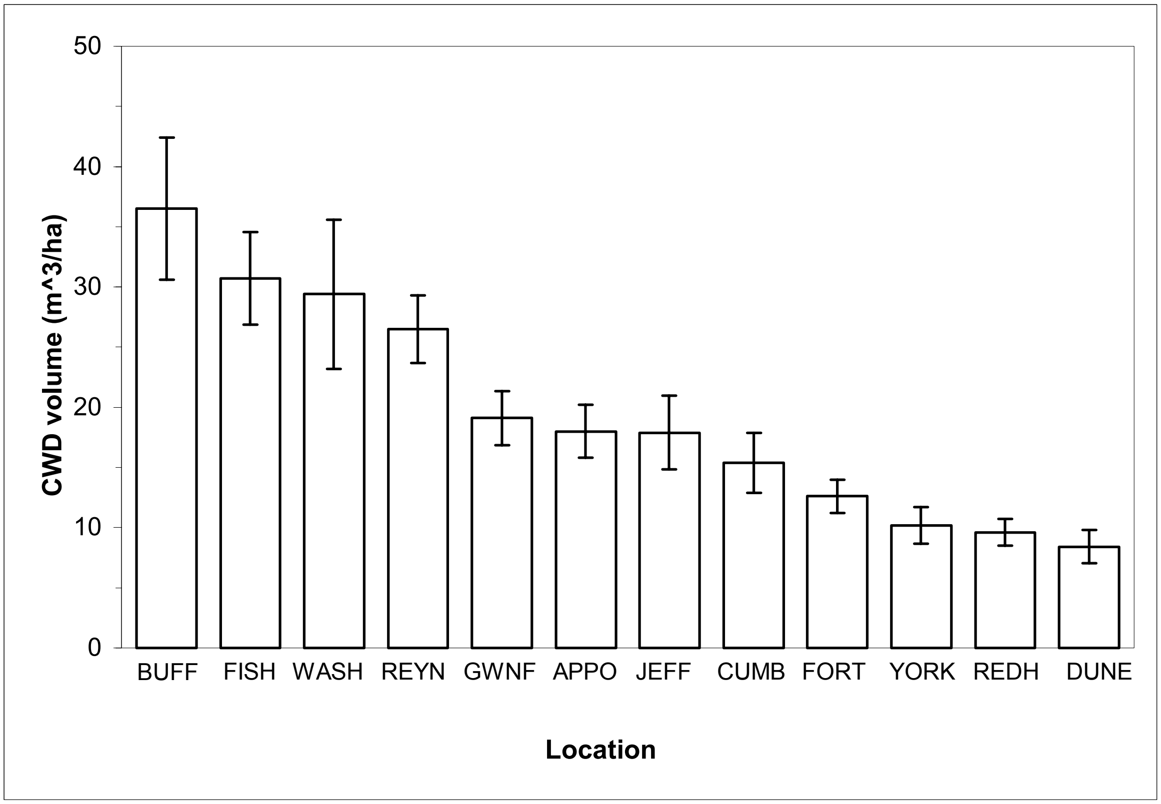

Figure 5. Mean coarse woody debris (CWD) volume by study site sampled across Virginia in the summer of 2003. Error bars represent the mean ± 1 SE.

Table 5. Distribution of CWD within 12 study sites sampled across Virginia in the summer of 2003. Values in parentheses indicate the proportion of CWD for each specified type.

Location	# Logs	# Snags	# Stumps
APPO	152 (78%)	21 (11%)	22 (11%)
BUFF	195 (81%)	21 (9%)	24 (10%)
CUMB	120 (62%)	22 (11%)	50 (26%)
DUNE	81 (54%)	34 (23%)	35 (23%)
FISH	121 (64%)	33 (18%)	34 (18%)
FORT	108 (63%)	26 (15%)	37 (22%)
GWNF	124 (64%)	21 (11%)	47 (24%)
JEFF	116 (47%)	58 (24%)	72 (29%)
REDH	122 (59%)	36 (18%)	48 (23%)
REYN	106 (61%)	45 (26%)	21 (12%)
WASH	132 (68%)	16 (8%)	47 (24%)
YORK	144 (81%)	20 (11%)	14 (8%)

Table 6. Distribution of mean log, snag, and stump volume within 12 study sites in Virginia sampled during the summer of 2003. Standard error is included in parentheses after each value.

Location	Log volume (m^3/ha)	Snag volume (m^3/ha)	Stump volume (m^3/ha)
APPO	10.99 (0.8)	5.57 (2.5)	1.50 (0.4)
BUFF	21.83 (5.2)	12.44 (7.3)	2.05 (0.5)
CUMB	6.75 (2.8)	6.90 (3.0)	1.74 (1.0)
DUNE	4.28 (1.1)	3.66 (1.8)	0.42 (0.1)
FISH	10.33 (1.7)	15.23 (5.4)	2.82 (1.6)
FORT	4.88 (0.9)	6.24 (1.7)	1.49 (0.8)
GWNF	11.76 (2.2)	4.57 (1.5)	2.03 (0.6)
JEFF	5.77 (1.9)	10.77 (4.4)	1.35 (0.2)
REDH	4.66 (0.4)	3.72 (1.6)	1.19 (0.5)
REYN	10.67 (3.4)	9.56 (1.7)	0.52 (0.2)
WASH	24.01 (8.2)	3.17 (1.8)	2.27 (0.6)
YORK	6.56 (1.2)	3.42 (1.5)	0.24 (0.1)

Table 7. Overstory characteristics of 12 study sites in Virginia from data collected in the summer of 2003. BA = basal area, conif. = coniferous, and decid. = deciduous.

Location	BA-conif. (m^2/ha)	BA-decid. (m^2/ha)	Density-conif. (#/ha)	Density-decid. (#/ha)	Canopy cover (%)	Simpson's diversity index	Species richness
APPO	0.00	20.34	0	522	60	0.16	9
BUFF	0.00	23.01	0	522	79	0.08	17
CUMB	4.83	24.59	50	650	75	0.09	15
DUNE	20.02	9.78	411	439	60	0.14	9
FISH	2.12	17.61	56	522	52	0.10	14
FORT	2.24	21.13	22	433	80	0.09	15
GWNF	0.34	15.98	17	350	49	0.09	15
JEFF	6.77	11.49	156	506	58	0.08	15
REDH	0.55	23.88	11	678	84	0.13	11
REYN	1.23	26.44	17	633	50	0.11	13
WASH	29.44	14.33	183	539	63	0.19	6
YORK	3.42	22.89	39	606	78	0.07	19

Of 240 pieces of CWD measured, 81% were logs, 9% were snags, and 10% were stumps (Table 5). The stand contained an average of 35 snags per ha. Of the 21 snags sampled, 81% were ≥ 15 cm DBH, 62% were ≥ 25 cm DBH, and 33% were ≥ 45 cm DBH. Slopes ranged from 24% to 42% with an average slope of 30%. The mean elevation was 1067 m, the highest of the 12 sampling locations (Table 3). Overall wildlife use was classified as high (Table 4). The most common use evidence was foraging, followed by movement. Evidence of natural or human-caused disturbance included an old road or skid trail, old flagging, discarded agricultural materials, an old fence post, cut and charred stumps, and beverage bottles. The three most dominant overstory species were *T. americana*, black/sweet birch (*Betula lenta* L.), and *Q. rubra* and their importance values were 24%, 11%, and 10%, respectively (Appendix A). Mean canopy cover was 79% and was occupied by deciduous species; no coniferous species were sampled in the canopy (Table 7). Of the 12 sampling locations, the second highest species richness (17) was found in this stand (Table 7).

Cumberland State Forest

At CUMB, the mean volume of CWD was 15.4 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 6.75, 6.90, and 1.74 m^3/ha, respectively (Table 6). Of 192 pieces of CWD measured, 62% were logs, 11% were snags, and 26% were stumps (Table 5). The stand contained an average of 37 snags per ha. Of the 22 snags sampled, 32% were ≥ 15 cm DBH and 9% were ≥ 25 cm DBH. Slopes ranged from 3% to 12% with an average slope of 7%. The mean elevation was 37 m (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by movement. Evidence of natural or human-caused disturbance included cut stumps and several recreational trails. The three most dominant overstory species were *Q. coccinea*, *Q. alba*, and *A. rubrum* and their importance values were 15%, 13%, and 13%, respectively (Appendix A). Mean canopy cover was 75% (Table 7). There were 13 times more deciduous stems per ha than coniferous stems per ha (Table 7). The BA of deciduous trees was 5.1 times the BA of coniferous trees (Table 7).

Savage Neck Dunes Natural Area Preserve

At DUNE, the mean volume of CWD was 8.4 m^3/ha, the lowest volume of the 12 sampling locations (Figure 5). Mean log, snag, and stump volumes were 4.28, 3.66, and 0.42 m^3/ha, respectively (Table 6). Of the 12 sampling locations, this stand had the lowest volume of logs (Table 6). Of 150 pieces of CWD measured, 54% were logs, 23% were snags, and 23% were stumps (Table 5). The stand contained an average of 57 snags per ha. Of the 34 snags sampled, 29% were ≥ 15 cm DBH and 3% were ≥ 25 cm DBH. Slopes ranged from 0% to 4% with an average slope of 1%. The mean elevation was 0 m (Table 3). Overall wildlife use was classified as low (Table 4). The most common use evidence was foraging. Evidence of natural or human-caused disturbance included old flagging (to mark access trails), old pieces of agricultural equipment, and beverage cans. The four most dominant overstory species were *P. taeda*, *L. styraciflua*, *A. rubrum*, and American holly (*Ilex opaca* Ait.) and their importance values were 47%, 14%, 11%, and 11%, respectively (Appendix A). Mean canopy cover was 60% (Table 7). The highest number of conifer stems per ha and the lowest deciduous BA of the 12 sampling locations were found in this stand (Table 7). The second highest coniferous BA was also found in this stand. Of all the study sites, the third highest Simpson's diversity index (0.14) was found in this stand (Table 7).

Fishburn Forest

At FISH, the mean volume of CWD was 30.7 m^3/ha, the second highest volume of the 12 sampling locations (Figure 5). Mean log, snag, and stump volumes were 10.33, 15.23, and 2.82 m^3/ha, respectively (Table 6). The highest snag and stump volumes and the highest variability in stump volume were found in this stand (Table 6). Of 188 pieces of CWD measured, 64% were logs, 18% were snags, and 18% were stumps (Table 5). The stand contained an average of 55 snags per ha. Of the 33 snags sampled, 48% were ≥ 15 cm DBH, 21% were ≥ 25 cm DBH, and 6% were ≥ 45 cm DBH. Slopes ranged from 15% to 28% with an average slope of 22%. The mean elevation was 661 m, the second highest elevation of all sampling locations (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by bodily. Evidence of natural or human-caused disturbance included old surveying flags (research or educational use), cut stumps, and bark beetle holes in many snags. The three most dominant overstory species were *Q. coccinea*, *Q. prinus*, and *A. rubrum* and their importance values were 19%, 15%, and 12%, respectively (Appendix A). Mean canopy cover was 52% (Table 7). There were 9.3 times as many deciduous stems per ha as coniferous stems per ha (Table 7). Deciduous BA was 8.3 times greater than coniferous BA (Table 7).

Fort A.P. Hill

At FORT, the mean volume of CWD was 12.6 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 4.88, 6.24, and 1.49 m^3/ha, respectively (Table 6). Of all the sampling locations, the third lowest log volume was found in this stand (Table 6). Of 171 pieces of CWD measured, 63% were logs, 15% were snags, and 22% were stumps (Table 5). The stand contained an average of 43 snags per ha. Of the 26 snags sampled, 54% were ≥ 15 cm DBH and 8% were ≥ 25 cm DBH. Slopes ranged from 9% to 17% with an average slope of 13%. The mean elevation was 18 m (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by movement. Evidence of natural or human-caused disturbance included beaver damage, an old logging road, and several old fence posts. The three most dominant overstory species were *L. tulipifera*, *C. tomentosa*, and *L. styraciflua* and their importance values were 27%, 14%, and 10%, respectively (Appendix A). Mean canopy cover was 80%, the second highest of the 12 sampling locations (Table 7). The density of deciduous trees per ha was 19.7 times greater than the density of coniferous trees per ha (Table 7). Deciduous BA was 9.4 times greater than coniferous BA (Table 7).

George Washington National Forest

At GWNF, the mean volume of CWD was 19.1 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 11.76, 4.57, and 2.03 m^3/ha, respectively (Table 6). Of 192 pieces of CWD measured, 64% were logs, 11% were snags, and 24% were stumps (Table 5). The stand contained an average of 35 snags per ha. Of the 21 snags sampled, 48% were ≥ 15 cm DBH and 10% were ≥ 25 cm DBH. Slopes ranged from 9% to 29% with an average slope of 20%. The mean elevation was 168 m (Table 3). Overall wildlife use was classified as high (Table 4). The most common types of use evidence were foraging and bodily. Evidence of natural or human-caused disturbance included cut logs and stumps and old beverage bottles and cans. The three most dominant overstory species were *Q. prinus*, *Q. alba*, and *Q. rubra* and their importance values were 21%, 14%, and 12%, respectively (Appendix A). Mean canopy cover was 49% (Table 7). The density of deciduous trees per ha was 20.6 times greater than the density of coniferous trees per ha (Table 7). Deciduous BA was 47 times greater than coniferous BA (Table 7).

Jefferson National Forest

At JEFF, the mean volume of CWD was 17.9 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 5.77, 10.77, and 1.35 m^3/ha, respectively (Table 6). The third highest snag volume of the 12 sampling locations was found in this stand (Table 6). Of 246 pieces of CWD measured, 47% were logs, 24% were snags, and 29% were stumps (Table 5). The stand contained an average of 97 snags per ha, the highest of all sampling locations. Of the 58 snags sampled, 35% were ≥ 15 cm DBH, 9% were ≥ 25 cm DBH, and 2% were ≥ 45 cm DBH. Slopes ranged from 12% to 24% with an average slope of 16%. The mean elevation was 220 m (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by movement. Evidence of natural or human-caused disturbance included several trees marked with paint, an old logging road, old flagging, and cut stumps. The three most dominant overstory species were *Q. alba*, scarlet oak (*Quercus coccinea* Muench.), and *A. rubrum* and their importance values were 21%, 12%, and 10%, respectively (Appendix A). Mean canopy cover was 58% (Table 7). The density of deciduous trees per ha was 3.2 times greater than the density of coniferous trees per ha (Table 7). Deciduous BA was 1.7 times as large as coniferous BA (Table 7). Of the 12 sampling locations, both the third highest density of coniferous trees and coniferous BA were found in this stand (Table 7).

Red Hill

At REDH, the mean volume of CWD was 9.6 m^3/ha, the second lowest volume of the 12 sampling locations (Figure 5). Mean log, snag, and stump volumes were 4.66, 3.72, and 1.19 m^3/ha, respectively (Table 6). The second lowest log volume and lowest variability in log volume of the 12 sampling locations were found in this stand (Table 6). Of 206 pieces of CWD measured, 59% were logs, 18% were snags, and 23% were stumps (Table 5). The stand contained an average of 60 snags per ha. Of the 36 snags sampled, 19% were ≥ 15 cm DBH and 3% were ≥ 25 cm DBH. Slopes ranged from 3% to 10% with an average slope of 7%. The mean elevation was 61 m (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by movement. Evidence of natural or human-caused disturbance included an old logging road, a recreation trail, and cut stumps. The three most dominant overstory species were *Q. prinus*, *Q. alba*, and sourwood (*Oxydendrum arboreum* (L.) DC) and their importance values were 31%, 19%, and 16%, respectively (Appendix A). Mean canopy cover was 84%, the highest of the sampling locations (Table 7). The density of deciduous trees per ha was 61.6 times greater than the density of coniferous trees per ha (Table 7). Deciduous BA was 43.4 times greater than coniferous BA (Table 7).

Reynold's Homestead

At REYN, the mean volume of CWD was 26.5 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 10.67, 9.56, and 0.52 m^3/ha, respectively (Table 6). The third lowest stump volume of the 12 sampling locations was found in this stand (Table 6). Of 172 pieces of CWD measured, 61% were logs, 26% were snags, and 12% were stumps

(Table 5). The stand contained an average of 75 snags per ha. Of the 45 snags sampled, 64% were ≥ 15 cm DBH and 7% were ≥ 25 cm DBH. Slopes ranged from 3% to 28% with an average slope of 13%. The mean elevation was 345 m, the third highest elevation of all the sampling locations (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by movement. Evidence of natural or human-caused disturbance included old flagging, painted trees, cut stumps, and an old tire. The three most dominant overstory species were *Q. alba*, *O. arboreum*, and *A. rubrum* and their importance values were 20%, 15%, and 14%, respectively (Appendix A). Mean canopy cover was 50% (Table 7). The density of deciduous trees per ha was 37.2 times greater than the density of coniferous trees per ha (Table 7). Deciduous BA was 21.5 times greater than coniferous BA (Table 7).

George Washington National Birthplace Monument

At WASH, the mean volume of CWD was 29.4 m^3/ha, the third highest and most variable volume of the 12 sampling locations (Figure 5). Mean log, snag, and stump volumes were 24.01, 3.17, and 2.27 m^3/ha, respectively (Table 6). The highest and most variable log volume, lowest snag volume, and second highest stump volume of the sampling locations were found in this stand (Table 6). Of 195 pieces of CWD measured, 68% were logs, 8% were snags, and 24% were stumps (Table 5). Of the 12 sampling locations, the lowest number of snags were found in this stand (Table 5). The stand contained an average of 27 snags per ha. Of the 16 snags sampled, 56% were ≥ 15 cm DBH and 13% were ≥ 25 cm DBH. Slopes ranged from 0% to 2% with an average slope of 1%. The mean elevation was 0 m (Table 3). Overall wildlife use was classified as medium (Table 4). The most common use evidence was foraging, followed by bodily.

Evidence of natural or human-caused disturbance included old flagging, cut stumps, a recreational trail, and several small mammal traps set for research purposes to monitor small mammal use in the area. The three most dominant overstory species were *P. taeda*, *L. styraciflua*, and *I. opaca* and their importance values were 38%, 24%, and 17%, respectively (Appendix A). Mean canopy cover was 63% (Table 7). The density of deciduous trees per ha was 2.9 times greater than the density of coniferous trees per ha (Table 7). The coniferous BA was 2.1 times as large as the deciduous BA (Table 7). Of the 12 sampling locations, the highest Simpson's diversity index (0.19) and the lowest species richness (6) were found in this stand (Table 7).

York River State Park

At YORK, the mean volume of CWD was 10.2 m^3/ha (Figure 5). Mean log, snag, and stump volumes were 6.56, 3.42, and 0.24 m^3/ha, respectively (Table 6). The lowest stump volume of the 12 sampling locations was found in this stand (Table 6). Of 178 pieces of CWD measured, 81% were logs, 11% were snags, and 8% were stumps (Table 5). The lowest percentage of stumps to logs and snags was found in this stand (Table 5). The stand contained an average of 33 snags per ha. Of the 20 snags sampled, 35% were $\geq$ 15 cm DBH and 5% were $\geq$ 25 cm DBH. Slopes ranged from 2% to 20% with an average slope of 13%. The mean elevation was 6 m, the second lowest elevation of the sampling locations (Table 3). Overall wildlife use was classified as low (Table 4). The most common use evidence was foraging, followed by minimal movement evidence. Evidence of natural or human-caused disturbance included recreational trails, old fencing, and beaver damage. The three most dominant overstory species were *A. rubrum*, *L. tulipifera*, and *I. opaca* and their importance values were 13%, 10%, and 9%, respectively (Appendix A). Mean canopy cover was 78% (Table 7). The density of deciduous trees per ha was 15.5 times greater than the density of coniferous trees per ha (Table 7). Deciduous BA was 6.7 times greater than coniferous BA (Table 7). Of the 12 sampling locations, the lowest Simpson's diversity index (0.07) and highest species richness (19) were found in this stand (Table 7).

CWD and wildlife use

Mean snag volume did not differ (P = 0.57) among low, medium, and high wildlife use classes (α = 0.05) (Figure 6). Mean stump volume was different (P = 0.03) among wildlife use classes (α = 0.05) (Figure 6). High wildlife use was associated with greater mean stump volumes (Figure 6). Mean log volume was also different (P = 0.04) among wildlife use classes (α = 0.05) (Figure 6). High wildlife use was associated with greater mean log volumes (Figure 6). Blobs were excluded from analysis due to a low number of occurrences. The chi-square test of homogeneity (χ^2 crit. = 33.924, df = 22, α = 0.05) resulted in a chi-square of 151.589, indicating that study sites had different proportions of snags, stumps, and logs.

Vegetation and wildlife use

Simpson's diversity index did not differ (P = 0.34) among low, medium, and high wildlife use classes (α = 0.05) (Figure 7). Mean canopy cover (%) was not significantly different (P = 0.09) among wildlife use classes (α = 0.05) (Figure 7). The BA of large mast producing species also did not differ (P = 0.92) among wildlife use classes (α = 0.05) (Figure 7).

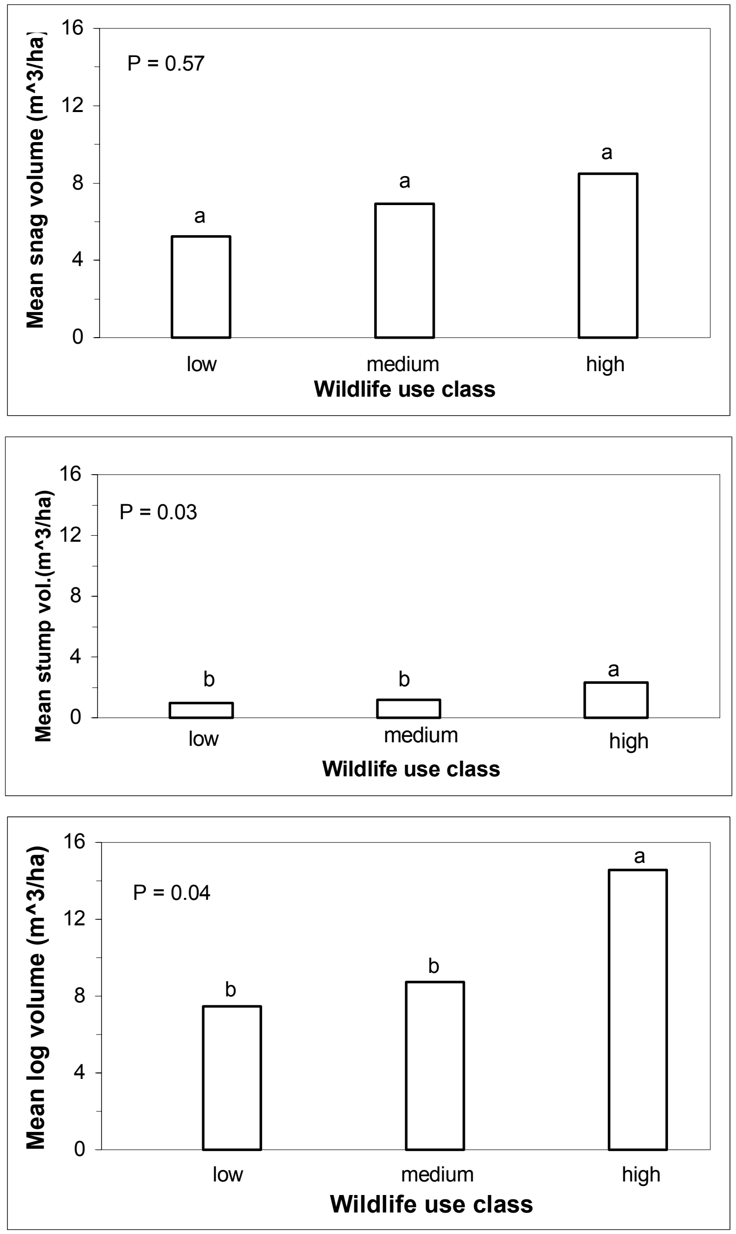

Figure 6. Mean snag, stump, and log CWD volumes and wildlife use classes from 12 second-growth mature stands sampled in Virginia, summer 2003. Of 72 plots sampled, 12 plots had low wildlife use, 39 plots had medium use, and 21 plots had high use. Letters above bars indicate a significant difference ($\alpha = 0.05$).

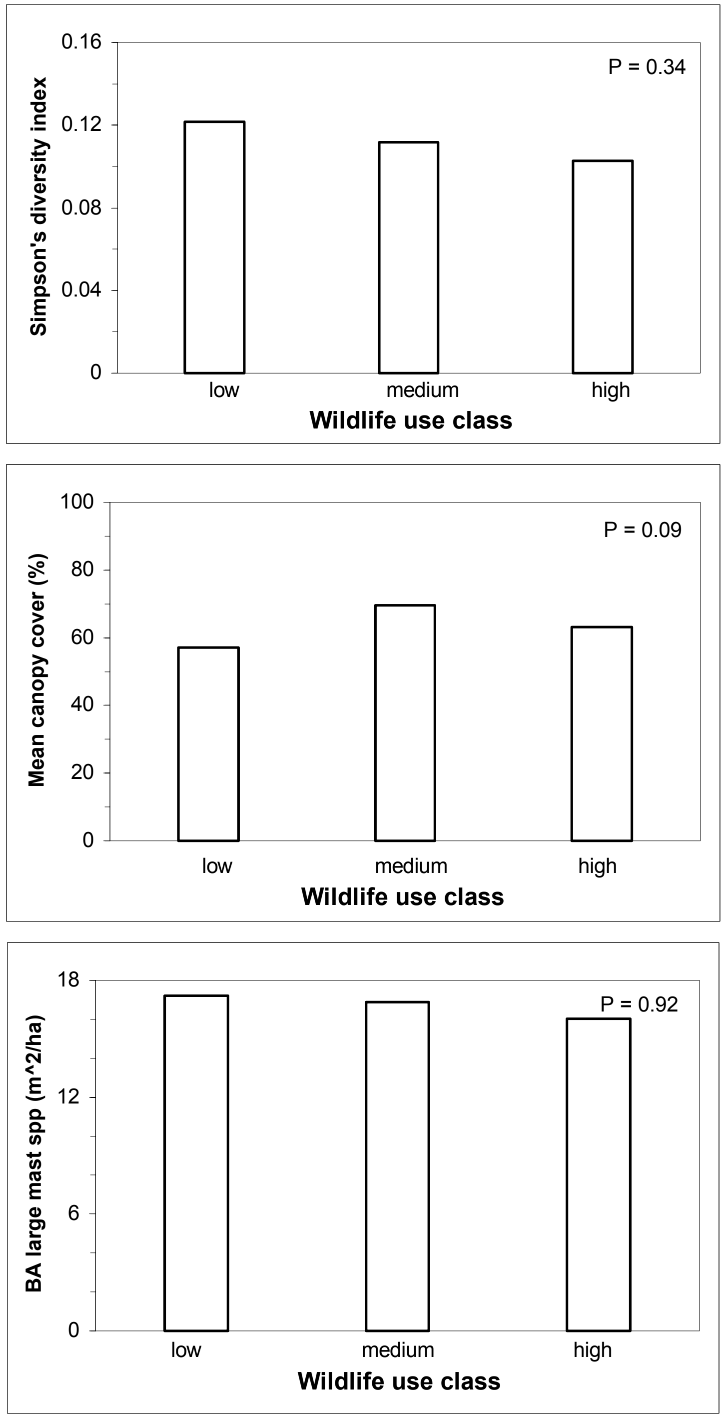

Figure 7. Species diversity, mean canopy cover, and basal area of large mast producing species and wildlife use classes from 12 second-growth mature stands sampled in Virginia, summer 2003. Of 72 plots sampled, 12 plots had low wildlife use, 39 plots had medium use, and 21 plots had high use.

CWD and environmental variables

Coarse woody debris volume did not significantly differ (P = 0.15) among aspects classified by cardinal direction (NE, NW, SE, SW) at the plot level ($\alpha = 0.05$) (Table 8). Elevation was significantly correlated with mean CWD volume (r = 0.792, P = 0.0001) at each study site ($\alpha = 0.05$) (Table 8). Percent slope was also significantly correlated with CWD volume (r = 0.106, P = 0.0054) at the plot level ($\alpha = 0.05$) (Table 8). Coniferous BA was not correlated with CWD volume (r = 0.00004, P = 0.9561) at the plot level ($\alpha = 0.05$) (Table 8). Deciduous BA was also not correlated with CWD volume (r = 0.002, P = 0.6889) at the plot level ($\alpha = 0.05$) (Table 8). A significance in correlation between CWD volume and environmental variable does not imply that CWD volume was caused by a particular environmental/site condition.

Table 8. Relationship between CWD volume (m^3/ha) and environmental variables from 12 sites in Virginia sampled in the summer of 2003.

Environmental variable	Significance
Aspect	P = 0.1549^{NS}
Elevation (m)	r = 0.792, P = 0.0001**
Percent slope	r = 0.106, P = 0.0054**
Coniferous BA (m^2/ha)	r = 0.00004, P = 0.9561^{NS}
Deciduous BA (m^2/ha)	r = 0.002, P = 0.6889^{NS}

P < .01**
P < .05*
P > .05 ^{NS} not sig.

Comparison of Fixed Area Plot and Line Transect Sampling Techniques

Fixed area plots were more time consuming to sample but estimated CWD volume with far less variability than line transects (Table B1). The mean CWD volume (m^3/ha) estimated using six 71 m line transects was 2.5 times larger than the mean CWD volume estimated using six 0.1 ha fixed area plots (Table B1). The variability (standard deviation) in CWD volume estimated using six 71 m line transects was 4.4 times larger than the variability in CWD volume estimated using six 0.1 ha fixed area plots (Table B1). The average field sampling time per 0.1 ha circular plot was 1.5 hours. It would take an estimated 9 hours to sample CWD in six 0.1 ha circular plots (Table B1). The average sampling time per 71 m line transect was 15 minutes. It would take an estimated 4.75 hours to complete the number of 71 m line transects needed to achieve the same SE as six 0.1 ha circular plots (19 transects, 1349 m of line) (Table B1).

Discussion

CWD patterns and overstory data

Overstory species composition can influence CWD volumes. Stands dominated by *Q. alba* and *A. rubrum* tended to have higher volumes of CWD (Appendix A; Figure 5). Stands dominated by either *Q. prinus* or *Q. coccinea* in western and central Virginia had high CWD volumes (Figure 5). Stands dominated by both *Q. prinus* and *Q. coccinea* (FISH) had the highest volumes of CWD (Appendix A; Figure 5). Coarse woody debris volume and frequency were dominated by *Quercus* spp. in southeastern Ohio (McCarthy et al. 2001).

The susceptibility of overstory species to natural disturbance influences resulting CWD volumes. The highest volume of CWD was found in BUFF where *T. americana* and *Q. rubra* were two of the dominant overstory species (Appendix A; Figure 5). *T. americana* was found to be one of the most susceptible species to ice storm damage and *Q. rubra* and *Q. alba* contributed 79% of the total CWD input following an ice storm in Missouri (Rebertus et al. 1997). BUFF was the most elevated site of the 12 sampling locations (Table 3) and the high altitude and greater likelihood of ice and wind damage may have influenced the resulting highest CWD volume. The second highest volume of CWD was found in FISH (Figure 5) where *Q. coccinea* represented the highest importance value (19%) (Appendix A). Goebel and Hix (1997) suggested that during understory reinitiation there may be density-independent mortality of *Q. coccinea* that creates more CWD. Although *A. rubrum* likely contributed to higher CWD volumes in this study, when compared to *T. canadensis* forests, CWD mass has been found to be significantly lower in forests with *A. saccharum* (Campbell and Gower 2000). A possible explanation for *A. rubrum* likely contributing to higher CWD volumes is that *A. rubrum* is more prone to decay and cavity formation (Harmon and Sexton 1996).

CWD and wildlife use: Snags

Small mammal and bird habitat use has been found to be positively associated with higher snag densities and volumes (Haggard and Gaines 2001, Showalter and Whitmore 2002, Payer and Harrison 2003). While mean snag volumes did not significantly differ among wildlife use classes (Figure 6), snag volumes have been found to differ significantly ($P < 0.001$) among *M. americana* use classes in Maine (Payer and Harrison 2003). BUFF and WASH were sites where snags comprised less than 10% of the total CWD volume (Table 5). Overall wildlife use at BUFF was high and overall wildlife use at WASH was medium (Table 4). Of the six largest snags at BUFF, with an average diameter of 56 cm and average height of 15 m, five of the six snags had extensive foraging evidence and three of the six snags had movement evidence. This agrees with previous work in southwest Virginia where snags ≥ 20 cm DBH were found to be preferred for foraging (Rosenberg et al. 1988).

Large diameter snags tend to be preferred by cavity-dwelling wildlife because large snags are more likely to have cavities (Raphael and White 1984, Rosenberg et al. 1988). Snag diameters in WASH ranged from 9 to 33 cm (mean 15 cm) and snag heights ranged from 2.2 to 16.5 m (mean 7.5 m). Foraging evidence was most common on snags ≥10 cm in diameter. This could have been due to availability because 88% of the snags sampled in WASH were less than 20 cm DBH. Snags ≥ 20 cm in diameter have been found to be preferred for foraging in the Sierra Nevada where as snags less than 20 cm in diameter were found to be used less often (Raphael and White 1984). The largest diameter snags have been found to be most likely to be used by birds for nesting and feeding (Raphael and White 1984). Although foraging evidence was most common, foraging and bodily evidence (bird scat) were detected on two snags in WASH, each 15 cm in diameter and about 4 m in height. Each of these snags had cavity holes located approximately 3 m off the ground. An earlier study examining bird use of snags in relation to snag height reported that about 90% of all cavity-nesting bird species nested in snags > 2 m tall (Morrison et al. 1983).

Snags greater than 30 cm in diameter have been observed as the most widely used by cavity nesting birds and small mammals (McComb and Lindenmayer 1999) and the wildlife use evidence on snags in BUFF support this. This may be because of the assumption that cavity presence is directly associated with snag diameter (Rosenberg et al. 1988). Even though many snags in BUFF and WASH were beginning to or had lost most of their bark, the spaces behind loose bark on snags have been found to be used by brown creepers (*Certhia americana* Bonaparte, 1838) and may be a valuable nesting and foraging habitat component (Scott et al. 1977).

Smaller diameter snags have been found to be less valuable to cavity-using wildlife than larger diameter snags (Scott et al. 1977, Evans and Conner 1979, Rosenberg et al. 1988, McComb and Lindenmayer 1999). In both BUFF and WASH, snags less than 40 cm in diameter tended to have more foraging evidence than movement or bodily evidence. Specifically, snags 8 to 10 cm in diameter in BUFF and WASH tended to have more foraging evidence and less movement or bodily evidence. Larger snags (> 40 cm DBH) tended to have both foraging and movement evidence. The lack of movement evidence on smaller (less than 40 cm DBH) snags may have been due to more attached bark (particularly coniferous bark in WASH) that would hinder visible impressions by small mammal and bird claws from being noticed. Snags or dead limbs less than 10 cm in diameter have been found to be of little or no value as nest sites for primary cavity-nesters (Scott et al. 1977, Evans and Conner 1979), however the results of this study suggest that snags less than 10 cm in diameter may be of value as foraging sites.

Of the 12 sampling locations, the presence of wildlife was most obvious in WASH. A number of pileated woodpeckers (*Dryocopus pileatus* Linnaeus, 1758) were heard pecking and calling at WASH. Although the number of snags as a proportion of the total amount of CWD was lowest in WASH (Table 5), other studies have found that in the absence of high numbers of snags, fewer, larger snags (> 23 cm DBH) may compensate for a low number of smaller snags and benefit woodpeckers (Gunn and Hagan 2000, Showalter and Whitmore 2002).

CWD and wildlife use: Stumps

High wildlife use is associated with greater mean stump volumes. Juvenile Formosan wood mice (*Apodemus semotus* Thomas, 1908) have been found to restrict their activities to microhabitats protected by cover such as stumps (Lin and Shiraishi 1992). In managed pine plantations of Canada, hooded warbler (*Wilsonia citrina* Boddaert, 1783) nests were found in stands that had more stumps (Whittam et al. 2002). In the White and Inyo Mountains of California, Bewick's wrens (*Thryomanes bewickii* Audubon, 1827) used nest-boxes in areas with short trees, sparse vegetation, and many stumps (Hall and Morrison 2003). In Vermont, Jefferson (*Ambystoma jeffersonianum* Green, 1827) and Spotted (*Ambystoma maculatum* Shaw, 1802) salamanders used well-shaded, deciduous forest stands with abundant logs and stumps (Faccio 2003).

In contrast to the results of this study, negative relationships between stump volume and wildlife use have been found in some forested ecosystems. In northeastern Oregon, only 6% of all *D. pileatus* observations of foraging were on stumps (Bull and Holthausen 1993). In *P. taeda* regeneration areas of South Carolina, *P. gossypinus* capture sites were characterized as having greater woody biomass but significantly smaller diameter stumps (Mengak and Guynn 2003). *P. gossypinus* used rotting stumps larger in diameter than randomly located stumps and logs for day refuges (McCay 2000).

Taller stumps can provide useful foraging and occasional nesting sites for birds (Morrison et al. 1983, Morrison 1992). The use of groups of coniferous short snags or "high-cut stumps" (1-2 m tall) by birds was assessed in the Sierra Nevada (Morrison

1992). About two-thirds of all high-cut stumps showed signs of woodpecker feeding and no other wildlife use evidence was found (Morrison 1992). In the present study, stumps in BUFF and FISH tended to be taller (Table 9). Slopes in these stands averaged 26% and may have contributed to the presence of taller stumps. Steeper slopes in FISH may have prevented a flush ground cut during felling and slopes may have influenced the breaking point of trees and snags during severe weather. Northern hardwood trees on an edge or slope tend to bend and snap in the direction dictated by crown asymmetry (Proulx and Greene 2001). Crown asymmetry on the downhill side of a slope may have caused a snag to snap higher up on the trunk, creating taller stumps.

Table 9. Mean stump height (m) within 12 study sites in Virginia sampled during the summer of 2003. Values in parentheses represent ± 1 standard error.

Location	Mean stump height (m)
APPO	0.36 (0.08)
BUFF	0.62 (0.08)
CUMB	0.32 (0.04)
DUNE	0.38 (0.06)
FISH	0.53 (0.06)
FORT	0.35 (0.05)
GWNF	0.36 (0.03)
JEFF	0.34 (0.03)
REDH	0.36 (0.04)
REYN	0.42 (0.06)
WASH	0.46 (0.05)
YORK	0.40 (0.08)

Stump height influences the likelihood of wildlife use. Although foraging evidence has been found on stumps 1-2 m tall (Morrison 1992), stumps less than 1 m tall showed signs of foraging in this study. Larger diameter stumps tended to contain more broken pieces of mast both on the tops and cached away inside the hollowed, rotten centers. This likely was because of the greater surface area of larger diameter stumps for sitting/perching during feeding and larger hollowed openings for food storage. Bodily evidence (small mammal scat) was rare but sometimes found in the hollow centers of stumps less than 0.5 m tall in this study and other studies report the use of stumps by small mammals as latrines (Page et al. 1999). Although Morrison (1992) found no other wildlife use evidence other than foraging on stumps 1-2 m tall, taller stumps, regardless of diameter, tended to contain more movement evidence in this study.

CWD and wildlife use: Logs

High wildlife use was associated with greater mean log volumes (Figure 6), a finding well supported (Harmon et al. 1986, Hunter 1990, McComb and Lindenmayer 1999). Logs > 5 cm in diameter have been found to be used as travel run-ways by small mammals such as *T. striatus* (Zollner and Crane 2003). A positive association between Trowbridge's shrews (*Sorex trowbridgii* Baird, 1857) and small diameter logs has been found in managed forests of western Oregon (Butts and McComb 2000). *S. trowbridgii* was negatively correlated with CWD > 10 cm in diameter in western Washington (Carey and Harrington 2001). In the northeastern US, *M. americana* have been found to most intensively use areas containing larger downed logs (Payer and Harrison 2003).

It has been suggested that the suitability of harvested stands for wildlife may be enhanced if CWD is retained and mean maximum diameters of logs exceed 22 cm (Payer and Harrison 2003). Others argue that logs smaller than 10 cm in diameter are of little value to most vertebrates (McComb and Lindenmayer 1999). This is because large logs seem to be used by more species than small logs and large logs persist longer than small logs (McComb and Lindenmayer 1999). Still other studies have found no significant relationship between small mammal abundance and overall abundance of logs (Bowman et al. 2000). In this study, all three types of wildlife use evidence were found on logs less than 10 cm in diameter.

The presence of large diameter logs influences small mammal and bird habitat suitability (Herren et al. 1996, McCay and Komoroski 2004). *A. funereus* have been found to prefer areas with old forest characteristics, including large downed logs > 32 cm in diameter (Herren et al. 1996). Barred owl (*Strix varia* Barton, 1799) flight and downy feathers were found near several large (> 20 cm) logs in GWNF, indicating perhaps the presence of fledgling owls known to practice flying from elevated objects on the ground (logs). Multiple piles of red fox (*Vulpes vulpes* Linnaeus, 1758) scat were also found on or next to large (> 30 cm) logs in GWNF. This may be evidence that fox in the area are marking territory extremities using logs as boundary landmarks. Other studies have found the use of CWD as landmarks and territorial markers by small mammals (McMillan and Kaufman 1995, Zollner et al. 1996).

The use of logs as travel pathways is influenced by vegetative cover (Barnum et al. 1992, Roche et al. 1999, McCay 2000). Although bodily evidence was found on large diameter logs in eastern Virginia, movement evidence became less frequent in extreme eastern Virginia. In DUNE, GWNF, and YORK, evidence of travel on logs was rare. Movement evidence at YORK was often contained to snags and logs less than 15 cm in diameter. Movement evidence was most rare at DUNE. This may have been because the dominant species type at DUNE was *P. taeda* (Appendix A). It can be speculated that small mammals may not have needed to travel atop logs to remain silent while walking in the pine dominated forests of extreme eastern Virginia. The presence of a thick layer of pine duff may have allowed small mammals to walk quietly on the soft pine needles, therefore ending the need to utilize the tops of interconnected logs for silent travel. In western Virginia where a hardwood overstory component existed, movement evidence on logs was more frequent. Perhaps this was because small mammal travel through the dry, crunchy leaves in the understory of such stands could be easily heard by predators and small mammals used the tops of logs more often for silent travel. Such speculation is well supported (Fitzgerald and Wolff 1988, Barnum et al. 1992, Planz and Kirkland 1992, Roche et al. 1999, Zollner and Crane 2003). Small mammals have been found to prefer dry coniferous litter over dry hardwood litter and travel more along logs placed on hardwood litter than on coniferous litter (Roche et al. 1999). Small mammals prefer traveling on dry coniferous litter, wet overall leaf litter, and logs because using quieter substrates reduces the risk of auditory detection by predators (Fitzgerald and Wolff 1988, Barnum et al. 1992, Planz and Kirkland 1992, Roche et al. 1999, Zollner and Crane 2003). Larger-diameter logs (> 5 cm) are often preferred for travel by small mammals because larger logs provide a wide travel surface, decrease the time and energy required for balancing, and are more likely to be straight and free of branches, all helping facilitate faster, more efficient movement (Barnum et al. 1992, Zollner and Crane 2003).

Vegetation and wildlife use

Wildlife use of CWD is influenced by vegetative composition and structure (Carey and Harrington 2001, Payer and Harrison 2003, Zollner and Crane 2003). Wildlife use decreased from western to eastern Virginia and varied with overstory composition. Although associations between wildlife and CWD have been found to be likely dependent on forest landscape context (Bowman et al. 2000), no relationship between wildlife use evidence and overstory vegetative diversity as measured using Simpson's diversity index was found in this study (Figure 7). Arthropod prey for grassland birds was compared to vegetative diversity in Texas and arthropod diversity and abundance was found to be related to vegetative diversity and structure, suggesting vegetative diversity may influence bird use (McIntyre and Thompson 2003).

Although percent canopy cover was not significantly different among wildlife use classes (Figure 7), use areas by *M. americana* in the northeastern US were found to have significantly higher percent canopy cover than no use areas (Payer and Harrison 2003). In the southern Appalachians, canopy gaps have been found to contain more CWD and have higher total densities and species richness of breeding birds than closed-canopy forests (Greenberg and Lanham 2001). Higher light levels in canopy gaps have also been found to positively influence reptile abundance (Greenberg 2001). However, canopy composition did not differ significantly between sites in southern Illinois with and without *T. striatus* (French et al. 2003).

Although the BA of large mast producing species did not differ among wildlife use classes (Figure 7), other studies have found relationships between fluctuations in acorn crops and wildlife habitat use in the southern Appalachians (McShea 2000, Castleberry et al. 2001). *P. leucopus*, *T. striatus*, and gray squirrel (*Sciurus carolinensis* Gmelin, 1788) populations were found to be significantly correlated with annual fluctuations in acorn crop in western Virginia (McShea 2000). Others speculate that when hard mast is scarce, species such as Allegheny woodrats (*Neotoma magister* Baird, 1857) increase foraging movements, home range size, and overall habitat use in an attempt to locate mast or sufficient alternative foods (Castleberry et al. 2001).

CWD and environmental variables

Although CWD volume did not significantly differ by plot aspect (Table 8), other studies have found highly decayed (class V, Pyle and Brown 1998) CWD volumes to be significantly negatively correlated with aspect in southern Ohio (Rubino and McCarthy 2003). Coarse woody debris density was significantly negatively correlated with percent slope (Rubino and McCarthy 2003). Percent slope was significantly positively correlated with CWD volume at the plot level in this study (Table 8). This contradicts other studies that suggest that CWD may be lost from steep slopes and transported to lower-slope positions where it can accumulate (Harmon et al. 1986, Rubino and McCarthy 2003). In the mountains of southeastern Australia, aspect and slope had no significant effect on log volume (Lindenmayer et al. 1999). In areas where cavity-nesting bird use was directly related to CWD volume, a tendency has been shown for nest plots to have a common aspect and CWD volume may also be related to aspect (Steeger and Hitchcock 1998).

Environmental variables such as elevation can influence CWD loadings. Elevation was significantly positively correlated with mean CWD volume (Table 8). The cooler temperatures of higher elevations have been found to slow woody decomposition rates, resulting in higher CWD accumulations and may be an explanation for the findings of this study (Harmon 1982, Muller and Liu 1991). However, lower elevation sites around mountain ponds and lakes in Washington, USA were found to have more abundant CWD when compared to higher elevation sites (Hoffman et al. 2003).

The BA of overstory vegetation can have an effect on CWD volume and wildlife use. Coniferous and deciduous BA were not correlated with CWD volume at the plot level in this study (Table 8). Payer and Harrison (2003) found that among habitat areas receiving use by *M. americana*, higher use intensity was associated with greater basal area of deciduous trees. Positive correlations have been found between northern goshawk (*Accipiter gentilis atricapillus* Linnaeus, 1758) fledgling rates and tree basal area within 1 ha of the nest (McGrath et al. 2003). Nest box occupancy by birds increased as stand basal area surrounding a nest box increased (Magill et al. 2003).

Overstory vegetative characteristics and disturbance type can impact CWD volumes. Although no correlation between BA and CWD volume was found in this study, the proportion of coniferous to deciduous overstory species and frequency and intensity of past disturbance may increase CWD volumes at the stand level. Tree species, height, and status (snag or alive) have been found to strongly influence the amount and type of wind damage (Veblen et al. 2001). Taller trees were more likely to be damaged than shorter trees and stand-level characteristics such as stand density, species composition, and amount of snag basal area were found to be predictive of the amount of wind damage (Veblen et al. 2001). More deciduous overstory trees than coniferous species were found to experience heavy ice damage in New York (Manion et al. 2001). Bigtooth aspen (*Populus grandidentata* Michx.), *Q. rubra*, *A. rubrum*, and *P. strobus* were found to have the most branch breakage (Manion et al. 2001).

Summary

Coarse woody debris volumes in Virginia tended to be highest in stands with a hardwood overstory. Stands dominated by *Quercus* and *A. rubrum* contained the highest CWD volumes, suggesting that management efforts to increase CWD volumes should focus on coniferous dominated stands. Knowledge gained from this study on the volume and distribution of CWD by type would be useful in modeling nutrient budgets in forests of Virginia and the southeast. These results also suggested that management of CWD for small mammals and birds may be most needed in southeastern Virginia where CWD volumes were lowest. Management of snags for cavity-nesting wildlife was most needed in WASH where the lowest proportion of snags was found. Smaller diameter logs and snags were found to be used by wildlife in the absence of larger logs and snags. These results suggested that forest management efforts to retain small diameter snags would benefit wildlife. Wildlife use of CWD was lowest in eastern Virginia, perhaps because downed CWD for wildlife travel may be less important in stands with a coniferous litter layer compared to the noisy hardwood litter layers of western Virginia.

Chapter II:

An Evaluation of Two Teaching Techniques:

A Case Study with Coarse Woody Debris

Introduction

Public perception of forestry is a matter of public attitude and opinion (Barber 1984). One's attitudes and opinions of forestry can be swayed by the visual impact of forest management practices. Coarse woody debris (CWD), including logs, stumps, and standing dead trees (snags) remaining after a timber harvest or natural disturbance may appear aesthetically unpleasing to the untrained eye. Though often misunderstood by the public, CWD is an important component of forested ecosystems (Harmon et al. 1986). Coarse woody debris provides fish and wildlife habitat, enhanced soil and slope stability, and a growing medium for plants. Coarse woody debris also plays a role in nutrient cycling and the formation of soil via decomposition (Hagan and Grove 1999). Environmental education can be used to influence public knowledge, understanding, and perception of CWD in the forest ecosystem.

Benefits of environmental education

Environmental education efforts between the general public and outreach professionals work to influence the perceptions and learning experiences of citizens. Environmental outreach programs provide a link between science and society and address natural resource related issues with local relevance (Morse 1996, Hudson 2001). Environmental education can be highly interactive, enabling outreach professionals to employ indoor and outdoor activities where participants may learn through hands-on experiences (Vasievich et al. 1993, Broussard et al. 2001). The flexibility of environmental outreach programming enables information to be delivered in a variety of ways, including formal presentations, cooperative learning activities, informational brochures, internet links, computer modules, interactive displays/exhibits, and educational videos (Rollins and Higginbotham 1997, Seiler et al. 1997, Seiler et al. 2002). Outreach education efforts promote and build cooperative partnerships between natural resource professionals and schools, allowing youth of various backgrounds and abilities to participate in unique learning experiences (Vasievich et al. 1993). Environmental outreach programs involving the general public, private landowners, and natural resource professionals influence behavior by changing citizen attitudes and perceptions (Fisher 1996, Brewer 2001, James 2002).

Environmental education: local relevance

Environmental education programs address natural resource related questions, issues, and problems with local relevance. Outreach education efforts cater to local community needs and interests in an innovative, inviting, and understandable way (Hudson 2001). Educational outreach between governmental agencies and the public can link environmental protection efforts with human health benefits at the town, community, and neighborhood level (Morse 1996). Public participation and community involvement are important components of environmental education and provide local policy makers with essential knowledge about environmental and social issues that can be incorporated into preservation and development decisions (Tran et al. 2002). Outreach education programs can also be used as a venue for assessment of local knowledge, beliefs, attitudes, and behavioral intentions when promoting environmental or conservation efforts (Aipanjiguly et al. 2003).

Environmental education: hands-on experiences

Environmental education can be highly interactive and promote learning through hands-on experiences. Outreach efforts encourage participants to learn about and develop an interest in natural resources outside the confines of a normal classroom (Vasievich et al. 1993). By fostering an interest in nature, environmental education can encourage citizen interaction with natural resource professionals and promote independent learning. The public may interact with professionals through indoor and outdoor hands-on activities such as community recycling programs, tree plantings, road or stream clean-ups, plant and animal surveys, and visits to demonstration areas and agricultural fairs (Vasievich et al. 1993, Broussard et al. 2001, Boleman and Burrell 2003). Environmental education efforts that encourage interaction and include hands-on experiences can foster a stewardship ethic and positively influence participant attitudes and knowledge (Broussard et al. 2001). Distance education programs can offer multi-sensory learning opportunities via hands-on activities such as tree plantings and the testing of wood strength and porosity (Lockee et al. 2003).

Environmental education: flexibility in educational techniques

The flexibility of environmental outreach programming enables information to be conveyed to the public in a variety of ways. Educational displays, life-history videos, and classroom lesson plans have been successful at increasing knowledge of wildlife overabundance and management (Rollins and Higginbotham 1997). Computer-based multimedia instructional programs can foster self-paced learning, provide immediate self-evaluation of progress, and have been successful at improving woody plant identification skills and student course grades (Seiler et al. 1997, Seiler et al. 2002). Informational brochures can be used in the advertising and promotion of extension workshops (Oelker 1995, Skelton and Josiah 2003). Brochures have also been useful in stimulating interest and questions from the public when made available in high profile locations (Ponessa

2003). Active learning strategies, specifically cooperative learning activities, can be used by extension professionals when interacting with concerned citizens to increase participant engagement, focus group discussion, and encourage participant consensus (Bean 1996, Ellefson and MacKay 1996).

Environmental education: reaching a diversity of audiences

Outreach education efforts promote and build cooperative partnerships between professionals and schools, allowing youth of various backgrounds and abilities to participate in unique learning experiences (Vasievich et al. 1993). High school students practicing to be professionals can be effective teachers and motivators of younger children's interest in environmental issues (Madruga and Batalha da Silveira 2003). Distance education programs through universities have been effective means of improving learning in areas of environmental sciences for rural elementary school students and their teachers (Lockee et al. 2003). Forestry education programs that are delivered by extension professionals and that incorporate classroom activities such as Project Learning Tree have been successful at fostering positive attitudes toward forestry for inner-city youth (Broussard et al. 2001). The training of outreach staff and volunteers has helped ensure that educational programs such as 4-H are inclusive to youth with disabilities (Stumpf et al. 2002). Involving youth with disabilities in 4-H programs can help develop a greater sense of self-confidence and self-reliance in disabled participants, give non-disabled participants an opportunity to interact with disabled youth, and help program leaders learn new techniques for working with individuals with special needs (Tormoehlen and Field 1994).

Environmental education: changing participant attitudes, perceptions, and behaviors

Environmental outreach programs that involve the general public, private landowners, and natural resource professionals influence behavior by changing citizen attitudes and perceptions. Including landowners in decision-making and plan-writing processes can create partnerships based on compromise and mutual respect and help reverse beliefs that natural resource professionals are elitists who do not value the knowledge and opinions of landowners (James 2002). Impacting the value systems of the general public through environmental education can instill a land ethic that results in responsible environmental actions (Egan and Jones 1993, Barden et al. 1996). Cooperative extension programs take a learning-by-doing approach and can influence landowner management choices through forest landowner and logger education workshops that promote environmental stewardship, active forest management, and harvesting safety (Johnson and Jenkins 1998, Jenkins 2001).

Overview of study

Two commonly used educational techniques in the natural resources and life sciences are informational brochures and cooperative learning activities/presentations. Knowledge of the effectiveness of such techniques is important to program design and evaluation efforts in teaching and extension. Pre- and post-survey instruments were used to evaluate how perceptions were altered in first year college students of introductory English and agriculture classes who either had an opportunity to read an informational brochure or participate in a cooperative learning activity and presentation. The researchers hypothesized that a participant's gender, whether they were of international residence, their location of upbringing (urban, suburban, rural), and choice of college major would influence their learning experiences and perceptions of coarse woody debris and forestry. It was also hypothesized that the learning experiences and perceptions of brochure participants would differ from the learning experiences and perceptions of presentation participants and that such a difference could be detected using surveys.

Literature Review

Environmental Education and Local Relevance

Environmental education programs provide a link between science and society and address natural resource related questions, issues, and problems with local relevance (Pebbles 1993, Vasievich et al. 1993, Ellefson and MacKay 1996, Morse 1996, Brewer 2001, Hudson 2001). To stay relevant to the changing needs and interests of the community, environmental education must express the complexity of modern environmental issues in ways that are understandable and inviting to the general public (Hudson 2001). An example of connecting local issues with an environmental education program is the U.S. Fish and Wildlife Service's (USFWS) "Meet the Mussel" field day in Keene, New Hampshire. The program applied various environmental educational tactics that addressed the need for conservation of the endangered dwarf wedge mussel (*Alasmidonta heterodon*) at the local level (Morse 1996). Key town officials, schoolteachers, the media, and all interested citizens were given a good look at the mussels, were taught about the species' life history, and were informed that by protecting mussel habitat in the Ashuelot River they were simultaneously protecting their area's water quality (Morse 1996). As a result, a cooperative partnership between citizen and biologist was formed (Morse 1996). Environmental education programs also provide a link between the natural resource sciences and youth from a variety of backgrounds

(Vasievich et al. 1993, Rollins and Higginbotham 1997, Broussard et al. 2001). Four case studies will be presented to demonstrate common methods of using environmental education for public benefit.

Case Study 1: Hands-on Environmental Education

At the North Central Forest Experiment Station in East Lansing, Michigan, a summer science academy for inner-city middle school students addressed local environmental concerns with a hands-on approach (Vasievich et al. 1993). By offering a learning environment outside the confines of a normal classroom, the program encouraged students to learn about and develop an interest in natural resources, improved self-confidence, and provided opportunities to meet a diverse group of natural resource professionals (Vasievich et al. 1993). Some of the outdoor hands-on activities included measuring natural resource features, electroshocking a stream, and plant and animal surveys.

Case Study 2: Indoor and Outdoor Environmental Education

Another program in Philadelphia, Pennsylvania involved inner-city middle school students (84% African American) who participated in a forestry education program that involved indoor and outdoor educational activities (Broussard et al. 2001). Three methods of delivering forestry information were compared: indoor classroom education, outdoor education in an urban park, and outdoor education at a demonstration forest. The success of each method at fostering a forest stewardship ethic among the youth was measured using a questionnaire. The effectiveness of each method on inner-city youths' attitudes and knowledge about forestry before, during, and after the educational program was also measured with a questionnaire. The results of the questionnaires showed that students who participated in the cumulative educational activities (indoor and outdoor) had more forestry knowledge than control and placebo groups. In addition, the educational activities together resulted in significant changes in student attitudes toward forestry. Overall, the results demonstrate that though forestry knowledge can be acquired via classroom and urban forestry (outdoor) educational activities, the only way to change student attitudes about forestry is to physically show students the direct results of various harvesting treatments in the field (Broussard et al. 2001). The ideal forestry education program should incorporate indoor and outdoor sessions.

Case Study 3: Environmental Education and Local Relevance

Third grade students in various Texas elementary schools participated in "The White-tailed Deer School Enrichment" module on deer and deer management (Rollins and Higginbotham 1997). The program addressed misconceptions about problems associated with local deer overabundance problems using an information module that consisted of a display, life-history video, and lesson plans. A 1992 survey/pre-test conducted prior to the introduction of the module showed that 60% of about 2,000 third graders surveyed believed that white-tailed deer (*Odocoileus virginianus*) were an endangered species in Texas. After exposure to the deer information program, students increased their knowledge of deer from 46% on the survey/pre-test to 78% and 73% on a 2-day and 60-day delayed post-survey.

Case Study 4: Incorporating Active Learning Strategies with Environmental Education

Active learning strategies have been used to help focus discussions of thought-provoking actual events (case studies) of practicing natural resource professionals

(Bonwell and Eison 1991, Bean 1996, Ellefson and MacKay 1996). Group-discussion of locally relevant environmental topics involves the participants emotionally, fosters dialogue, and forces a decision of participants concerning the real-world situations (Bean 1996, Ellefson and MacKay 1996). The case study method of instruction is often based on problem-solving models that encourage and increase participant engagement (Bonwell and Eison 1991, Bean 1996).

Cooperative learning, the instructional use of small groups, is an active learning strategy that can be incorporated within or outside the classroom (Bonwell and Eison 1991, Johnson et al. 1991). The two goals commonly associated with cooperative learning are: (a) enhance participant learning and (b) develop participant social skills such as decision-making, conflict management, and communication (Bonwell and Eison 1991). For small-group learning to be truly cooperative, five essential components are suggested (Johnson et al. 1991):

(1) A group must have clear positive interdependence;

(2) Members must promote each other's learning and individual success face to face;

(3) Members must hold each other personally/individually accountable to do his/her fair share of the work;

(4) Members should use appropriately the interpersonal and small-group skills needed for cooperative efforts to be successful;

(5) A group must process together how effectively members are working together.

Cooperative learning strategies fall within three broad categories: (a) formal cooperative learning groups, (b) informal cooperative learning groups, and (c) cooperative base groups (Johnson et al. 1991). Formal cooperative learning groups last from one class period to several weeks and are used to teach specific content and problem-solving skills (Johnson et al. 1991). Informal cooperative learning groups are temporary, last for only one discussion or class period, and ensure active cognitive processing during a lecture (Johnson et al. 1991). The informal cooperative learning group focuses participant attention, establishes a mood conducive to learning, better ensures that participants cognitively process the material being taught, and can often provide closure to an instructional session (Johnson et al. 1991). Cooperative base groups provide long-term support, encouragement, and assistance, are heterogeneous, and have stable membership (Johnson et al. 1991).

The Cooperative Extension Service provides practical information to landowners through publications, short courses, and personal contact and encourages long-term sustainability of natural resources (Sharpe et al. 1995, Barden et al. 1996). Strongly focused on local area concerns, extension education efforts provide landowners and the public with programs addressing the broad categories of agriculture, forestry, wildlife, and fisheries, as well as the environment, home economics, 4-H clubs, and other youth and community resource development efforts (Sharpe et al. 1995). Jointly administered by the U.S. Department of Agriculture and land grant universities of various states, extension forestry efforts are specifically concentrated on providing landowner and public assistance in (a) forest resources management, (b) forest products processing, marketing, and distribution, (c) wildlife and fisheries, and (d) urban forestry (Sharpe et al.

1995). Traditional wildlife management extension education approaches have relied on direct (e.g., public meetings) and indirect (e.g., facts sheets) methods of information dispersal (Rollins and Higginbotham 1997). With a strong emphasis on increasing the land manager's decision-making abilities, extension education focuses on a learning-by-doing approach while providing opportunities to see management practices in action at the local level (Rollins and Higginbotham 1997, Broussard et al. 2001, Hudson 2001).

The Instructor's Role in the Cooperative Learning Experience

Cooperative learning experiences have been said to promote more positive attitudes toward a subject area and the instructional experience, as well as promote greater motivation to learn more about the subject area being discussed (Johnson and Johnson 1989). However, the instructor's role in the cooperative learning experience is important in creating an environment that welcomes communication and interaction (Johnson et al. 1991, Fisch 2002). The instructor is responsible for establishing the learning groups and learning environment (e.g., room arrangement), teaching the basic concepts and strategies for discussion, monitoring the functioning of the learning groups, intervening occasionally to teach small-group skills, and ensuring that each cooperative group processes how effectively members worked together (Johnson et al. 1991). The environment the instructor creates must be accessible to all participants (Fisch 2002). Cooperative learning participants may look to their peers for assistance, feedback, reinforcement, and support throughout the learning experience, but it is the instructor's role to create an environment that encourages honest feedback and contributions (Johnson et al. 1991, Fisch 2002).

Changing Perceptions using Environmental Education

Formal and informal public relations efforts between the general public, private-landowners, and natural resource professionals work to influence the shifting perceptions and values of citizens using various teaching/learning techniques (Fisher 1996, Brewer 2001, James 2002). Though many believe innovative approaches to extension forestry and wildlife management are necessary, some feel such efforts are insufficient to meet the natural resource management educational needs of today's America and that the answer rests with education (Barden et al. 1996). Education is thought to impact the diverse value system of the general public, known to vary with age, source and amount of income, place of residence, location of upbringing, family history, and amount of education (Barden et al. 1996, James 2002). By impacting values, attitudes, and beliefs, the land ethic of landowners and the general public will be translated into responsible actions (Egan and Jones 1993, Barden et al. 1996). Others have found extension efforts to be instrumental in fulfilling forestry and wildlife management objectives (Brendel et al. 2002). Often the most effective way to ensure close cooperation of conservationists and land users is to use intensive environmental education and user-specific public relation activities (Brendel et al. 2002).

Purpose and Objectives

The overall purpose of this study was to test the effectiveness of two educational techniques at changing public perceptions of coarse woody debris (CWD) and the practice of forestry in general. The degree to which such perceptions were altered was tested on an audience of first year college students using survey instruments before and after (a) reading an informational brochure and (b) listening to a 50-minute presentation and participating in a cooperative learning activity. Both teaching methods addressed the benefits of CWD within the forest ecosystem and to society interacting with the forest. Specifically, objectives of both the brochure and presentation included:

(1) To provide a general overview of the science of forestry and it's often overlooked broad-based ecological practices.

(2) To define "coarse woody debris" and its associated terminology (snag, cavity, and debris), and provide examples of CWD (using color photographs).

(3) Define CWD as an integral component of the forest ecosystem and discuss the misconceptions of its presence and the benefits it provides for wildlife and people.

(4) To use active learning strategies to motivate group discussion and brainstorming concerning perceptions of CWD and to provide a recorded data source for later analysis.

Methods

CWD Informational Brochure

A short informational brochure was used as one of the instruments to test whether audience perception of CWD and forestry could be positively changed using only written text and color pictures. The brochure defined CWD, discussed specific examples of CWD, and addressed opportunities that CWD provide for vegetation, wildlife, and people. Disadvantages associated with CWD were discussed and suggestions to landowners on how to manage for CWD on their land were listed. The brochure was evaluated by faculty and students prior to the study.

Before being given the brochure, study participants were asked to answer two questions on the front and back of a 3 x 5 note card (Figure 1).

Question #1	Question #2
(Picture of downed logs shown) What is your perception of the picture on the screen? What words/phrases would you use to describe this picture?	What is "coarse woody debris?" Write any words/phrases that come to mind. There is no right or wrong answer.

Figure 1. Two questions answered on 3 x 5 note cards by participants in the first 5-minutes of the brochure/presentation activity.

After answering the proposed questions, note cards were collected by the researcher and used in later analyses to test whether initial participant perceptions of CWD and forestry were changed following review of the brochure. Participants were allowed as much time as needed to review the text and photographs of the brochure, so long as the time needed did not exceed a 50-minute class period.

When finished reviewing the brochure, participants were asked to complete a post-brochure survey (Figure 1). Participants could refer back to the brochure at any time while completing the survey.

Survey instrument

A survey was designed to determine participants' knowledge and attitudes toward CWD following either the brochure or presentation (Figure 2). The survey was made up of 9 questions related to CWD and 6 questions concerning participant demographic information (Figure 2). Two of the CWD questions were free response questions and were identical to those asked on the note cards (Figure 1). All but one of the other CWD questions were 5-point Likert-type questions with response choices ranging from *not important* to *very important* and *strongly disagree* to *strongly agree*, including a *neutral* middle response category (Figure 2). One of the CWD questions had response choices ranging from 0% to 100% (Figure 2). Demographic questions requested participants to provide information such as gender, nationality, sociodemographic setting of residence, age, and academic major. A reliability test yielded a Cronbach's alpha of 0.524. Validity of the survey was determined using an expert panel of professors in the departments of forestry and agricultural and extension education at Virginia Polytechnic Institute and State University. Based upon recommendations, revisions were made to the survey.

CWD Presentation—Overview

A 50-minute presentation and cooperative learning activity was given to first year college students and was used as a second instrument to test whether audience perception of CWD and forestry could be positively influenced by interaction with an instructor in a classroom setting. The presentation presented the same information in the same order with many of the same color photographs as written in the brochure. Coarse woody debris was defined, specific examples of CWD were presented, and opportunities that CWD provide for vegetation, wildlife, and people were discussed. To motivate group discussion and brainstorming, the presentation used active learning strategies (Bean 1996) to help reveal audience perceptions of CWD and to provide a means for participants to record their thoughts for later correlation based analysis.

Post-brochure/Post-presentation Survey

(1) What is "coarse woody debris?"

____

____

(2) What words or phrases come to mind when viewing this picture?

_________________________ _________________________

_________________________ _________________________

_________________________ _________________________

(3) You are a landowner who owns 100 acres of forest. On what percentage of your total land would you be concerned about managing for/promoting coarse woody debris? Please circle one.

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

(4) Your neighbor also owns forestland. How important to you would it be to educate your neighbor to maintain coarse woody debris on his/her land?

1	2	3	4	5
[not important]				[very important]

(5) I would support governmental policy action for the management of coarse woody debris on private (example: Farmer Fred's 50 acres of forest) lands.

1	2	3	4	5
[strongly disagree]	[disagree]	[neutral]	[agree]	[strongly agree]

(6) The government should provide financial ($) support to landowners who leave coarse woody debris on their land, versus having it removed in timber harvesting operations.

1	2	3	4	5
[strongly disagree]	[disagree]	[neutral]	[agree]	[strongly agree]

(7) Coarse woody debris is an environmental hazard and should be removed from both private and public (example: a national park) lands.

1	2	3	4	5
[strongly disagree]	[disagree]	[neutral]	[agree]	[strongly agree]

(8) Coarse woody debris is valuable to plants and wildlife.

1	2	3	4	5
[strongly disagree]	[disagree]	[neutral]	[agree]	[strongly agree]

(9) Coarse woody debris is valuable to people.

1	2	3	4	5
[strongly disagree]	[disagree]	[neutral]	[agree]	[strongly agree]

Please provide some information on yourself:

Gender:	Female		Male
International Student?	YES		NO
Where is your hometown?	Urban	Suburban	Rural

What is your age? __________

What is your major? __________________________

Note: The information gained from this survey will be kept confidential and viewed only by the researcher and his graduate committee.

Thanks for your participation!

Figure 2. Example of the survey instrument completed by first year college students following participation in a presentation/cooperative learning activity or review of a brochure on coarse woody debris.

CWD Presentation—Lesson Plan: 50-minute session

I. <u>Instructor introduction and welcome</u> (estimated time: 5-minutes)

A. Participants are given one 3 x 5 note card and asked to direct their attention to a screen at the front of the classroom and answer the two questions presented to the best of their ability on their note cards (Figure 1)

B. Instructor then collects note cards after approximately 5-minutes and ensures participants that their answers will not be graded, but will be used to assess instructor effectiveness sometime in the future

II. <u>CWD main lecture</u> (estimated time: 15-minutes)

A. Management of coarse woody debris as related to vegetation, wildlife, and people

1. What is "coarse woody debris?"
   a. Formal and general definition (versus "fine woody debris")
   b. Specific examples of CWD in forest ecosystems of the southeastern U.S. and beyond (listing of types and color slides of CWD shown)
   c. CWD examples defined

2. Who cares about CWD?
   a. It depends...
   b. Vegetation vs. wildlife vs. people
   c. The exhaustive list of benefits that CWD provides the vegetative community (plants and trees), the wildlife and wildlife habitat, and the people who enjoy spending time in the forest (e.g., for recreation)
      i. For vegetation, CWD…
         - Replenish the soil in which such plants and trees grow
         - Hold back loose soil from eroding away (especially on steeper slopes)
         - Provide a place (substrate) for plants to grow on (e.g., lichens and bryophytes)
      ii. For wildlife and wildlife habitat, CWD…
         - Such as <u>snags</u>, provide foraging sites (e.g., woodpeckers), nesting cavities (e.g., owls), hiding places (e.g., raccoons and northern flying squirrels), and hibernation dens (bears—with large enough snags) for a wide variety of forest dwelling mammals and birds [pictures of snags and the

beautiful wildlife that use such entities shown via slides]

- Such as <u>logs, broken treetops, branches, twigs, and stumps</u>, provide refuges for small mammals (mice, chipmunks, squirrels, etc.) and birds (whip-poor-wills, grouse, various songbirds for escape from severe climates, etc.) and provide a moist microclimate for reptiles and amphibians
- Such as <u>logs</u> serve as travel routes ("run-ways") for small mammals to move through the forest with minimal noise (versus moving through dry, crunchy, loud leaves of the forest floor)
- Such as <u>stumps</u> provide drumming (grouse and quail) and perching (for hunting and calling) sites for birds

iii. For people, CWD…

- As mentioned, serve multiple functions for wildlife and wildlife habitat and thus can be used as wildlife watching "hot-spots" by recreational wildlife watchers (i.e., bird watchers) and hunters
- Provide for a challenging obstacle for mountain bikers and thrill-seeking hikers

<u>III. Small group work concerning CWD perceptions</u> (estimated time: 20-minutes)

A. Justification: active learning strategies will be used to motivate group discussion and brainstorming of participants when confronted with difficult to answer questions regarding CWD and forestry in general. Note: Audience size is assumed to be 25.

B. Instructor will provide the following instructions and guidelines to participants

1. The Problem-Posing Strategy as described by Bean (1996) will be used as a way to compile group perspectives and opinions of CWD and forestry in an attempt to answer a series of difficult, often no-one-answer type questions

2. A technique known as "Graffiti" will be used to generate and record answers within each group

    a. Instructor will assign each participant a number, 1 through 5. All 1's will be a group, all 2's will be a group, and so on. Thus, each group will be comprised of 5 team members.
    b. Once all participants know their assigned number, all 1's will be directed to a specified area of the room, all 2's to a specified

area, and so on. One member of each team will report to the instructor for a marker and a large sheet of paper.

c. On the top of each large sheet of paper will be a question. The group is to come to a consensus as quickly as possible and attempt to answer the question to the best of their ability.
d. One member of the team must be selected as a Group Spokesperson; ALL team members should participate in the recording of their own thoughts concerning the question and help in reaching a group consensus.
e. Each group will have only 3-minutes to record their answers before being asked to rotate to the next large sheet of paper and a new question. A total of 15-minutes will be allowed during the group-recording period (3-minutes per question x 5 questions). The instructor will keep a close watch on time and facilitate group movement to each question.
f. Promptly at the end of the 15-minute recording period, the Group Spokesperson will be asked to report on their groups' success throughout the answering period, including such things as group problems, uncertainties, unclear questions, overall thoughts, etc.
g. The 5 Group Spokespersons will have 1-minute to summarize their group's experience. A total of 5-minutes will be devoted to group reporting (1-minute per group x 5 groups). The instructor will keep a close watch on time and facilitate group participation.

C. The following 5 questions will be used as Graffiti Questions:

(1) What "sources" influenced your perception of forestry/forestry practices before today? Briefly, how?

(2) Following the short lecture on forestry and coarse woody debris, tell me, what does a Forester *do*?

(3) Following the short lecture on forestry and coarse woody debris, define *"forestry"* so that someone *not* in attendance today would understand what you're talking about.

(4) Generate a list of potential problems/disadvantages with managing and promoting coarse woody debris in forests around Blacksburg.

(5) Is it possible to put a "value" on coarse woody debris? Briefly, why or why not?

IV. Post-presentation survey (estimated time: 10-minutes)

A. Participants will be asked to return to their seats for the last 10-minutes of the class. A short survey will be distributed and participants will be asked to complete the survey honestly and to the best of their ability (Figure 2).

Data analysis

Post-brochure and post-presentation survey data were analyzed using SPSS Version 11.0. Survey questions with Likert-scale response choices (Questions 4-9; Figure 2) were entered into SPSS with no recoding necessary. Question 3, with response choices 0% through 100% (Figure 2), was recoded. Demographic data (gender, international student status, hometown location, age, and major) were coded for analysis. Student majors were analyzed and coded according to the location of their major within 7 colleges on the Virginia Polytechnic Institute and State University main campus in Blacksburg, VA. Colleges included: Agriculture and Life Sciences (Aglife), Architecture and Urban Studies (Archit), Business (Busine), Engineering (Engine), Liberal Arts and Human Sciences (Univst), Natural Resources (Natres), and Science (Scienc).

Survey questions requesting free responses of participants (Questions 1-2; Figure 2) were analyzed using qualitative analysis techniques. Pre-brochure and pre-presentation note card responses to Questions 1 and 2 were compared to post-brochure and post-presentation survey responses. Post-brochure and post-presentation surveys were examined and words/phrases conforming to a particular theme or showing evidence of a particular attitude were grouped and coded (Table 1 and 2).

Table 1. Categorical grouping of student responses to post-brochure/post-presentation survey question 1 (What is "coarse woody debris?") and SPSS codes used in the analysis of Virginia Polytechnic Institute and State University student perceptions and learning gains concerning coarse woody debris and forestry, sampled during Fall 2003.

Theme/attitude category	Words used to describe	SPSS code
CWD definition	"dead wood in a forest with a minimum diameter of 4 inches;" "stumps, snags, big branches, logs"	1
Definition + Habitat	(same as CWD definition, with habitat related terms) "...provide animal habitats;" "...are homes for wildlife and plants;" "...that create run-ways for small mammals"	2
Definition + Landscape	(same as CWD definition, with landscape related terms) "...that help slow erosion on slopes;" "...that help the soil;" "...fertilize the soil"	3
Definition + Importance	(same as CWD definition, with terms that imply CWD is "important") "...that is important in the forest;" "...that is beneficial;" "that is important for the environment"	4
No definition - Positive statement	"CWD is ok;" "...habitat, shelter, recreation;" "dead wood that helps the environment;" "dead wood that benefits the forest"	5

Table 1 (cont'd). Categorical grouping of student responses to post-brochure/post-presentation survey question 1 (What is "coarse woody debris?") and SPSS codes used in the analysis of Virginia Polytechnic Institute and State University student perceptions and learning gains concerning coarse woody debris and forestry, sampled during Fall 2003.

Theme/attitude category	Words used to describe	SPSS code
No definition - Negative statement	"dead wood that looks trashy;" "dead wood that is unpleasant to look at;" "destroyed forest"	6
No definition - Neutral	"dead wood;" "dead trees;" "dead wood in the environment;" "snags, stumps, logs, branches;" "dead wood in the forest of a certain diameter"	7
Wrong definition	"4 inch dead wood;" "trees 4 inches in diameter;" "dead wood 4 cm in diameter;" "dead wood with 4 m diameter"	8

Table 2. Categorical grouping of student responses to post-brochure/post-presentation survey question 2 (What words or phrases come to mind when viewing this picture?) and SPSS codes used in the analysis of Virginia Polytechnic Institute and State University student perceptions and learning gains concerning coarse woody debris and forestry, sampled during Fall 2003.

Theme/attitude category	Words used to describe	SPSS code
Coarse woody debris	"coarse woody debris;" "dead wood;" "dead trees;" "logs, snags, stumps;"	1
Habitat	"animal habitats;" "run-ways for small mammals;" "habitat for vegetation;" "insect homes;" "hibernation dens;" "shelter;" "forestry;" "owls;" "hiding place;" "perch;" "drumming spot;" "squirrels;" "home for animals"	2
Fire	"fuel for a fire;" "fire hazard"	3
Negative	"eye-sore;" "disaster;" "tornado;" "devastation;" "aesthetically unpleasing;" "messy;" "bulldozer;" "ugly;" "destroyed;" "harmed;" "needing help;" "disorder;" "trashy;" "unmanageable;" "wreckage;" "death;" "chaotic;"	4
Recreation	"good for nature watchers;" "wilderness;" "hunting blind;" "challenge for bikers and hikers;" "obstacle for bikers;" "paintball;" "adventure;" "gold mine;" "artistic;" "opportunity;" "firewood cutting;"	5

Table 2 (cont'd). Categorical grouping of student responses to post-brochure/post-presentation survey question 2 (What words or phrases come to mind when viewing this picture?) and SPSS codes used in the analysis of Virginia Polytechnic Institute and State University student perceptions and learning gains concerning coarse woody debris and forestry, sampled during Fall 2003.

Theme/attitude category	Words used to describe	SPSS code
Landscape	"food for soil;" "replenish soil;" "prevent erosion;" "soil conservation;" "nutrients;" "landscape;" "regrowth;" "fertile soil;" "decomposition;" "regeneration of forest soil;"	6
Lumberjack	"lumberjack"	7

Quantitative data analysis

Frequency tables were generated using post-brochure and post-presentation categorical (Question 3) and Likert responses (Questions 4 through 9) in SPSS. Descriptive statistics (means, modes, and standard deviations) were calculated for each categorical and Likert response on post-brochure and post-presentation survey instruments. Frequencies were generated for demographic variables in SPSS and brochure participants were compared to presentation/cooperative learning activity participants. The number of females to males, international students, participants residing from urban, suburban, and rural locations, and students by major within 7 colleges (Table 2) were examined using frequencies in SPSS. Crosstabulations were generated in SPSS and used to compare proportions of brochure and presentation participants selecting response choices based on gender, hometown location (urban, suburban, rural), and major. Bivariate Pearson's correlations and Spearman's nonparametric correlations were tested using SPSS software ($\alpha = 0.05$). Dummy variables were created for participant demographic data (gender, sociodemographic setting, and major) to allow the extraction of variable components for analysis and to simplify interpretation. When a test for correlation between variables was performed using brochure data, an identical correlation was performed using presentation data (α = 0.05). Correlations tested for relationships between participant gender, sociodemographic setting (urban, suburban, rural), and major against responses to the 9 post-brochure and post-presentation survey questions (α = 0.05).

Results

Participant demographic information

An average of 2.1 times as many males participated in the brochure and presentation studies as did females (Table 3). Two brochure participants did not indicate their gender. The majority of participants were U.S. citizens (Table 3). Participant sociodemographic residence differed between brochure and presentation studies. The majority of brochure participants were from suburban hometowns (Table 3). Two brochure participants did not indicate a sociodemographic setting. The majority of presentation participants were from suburban and rural hometowns (Table 3). Three presentation participants did not indicate a sociodemographic setting.

The distribution of participants by academic college differed between brochure and presentation studies. About one-third (31.8%) of brochure participants indicated majors within the College of Liberal Arts and Human Sciences (Table 3). This included students of university studies and undecided majors. About one-third (31.9%) of presentation participants indicated majors within the College of Agriculture and Life

Table 3. Comparison of demographic information collected from first year college student survey responses following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182.

Demographic variable	Brochure		Presentation	
	Frequency	Percent	Frequency	Percent
Gender				
Female	58	34.1	55	30.2
Male	110	64.7	127	69.8
International student	6	3.6	8	4.4
U.S. citizen	162	95.2	174	95.6
Hometown location				
Urban	26	15.5	21	11.5
Suburban	98	58.3	77	42.3
Rural	44	26.2	81	44.5
Student's academic college				
Agriculture & Life Sciences	3	1.8	58	31.9
Architecture & Urban Studies	9	5.3	12	6.6
Business	14	8.2	5	2.7
Engineering	36	21.2	30	16.5
Natural Resources	26	15.3	15	8.2
Science	25	14.7	16	8.8
Liberal Arts & Human Sci. (univ. studies/undecided)	54	31.8	46	25.3

Sciences (Table 3). Most of the students from the College of Agriculture and Life Sciences received the presentation (Table 3).

Participant responses to survey questions following review of the brochure or participation in the presentation/cooperative learning activity were similar (Table 4). Mean responses to survey questions for presentation participants tended to be slightly higher than mean responses of brochure participants (Table 4). Both brochure and presentation participants indicated a more neutral standpoint when presented with statements regarding governmental policy action and financial support for the retention and management of CWD on private lands (Table 4). Brochure and presentation participants tended to disagree that CWD is an environmental hazard and should be removed from private and public lands (Table 4). Brochure and presentation participants tended to agree that CWD is valuable to plants and wildlife (Table 4). Brochure participants indicated a more neutral standpoint when asked to consider whether CWD is valuable to people (Table 4). Modal responses of brochure and presentation participants were similar (Table 4). Presentation participants most frequently strongly agreed that CWD is valuable to plants and wildlife whereas brochure participants most frequently agreed that CWD is valuable to plants and wildlife (Table 4).

Comparison of brochure and presentation responses by gender

When questioned as to the percentage of land that they would be concerned about managing for/promoting CWD, brochure and presentation participants most frequently indicated 30%, regardless of gender. Males more often selected a lower amount of land (0 to 30%) to manage/promote CWD in both the brochure and presentation studies. Females more often selected a higher amount of land (40 to 90%) to manage/promote

Table 4. Comparison of first year college student responses to survey questions following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry (SD = standard deviation). Brochure n = 170; Presentation n = 182.

	Brochure	**Presentation**	**Brochure**	**Presentation**
Question	Mean (SD)	Mean (SD)	Mode (% of total)	Mode (% of total)
Let's say you are a landowner who owns 100 acres of forest. On what percentage of your total land would you be concerned about managing for/promoting coarse woody debris?	38.8% (26.0)	43.0% (25.8)	30.0% (26.5%)	30.0% (24.3%)
Now let's say your neighbor also owns forestland. How important to you would it be to educate your neighbor to maintain coarse woody debris on his/her land? *1 = not important; 5 = very important*	3.3 (1.1)	3.3 (1.1)	3 (35.9%)	3 (33.0%)
I would support governmental policy action for the management of coarse woody debris on private lands. *1 = strongly disagree; 3 = neutral; 5 = strongly agree*	3.1 (0.9)	3.2 (1.0)	3 (47.6%)	3 (40.1%)
The government should provide financial support to landowners who leave coarse woody debris on their land, versus having it removed in timber harvesting operations. *1 = strongly disagree; 3 = neutral; 5 = strongly agree*	3.2 (1.0)	3.3 (1.0)	3 (38.8%)	3 (38.7%)
Coarse woody debris is an environmental hazard and should be removed from both private and public lands. *1 = strongly disagree; 3 = neutral; 5 = strongly agree*	2.2 (0.8)	2.1 (0.8)	2 (63.5%)	2 (56.6%)
Coarse woody debris is valuable to plants and wildlife. *1 = strongly disagree; 3 = neutral; 5 = strongly agree*	4.3 (0.6)	4.4 (0.7)	4 (59.4%)	5 (51.6%)
Coarse woody debris is valuable to people. *1 = strongly disagree; 3 = neutral; 5 = strongly agree*	3.4 (0.8)	3.7 (0.8)	4 (47.0%)	4 (57.1%)

CWD in the brochure study. Over twice the amount of females to males participating in both the brochure and presentation studies indicated that they would manage/promote CWD on 40% of their land. When compared to females, more males indicated that they would be concerned about managing for/promoting CWD on 100% of their land following the brochure and presentation.

When questioned on how important it would be to educate a neighbor who owns forestland to maintain CWD on their land, a higher proportion of males indicated that it would not be important following the brochure and presentation (Table 5). About twice (2.1 times) the proportion of female brochure participants indicated that it would be important to educate a neighbor to maintain CWD on their land as did female presentation participants (Table 5). However, over twice (2.5 times) the proportion of female presentation participants indicated that it would be very important to educate a neighbor to maintain CWD on their land as did female brochure participants (Table 5). More males indicated that it would be important to educate a neighbor to maintain CWD on their land than females following the presentation (Table 5).

When asked whether they would support governmental policy action for the management of CWD on private lands, more male participants than female participants strongly disagreed. No female brochure participants strongly disagreed to support policy action for the management of CWD on private lands. The majority of both female (48.3%) and male (47.3%) brochure participants indicated a neutral standpoint. Within brochure and presentation studies, more females agreed to support governmental policy action for the management of CWD on private lands. Comparing brochure and presentation studies, 10.8% more female presentation participants agreed to support

Table 5. Comparison of female and male responses to a survey question asked of first year college students following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within gender were generated using a Crosstabulations function.

Question: *Now let's say your neighbor also owns forestland. How important to you would it be to educate your neighbor to maintain coarse woody debris on his/her land?*

Response	Brochure		Presentation	
	Female (%)	Male (%)	Female (%)	Male (%)
1 (not important)	3.4	10.0	1.8	11.0
2	10.3	14.5	16.4	12.6
3	37.9	34.5	38.2	30.7
4	37.9	28.2	18.2	33.9
5 (very important)	10.3	12.7	25.5	11.8

policy action for CWD management on private lands than female brochure participants. More females indicated strong agreement to support governmental policy action for the management of CWD on private lands in both brochure and presentation studies.

When asked whether the government should provide financial support to landowners who leave CWD on their land versus having it removed in timber harvesting operations, the proportion of males selecting each answer choice varied little between brochure and presentation studies. More male participants strongly disagreed that the government should provide financial support to landowners who leave CWD on their land following both the brochure and presentation. When compared to female presentation participants, 3.1 times the proportion of female brochure participants disagreed that the government should provide financial support to landowners who leave CWD on their land. More males indicated a neutral standpoint following the brochure and more females indicated a neutral standpoint following the presentation. A greater proportion of females strongly agreed when asked whether the government should provide financial support to landowners who leave CWD on their land following the brochure and more males strongly agreed following the presentation.

When questioned whether CWD is an environmental hazard and should be removed from both private and public lands, male responses following either the brochure or presentation were similar (Table 6). However, more females participating in the presentation strongly disagreed that CWD is an environmental hazard and should be removed from both private and public lands when compared to females participating in the brochure (Table 6). Following review of the brochure, 4.8 times more males than females strongly disagreed that CWD is an environmental hazard and should be removed

Table 6. Comparison of female and male responses to a survey question asked of first year college students following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within gender were generated using a Crosstabulations function.

Question: *Coarse woody debris is an environmental hazard and should be removed from both private and public (example: a national park) lands.*

Response	Brochure		Presentation	
	Female (%)	Male (%)	Female (%)	Male (%)
1 (strongly disagree)	3.4	16.4	20.0	20.5
2 (disagree)	74.1	58.2	58.2	55.9
3 (neutral)	13.8	20.9	16.4	18.1
4 (agree)	6.9	3.6	5.5	4.7
5 (strongly agree)	1.7	0.9	0.0	0.8

from both private and public lands (Table 6). However, 15.9% more females than males disagreed that CWD is an environmental hazard and should be removed from both private and public lands following review of the brochure (Table 6). The researchers believed that the "correct" response to this statement was disagree.

When presented with the statement, CWD is valuable to plants and wildlife, responses between females and males were similar within brochure and presentation studies (Table 7). More females (25.5% more) agreed that CWD is valuable to plants and wildlife following the brochure than the presentation (Table 7). More males (14.7% more) agreed that CWD is valuable to plants and wildlife following the brochure than the presentation (Table 7). However, more males (13.1% more) strongly agreed that CWD is valuable to plants and wildlife following the presentation (Table 7). More females (25.2% more) also strongly agreed that CWD is valuable to plants and wildlife following the presentation (Table 7).

When presented with the statement, CWD is valuable to people, gender seemed to influence participant responses between brochure and presentation groups (Table 8). Though little differences existed between brochure and presentation groups in the strongly disagree response category, 10.3% more females participating in the brochure disagreed that CWD was valuable to people when compared to females participating in the presentation (Table 8). Slightly more males (3.8% more) participating in the brochure disagreed that CWD was valuable to people (Table 8). Both female and male participants took more of a neutral standpoint when asked of the value of CWD to people following the brochure (Table 8). More males than females agreed that CWD was valuable to people following the brochure (Table 8). More males than females agreed

Table 7. Comparison of female and male responses to a survey question asked of first year college students following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within gender were generated using a Crosstabulations function.

Question: *Coarse woody debris is valuable to plants and wildlife.*

Response	Brochure		Presentation	
	Female (%)	Male (%)	Female (%)	Male (%)
1 (strongly disagree)	0.0	0.0	0.0	1.6
2 (disagree)	1.7	0.0	0.0	0.0
3 (neutral)	3.4	6.4	5.5	6.3
4 (agree)	65.5	56.4	40.0	41.7
5 (strongly agree)	29.3	37.3	54.5	50.4

Table 8. Comparison of female and male responses to a survey question asked of first year college students following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within gender were generated using a Crosstabulations function.

Question: *Coarse woody debris is valuable to people.*

Response	Brochure		Presentation	
	Female (%)	Male (%)	Female (%)	Male (%)
1 (strongly disagree)	1.7	0.9	1.8	0.8
2 (disagree)	12.1	10.9	1.8	7.1
3 (neutral)	44.8	33.6	27.3	23.6
4 (agree)	36.2	52.7	49.1	60.6
5 (strongly agree)	5.2	1.8	20.0	7.9

that CWD was valuable to people following the presentation (Table 8). Comparing brochure and presentation audiences, more females and males agreed that CWD was valuable to people after the presentation (Table 8). More females and males strongly agreed that CWD was valuable to people after the presentation (Table 8). The researchers believed that the "correct" response to this statement was agree.

No significant correlation was found (P = 0.23) between gender and whether a participant disagreed/agreed that CWD was an environmental hazard and should be removed from private and public lands following the brochure. No significant correlation was found (P = 0.38) between gender and whether a participant disagreed/agreed that CWD was valuable to plants and wildlife following the brochure. No significant correlation was found (P = 0.87) between gender and whether a participant disagreed/agreed that CWD was an environmental hazard and should be removed from private and public lands following the presentation. No significant correlation was found (P = 0.40) between gender and whether a participant disagreed/agreed that CWD was valuable to plants and wildlife following the presentation.

Comparison of brochure and presentation responses by sociodemographic setting

When questioned as to the percentage of land that they would be concerned about managing for/promoting CWD, brochure and presentation participants most frequently indicated 30%, regardless of whether they were from an urban, suburban, or rural sociodemographic setting. Differences in answer choice selection between brochure and presentation groups were most noticeable in participants from urban areas. For example, 10.5% more students from urban areas that participated in the presentation indicated that they would manage for CWD on 70% of their land when compared to brochure participants. In both brochure and presentation groups, more students from rural areas indicated that they would be concerned about managing for/promoting CWD on 100% of their land than did students from suburban and urban areas.

When asked how important it would be to educate a neighbor who owns forestland to maintain CWD on their land, participants from suburban areas seemed to be most influenced by the presentation (Table 9). Over twice as many (2.1 times) suburban participants receiving the presentation indicated that it would be very important to educate a neighbor to maintain CWD on their land when compared to suburban participants receiving the brochure (Table 9). More urban participants that received the presentation indicated that it would be important to educate a neighbor to maintain CWD on their land than did urban participants who received the brochure (Table 9).

When asked whether they would support governmental policy action for the management of CWD on private lands, the majority of participants receiving either the brochure or presentation responded neutrally, regardless of sociodemographic setting. The proportion of neutral responses among all brochure participants decreased when students received the presentation. For example, 42.9% of suburban participants receiving the brochure responded neutrally to the statement regarding support of governmental policy for CWD management on private lands and 33.8% of suburban participants receiving the presentation responded neutrally. Although 7.7% of urban participants who received the brochure strongly disagreed with support of policy action for the management of CWD on private lands, no urban participants who received the presentation strongly disagreed. More suburban participants agreed in support of policy action after the presentation than did suburban participants who received the brochure.

Table 9. Comparison of participant responses to a survey question asked of first year college students from urban, suburban, or rural hometowns following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within hometown locations were generated using a Crosstabulations function.

Question: *Now let's say your neighbor also owns forestland. How important to you would it be to educate your neighbor to maintain coarse woody debris on his/her land?*

Response	Brochure			Presentation		
	urban (%)	suburban (%)	rural (%)	urban (%)	suburban (%)	rural (%)
1 (not important)	11.5	9.2	2.3	4.8	6.5	11.1
2	11.5	15.3	9.1	4.8	11.7	17.3
3	38.5	30.6	45.5	38.1	35.1	28.4
4	23.1	33.7	31.8	42.9	23.4	32.1
5 (very important)	15.4	11.2	11.4	9.5	23.4	11.1

When asked whether the government should provide financial support to landowners who leave CWD on their land versus having it removed in timber harvesting operations, the majority of participants responded neutrally, regardless of sociodemographic setting. When urban participants received the presentation, the proportion of neutral responses increased by 27.3% when compared to urban participants who received the brochure. No urban participants who received the presentation strongly disagreed that the government should provide financial support to landowners who leave CWD on their land but 7.7% of urban participants who received the brochure strongly disagreed. No urban participants who received the presentation strongly agreed that the government should provide financial support to landowners who leave CWD on their land but 11.5% of urban participants who received the brochure strongly agreed.

When questioned whether CWD was an environmental hazard and should be removed from private and public lands, the majority of brochure and presentation participants disagreed, regardless of sociodemographic setting (Table 10). Students from suburban areas who participated in either the brochure or presentation most often disagreed that CWD was an environmental hazard and should be removed from both private and public lands (Table 10). More suburban participants who received the presentation strongly disagreed that CWD was an environmental hazard and should be removed from private and public lands than did suburban participants who received the brochure (Table 10). No rural participants who received the brochure agreed or strongly agreed that CWD was an environmental hazard and should be removed from private and public lands (Table 10).

Table 10. Comparison of participant responses to a survey question asked of first year college students from urban, suburban, or rural hometowns following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within hometown locations were generated using a Crosstabulations function.

Question: *Coarse woody debris is an environmental hazard and should be removed from both private and public (example: a national park) lands.*

Response	Brochure			Presentation		
	urban (%)	suburban (%)	rural (%)	urban (%)	suburban (%)	rural (%)
1 (strongly disagree)	23.1	6.1	18.2	14.3	24.7	18.5
2 (disagree)	46.2	67.3	65.9	57.1	61.0	53.1
3 (neutral)	19.2	19.4	15.9	19.0	13.0	19.8
4 (agree)	7.7	6.1	0.0	9.5	1.3	7.4
5 (strongly agree)	3.8	1.0	0.0	0.0	0.0	1.2

When presented with the statement, CWD is valuable to plants and wildlife, few participants who received the brochure or presentation strongly disagreed or disagreed, regardless of sociodemographic setting (Table 11). No brochure participants strongly disagreed that CWD was valuable to plants and wildlife (Table 11). The proportion of neutral responses among participants was highest for participants from urban areas (Table 11). More rural participants who received the presentation responded neutrally than did rural participants who received the brochure (Table 11). More urban participants who received the presentation strongly agreed that CWD was valuable to plants and wildlife than did urban participants who received the brochure (Table 11). More suburban participants who received the presentation strongly agreed that CWD was valuable to plants and wildlife than did suburban participants who received the brochure (Table 11).

When presented with the statement, CWD is valuable to people, responses differed based on participant sociodemographic setting and method of instruction experienced (Table 12). More urban and suburban participants who received the brochure disagreed that CWD was valuable to people than urban and suburban participants who received the presentation (Table 12). Of participants who received the presentation and responded neutrally to the statement regarding the value of CWD to people, participants from urban areas responded neutrally the most (Table 12). More suburban participants strongly agreed that CWD was valuable to people after receiving the presentation than did suburban participants after receiving the brochure (Table 12). More suburban participants strongly agreed that CWD was valuable to people than did urban or rural participants, regardless of educational technique experienced (Table 12).

Table 11. Comparison of participant responses to a survey question asked of first year college students from urban, suburban, or rural hometowns following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within hometown locations were generated using a Crosstabulations function.

Question: *Coarse woody debris is valuable to plants and wildlife.*

Response	Brochure			Presentation		
	urban (%)	suburban (%)	rural (%)	urban (%)	suburban (%)	rural (%)
1 (strongly disagree)	0.0	0.0	0.0	0.0	0.0	2.5
2 (disagree)	0.0	1.0	0.0	0.0	0.0	0.0
3 (neutral)	11.5	5.1	2.3	14.3	1.3	8.6
4 (agree)	57.7	63.3	52.3	42.9	40.3	40.7
5 (strongly agree)	30.8	30.6	45.5	42.9	58.4	48.1

Table 12. Comparison of participant responses to a survey question asked of first year college students from urban, suburban, or rural hometowns following either the review of an informational brochure or participation in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within hometown locations were generated using a Crosstabulations function.

Question: *Coarse woody debris is valuable to people.*

Response	Brochure			Presentation		
	urban (%)	suburban (%)	rural (%)	urban (%)	suburban (%)	rural (%)
1 (strongly disagree)	0.0	2.0	0.0	0.0	1.3	1.2
2 (disagree)	11.5	12.2	9.1	0.0	3.9	8.6
3 (neutral)	26.9	38.8	40.9	42.9	22.1	23.5
4 (agree)	61.5	42.9	47.7	57.1	55.8	56.8
5 (strongly agree)	0.0	4.1	2.3	0.0	16.9	9.9

No significant correlation was found (P = 0.84) between participants from urban sociodemographic settings and whether they disagreed/agreed that CWD was an environmental hazard and should be removed from private and public lands after receiving the brochure (Table 13). No significant correlation was found (P = 0.43) between participants from urban sociodemographic settings and whether they disagreed/agreed that CWD was valuable to plants and wildlife after receiving the brochure (Table 13). No significant correlation was found (P = 0.33) between participants from urban sociodemographic settings and whether they disagreed/agreed that CWD was an environmental hazard and should be removed from private and public lands after receiving the presentation (Table 13). No significant correlation was found (P = 0.27) between participants from urban sociodemographic settings and whether they disagreed/agreed that CWD was valuable to plants and wildlife after receiving the presentation (Table 13). A significant positive correlation was found (P = 0.05) between participants from suburban sociodemographic settings and whether they disagreed/agreed that CWD was an environmental hazard and should be removed from private and public lands after receiving the brochure (Table 13). No significant correlation was found (P = 0.24) between participants from suburban sociodemographic settings and whether they disagreed/agreed that CWD was valuable to plants and wildlife after receiving the brochure (Table 13). A significant negative correlation was found (P = 0.02) between participants from suburban sociodemographic settings and whether they disagreed/agreed that CWD was an environmental hazard and should be removed from private and public lands after receiving the presentation (Table 13). A significant positive correlation was found (P = 0.04) between participants from suburban sociodemographic settings and

Table 13. Relationship between first year college student hometown residence and their response to 2 statements on a survey completed after either reviewing an informational brochure or participating in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Survey statements: "Hazard" = Coarse woody debris is an environmental hazard and should be removed from both private and public lands (1 = strongly disagree, 5 = strongly agree); "Wildlife" = Coarse woody debris is valuable to plants and wildlife (1 = strongly disagree, 5 = strongly agree).

	Brochure		Presentation	
Hometown residence	Hazard	Wildlife	Hazard	Wildlife
urban	-0.02	-0.06	0.07	-0.08
	P = 0.84	P = 0.43	P = 0.33	P = 0.27
suburban	0.15*	-0.09	-0.17*	0.15*
	P = 0.05	P = 0.24	P = 0.02	P = 0.04
rural	-0.16*	0.15*	0.12	-0.10
	P = 0.04	P = 0.05	P = 0.11	P = 0.20

* Spearman's correlation is significant at the 0.05 level.

whether they disagreed/agreed that CWD was valuable to plants and wildlife after receiving the presentation (Table 13). A significant negative correlation was found (P = 0.04) between participants from rural sociodemographic settings and whether they disagreed/agreed that CWD was an environmental hazard and should be removed from both private and public lands after receiving the brochure (Table 13). A significant positive correlation was found (P = 0.05) between participants from rural sociodemographic settings and whether they disagreed/agreed that CWD was valuable to plants and wildlife after receiving the brochure (Table 13). No significant correlation was found (P = 0.11) between participants from rural sociodemographic settings and whether they disagreed/agreed that CWD was an environmental hazard and should be removed from both private and public lands after receiving the presentation (Table 13). No significant correlation was found (P = 0.20) between participants from rural sociodemographic settings and whether they disagreed/agreed that CWD was valuable to plants and wildlife after receiving the presentation (Table 13).

Comparison of brochure and presentation responses by academic college

When questioned whether CWD was an environmental hazard and should be removed from private and public lands, participant responses by academic college differed between brochure and presentation groups (Table 14). More students in the colleges of agriculture and life sciences, architecture and urban studies, and business who received the presentation strongly disagreed that CWD was an environmental hazard and should be removed from private and public lands than did students in those colleges who received the brochure (Table 14). More students in the College of Business who received the presentation disagreed that CWD was an environmental hazard and should be

Table 14. Comparison of participant responses to a survey question asked of first year college students with majors in eight colleges located on the central campus of Virginia Polytechnic Institute and State University, Blacksburg, VA. Participants completed the survey after either reviewing an informational brochure or participating in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within majors were generated using a Crosstabulations function. Aglife = College of Agriculture and Life Sciences; Archit = College of Architecture and Urban Studies; Busine = College of Business; Engine = College of Engineering; Natres = College of Natural Resources; Scienc = College of Science; Univst = university studies/undecided major.

Question: *Coarse woody debris is an environmental hazard and should be removed from both private and public (example: a national park) lands.*

Response	Brochure				Presentation			
	Aglife (%)*	Archit (%)	Busine (%)	Engine (%)	Aglife (%)	Archit (%)	Busine (%)	Engine (%)
1 (strongly disagree)	0.0	0.0	0.0	22.2	15.5	25.0	20.0	13.3
2 (disagree)	100.0	55.6	57.1	50.0	37.9	66.7	80.0	73.3
3 (neutral)	0.0	44.4	35.7	16.7	32.8	0.0	0.0	13.3
4 (agree)	0.0	0.0	7.1	11.1	12.1	8.3	0.0	0.0
5 (strongly agree)	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0

*Only 3 students that reviewed the brochure were from the College of Agriculture and Life Sciences.

Table 14 (cont'd). Comparison of participant responses to a survey question asked of first year college students with majors in eight colleges located on the central campus of Virginia Polytechnic Institute and State University, Blacksburg, VA. Participants completed the survey after either reviewing an informational brochure or participating in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within majors were generated using a Crosstabulations function. Aglife = College of Agriculture and Life Sciences; Archit = College of Architecture and Urban Studies; Busine = College of Business; Engine = College of Engineering; Natres = College of Natural Resources; Scienc = College of Science; Univst = university studies/undecided major.

Question: *Coarse woody debris is an environmental hazard and should be removed from both private and public (example: a national park) lands.*

Response	Brochure			Presentation		
	Natres (%)	Scienc (%)	Univst (%)	Natres (%)	Scienc (%)	Univst (%)
1 (strongly disagree)	30.8	8.0	3.7	40.0	25.0	21.7
2 (disagree)	57.7	72.0	72.2	60.0	50.0	65.2
3 (neutral)	7.7	20.0	16.7	0.0	18.8	13.0
4 (agree)	0.0	0.0	5.6	0.0	6.3	0.0
5 (strongly agree)	3.8	0.0	1.9	0.0	0.0	0.0

removed from private and public lands than did business students who received the brochure (Table 14). More students in the College of Engineering who received the presentation disagreed that CWD was an environmental hazard and should be removed from private and public lands than did engineering students who received the brochure (Table 14). More students in the College of Architecture and Urban Studies who received the brochure responded neutrally when asked if CWD was an environmental hazard and should be removed from private and public lands than after receiving the presentation (Table 14). More students in the College of Business and the College of Natural Resources who received the brochure responded neutrally to the same statement than after receiving the presentation (Table 14). More students in the College of Science strongly disagreed that CWD was an environmental hazard and should be removed from private and public lands after receiving the presentation than the brochure (Table 14). More students in university studies or undecided majors strongly disagreed with that statement after receiving the presentation than the brochure (Table 14).

When presented with the statement, CWD is valuable to plants and wildlife, the proportion of participants responding neutrally or in strong agreement differed by academic college and between brochure and presentation groups (Table 15). More students from the College of Architecture and Urban Studies, College of Business, and College of Engineering responded neutrally when asked to consider the value of CWD to plants and wildlife after reviewing the brochure than after the presentation (Table 15). No students from the College of Architecture and Urban Studies strongly agreed that CWD is valuable to plants and wildlife after reviewing the brochure (Table 15). More architecture and urban studies students, business students, natural resources students,

Table 15. Comparison of participant responses to a survey question asked of first year college students with majors in eight colleges located on the central campus of Virginia Polytechnic Institute and State University, Blacksburg, VA. Participants completed the survey after either reviewing an informational brochure or participating in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within majors were generated using a Crosstabulations function. Aglife = College of Agriculture and Life Sciences; Archit = College of Architecture and Urban Studies; Busine = College of Business; Engine = College of Engineering; Natres = College of Natural Resources; Scienc = College of Science; Univst = university studies/undecided major.

Question: *Coarse woody debris is valuable to plants and wildlife.*

Response	Brochure				Presentation			
	Aglife (%)*	Archit (%)	Busine (%)	Engine (%)	Aglife (%)	Archit (%)	Busine (%)	Engine (%)
1 (strongly disagree)	0.0	0.0	0.0	0.0	3.4	0.0	0.0	0.0
2 (disagree)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 (neutral)	0.0	33.3	7.1	11.1	13.8	8.3	0.0	3.3
4 (agree)	66.7	66.7	71.4	47.2	43.1	33.3	60.0	50.0
5 (strongly agree)	33.3	0.0	21.4	41.7	39.7	58.3	40.0	46.7

*Only 3 students that reviewed the brochure were from the College of Agriculture and Life Sciences.

Table 15 (cont'd). Comparison of participant responses to a survey question asked of first year college students with majors in eight colleges located on the central campus of Virginia Polytechnic Institute and State University, Blacksburg, VA. Participants completed the survey after either reviewing an informational brochure or participating in a presentation/cooperative learning activity on coarse woody debris and forestry. Brochure n = 170; Presentation n = 182. Percentages within majors were generated using a Crosstabulations function. Aglife = College of Agriculture and Life Sciences; Archit = College of Architecture and Urban Studies; Busine = College of Business; Engine = College of Engineering; Natres = College of Natural Resources; Scienc = College of Science; Univst = university studies/undecided major.

Question: *Coarse woody debris is valuable to plants and wildlife.*

Response	Brochure			Presentation		
	Natres (%)	Scienc (%)	Univst (%)	Natres (%)	Scienc (%)	Univst (%)
1 (strongly disagree)	0.0	0.0	0.0	0.0	0.0	0.0
2 (disagree)	0.0	0.0	1.9	0.0	0.0	0.0
3 (neutral)	0.0	4.0	0.0	0.0	0.0	2.2
4 (agree)	42.3	56.0	72.2	26.7	18.8	45.7
5 (strongly agree)	57.7	40.0	25.9	73.3	81.3	52.2

students in the College of Science, and university studies/undecided major students strongly agreed after the presentation (Table 15).

When presented with the statement, CWD is valuable to people, responses differed by academic college and between brochure and presentation groups. Although 21.4% of students from the College of Business disagreed that CWD was valuable to people after reviewing the brochure, 0% disagreed after the presentation. Although 28.0% of students from the College of Science disagreed that CWD was valuable to people after reviewing the brochure, 0% disagreed after the presentation. Of students from the College of Architecture and Urban Studies, 33.3% responded neutrally when asked of the value of CWD to people after reviewing the brochure and 16.7% responded neutrally after the presentation. Of students in the College of Engineering, 41.7% responded neutrally when asked of the value of CWD to people after reviewing the brochure and 20.0% responded neutrally after the presentation. Although 42.9% of students in the College of Business responded neutrally to that statement after reviewing the brochure, 40.0% responded neutrally after the presentation. Although 30.8% of students in the College of Natural Resources responded neutrally to that statement after reviewing the brochure, 6.7% responded neutrally after the presentation. Of students in the College of Science, 36.0% responded neutrally after reviewing the brochure and 6.3% responded neutrally after the presentation. Although 28.6% of students in the College of Business agreed that CWD was valuable to people (the “correct” response) after reviewing the brochure, 60.0% agreed after the presentation. Of students in the College of Natural Resources, 3.8% strongly agreed that CWD was valuable to people after reviewing the brochure and 20.0% strongly agreed after the presentation. Of students in the College of Science, 4.0% strongly agreed that CWD was valuable to people after reviewing the brochure and 37.5% strongly agreed after receiving the presentation. Of students with university studies/undecided majors, 1.9% strongly agreed that CWD was valuable to people after the brochure and 13.0% strongly agreed after the presentation.

A significant negative correlation was found (P = 0.005) between students from the College of Natural Resources who reviewed the brochure and whether they believed CWD was an environmental hazard and should be removed from private and public lands. A significant negative correlation was found (P = 0.009) between students from the College of Natural Resources who received the presentation and whether they believed CWD was an environmental hazard and should be removed from private and public lands. A significant positive correlation was found (P = 0.004) between students from the College of Natural Resources who reviewed the brochure and whether they believed CWD was valuable to plants and wildlife. No significant correlation was found (P = 0.064) between students from the College of Natural Resources who received the presentation and whether they believed CWD was valuable to plants and wildlife. No other significant correlations were found between survey question responses and student academic college.

Discussion

Comparison of brochure and presentation responses by gender

Gender influences attitudes toward nature and the environment (Kellert and Berry 1987, Riechard and Peterson 1998, Tikka et al. 2000). Females more often selected a higher proportion of land to manage/promote CWD following review of the brochure. Over twice the percentage of females to males participating in both the brochure and presentation indicated that they would manage/promote CWD on almost half of their land. Regardless of educational technique employed, females tended to have a more positive attitude toward CWD left on their land than males. These results agree with the results of a previous study involving college student attitudes toward nature and the environment where female students tended to have more positive attitudes than male students (Tikka et al. 2000). Female college student attitudes toward nature were more life centered than male student attitudes before and after a course in conservation biology (Caro et al. 1994). Although males tended to be more knowledgeable of environmental issues and wildlife (Kellert and Berry 1987, Tikka et al. 2000), females tended to express stronger emotional attachments for individual animals and were more likely to reveal anthropomorphic feelings toward large and aesthetically appealing animals (Kellert and Berry 1987). Females tended to value wild animals as objects of affection, expressed sympathetic concern over the consumptive exploitation of wildlife, and took a more positive attitude toward nature (Kellert and Berry 1987, Caro et al. 1994). Males were less fearful of wildlife and valued animals for practical and recreational reasons (Kellert and Berry 1987, Caro et al. 1994). Younger females (less than 55 years old) with high formal education who owned non-industrial private forestland had the most positive attitude toward nature conservation when compared to males (Uliczka et al. 2004).

Gender and environmental risk

Gender influences perceptions of environmental risk. Males more often indicated that they would be concerned about managing CWD on 100% of their land following both the brochure and presentation. More females participating in the presentation tended to strongly disagree that CWD was an environmental hazard. Perhaps when females are presented with information on environmental hazards through a presentation they are less risk adverse. Female pre-college students perceived greater risk than male students concerning environmental hazards such as tornadoes, earthquakes, pesticides, and oil spills (Riechard and Peterson 1998). Female presentation participants may have exaggerated when answering the survey question on CWD as an environmental hazard if they perceived that the attitude of their instructor was positive toward CWD (Tikka et al. 2000). However, females have been found to be significantly more open-minded than males, indicating that female presentation participants would have respected the rights of the instructor to holding a perhaps differing opinion and responded honestly (Rudd and Moore 2003).

Gender and wildlife value

Gender influences how one values wildlife and wildlife habitat. Males more often strongly agreed that CWD was valuable to plants and wildlife following the presentation. Perhaps male participants' perception of the "value" of CWD was as a habitat component for plants and wildlife and they exhibited concern for the well-being of plants, wildlife, and their habitat. Interestingly, females also more often strongly agreed that CWD was valuable to plants and wildlife following the presentation. Also in this study, more males and females agreed that CWD was valuable to people following the presentation versus the brochure. Although females were less supportive of the exploitation of nature than males, males were more utilitarian in terms of wildlife and the environment (Kellert and Berry 1987). Males more often expressed a desire for direct contact with wildlife in the context of exposure to nature (Kellert and Berry 1987). In addition, males expressed a greater concern for maintaining viable relationships between wildlife, their habitat, and the ecosystem as a whole (Kellert and Berry 1987). These results suggest that when participants are asked to consider the "value" of an ecological entity to the environment or people, orally persuading an audience through a live presentation and cooperative learning activity can be a more effective teaching technique than using written text.

Comparison of brochure and presentation responses by sociodemographic setting

Sociodemographic setting influences attitudes toward the environment (Arcury and Christianson 1993, Suvedi et al. 2000, Tikka et al. 2000). When asked to consider the value of CWD to plants and wildlife in this study, the proportion of neutral responses was highest for participants from urban areas, regardless of educational technique used. Urban students may have responded neutrally because of uncertainty in whether the presence of CWD was a form of environmental protection. Perhaps if an outdoor educational session, such as a visit to a demonstration forest was added to the indoor brochure and presentation activities, the value of CWD to plants and wildlife might be more obvious to urban students (Broussard et al. 2001). The size and location of an individual's hometown has been found to influence their attitudes toward the environment (Tikka et al. 2000). Individuals from metropolitan and urban settings were more knowledgeable about global environmental problems and had a stronger environmental world view than individuals from urban-nonmetropolitan and rural-nonmetropolitan locations (Arcury and Christianson 1993). College students from metropolitan and urban settings where population levels were the densest had the most positive attitudes toward the environment (Tikka et al. 2000). Individuals who live in crowded, urban locations may be more likely to become aware of existing environmental problems and adopt sympathetic attitudes toward nature and the protection of the environment (Tikka et al. 2000). Middle school youth from urban Michigan, USA indicated that their knowledge of and attitude toward natural resources changed following a summer science academy experience (Vasievich et al. 1993). Such students became more aware of the scope of natural resources and developed a better understanding of people's need to use natural resources and the need for environmental preservation (Vasievich et al. 1993). However, middle school youth from urban Iowa, USA were ignorant of agriculture, had no interest in agricultural practices, and expressed negative attitudes toward agriculturally related careers (Holz-Clause and Jost 1995).

Sociodemographic setting and environmental risk

Sociodemographic setting can influence an individual's perception of environmental risk (Suvedi et al. 2000). When questioned whether CWD was an environmental hazard, an average of only 10% of the participants from urban areas agreed/strongly agreed that CWD posed a risk, regardless of educational technique used. Participants from urban areas more often disagreed/strongly disagreed that CWD posed a risk, regardless of educational technique used. The fact that urban participants would be less likely to have seen CWD than rural participants may explain the lack of perceived risk. However, rural participants also more often disagreed/strongly disagreed that CWD was an environmental hazard, regardless of educational technique used. Rural participants were more likely to interact with CWD than urban participants and this similarity in responses across sociodemographic settings may be indicative of brochure and presentation effectiveness. However, pre-brochure and pre-presentation note card questions did not address potential environmental risks with CWD and therefore perceptions of risk cannot be compared before and after either educational technique.

Individuals from urban and rural areas differed significantly in their perceptions of risks posed by various land use practices on groundwater quality (Suvedi et al. 2000). People with homes in urban areas perceived a higher level of risk to groundwater associated with roadside weed control, industrial areas, and agricultural lands than did individuals living in rural areas (Suvedi et al. 2000).

Comparison of brochure and presentation responses by academic college

Choice of academic college and major can influence an individual's knowledge and attitude toward the environment (Caro et al. 1994, Tikka et al. 2000, Hodgkinson and Innes 2001). In this study, students in the College of Science with majors such as biology and environmental studies strongly disagreed that CWD was an environmental hazard and should be removed from both private and public lands. By strongly disagreeing that CWD should be removed from private and public lands, biology and environmental studies students evidenced a positive attitude toward the environment and the presence of CWD in the forest landscape. Although most first year university students held positive attitudes toward the environment, students majoring in sociology, biology, or environmental studies consistently had stronger positive beliefs and attitudes toward the environment than students from other disciplines (Caro et al. 1994, Hodgkinson and Innes 2001). Positive attitudes toward the environment were also found in students majoring in the natural resources (Tikka et al. 2000). Students majoring in forestry showed positive attitudes toward the environment (Tikka et al. 2000). In this study, students in the College of Natural Resources showed positive attitudes toward the environment by strongly agreeing that CWD was valuable to plants and wildlife following the brochure or presentation but the presentation was more persuasive. These results suggest that when attempting to enhance positive attitudes toward the environment in college students majoring in the life sciences, the use of a presentation may be the most effective teaching technique.

Academic major and environmental consciousness

Students with undecided majors were among the least environmentally minded (Hodgkinson and Innes 2001). In this study, students with undecided majors responded more environmentally when asked to consider the potential environmental risks associated with CWD. Students in university studies and undecided majors more often strongly disagreed that CWD was an environmental hazard and should be removed from both private and public lands following the presentation. By strongly disagreeing with that statement, such students perhaps believed CWD should not be removed because of its perceived ecological value. These results suggest that when attempting to instill positive attitudes concerning the environment--particularly forestry--in college students with majors outside of the life sciences, the use of a presentation may be a more effective teaching technique than the use of a brochure. A presentation might also be more useful than a brochure when recruiting pre-college students and college students with undecided majors who may be considering the life sciences as an academic major.

Academic major and attitude toward the environment

Compared to other academic majors, engineering students showed the most negative attitudes toward the environment (Tikka et al. 2000). However, the majority of engineering students in this study showed positive attitudes toward the environment when asked to consider the value of CWD in the forest landscape. Most students in the College of Engineering agreed/strongly agreed that CWD was valuable to plants and wildlife regardless of whether they received the brochure or presentation. All of the engineering students in the previous study were male and we are unsure of their academic level (Tikka et al. 2000). Because males have been shown to have more negative attitudes toward the environment than females, engineering students as a whole were classified as having negative environmental attitudes (Tikka et al. 2000). In this study, 87% of the engineering students were male and 13% were female. Given the higher proportion of males to females, one might expect gender to influence participant attitudes toward CWD more so than academic major. Perhaps the engineering students referenced in the previous study were of higher academic rank than the first year college students sampled in this study. If so, the subject matter emphasized in their coursework may have influenced the students' negative attitudes toward the environment more so than gender.

Political orientation of Virginia Tech first year students

The political orientation of this study's participants may have influenced their responses to questions regarding political activity related to CWD. When asked whether they would support policy action for the management of CWD on private lands and whether the government should provide financial support to landowners who leave CWD on their land, most brochure and presentation participants responded neutrally. In a survey of incoming first year college students conducted by the Cooperative Institutional Research Program of the Higher Education Research Institute (2003), 29.8% of Virginia Tech's first year students identified themselves as politically conservative (8% more conservative than counterparts at other universities). First year students participating in this study may have been more cautious when responding to the politically related questions and responded neutrally because of uncertainty. If this was the case, these results indicate that informational brochures and live presentations do not present information in a manner that will allow conservative first year college students to make an educated decision concerning political activity related to CWD.

Summary

Informational brochures were more effective at fostering positive attitudes toward CWD in female first year college students than male students. Females tended to exhibit more positive attitudes toward CWD than males following either the brochure or presentation. Regardless of gender, these results suggested that orally persuading an audience to consider the value of an ecological entity (e.g., CWD) by using a presentation and cooperative learning activity could be a more effective teaching technique than brochures. Participants from urban areas responded neutrally most often when asked to consider the ecological value of CWD following either the brochure or presentation. However, perceptions of participants from suburban areas toward CWD were most positively influenced following the presentation. Results also suggested that when attempting to generate positive attitudes toward the environment in college students majoring in the life sciences and with majors outside of the life sciences, the use of a presentation may be more effective than a brochure.

Conclusion

Conclusion

Environmental education: ecological importance of coarse woody debris

Coarse woody debris, including logs, stumps, and standing dead trees (snags), may appear aesthetically unpleasing to a citizen uneducated in forest ecology. Though often misunderstood by the public, CWD is an important component of forested ecosystems (Harmon et al. 1986). Coarse woody debris provides fish and wildlife habitat, enhanced soil and slope stability, and a growing medium for plants. Coarse woody debris also plays a role in nutrient cycling and the formation of soil via decomposition (Hagan and Grove 1999). The ecological importance of CWD must be shared with the public if negative attitudes and perceptions toward CWD are to be changed. Environmental education strategies such as informational brochures and presentations can be used to influence public knowledge, understanding, and perception of agricultural and natural resource issues (Broussard et al. 2001, Myers et al. 2003).

Landowner education on coarse woody debris

Informational brochures and live presentations can be effective educational techniques for educating the public about natural resources. Brochures and presentations market the benefits of ecological entities such as CWD and can address common misconceptions of forestry in a variety of educational settings. Study findings that the management of CWD for wildlife was most needed in southeastern Virginia where CWD volumes were lowest and that the value of CWD for wildlife was best conveyed through presentations may be important to landowner education efforts. The results of this study suggested that landowner education programs in southeastern Virginia might be most effective using presentations. This study also suggested that management efforts to increase CWD volumes in Virginia should focus on coniferous dominated stands. Because coniferous stands tended to lack the CWD volumes found in hardwood stands of western Virginia, increasing CWD volumes in eastern Virginia would enhance the ability of coniferous ecosystems to store carbon (Hubbard et al. 2004). Therefore, knowledge provided by this study of the volume and distribution of CWD across Virginia would be useful to forest managers modeling nutrient budgets in Virginia and southeastern forests. Given that coniferous stands lacked the CWD volumes found in western Virginia, combined with the knowledge that the value of CWD was best conveyed through presentations, suggests that landowners of coniferous woodlots could be effectively educated with presentations. If forest managers were trained in a natural resources related academic major, this study suggested that they could be effectively educated on the benefits of leaving CWD with either a brochure or presentation. Such a prediction is supported by the significant correlation found between natural resources majors and their disagreement that CWD was a hazard and should be removed after participants were exposed to either the brochure or presentation.

Coarse woody debris education for the non-landowner

The design of educational outreach programs for the non-landowning public requires information on the effectiveness of educational techniques such as brochures and presentations (Young and Witter 1994, Dettmann-Easler and Pease 1999). Knowledge gained from this study that downed CWD management for wildlife would be most appropriate in western Virginia and that presentations were most effective at reaching suburban participants may be important to outreach program design efforts. If downed

CWD is to be created near high recreational use areas in western Virginia, suburban participants visiting such areas might benefit from an educational presentation justifying such management. Given that presentations were more effective at convincing suburban participants of the importance of neighbor-to-neighbor education on CWD, a presentation at a community meeting in eastern Virginia where snag volumes were lowest could be helpful. Suburban visitors to parks in eastern Virginia who learned about CWD from a neighbor might be more willing to educate someone else on the benefits of snags and the need for more of them in eastern Virginia. A presentation might also be more effective than a brochure during college recruiting efforts with high school students interested in agriculture and natural resources (Richardson and Skelton 1991). Given that brochures were more effective for females than males, brochures addressing natural resource issues might be the most appropriate, cost effective method of education and/or recruitment if made available at events that target female audiences. Promotional brochures and informal presentations have already been effective recruitment strategies used by agriculture teachers (Myers et al. 2003). The results of this study suggest that the choice between informational brochures and live presentations for influencing public perceptions of CWD in Virginia will likely be influenced by the demographics of the target audience and the relevance of the topic locally.

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Appendix A: Importance values of overstory vegetation at 12 study sites sampled across Virginia in the summer of 2003.

(A) APPO

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum L.	21.3	6.0	16.7	15
Carya glabra (Mill.) Sweet	4.3	0.6	8.3	4
Carya tomentosa Nutt.	1.1	0.3	4.2	2
Nyssa sylvatica Marsh.	11.7	1.9	20.8	12
Oxydendrum arboreum (L.) D.C.	7.4	1.9	4.2	5
Quercus alba L.	11.7	32.4	16.7	20
Quercus coccinea Muench.	2.1	2.9	4.2	3
Quercus prinus L.	39.4	51.0	20.8	37
Quercus rubra L.	1.1	2.9	4.2	3

(B) BUFF

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer pensylvanicum L.	2.1	0.7	2.4	2
Acer rubrum	1.1	0.4	2.4	1
Betula lenta L.	9.5	17.0	7.3	11
Carya glabra	4.2	5.9	9.8	7
Carya ovata (Mill.) K. Koch.	2.1	2.3	4.9	3
Carya tomentosa	2.1	2.3	4.9	3
Crataegus spp.	1.1	0.1	2.4	1
Fraxinus pennsylvanica Marsh.	10.5	6.2	9.8	9
Liriodendron tulipifera L.	2.1	3.3	4.9	3
Magnolia acuminata L.	2.1	2.2	2.4	2
Nyssa sylvatica	4.2	2.9	7.3	5
Ostrya virginiana (Mill.) K. Koch	11.6	2.5	7.3	7
Quercus alba	4.2	6.1	4.9	5
Quercus coccinea	2.1	4.0	4.9	4
Quercus rubra	8.4	11.9	9.8	10
Rhododendron maximum L.	4.2	0.5	2.4	2
Tilia americana L.	28.4	31.8	12.2	24

(C) CUMB

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	15.9	10.2	13.0	13
Carpinus caroliniana Walt.	0.8	0.1	2.2	1
Carya glabra	6.3	4.2	10.9	7
Carya tomentosa	2.4	0.9	2.2	2
Liquidambar styraciflua L.	14.3	3.2	10.9	10
Liriodendron tulipifera	7.9	7.1	8.7	8
Nyssa sylvatica	8.7	2.6	10.9	7
Ostrya virginiana	0.8	0.3	2.2	1
Pinus echinata Mill.	1.6	2.8	2.2	2
Pinus taeda L.	5.6	13.7	4.3	8
Prunus serotina Ehrh.	0.8	0.4	2.2	1
Quercus alba	11.9	15.4	10.9	13
Quercus coccinea	12.7	20.5	10.9	15
Quercus falcata Michx.	9.5	15.5	6.5	11
Quercus phellos L.	0.8	3.0	2.2	2

(D) DUNE

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	13.1	7.5	12.0	11
Cornus florida L.	0.7	0.4	4.0	2
Ilex opaca Ait.	13.1	7.0	12.0	11
Liquidambar styraciflua	14.4	11.9	16.0	14
Nyssa sylvatica	3.3	0.6	8.0	4
Pinus taeda	48.4	67.2	24.0	47
Prunus serotina	3.9	3.2	8.0	5
Quercus falcata	2.0	2.0	8.0	4
Sassafras albidum (Nutt.) Nees	1.3	0.4	8.0	3

(E) FISH

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer pensylvanicum	1	0.1	2.6	1
Acer rubrum	16.3	6.2	13.2	12
Amelanchier arborea (Michx. f.) Fernald	1.9	0.4	2.6	2
Nyssa sylvatica	16.3	3.0	13.2	11
Ostrya virginiana	2.9	0.6	2.6	2
Oxydendrum arboreum	2.9	1.8	5.3	3
Pinus strobus L.	8.7	6.6	10.5	9
Pinus virginiana Mill.	1	4.1	2.6	3
Quercus alba	8.7	8.3	10.5	9
Quercus coccinea	12.5	32.5	13.2	19
Quercus prinus	18.3	15.3	10.5	15
Quercus rubra	4.8	11.8	7.9	8
Quercus velutina Lam.	3.8	8.9	2.6	5
Sassafras albidum	1	0.2	2.6	1

(F) FORT

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	3.7	1.8	5.9	4
Carya glabra	1.2	0.3	2.9	2
Carya tomentosa	12.2	17.7	11.8	14
Fagus grandifolia Ehrh.	8.5	4.4	11.8	8
Ilex opaca	1.2	0.1	2.9	1
Liquidambar styraciflua	11.0	10.2	8.8	10
Liriodendron tulipifera	31.7	38.8	11.8	27
Nyssa sylvatica	1.2	0.2	2.9	1
Oxydendrum arboreum	3.7	0.7	8.8	4
Pinus taeda	4.9	9.6	5.9	7
Quercus alba	6.1	12.1	8.8	9
Quercus coccinea	3.7	0.6	2.9	2
Quercus falcata	2.4	0.4	2.9	2
Quercus phellos	1.2	0.8	2.9	2
Quercus rubra	7.3	2.4	8.8	6

(G) GWNF

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	12.1	3.8	13.5	10
Amelanchier arborea	7.6	0.8	5.4	5
Carpinus caroliniana	3.0	0.5	2.7	2
Carya glabra	1.5	3.3	2.7	3
Carya tomentosa	9.1	3.7	13.5	9
Liriodendron tulipifera	1.5	5.2	2.7	3
Nyssa sylvatica	3.0	0.4	2.7	2
Ostrya virginiana	4.5	0.9	8.1	5
Pinus strobus	1.5	0.5	2.7	2
Pinus virginiana	3.0	1.6	2.7	2
Quercus alba	13.6	20.1	8.1	14
Quercus coccinea	4.5	4.8	5.4	5
Quercus prinus	21.2	30.0	10.8	21
Quercus rubra	9.1	15.7	10.8	12
Quercus velutina	4.5	8.7	8.1	7

(H) JEFF

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	11.8	6.1	12.2	10
Amelanchier arborea	6.7	2.0	9.8	6
Carya glabra	1.7	0.6	4.9	2
Carya tomentosa	1.7	5.0	2.4	3
Fagus grandifolia	0.8	0.2	2.4	1
Nyssa sylvatica	5.0	1.2	9.8	5
Oxydendrum arboreum	0.8	0.9	2.4	1
Pinus pungens Lamb.	6.7	12.0	4.9	8
Pinus rigida Mill.	4.2	8.2	4.9	6
Pinus strobus	3.4	0.5	7.3	4
Pinus virginiana	8.4	9.9	7.3	9
Quercus alba	25.2	26.7	12.2	21
Quercus coccinea	13.4	13.6	9.8	12
Quercus prinus	9.2	11.3	7.3	9
Tsuga canadensis (L.) Carr.	0.8	2.0	2.4	2

(I) REDH

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	16.9	7.6	17.6	14
Carya glabra	0.8	0.8	2.9	2
Liriodendron tulipifera	1.6	1.8	5.9	3
Nyssa sylvatica	2.4	0.5	5.9	3
Oxydendrum arboreum	23.4	6.9	17.6	16
Pinus virginiana	1.6	2.2	2.9	2
Quercus alba	13.7	26.6	17.6	19
Quercus coccinea	4.8	6.4	8.8	7
Quercus prinus	33.1	45.4	14.7	31
Quercus velutina	0.8	1.5	2.9	2
Sassafras albidum	0.8	0.2	2.9	1

(J) REYN

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	12.8	13.9	15	14
Carya glabra	3.4	4.4	7.5	5
Fagus grandifolia	9.4	6.0	7.5	8
Liriodendron tulipifera	7.7	8.4	7.5	8
Nyssa sylvatica	12.0	4.9	10	9
Oxydendrum arboreum	21.4	7.3	15	15
Pinus strobus	0.9	2.4	2.5	2
Pinus virginiana	1.7	2.1	2.5	2
Quercus alba	18.8	26.0	15	20
Quercus falcata	0.9	2.2	2.5	2
Quercus prinus	1.7	2.8	2.5	2
Quercus rubra	8.5	18.8	10	12
Quercus velutina	0.9	0.9	2.5	1

(K) WASH

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Ilex opaca	23.1	5.4	22.2	17
Liquidambar styraciflua	33.1	17.2	22.2	24
Nyssa sylvatica	9.2	1.7	14.8	9
Pinus taeda	25.4	67.3	22.2	38
Quercus phellos	6.2	5.9	11.1	8
Quercus velutina	3.1	2.5	7.4	4

(L) YORK

Species	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value (%)
Acer rubrum	18.1	9.2	11.1	13
Carpinus caroliniana	9.5	2.1	6.7	6
Carya tomentosa	6.9	8.1	6.7	7
Cornus florida	1.7	0.2	4.4	3
Fagus grandifolia	5.2	7.7	6.7	7
Fraxinus pennsylvanica	3.4	4.0	2.2	3
Ilex opaca	13.8	4.0	8.9	9
Juglans nigra L.	1.7	2.6	2.2	2
Kalmia latifolia L.	1.7	0.2	2.2	1
Liquidambar styraciflua	8.6	2.1	8.9	7
Liriodendron tulipifera	6.0	16.2	8.9	10
Nyssa sylvatica	6.0	9.9	2.2	6
Ostrya virginiana	1.7	0.2	2.2	1
Oxydendrum arboreum	0.9	0.6	2.2	1
Pinus echinata	5.2	12.1	4.4	7
Pinus virginiana	0.9	1.0	2.2	1
Quercus alba	4.3	6.2	8.9	7
Quercus falcata	0.9	0.5	2.2	1
Quercus prinus	3.4	13.0	6.7	8

Appendix B: A comparison of 0.1 ha fixed area plots and 71 m line transect estimates of coarse woody debris (CWD) volume (m^3/ha) and variability in the Fishburn Forest (FISH) of Virginia, sampled in the summer of 2003.

Estimates of CWD volume and variability were compared using fixed area plots and line transects. Six 0.1 ha fixed area plots were randomly established as detailed in the Methods section (page 29). Within each 0.1 ha circular plot, two parallel 35.5 m line transects were established 17.8 m apart and the line intercept method was used to estimate CWD volume (Van Wagner 1968). The two 35.5 m parallel lines were combined to estimate CWD volume, variability, and estimated sampling time for one 71m line transect per plot (Table B1). The diameter (m) of all pieces intersecting a transect was recorded at the point of intersection. Volume (m^3/ha) was calculated as follows (Van Wagner 1968):

$$V = (\pi^2 \Sigma d^2 / 8L) * 10,000$$

where

V = volume of CWD per ha
d = piece diameter at point of intersection (m)
L = transect length (m)

The average field sampling time per 0.1 ha circular plot was 1.5 hours. It would take an estimated 9 hours to sample CWD in six 0.1 ha circular plots (Table B1). The average sampling time per 71 m line transect was 15 minutes. It would take an estimated 4.75 hours to complete the number of 71 m line transects needed to achieve the same SE as six 0.1 ha circular plots (19 transects, 1349 m of line) (Table B1).

Appendix B (cont'd): A comparison of 0.1 ha fixed area plots and 71 m line transect estimates of coarse woody debris (CWD) volume (m^3/ha) and variability in the Fishburn Forest (FISH) of Virginia, sampled in the summer of 2003.

Table B1. Comparison of six 0.1 ha fixed area plots and six 71 m line transects at estimating coarse woody debris (CWD) volume (m^3/ha) and variability in the Fishburn Forest (FISH) of Virginia, sampled in the summer of 2003.

CWD variable	Six 0.1 ha fixed area plots	Six 71 m line transects
Mean volume (m^3/ha)	15.15	38.01
Standard deviation (m^3/ha)	8.37	36.66
Coefficient of Variation (%)	55.25 (SE = 22.56)	96.45
Estimated sampling time (hrs)	9	4.75[#]

[#] Estimated sampling time to complete the number of 71 m line transects to achieve the same SE as six 0.1 ha fixed area plots (19 line transects).

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I. EDUCATION

2002 B.S. Forestry
Virginia Polytechnic Institute and State University
(overall GPA = 3.4 / 4.0)

2004 M.S. Forestry
Virginia Polytechnic Institute and State University
(GPA = 3.7 / 4.0)

II. PUBLICATIONS

Copenheaver, C.A., Fuhrman, N.E., Gellerstedt, L.S., and Gellerstedt, P.A. A method for assessing tree encroachment in forest openings: A case study from Buffalo Mountain, Virginia. *Castanea* (in press).

Fuhrman, N.E., and Copenheaver, C.A. The relationship between coarse woody debris volume and wildlife use in Virginia. *American Midland Naturalist* (in review).

III. CONFERENCE PRESENTATIONS OR POSTERS

Fuhrman, N.E. and Copenheaver, C.A. August 3-8, 2003. Forest encroachment into glades on Buffalo Mountain, Virginia. Ecological Society of America Annual Meeting. Savannah, Georgia.

Fuhrman, N.E. and Copenheaver, C.A. October 5-7, 2003. An ecological assessment of coarse woody debris in Virginia. Joint Conference of Southern and Northern Mensurationists. Roanoke, Virginia.

Fuhrman, N.E. and Copenheaver, C.A. March 27-28, 2004. An ecological assessment of coarse woody debris volume and wildlife use in Virginia. Ecological Society of America Mid-Atlantic Ecology Conference. Lancaster, Pennsylvania.

Fuhrman, N.E., Duncan, D.W., and Copenheaver, C.A. June 21-23, 2004. A comparison of the effectiveness of two educational techniques: informational brochures vs. cooperative learning activities. 50th Annual Conference of the North American Colleges and Teachers of Agriculture. Gainesville, Florida.

IV. EMPLOYMENT HISTORY

2002 - 2004: Graduate Teaching Assistant
Virginia Polytechnic Institute and State University
Served as assistant in: Dendrology, Forest Ecology and Silvics, and the Forestry Equipment Room

1996 - 2002: Naturalist/Environmental Interpreter
Maryland Department of Natural Resources
State Forest and Park Service
Scales & Tales, Environmental Educational Outreach Program

V. MEMBERSHIPS AND PROFESSIONAL SOCIETIES

Southern Appalachian Botanical Society
The Ecological Society of America

VI. SELECTED GUEST LECTURES

The Wildlife Society, Student Chapter, April 2001, Virginia Tech Campus
Society of American Foresters, Student Chapter, March 2003, Virginia Tech Campus
The Wildlife Society, Student Chapter, April 2004, Virginia Tech Campus