Forest Floor Bulk Density and Depth at Savannah River –Draft Final Report

By

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Introduction

Knowing the amount of biomass across a landscape is becoming increasingly important to fire managers as new fuel and fire management decision support systems come on line. Fire managers rarely have the time or funding available to sample fuels operationally and often depend upon mean values for critical variables whose variation is often associated with simple stand characteristics such as age, forest type, time since last burn, stocking, or site, and other easily measured variables. This report outlines a study to collect and analyze litter and duff bulk density samples for developing a simple predictive tool to estimate forest floor fuel loading based on simple stand characteristics.

The forest floor fuelbed component can represent the bulk of the fuels that consume during wildland fires and therefore smoke emissions in the southern forests. It is therefore imperative the mass of this fuelbed component is accounted for when characterizing fuels. Although forest floor depths (inches) are relatively easy to measure for a specific site, it is very difficult to convert those forest floor depths to fuel loading (tons/acre). Loading is the variable most often required for fuels and fire management decision support systems. Mean bulk density (tons/acre/inch) values associated with simple stand characteristics need to be acquired from field data collection to allow conversion of forest floor depth to forest floor mass.

There have been several studies in the past to collect bulk density values for forested areas of the south. However, these studies were very limited in scope (Scholl and Waldrop 1999) or were completed at locations other than at the Savannah River Site (SRS) (Ottmar and Vihnanek 2000; Ottmar and others 2003; McNab and others 1978). Accurate, mean forest floor bulk densities for the SRS do not exist and require local measurements to understand the major factors that control variation in fuel bulk density across a wide array of conditions. This will provide a bulk density predictive capability to apply to forest floor depths, enabling accurate forest floor loadings to be calculated.

The Forest Inventory and Assessment (FIA) group has completed an inventory of 622 sites within the boundaries of the Savannah River Site. Live and dead vegetation along with dead and down woody fuels, and litter and duff depth has been measured. In order to convert the litter and duff depths to mass (tons/acre), a bulk density (tons/acrfe/inch) needs to be applied. Since the bulk density of the forest floor layers can vary widely depending on forest type, forest age, years

since last fire, site productivity, stocking, and climate, average bulk densities determined from other regions in the south (Ottmar and Vihnanek 1999, Ottmar and others 2003) may not prove to be adequate in the Savannah River region.

The primary objective of the Savannah River Site (SRS) study was to collect litter and duff samples to adequately characterize forest floor depth and bulk density (mean and variance) for combinations of 4 common forest types (loblolly and slash pine, long leaf pine, pine and hardwood mix, and upland hardwood), 3 age classes (5-20, 20-40, 40+ years), and 3 ages of rough (0-3, 3-10, 10+ years since last burn).

The secondary objective of the study was to analyze the data to determine the factors that control the variation in depth and bulk density using stocking or basal area and site quality or soils as covariates. This objective has yet to be completed. Dr. Bernie Parresol (Southern Research Station) will conduct this analysis with the assistance of the Fire Environmental Research Applications Group using the Forest Inventory and Analysis data previously collected.

Methods

Site Selection

Bulk density sampling points were randomly selected from the Forest Inventory and Assessment sites established on the Savannah River Site.   The FIA sample sites provided a convenient way to locate sites and to compare forest floor depth values previously collected by FIA crews. Bulk density sample ID's corresponded directly with the FIA sample plot ID's. Sites were selected and grouped based on stand type, stand age, and rough age as suggested by the SRS managers. A total of 97 FIA sites were visited (Appendix A) and 388 bulk density samples collected. It should be noted that within each stand type and age class not all ages of rough existed at SRS and therefore were not available for sampling (Tables 1 and 5).

Plot Center Location

Within each FIA sample site, FIA subplot 1 was designated as the plot center. Subplot 1 was located using a combination of GPS coordinates and bearing tree information to find the plot center. Subplot 1 plot center was confirmed by locating a metal marker that was placed in the ground during the FIA study.

Finding the FIA subplot 1 plot center marker was not always possible. On these occasions, the recorded distance and azimuth from the bearing tree or FIA data sheet was used to establish the plot center as close to the original location as possible.

Sample Location

The lower left bulk density sample square point was established 33 feet from the plot center at each of the four cardinal directions (Figure 1). If the sample point proved unrepresentative of the surrounding forest floor (live tree/stump, mineral soil/rocks, downed bole, topographic barriers

such as streams/ravines, etc.), 10 additional feet were added to the original end point until a suitable sample point was located or a different stand type was encountered. If the first suitable sample point encountered was located outside of the desired stand type, 45 degrees were added to the original cardinal bearing and the point was relocated 33 feet away from plot center. This process was repeated until four suitable sample points were located at each plot.
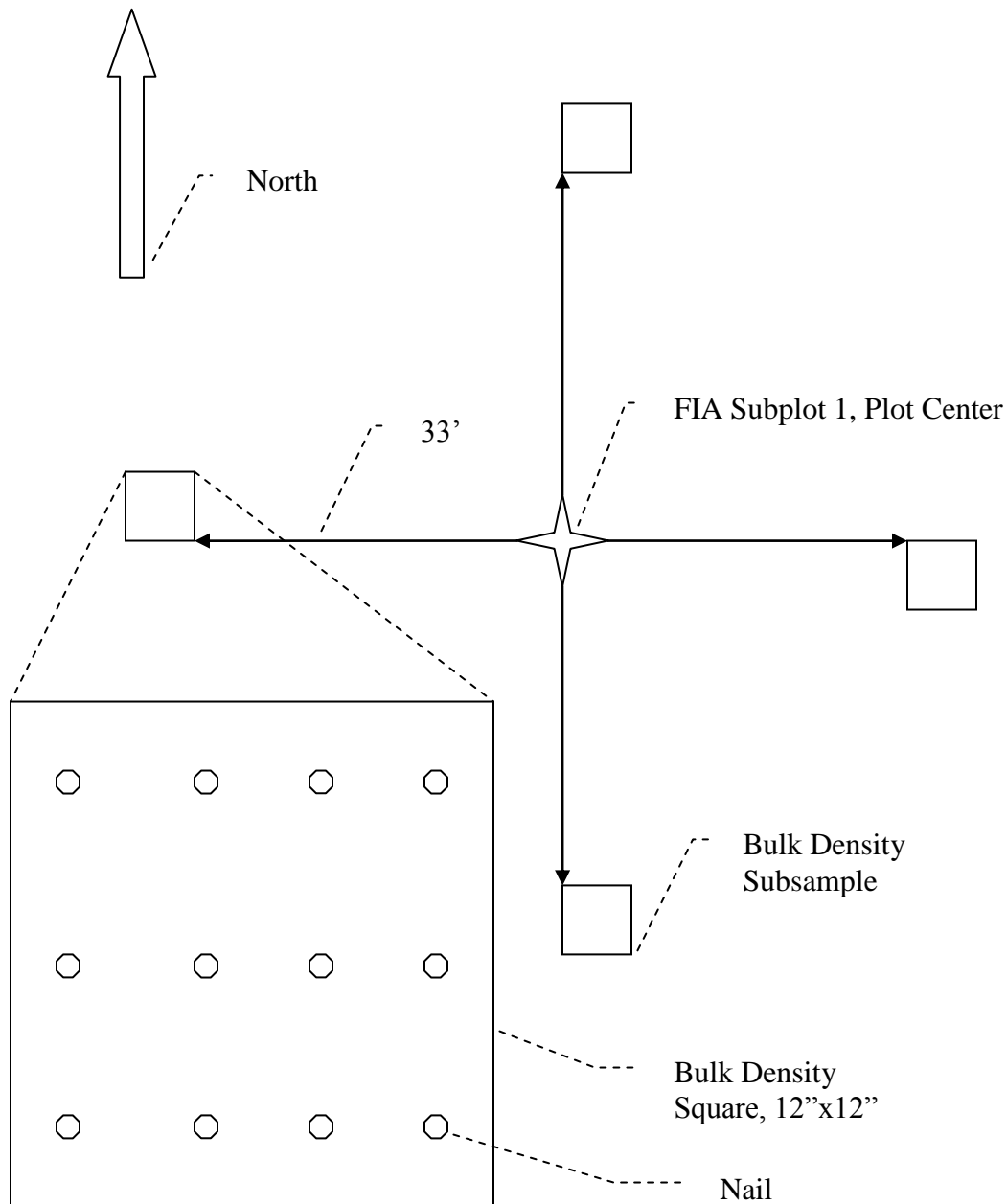
North

33'

FIA Subplot 1, Plot Center

Bulk Density
Subsample

Bulk Density
Square, 12"x12"

Nail

Figure 1. Typical sample point layout for SRS bulk density project.

Data Collection

Once a suitable sample point was identified, a 12 inch beveled steel square was positioned on top of the forest floor with the selected sample point located in the bottom left corner and the left edge of the square aligned parallel with the cardinal direction. Hand clippers and a small flat spade were used to cut the litter and duff around the outside edge of the square in combination with gentle downward pressure until either the top of the square was flush with the top of the litter layer or the bottom of the square was embedded in mineral soil (Figure 2).

Figure 2: Bulk density sampling in the field.

Twelve markers (6 inch gutter nails) were then placed in a grid pattern evenly within the square (Figure 1). The nails were tapped downwards until the top of the nail was flush with the top of the litter layer. Litter was then carefully removed from the square and placed within a labeled bag (FIA plot ID, sample type, sub-sample direction, and date). The distance between the top of each marker and the top of the duff layer was measured and recorded. The average of these twelve depth measurements represents the litter depth for the sample. After measurements were recorded the markers (nails) were again tapped down so that the tops were all flush with the top of the duff layer. The duff layer was then carefully removed, placed in a labeled bag, and the distance between the top of the marker and the substrate was measured, the average of these twelve measurements represents the duff depth for the sample. All litter and duff samples were then shipped back to Seattle and oven dried for 48 hours. Litter samples were dried at 70 degrees Celsius and duff samples at 100 degrees Celsius.

Analysis

Determining Litter and Duff Depth

Forest floor litter and duff layer depth was determined for each sample by calculating the average of the twelve measurements taken for litter and duff within each sample square.

Calculating Bulk Density

The oven dry mass (lbs) of the litter and duff collected for each sample was divided by the area of the sampling square (144 in^2) divided by the average layer depth (in) to determine bulk density (lbs/in^2/in) for each sample. The results were converted to more appropriate units (tons/acre/inch).

Preliminary Data Analysis

A total of 388 litter samples and 270 duff samples were used for preliminary analysis (Appendix A, Tables 1-4).   Initial review of the data indicated duff samples collected with an average thickness of less than 0.2 inch (5 mm) were often contaminated with mineral soil and the data was removed from the analysis.   A total of 118 duff samples were removed from analysis. Statistical tests will be preformed by Dr. Bernie Parresol to confirm if these samples are truly outliers and can be removed from the final analysis. There were no litter samples with an average depth of less than 0.2 inch, and therefore no litter samples were removed.

Forest Floor Litter and Duff Depth and Bulk Density at the Savannah River Site

Samples were plotted for each stand type by average bulk density and average depth. Grid lines showing the mean and +/- two standard deviations were added to identify plot to asses potential outlier samples. (Appendix B, figures 1 – 4). No potential outliers (i.e., values > 2 standard deviations from the mean) were removed from the preliminary analysis.

Results

Average litter and duff depths and bulk densities as well as variances for each combination of forest type, age class, rough age, and sample types was calculated and graphed in Appendix C and D. Summary tables are presented in this section (tables 1-8).

Forest Floor Litter and Duff Depth-Overview

Average litter depths ranged from 0.9 inch for upland hardwoods greater than 40 years in age without fire for over 10 years, to 1.6 inches on longleaf pine sites greater between 20 and 40 years in age and more than 3 years since fire. Average duff depth ranged from 0.4 inch on upland hardwood and pine and hardwood mix between 5 and 20 years in age with greater than 10 years since fire to 1.0 inch in pine and hardwood stands greater than 40 years in age and greater than 10 years since fire.

Table 1. Average litter and duff depth (inches) for forest types by age class (years) and rough age (years).

Age Class	Rough Age	Forest Type							
		Loblolly & Slash Pine		Longleaf pine		Pine & Hardwood Mix		Upland hardwood	
		Litter	Duff	Litter	Duff	Litter	Duff	Litter	Duff
5-20	0-3	--	--	1.1	0.2	--	--	--	--
	3-10	1.4	0.9	1.7	0.7	--	--	--	--
	10+	1.2	0.7	1.3	0.4	1.0	0.4	1.3	0.4
21-40	0-3	1.3	0.6	1.1	0.4	1.4	0.5	--	--
	3-10	1.5	0.6	1.6	1.0	1.3	0.7	1.2	0.6
	10+	1.0	0.7	1.6	0.9	1.2	0.8	1.2	0.6
40+	0-3	1.1	0.6	1.4	0.7	1.2	0.7	1.2	0.5
	3-10	1.4	1.0	1.4	0.7	0.9	0.9	1.3	0.7
	10+	1.5	0.8	1.6	0.9	1.3	1.0	0.9	0.6

Forest Floor Litter and Duff Depth by Age Class

For stands age 5-20 years old:
Longleaf pine stands have the highest average litter depth (1.4 in), followed by upland hardwood (1.3 in), loblolly and slash pine (1.2 in), and mixed pine and hardwood (1.0 in).

Loblolly and slash pine stands have the highest average duff depth (0.8 in), followed by longleaf pine (0.6 in), and mixed pine and hardwood and upland hardwood (0.4 in).

For stands age 21-40 years old:
Longleaf pine stands have the highest average litter depth (1.4 in), followed by loblolly and slash pine and mixed pine and hardwood (1.3 in) and upland hardwood (1.2 in).

Longleaf pine stands have the highest average duff depth (0.9 in), followed by mixed pine and hardwood (0.7 in) and loblolly and slash pine and upland hardwood (0.6 in).

For stands age 40+ years old:
Longleaf pine stands have the highest average litter depth (1.5 in), followed by loblolly and slash pine (1.3 in) and mixed pine and hardwood and upland hardwood (1.2 in).

Mixed pine and hardwood stands have the highest average duff depth (0.9 in), followed by loblolly and slash pine and longleaf pine (0.8 in) and upland hardwood (0.6 in).

Table 2. Litter and duff depths (inches) for forest types by age class (years).

| Age Class | Forest Type | | | | | | | |
| | Loblolly & Slash Pine | | Longleaf pine | | Pine & Hardwood Mix | | Upland hardwood | |
	Litter	Duff	Litter	Duff	Litter	Duff	Litter	Duff
5-20	1.2	0.8	1.4	0.6	1.0	0.4	1.3	0.4
21-40	1.3	0.6	1.4	0.9	1.3	0.7	1.2	0.6
40+	1.3	0.8	1.5	0.8	1.2	0.9	1.2	0.6

Forest Floor Litter and Duff Depth by Rough Age

For stands with a rough age of 0-3 years:
Mixed pine and hardwood stands have the highest average litter depth (1.3 in), followed by loblolly and slash pine, longleaf pine, and upland hardwood (1.2 in).

Loblolly and slash pine, longleaf pine, and mixed pine and hardwood stands have the highest average duff depth (0.6 in), followed by upland hardwood (0.5 in).

For stands with a rough age of 3-10 years:
Longleaf pine stands have the highest average litter depth (1.5 in), followed by loblolly and slash pine (1.4 in), upland hardwood (1.2 in), and mixed pine and hardwood (1.0 in).

Loblolly and slash pine, longleaf pine, and mixed pine and hardwood stands have the highest average duff depth (0.8 in), followed by upland hardwood (0.6 in).

For stands with a rough age of 10+ years:
Longleaf pine stands have the highest average litter depth (1.5 in), followed by loblolly and slash pine and mixed pine and hardwood (1.2 in) and upland hardwood (1.1 in).

Longleaf pine and mixed pine and hardwood stands have the highest average duff depth (0.8 in), followed by loblolly and slash pine (0.7 in) and upland hardwood (0.6 in).

Table 3. Litter and duff depths (inches) for forest types by rough age (years).

| Rough Age | Forest Type | | | | | | | |
| | Loblolly & Slash Pine | | Longleaf pine | | Pine & Hardwood Mix | | Upland hardwood | |
	Litter	Duff	Litter	Duff	Litter	Duff	Litter	Duff
0-3	1.2	0.6	1.2	0.6	1.3	0.6	1.2	0.5
3-10	1.4	0.8	1.5	0.8	1.0	0.8	1.2	0.6
10+	1.2	0.7	1.5	0.8	1.2	0.8	1.1	0.6

Forest Floor Litter and Duff Depth by Forest Type

Longleaf pine stands have the highest average litter depth (1.4 in), followed by loblolly and slash pine (1.3 in), pine and hardwood mix and upland hardwood (1.2 in).

Mixed pine and hardwood stands have the highest average duff depth (0.8 in), followed by loblolly and slash pine and longleaf pine (0.7 in), and upland hardwood (0.6 in).

Table 4. Average litter and duff depth (inches) by forest type.

Forest Type	Average Depth (in)	
	Litter	Duff
Loblolly & Slash Pine	1.3	0.7
Longleaf pine	1.4	0.7
Pine & Hardwood Mix	1.2	0.8
Upland hardwood	1.2	0.6

Forest Floor Litter and Duff Bulk Density – Overview

Average litter bulk densities ranged from 1.5 t/ac/in for pine and hardwood mix between 5-20 years old without fire for over 10 years to 2.4 t/ac/in for loblolly and slash pine sites between 5 and 20 years in age and more than 3 years since fire. Average duff bulk densities ranged from 2.6 t/ac/in on upland hardwood mix between 5 and 20 years in age with greater than 10 years since fire to 9.0 t/ac/in for loblolly and slash pine greater than 40 years in age and 3 to 10 years since fire (table 5).

Table 5. Litter and duff bulk densities (tons/acre/inch) for forest types by age class (years) and rough age (years).

Age Class	Rough Age	Forest Type							
		Loblolly & Slash Pine		Longleaf pine		Pine & Hardwood Mix		Upland hardwood Mix	
		Litter	Duff	Litter	Duff	Litter	Duff	Litter	Duff
	0-3	--	--	1.8	3.8	--	--	--	--
5-20	3-10	2.0	4.4	1.6	4.5	--	--	--	--
	10+	1.9	4.8	1.8	4.1	1.5	3.9	1.8	2.6
	0-3	2.4	6.0	2.6	8.2	2.8	6.7	--	--
21-40	3-10	2.4	6.4	2.9	6.3	1.6	5.3	1.9	5.1
	10+	1.9	5.9	2.7	8.6	1.7	4.0	2.1	5.7
	0-3	1.9	6.4	2.2	8.2	2.1	8.8	2.2	6.6
40+	3-10	2.3	9.0	2.1	7.0	2.2	7.0	1.9	6.2
	10+	2.3	7.2	2.5	8.2	2.0	5.3	2.0	7.1

Forest Floor Litter and Duff Bulk Density by Stand Age (table 6)

For stands age 5-20 years:
Loblolly and slash pine stands have the highest average litter bulk density (2.0 t/ac/in), followed by upland hardwood (1.8 t/ac/in), longleaf pine (1.7 t/ac/in) and mixed pine and hardwood (1.5 t/ac/in).

Loblolly and slash pine stands have the highest average duff bulk density (4.6 t/ac/in), followed by longleaf pine (4.3 t/ac/in), mixed pine and hardwood (3.9 t/ac/in), and upland hardwood (2.6 t/ac/in).

For stands age 21-40 years:
Longleaf pine stands have the highest average litter bulk density (2.7 t/ac/in), followed by loblolly and slash pine and mixed pine and hardwood (2.2 t/ac/in), and upland hardwood (2.0 t/ac/in).

 Longleaf pine stands have the highest average duff bulk density (7.1 t/ac/in), followed by loblolly and slash pine (6.1 t/ac/in), upland hardwood and mixed pine and hardwood (5.5 t/ac/in).

For stands over 40 years old:
Longleaf pine stands have the highest average litter bulk density (2.3 t/ac/in), followed by loblolly and slash pine (2.2 t/ac/in) and mixed pine and hardwood and upland hardwood (2.1 t/ac/in).

Longleaf pine stands have the highest average duff bulk density (7.8 t/ac/in), followed by loblolly and slash pine (7.7 t/ac/in), upland hardwood (6.7 t/ac/in), and mixed pine and hardwood (6.5 t/ac/in).

Table 6. Litter and duff bulk densities (tons/acre/inch) for forest types by age class (years).

Age Class	Forest Type							
	Loblolly & Slash Pine		Longleaf pine		Pine & Hardwood Mix		Upland hardwood	
	Litter	Duff	Litter	Duff	Litter	Duff	Litter	Duff
5-20	2.0	4.6	1.7	4.3	1.5	3.9	1.8	2.6
21-40	2.2	6.1	2.7	7.1	2.2	5.5	2.0	5.5
40+	2.2	7.7	2.3	7.8	2.1	6.5	2.1	6.7

Forest Floor Litter and Duff Bulk Density by Rough Age (table 7)

For stands with a rough age of 0-3 years:

Mixed pine and hardwood stands have the highest average litter bulk density (2.5 t/ac/in), followed by longleaf pine and upland hardwood (2.2 t/ac/in), and loblolly and slash pine (2.1 t/ac/in).

Longleaf pine stands have the highest average duff bulk density (7.7 t/ac/in), followed by mixed pine and hardwood (7.6 t/ac/in), upland hardwood (6.6 t/ac/in), and loblolly and slash pine (6.2 t/ac/in).

For stands with a rough age of 3-10 years:
Loblolly and slash pine stands have the highest average litter bulk density (2.3 t/ac/in), followed by longleaf pine (2.2 t/ac/in,) mixed pine and hardwood (2.0 t/ac/in), and upland hardwood (1.9 t/ac/in).

Loblolly and slash pine stands have the highest average duff bulk density (6.8 t/ac/in), followed by mixed pine and hardwood (6.4 t/ac/in), longleaf pine (6.1 t/ac/in), and upland hardwood (5.5 t/ac/in).

For stands with a rough age of 10+ years:
Longleaf pine stands have the highest average litter bulk density (2.3 t/ac/in), followed by loblolly and slash pine and upland hardwood (2.0 t/ac/in), and mixed pine and hardwood (1.8 t/ac/in).

Longleaf pine stands have the highest average duff bulk density (7.2 t/ac/in), followed by upland hardwood and loblolly and slash pine (5.9 t/ac/in,) and mixed pine and hardwood (4.7 t/ac/in).

Table 7. Litter and duff bulk densities (tons/acre/inch) for forest types by rough age (years).

| | Forest Type | | | | | | | |
| | Loblolly & Slash Pine | | Longleaf pine | | Pine & Hardwood Mix | | Upland hardwood | |
Rough Age	Litter	Duff	Litter	Duff	Litter	Duff	Litter	Duff
0-3	2.1	6.2	2.2	7.7	2.5	7.6	2.2	6.6
3-10	2.3	6.8	2.2	6.1	2.0	6.4	1.9	5.5
10+	2.0	5.9	2.3	7.2	1.8	4.7	2.0	5.9

Forest Floor Litter and Duff Bulk Density by Forest Type (table 8)

Longleaf pine stands have the highest average litter bulk density (2.3 t/ac/in), followed by loblolly and slash pine (2.1 t/ac/in), upland hardwood and mixed pine and hardwood (2.0 t/ac/in).

Longleaf pine stands have the highest average duff bulk density (6.8 t/ac/in), followed by loblolly and slash pine (6.3 t/ac/in), upland hardwood (6.0 t/ac/in) and mixed pine and hardwood (5.9 t/ac/in).

Table 8.

	Average Bulk Density (t/ac/in)	
Forest Type	Litter	Duff
Loblolly & Slash Pine	2.1	6.3
Longleaf pine	2.3	6.8
Pine & Hardwood Mix	2.0	5.9
Upland hardwood	2.0	6.0

Discussion

Litter and Duff Depth

Initial review of litter depth data indicates average litter depth increased with stand age in the loblolly and slash pine and longleaf stands. As the stands age, increased needle mass enabled the litter layer to increase in depth and produce more litter than could decay (Appendix C, Table and Figure C5 and C6). The litter depth did not show a relationship between age in the mixed pine and hardwood or upland hardwood stands. This may have been due to the broadleaf litter layer that would decay very quickly and not build-up over the years. Litter depth also showed an increase with years since fire. This was related to the forest floor build-up associated with limited fire activity that would have reduced the forest floor.

Initial review of the duff depth data indicates average duff depth did not increase with stand age or years of rough. This may have been due to the limited availability of older sites and sites with long periods since fire.   For all forest types average litter depth is greater than the average duff depth (Appendix C, Table and Figure C1-C4).

Litter and Duff Bulk Density

Litter bulk density remained relatively constant across stand age. Rough age does not appear to be a major contributing factor in bulk density variation for either litter or duff (Appendix D, Table 1 Figure 1). This may be due to the active burn program initiated at SRS leaving few sites to sample with a high number of years since fire.   For all forest types average duff bulk density is greater than the average litter bulk density (Appendix D, Table and Figure D1-D4).

Initial review of the duff bulk density data however, indicates stand age is the main factor contributing to duff bulk density variation across forest types. Duff bulk densities noticeably increased as stand age increased as more material was added to the forest floor and decayed (Appendix D, Table and Figure D5 and D6).   The added material over the years becomes more dense.

A similar study will be conducted for different locations and forest types throughout the southern States funded by the Joint Fire Science Program. The study will use a modified approach for sampling forest floor depths and bulk density based on knowledge and experience gained from the Savannah River study.

Summary

A 12 month field study was conducted at Savannah River to characterize the forest floor depth and bulk density of the litter and duff fuelbed layers for a combination of forest types, stand age classes, and time since burning. A total of 388 depth and bulk density samples were collected from 97 Forest Inventory and Assessment Sites at Savannah River. The data will be further analyzed to determine the factors that control the variation in depths and bulk density. This information is becoming increasingly important to fire managers as new fuel and fire management decision support systems come on line.

Variation in depth of the forest floor across all forest types appears to be independent of stand age and rough age. While litter depth for the pure pine stands increases with stand age the same cannot be said for mixed pine and hardwood stands or upland hardwood stands.

Stand age appears to be the main factor contributing to variation in bulk density throughout all stand types, with duff bulk densities noticeably increasing as stand age increases. Litter bulk density remained relatively constant across stand age and rough age. Rough age does not appear to play a major role in litter and duff bulk density variation.

Forest floor bulk density, to some extent, is independent of the forest floor depth. Litter depth for all forest types is greater than the duff depth but conversely duff bulk density is significantly greater than litter bulk density. While litter bulk density is relatively constant across stand age significantly greater variation occurs in litter depth across stand age. And, although duff bulk density increases with stand age across all forest types the same correlation cannot be made with duff depth.

Acknowledgements

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Table A1. Number of **loblolly and slash pine** samples, with an average depth greater than or equal to 5 mm, by age class (yrs), rough age (yrs), FIA sample ID, and sample type.

Forest Type	Age Class	Rough Age	Sample ID	Duff	Litter
Loblolly & Slash Pine				**103**	**124**
	5-20			**27**	**32**
		3-10		12	12
			1186	4	4
			4066	4	4
			4110	4	4
		10+		15	20
			1091	4	4
			1256	3	4
			4101	0	4
			4169	4	4
			4206	4	4
	21-40			**38**	**44**
		0-3		8	12
			1046	4	4
			4244	0	4
			4376	4	4
		3-10		15	16
			1033	4	4
			1045	3	4
			1132	4	4
			4107	4	4
		10+		15	16
			1197	3	4
			4153	4	4
			4315	4	4
	40+			**38**	**48**
		0-3		10	16
			1242	2	4
			4010	4	4
			4296	0	4
		3-10		15	16
			1086	4	4
			1180	4	4
			4139	4	4
			4174	3	4
		10+		13	16
			4031	2	4
			4043	4	4
			4177	4	4
			4283	3	4

Table A2. Number of **longleaf pine** samples, with an average depth greater than or equal to 5 mm, by age class (yrs), rough age (yrs), FIA sample ID, and sample type.

Forest Type	Age Class	Rough Age	Sample ID	Duff	Litter
Longleaf pine				**78**	**124**
	5-20			**18**	**36**
		0-3		2	12
			4083	0	4
			4084	0	4
			4400	2	4
		3-10		10	12
			4093	4	4
			4299	2	4
			4401	4	4
		10+		6	12
			1160	2	4
			4140	1	4
			4143	3	4
	21-40			**23**	**40**
		0-3		5	12
			1003	0	4
			1295	3	4
			4055	2	4
		3-10		14	16
			1023	3	4
			1031	3	4
			1074	4	4
			4078	4	4
		10+		4	12
			1026	2	4
			4015	2	4
	40+			**37**	**48**
		0-3		11	16
			4001	2	4
			4301	2	4
			4375	4	4
		3-10		13	16
			1017	3	4
			1022	4	4
			4064	3	4
			4100	3	4
		10+		13	16
			1029	1	4
			1048	4	4
			4045	4	4

Table A3. Number of **pine and hardwood mix** samples, with an average depth greater than or equal to 5 mm, by age class (yrs), rough age (yrs), FIA sample ID, and sample type.

Forest Type	Age Class	Rough Age	Sample ID	Duff	Litter
Pine & Hardwood Mix				39	56
	5-20			4	8
		10+		4	8
			1064	0	4
			4330	4	4
	21-40			14	16
		0-3		6	8
			1032	3	4
			4027	3	4
		3-10		4	4
			4119	4	4
		10+		4	4
			1195	4	4
	40+			21	32
		0-3		4	8
			1061	0	4
			1069	4	4
		3-10		7	8
			4046	3	4
			4451	4	4
		10+		10	16
			1036	2	4
			1090	4	4
			4035	4	4
			4236	0	4

Table A4. Number of **upland hardwood** samples, with an average depth greater than or equal to 5 mm, by age class (yrs), rough age (yrs), FIA sample ID, and sample type.

Forest Type	Age Class	Rough Age	Sample ID	Duff	Litter
Upland hardwood				49	84
	5-20			2	4
		10+		2	4
			1173	2	4
	21-40			20	28
		3-10		7	12
			4008	3	4
			4105	0	4
			4438	4	4
		10+		13	16
			4103	4	4
			4104	1	4
			4433	4	4
			4477	4	4
	40+			27	52
		0-3		15	28
			1079	2	4
			1218	1	4
			4005	2	4
			4011	1	4
			4098	4	4
			4227	3	4
			4243	2	4
		3-10		4	12
			1149	1	4
			4412	3	4
		10+		8	12
			1052	3	4
			1136	3	4
			4286	2	4

Table B1a. Loblolly and slash pine litter data by age class (yrs) and rough age (yrs).

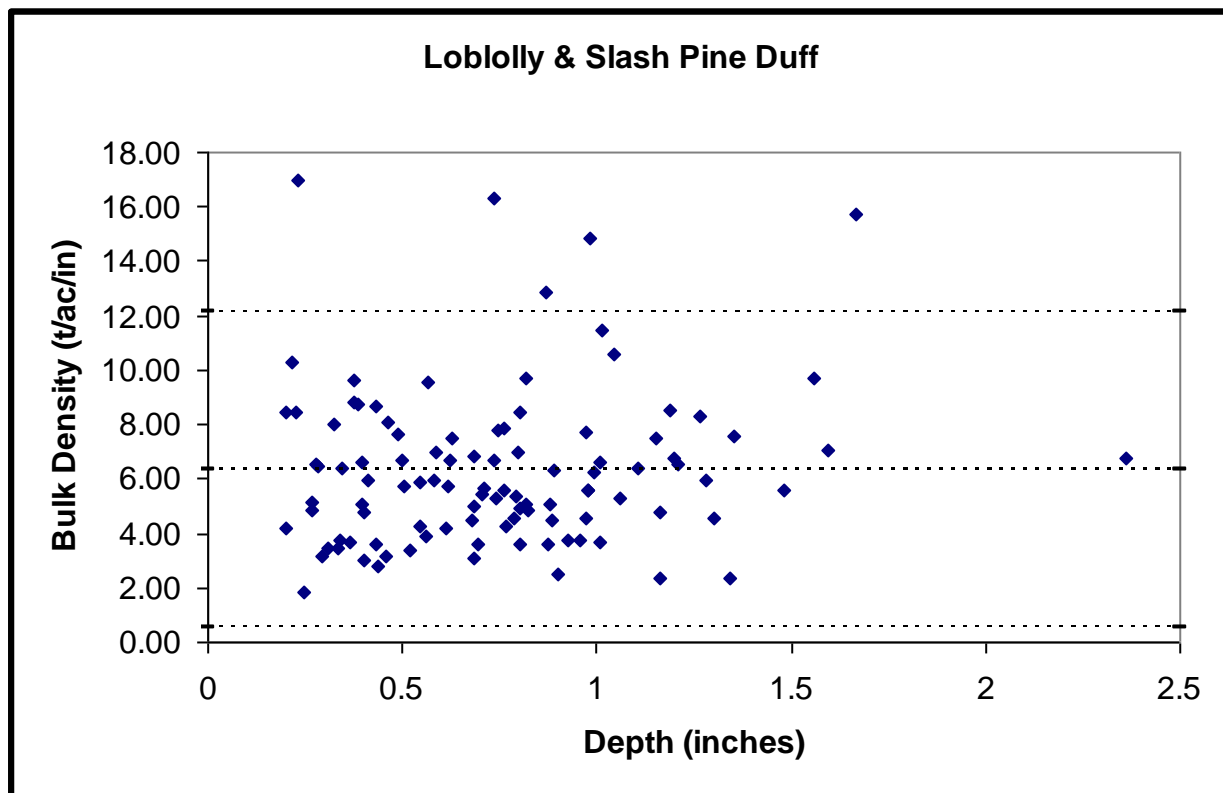| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Loblolly & Slash Pine								
	Litter			0.5	2.3	0.7	4.7	0.6
		5-20		0.5	1.8	0.7	2.9	0.5
			3-10	1.0	1.8	0.7	2.9	0.6
			10+	0.5	1.6	0.9	2.8	0.4
		21-40		0.7	2.1	0.8	3.8	0.7
			0-3	0.8	1.7	1.3	3.8	0.8
			3-10	1.2	2.1	1.6	3.3	0.5
			10+	0.7	1.4	0.8	2.9	0.6
		40+		0.6	2.3	0.9	4.7	0.7
			0-3	0.6	1.6	0.9	2.9	0.6
			3-10	0.8	2.3	1.5	4.7	0.8
			10+	1.2	2.2	1.1	3.3	0.6
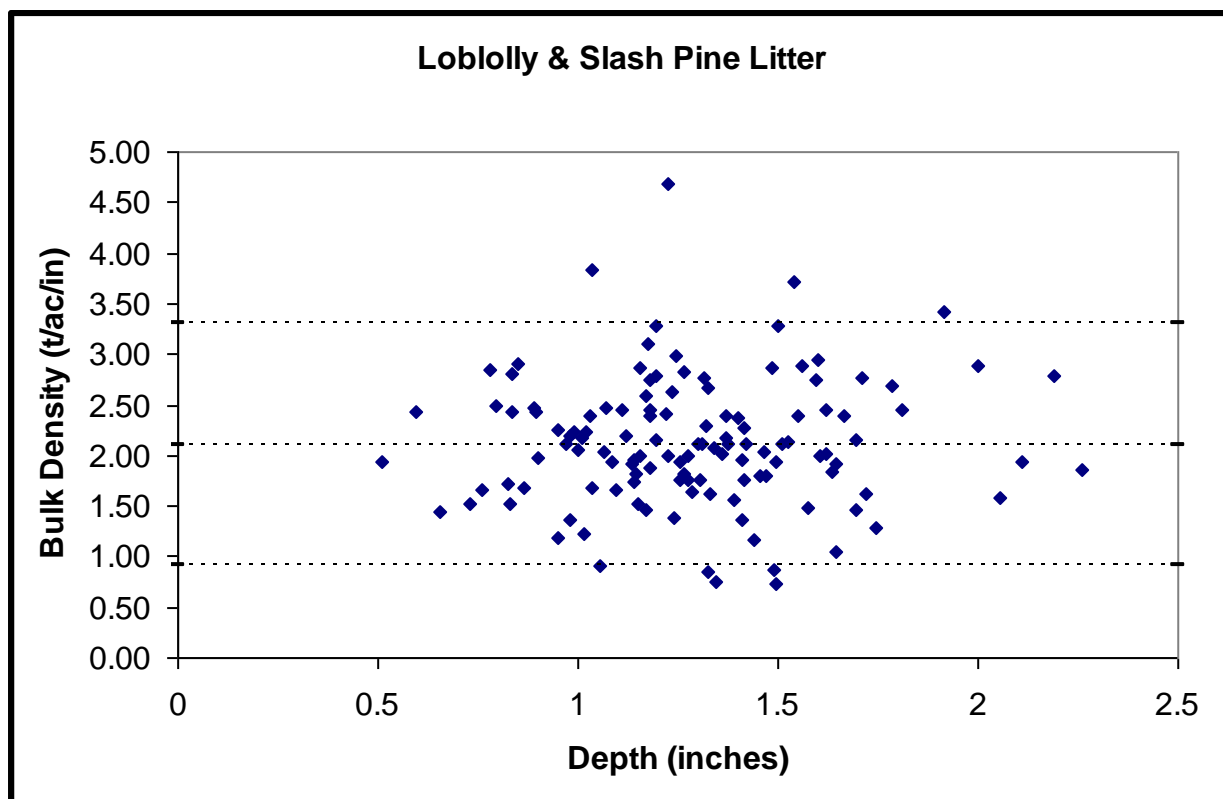
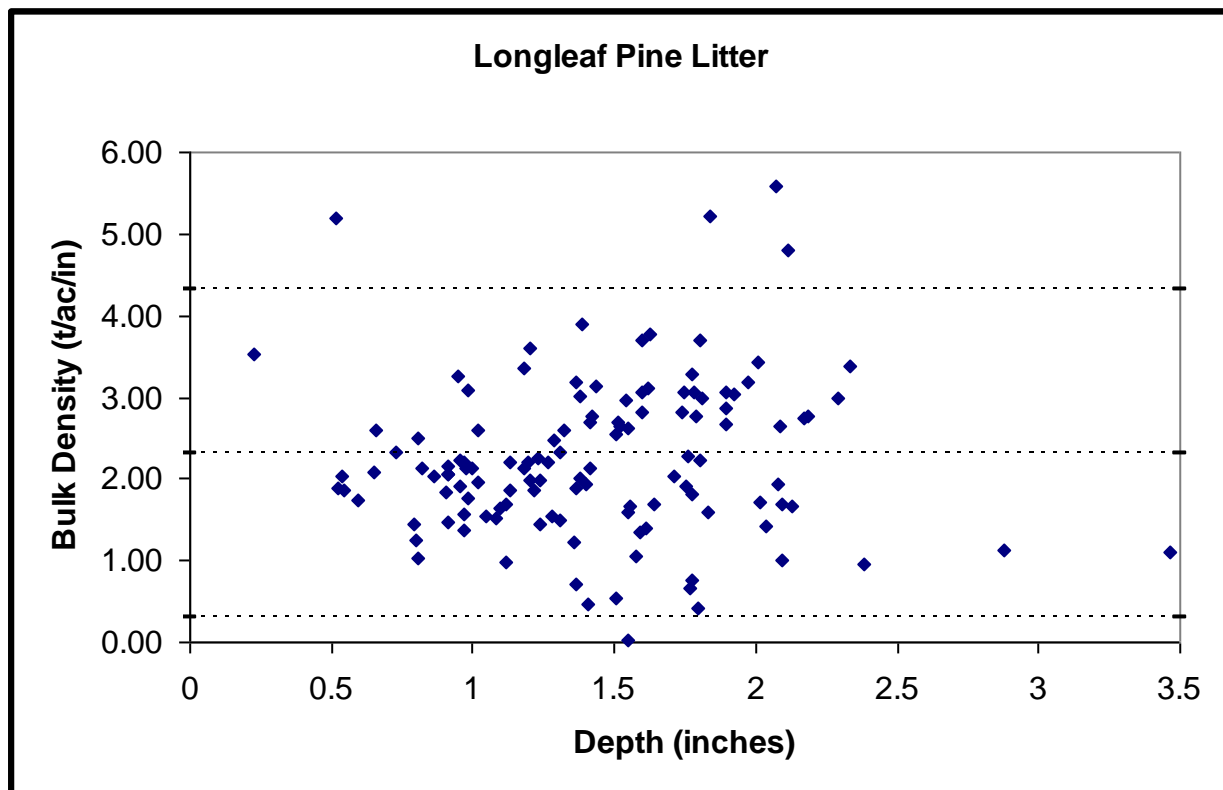**Figure B1a. Loblolly and slash pine** litter samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B1b. Loblolly and slash pine duff data by age class (yrs) and rough age (yrs).

Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Loblolly & Slash Pine								
	Duff			0.2	2.4	1.9	17.0	2.9
		5-20		0.2	1.5	1.9	8.4	1.5
			3-10	0.2	1.5	1.9	8.4	2.0
			10+	0.3	1.1	2.8	6.7	1.1
		21-40		0.2	1.3	2.4	11.5	2.2
			0-3	0.3	1.0	3.5	9.7	2.0
			3-10	0.2	1.1	3.6	10.3	2.1
			10+	0.2	1.3	2.4	11.5	2.6
		40+		0.2	2.4	3.1	17.0	3.5
			0-3	0.2	1.6	3.4	9.7	2.1
			3-10	0.2	2.4	3.1	17.0	4.4
			10+	0.2	1.7	3.9	15.7	3.0

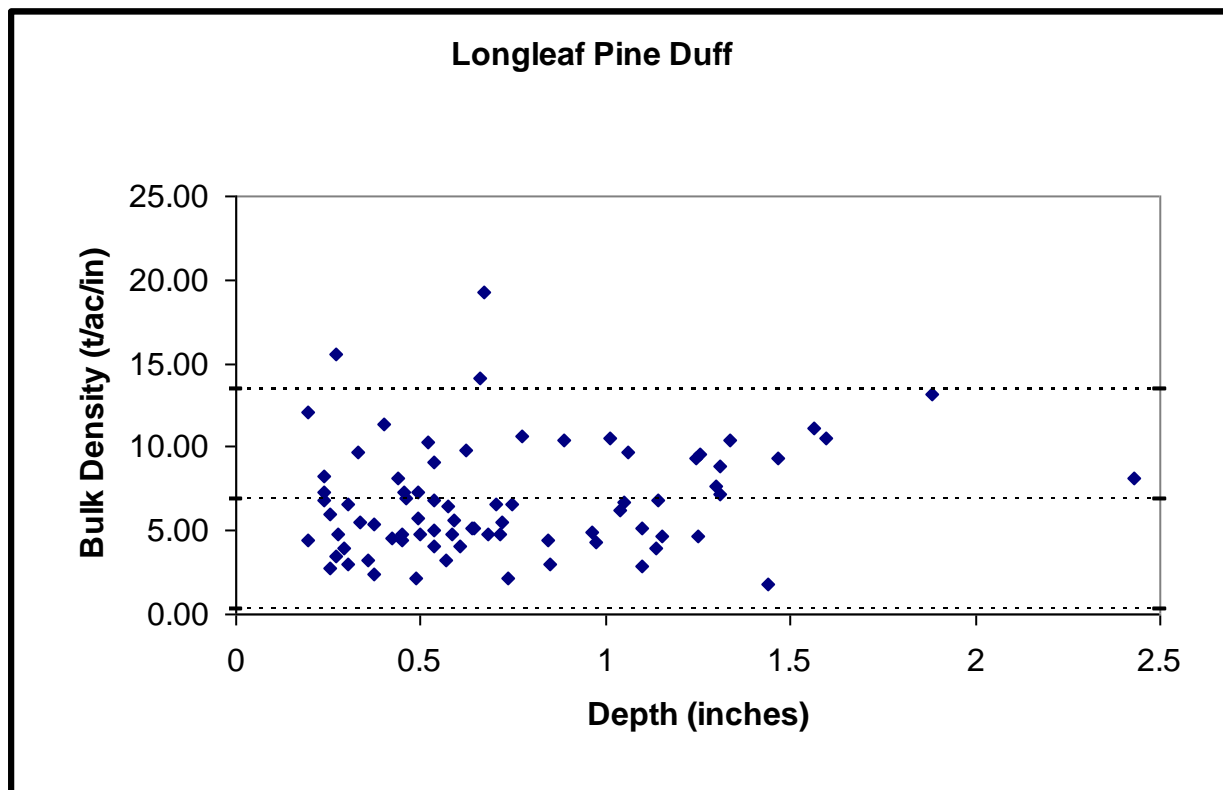**Figure B1b. Loblolly and slash pine** duff samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B2a. Longleaf pine litter data by age class (yrs) and rough age (yrs).

Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Longleaf pine								
	Litter			0.2	3.5	0.0	5.6	1.0
		5-20		0.5	2.9	0.4	3.0	0.6
			0-3	0.5	1.8	0.4	2.8	0.6
			3-10	0.9	2.9	0.7	2.6	0.6
			10+	0.6	2.0	0.8	3.0	0.6
		21-40		0.2	2.3	0.5	5.2	0.9
			0-3	0.2	2.0	0.5	5.2	1.2
			3-10	1.0	2.3	1.9	3.9	0.6
			10+	0.9	2.3	1.5	5.2	1.0
		40+		0.5	3.5	0.0	5.6	1.0
			0-3	0.9	2.2	0.5	3.7	0.8
			3-10	0.5	2.1	0.0	3.2	0.9
			10+	0.7	3.5	1.0	5.6	1.3

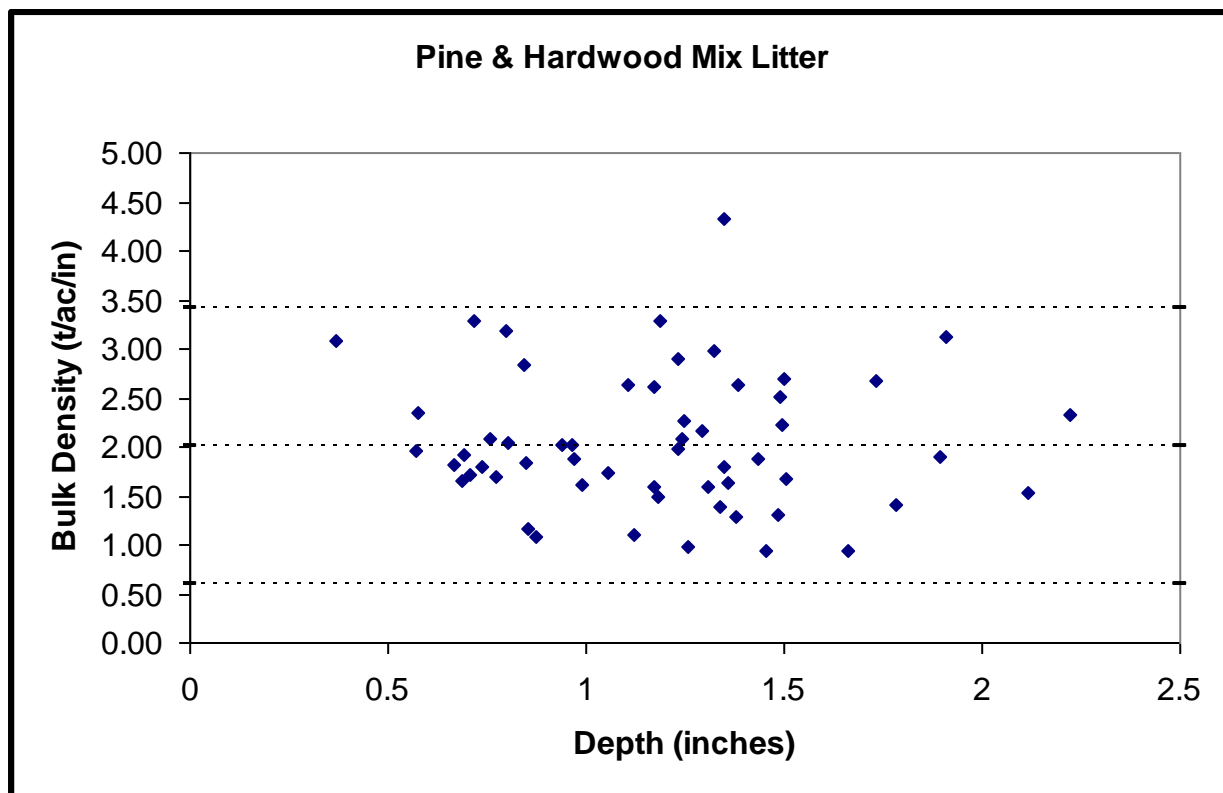
Figure B2a. Longleaf pine litter samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B2b. Longleaf pine duff data by age class (yrs) and rough age (yrs).

Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Longleaf pine								
	Duff			0.2	2.4	1.9	19.2	3.3
		5-20		0.2	1.4	1.9	8.1	1.8
			0-3	0.2	0.3	3.0	4.5	1.0
			3-10	0.2	1.4	1.9	8.1	2.2
			10+	0.3	0.7	2.2	6.5	1.6
		21-40		0.2	2.4	2.2	14.2	2.8
			0-3	0.2	0.7	6.0	14.2	3.4
			3-10	0.2	2.4	2.2	10.4	2.2
			10+	0.2	1.5	4.1	12.1	3.3
		40+		0.3	1.9	3.3	19.2	3.6
			0-3	0.3	1.6	3.3	19.2	4.5
			3-10	0.3	1.9	3.3	15.5	3.7
			10+	0.4	1.6	3.9	11.3	2.5

Figure B2b. Longleaf pine duff samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B3a. Pine and hardwood mix litter data by age class (yrs) and rough age (yrs).

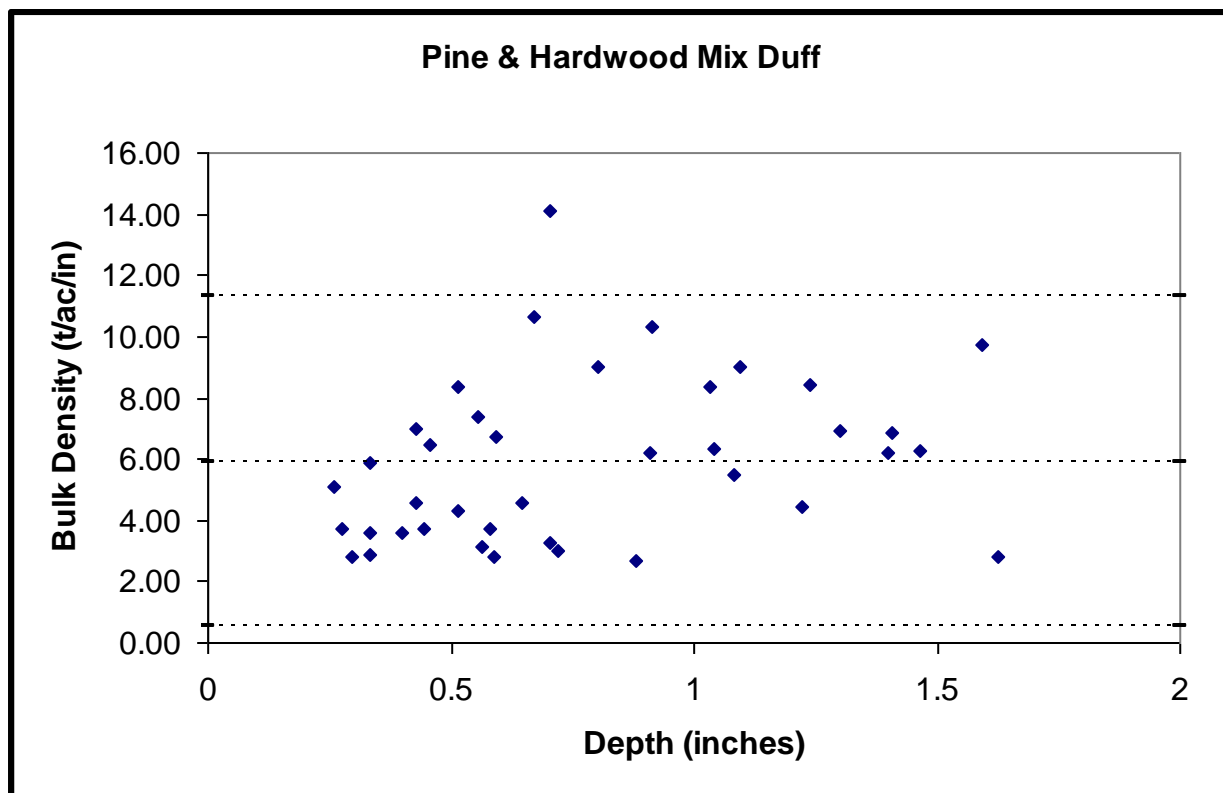| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Pine & Hardwood Mix								
	Litter			0.4	2.2	0.9	4.3	0.7
		5-20		0.7	1.5	1.0	2.0	0.4
			10+	0.7	1.5	1.0	2.0	0.4
		21-40		0.7	1.9	0.9	4.3	0.9
			0-3	0.7	1.9	1.9	4.3	0.8
			3-10	1.1	1.5	0.9	2.0	0.5
			10+	0.7	1.5	1.4	2.2	0.4
		40+		0.4	2.2	0.9	3.3	0.6
			0-3	0.6	1.7	1.3	2.7	0.5
			3-10	0.4	1.3	1.1	3.2	0.7
			10+	0.7	2.2	0.9	3.3	0.6

Figure B3a. Pine and Hardwood Mix litter samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B3b. Pine and hardwood mix duff data by age class (yrs) and rough age (yrs).

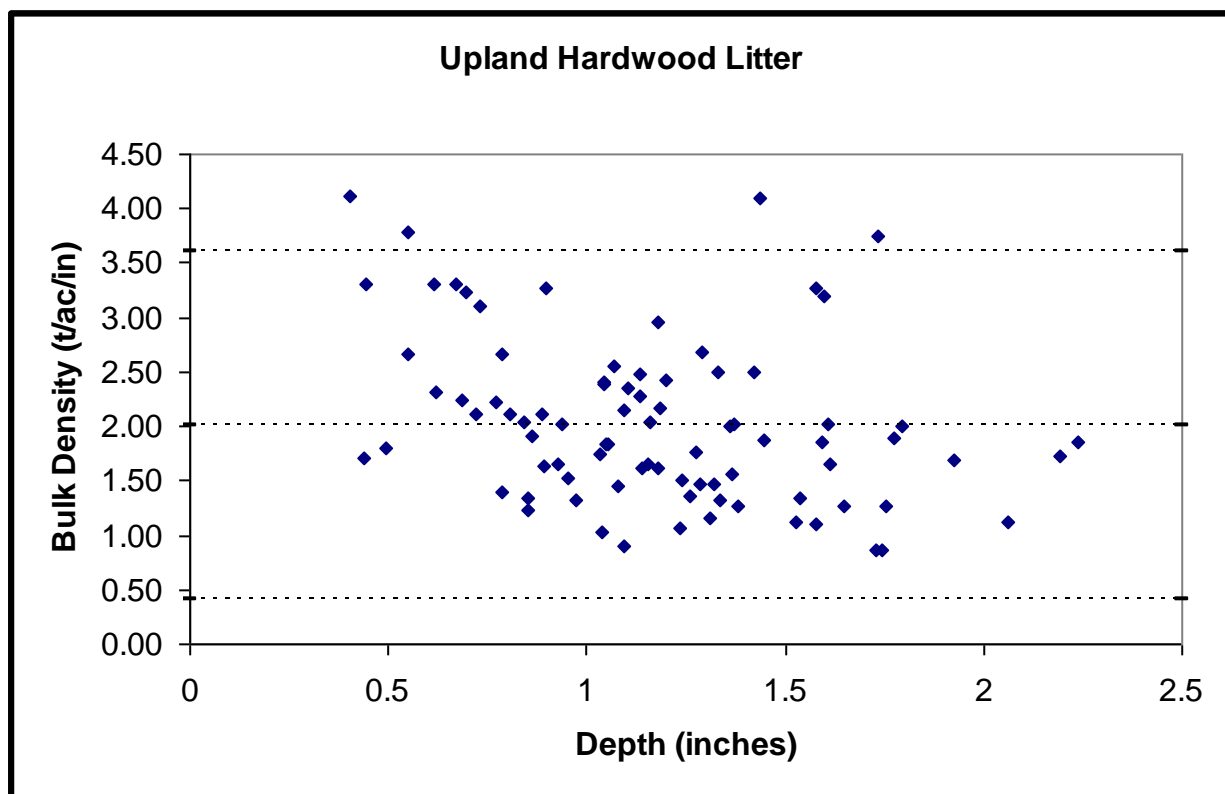| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Pine & Hardwood Mix								
	Duff			0.3	1.6	2.6	14.1	2.7
		5-20		0.3	0.6	2.9	5.9	1.4
			10+	0.3	0.6	2.9	5.9	1.4
		21-40		0.3	1.4	2.6	8.3	2.0
			0-3	0.3	1.0	2.8	8.3	2.1
			3-10	0.5	1.1	4.3	6.7	1.1
			10+	0.4	1.4	2.6	6.9	2.0
		40+		0.3	1.6	2.8	14.1	3.1
			0-3	0.3	1.3	3.7	14.1	4.5
			3-10	0.3	1.4	3.7	10.3	2.3
			10+	0.3	1.6	2.8	9.7	2.5

Figure B3b. Pine and hardwood mix duff samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B4a. Upland hardwood litter data by age class (yrs) and rough age (yrs).

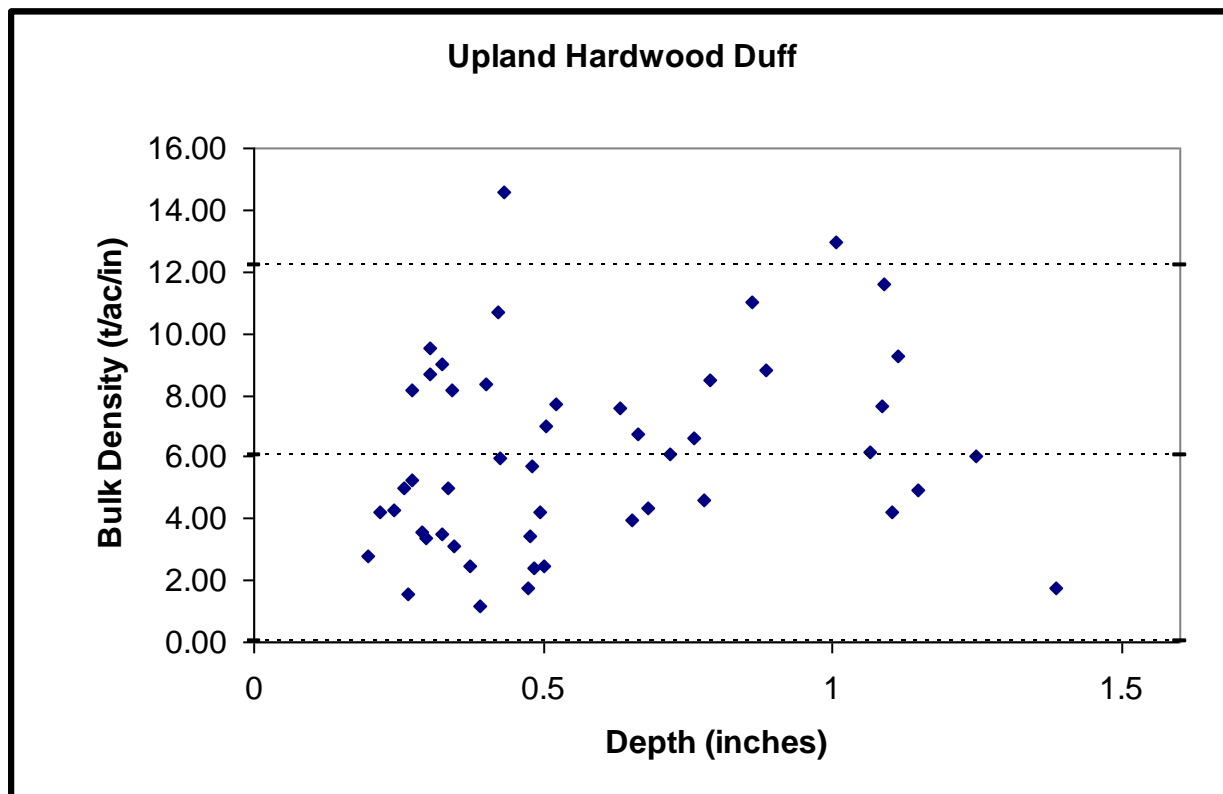| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Upland hardwood								
	Litter			**0.4**	**2.2**	**0.9**	**4.1**	**0.8**
		5-20		1.1	1.6	1.5	2.0	0.2
			10+	1.1	1.6	1.5	2.0	0.2
		21-40		0.5	2.1	0.9	4.1	0.8
			3-10	0.5	2.1	0.9	3.3	0.8
			10+	0.5	1.9	1.1	4.1	0.9
		40+		0.4	2.2	0.9	4.1	0.8
			0-3	0.4	2.2	0.9	3.7	0.8
			3-10	0.6	2.2	0.9	3.3	0.8
			10+	0.4	1.3	1.2	4.1	0.8

Figure B4a. Upland hardwood litter samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table B4b. Upland hardwood duff data by age class (yrs) and rough age (yrs).

Forest Type	Sample Type	Age Class (years)	Rough Age (years)	Min Sample Depth (in)	Max Sample Depth (in)	Min Bulk Density (t/ac/in)	Max Bulk Density (t/ac/in)	StdDev of Bulk Density
Upland hardwood								
	Duff			**0.2**	**1.4**	**1.1**	**14.6**	**3.1**
		5-20		0.3	0.5	1.8	3.4	1.1
			10+	0.3	0.5	1.8	3.4	1.1
		21-40		0.2	1.2	1.1	11.6	2.8
			3-10	0.2	1.1	2.5	9.0	2.0
			10+	0.2	1.2	1.1	11.6	3.1
		40+		0.2	1.4	1.7	14.6	3.3
			0-3	0.2	1.4	1.7	14.6	3.5
			3-10	0.3	1.1	4.2	8.5	1.9
			10+	0.3	1.1	2.4	11.0	3.6

Figure B4b. Upland hardwood duff samples by bulk density (t/ac/in) and average depth (in). Trend lines show +/- two standard deviations of bulk density.

Table C1. Loblolly and slash pine average depth (in) by age class (yrs) and rough age (yrs).

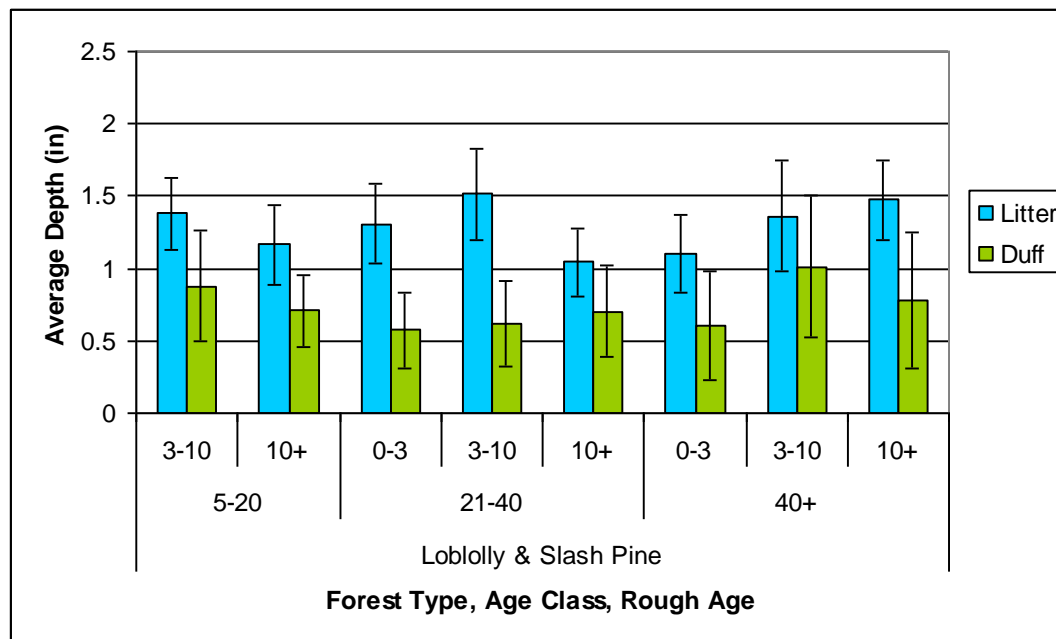| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Sample Depth (in)	SD
Loblolly & Slash Pine				227	2.0	
	Litter			124	1.3	0.3
		5-20		32	1.2	0.3
			3-10	12	1.4	0.2
			10+	20	1.2	0.3
		21-40		44	1.3	0.3
			0-3	12	1.3	0.3
			3-10	16	1.5	0.3
			10+	16	1.0	0.2
		40+		48	1.3	0.3
			0-3	16	1.1	0.3
			3-10	16	1.4	0.4
			10+	16	1.5	0.3
	Duff			103	0.7	0.4
		5-20		27	0.8	0.3
			3-10	12	0.9	0.4
			10+	15	0.7	0.3
		21-40		38	0.6	0.3
			0-3	8	0.6	0.3
			3-10	15	0.6	0.3
			10+	15	0.7	0.3
		40+		38	0.8	0.5
			0-3	10	0.6	0.4
			3-10	15	1.0	0.5
			10+	13	0.8	0.5

Figure C1. Loblolly and slash pine average depth (in) by age class (yrs) and rough age (yrs).

Table C2. Longleaf pine average depth (in) by age class (yrs) and rough age (yrs).

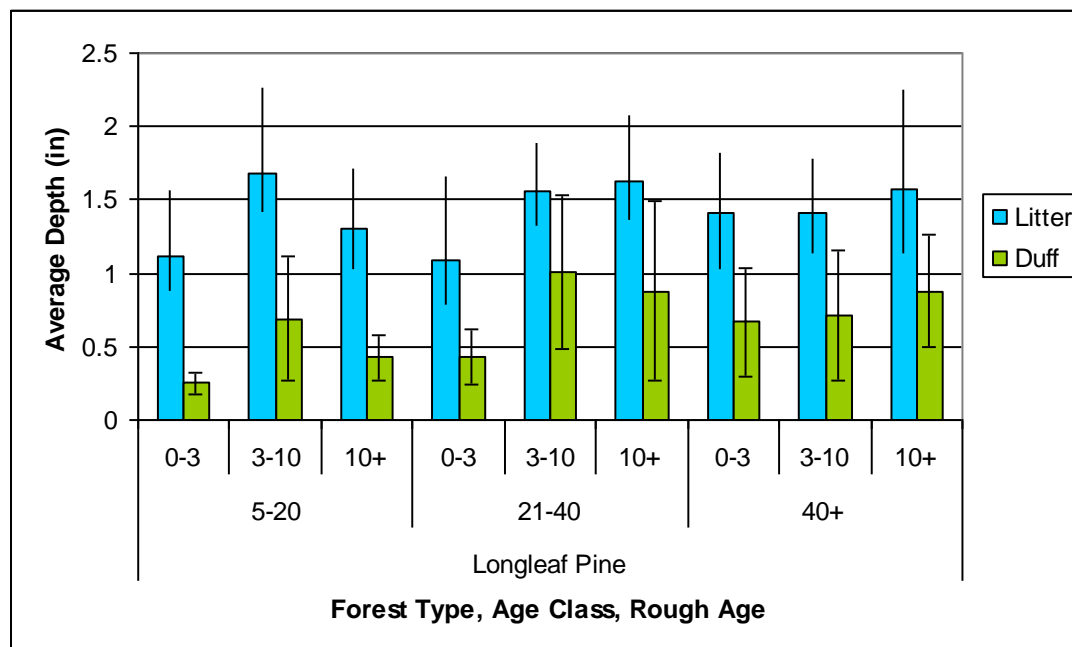| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Sample Depth (in)	SD
Longleaf pine				202	2.1	
	Litter			124	1.4	0.5
		5-20		36	1.4	0.5
			0-3	12	1.1	0.5
			3-10	12	1.7	0.6
			10+	12	1.3	0.4
		21-40		40	1.4	0.5
			0-3	12	1.1	0.6
			3-10	16	1.6	0.3
			10+	12	1.6	0.5
		40+		48	1.5	0.5
			0-3	16	1.4	0.4
			3-10	16	1.4	0.4
			10+	16	1.6	0.7
	Duff			78	0.7	0.4
		5-20		18	0.6	0.4
			0-3	2	0.2	0.1
			3-10	10	0.7	0.4
			10+	6	0.4	0.2
		21-40		23	0.9	0.5
			0-3	5	0.4	0.2
			3-10	14	1.0	0.5
			10+	4	0.9	0.6
		40+		37	0.8	0.4
			0-3	11	0.7	0.4
			3-10	13	0.7	0.4
			10+	13	0.9	0.4

Figure C2. Longleaf pine average depth (in) by age class (yrs) and rough age (yrs).

Table C3. Pine and hardwood mix average depth (in) by age class (yrs) and rough age (yrs).

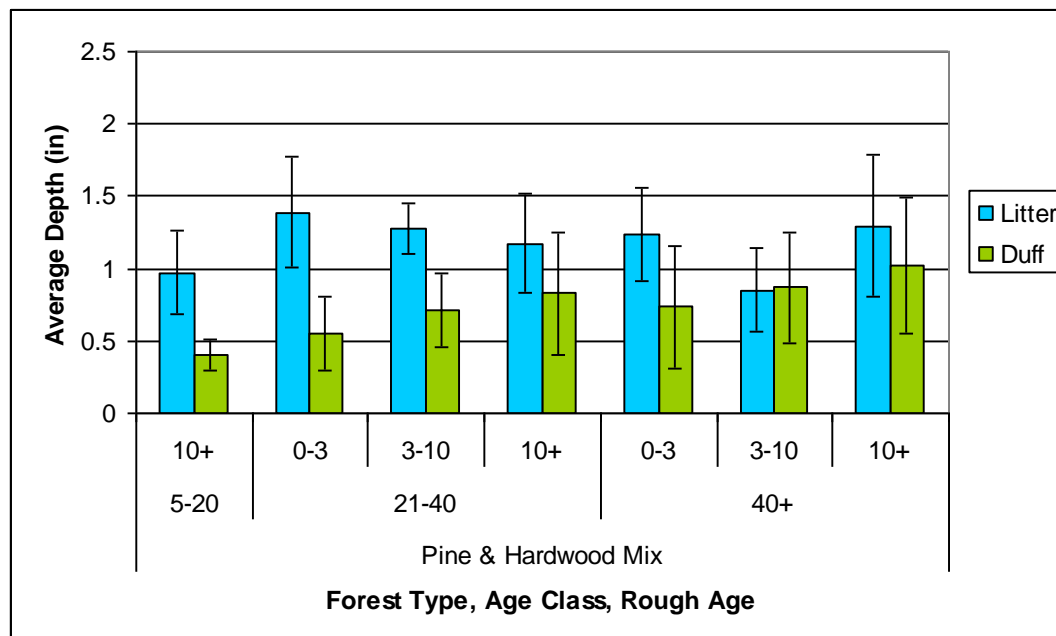| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Sample Depth (in)	SD
Pine & Hardwood Mix				95	2.0	
	Litter			56	1.2	0.4
		5-20		8	1.0	0.3
			10+	8	1.0	0.3
		21-40		16	1.3	0.3
			0-3	8	1.4	0.4
			3-10	4	1.3	0.2
			10+	4	1.2	0.3
		40+		32	1.2	0.4
			0-3	8	1.2	0.3
			3-10	8	0.9	0.3
			10+	16	1.3	0.5
	Duff			39	0.8	0.4
		5-20		4	0.4	0.1
			10+	4	0.4	0.1
		21-40		14	0.7	0.3
			0-3	6	0.5	0.3
			3-10	4	0.7	0.3
			10+	4	0.8	0.4
		40+		21	0.9	0.4
			0-3	4	0.7	0.4
			3-10	7	0.9	0.4
			10+	10	1.0	0.5

Figure C3. Pine and hardwood mix average depths (in) by age class (yrs) and rough age (yrs).

Table C4. Upland hardwood average depth (in) by age class (yrs) and rough age (yrs).

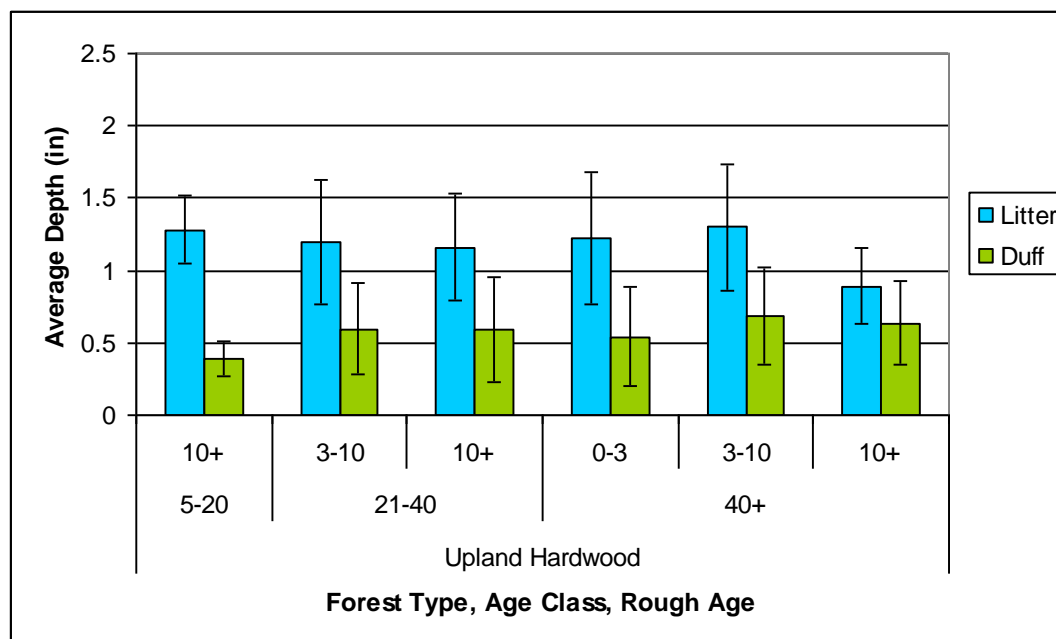| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Sample Depth (in)	SD
Upland Hardwood				133	1.8	
	Litter			84	1.2	0.4
		5-20		4	1.3	0.2
			10+	4	1.3	0.2
		21-40		28	1.2	0.4
			3-10	12	1.2	0.4
			10+	16	1.2	0.4
		40+		52	1.2	0.4
			0-3	28	1.2	0.5
			3-10	12	1.3	0.4
			10+	12	0.9	0.3
	Duff			49	0.6	0.3
		5-20		2	0.4	0.1
			10+	2	0.4	0.1
		21-40		20	0.6	0.3
			3-10	7	0.6	0.3
			10+	13	0.6	0.4
		40+		27	0.6	0.3
			0-3	15	0.5	0.3
			3-10	4	0.7	0.3
			10+	8	0.6	0.3

Figure C4. Upland hardwood average depth (in) by age class (yrs) and rough age (yrs).

Table C5. Average depth (in) for forest types by age class (yrs).

Forest Type	Sample Type	Age Class (years)	n	Average Sample Depth (in)	SD
Loblolly & Slash Pine			**227**	**2.0**	
	Litter		**124**	**1.3**	**0.3**
		5-20	32	1.2	0.3
		21-40	44	1.3	0.3
		3.0	48	1.3	0.3
	Duff		**103**	**0.7**	**0.4**
		5-20	27	0.8	0.3
		21-40	38	0.6	0.3
		3.0	38	0.8	0.5
Longleaf Pine			**202**	**2.1**	
	Litter		**124**	**1.4**	**0.5**
		5-20	36	1.4	0.5
		21-40	40	1.4	0.5
		3.0	48	1.5	0.5
	Duff		**78**	**0.7**	**0.4**
		5-20	18	0.6	0.4
		21-40	23	0.9	0.5
		3.0	37	0.8	0.4
Pine & Hardwood Mix			**95**	**2.0**	
	Litter		**56**	**1.2**	**0.4**
		5-20	8	1.0	0.3
		21-40	16	1.3	0.3
		3.0	32	1.2	0.4
	Duff		**39**	**0.8**	**0.4**
		5-20	4	0.4	0.1
		21-40	14	0.7	0.3
		3.0	21	0.9	0.4
Upland Hardwood			**133**	**1.8**	
	Litter		**84**	**1.2**	**0.4**
		5-20	4	1.3	0.2
		21-40	28	1.2	0.4
		3.0	52	1.2	0.4
	Duff		**49**	**0.6**	**0.3**
		5-20	2	0.4	0.1
		21-40	20	0.6	0.3
		3.0	27	0.6	0.3

Table C6. Average depth for forest types (in) by rough age (yrs).

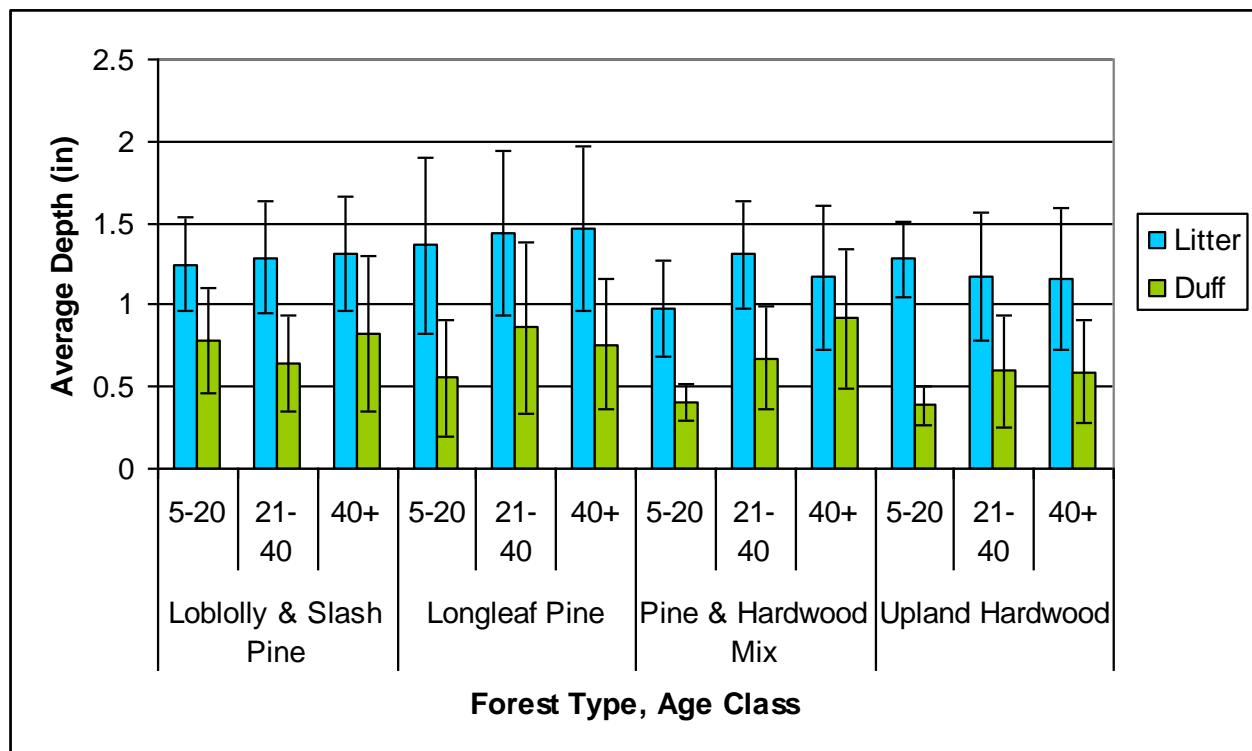| Forest Type	Sample Type	Rough Age (years)	n	Average Sample Depth (in)	SD
Loblolly & Slash Pine			**227**	**2.0**	
	Litter		**124**	**1.3**	**0.3**
		0-3	28	1.2	0.3
		3-10	44	1.4	0.3
		10+	52	1.2	0.3
	Duff		**103**	**0.7**	**0.4**
		0-3	18	0.6	0.3
		3-10	42	0.8	0.4
		10+	43	0.7	0.3
Longleaf Pine			**202**	**2.1**	
	Litter		**124**	**1.4**	**0.5**
		0-3	40	1.2	0.5
		3-10	44	1.5	0.4
		10+	40	1.5	0.6
	Duff		**78**	**0.7**	**0.4**
		0-3	18	0.6	0.3
		3-10	37	0.8	0.5
		10+	23	0.8	0.4
Pine & Hardwood Mix			**95**	**2.0**	
	Litter		**56**	**1.2**	**0.4**
		0-3	16	1.3	0.4
		3-10	12	1.0	0.3
		10+	28	1.2	0.4
	Duff		**39**	**0.8**	**0.4**
		0-3	10	0.6	0.3
		3-10	11	0.8	0.3
		10+	18	0.8	0.5
Upland Hardwood			**133**	**1.8**	
	Litter		**84**	**1.2**	**0.4**
		0-3	28	1.2	0.5
		3-10	24	1.2	0.4
		10+	32	1.1	0.3
	Duff		**49**	**0.6**	**0.3**
		0-3	15	0.5	0.3
		3-10	11	0.6	0.3
		10+	23	0.6	0.3

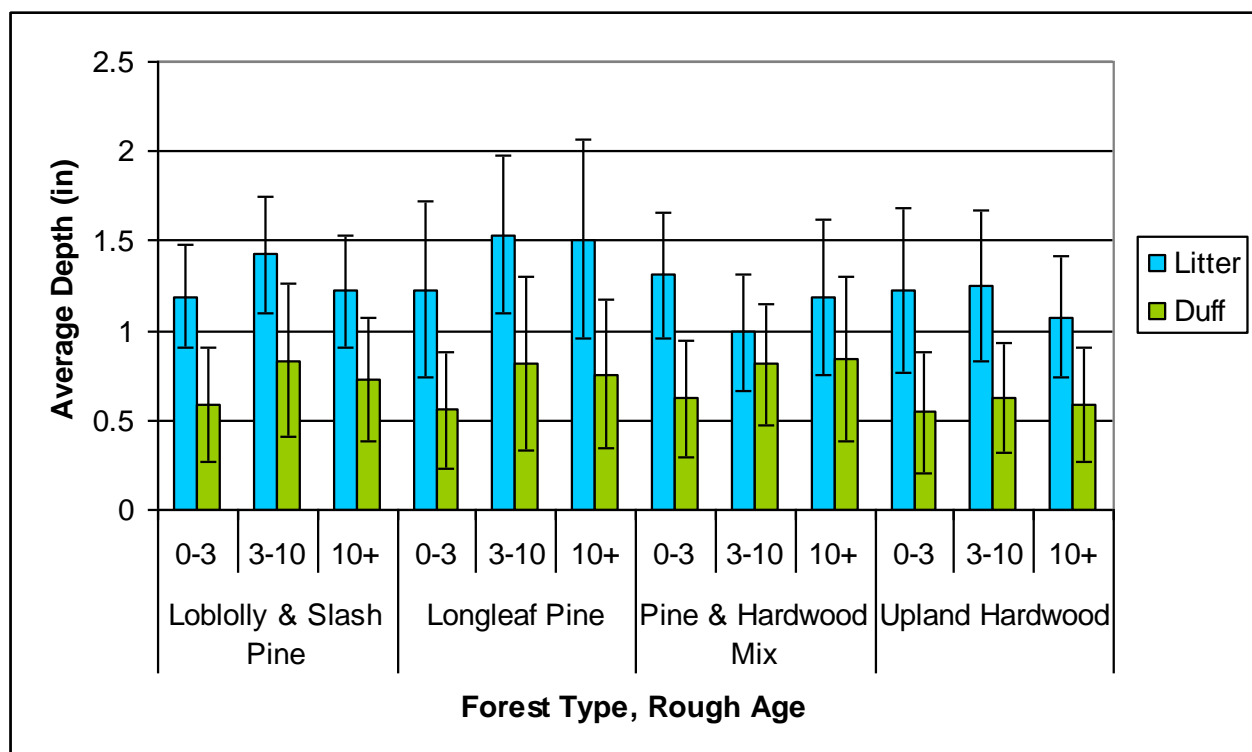**Figure C5.** Average depth (in) for forest types by age class (yrs).

Figure C6. Average depth (in) for forest types by rough age (yrs).

Table C7. Forest type average depths (in).

Forest Type	Sample Type	n	Average Depth (in)	SD
Loblolly & Slash Pine		**227**	**2.0**	
	Litter	124	1.3	0.3
	Duff	103	0.7	0.4
Longleaf Pine		**202**	**2.1**	
	Litter	124	1.4	0.5
	Duff	78	0.7	0.4
Pine & Hardwood Mix		**95**	**2.0**	
	Litter	56	1.2	0.4
	Duff	39	0.8	0.4
Upland Hardwood		**133**	**1.8**	
	Litter	84	1.2	0.4
	Duff	49	0.6	0.3
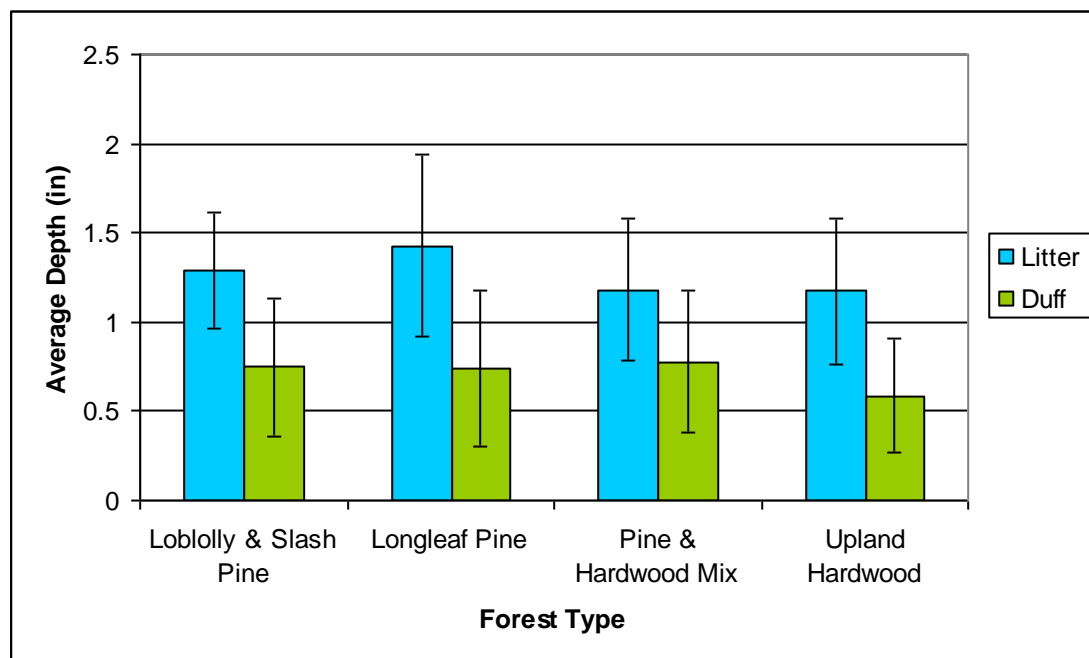
Figure C7. Forest type average depth (in.).

Table D1. Loblolly and slash pine average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

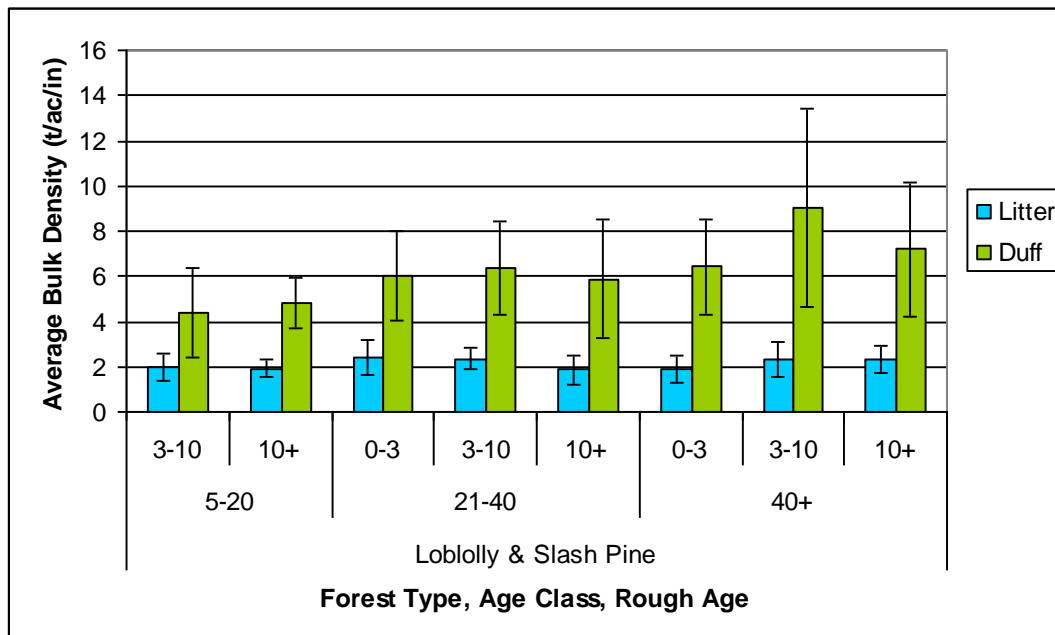| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Bulk Density (t/ac/in)	SD
Loblolly & Slash Pine				227	8.4	
	Litter			124	2.1	0.6
		5-20		32	2.0	0.5
			3-10	12	2.0	0.6
			10+	20	1.9	0.4
		21-40		44	2.2	0.7
			0-3	12	2.4	0.8
			3-10	16	2.4	0.5
			10+	16	1.9	0.6
		40+		48	2.2	0.7
			0-3	16	1.9	0.6
			3-10	16	2.3	0.8
			10+	16	2.3	0.6
	Duff			103	6.3	2.9
		5-20		27	4.6	1.5
			3-10	12	4.4	2.0
			10+	15	4.8	1.1
		21-40		38	6.1	2.2
			0-3	8	6.0	2.0
			3-10	15	6.4	2.1
			10+	15	5.9	2.6
		40+		38	7.7	3.5
			0-3	10	6.4	2.1
			3-10	15	9.0	4.4
			10+	13	7.2	3.0

Figure D1. Loblolly and slash pine average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

Table D2. Longleaf pine average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

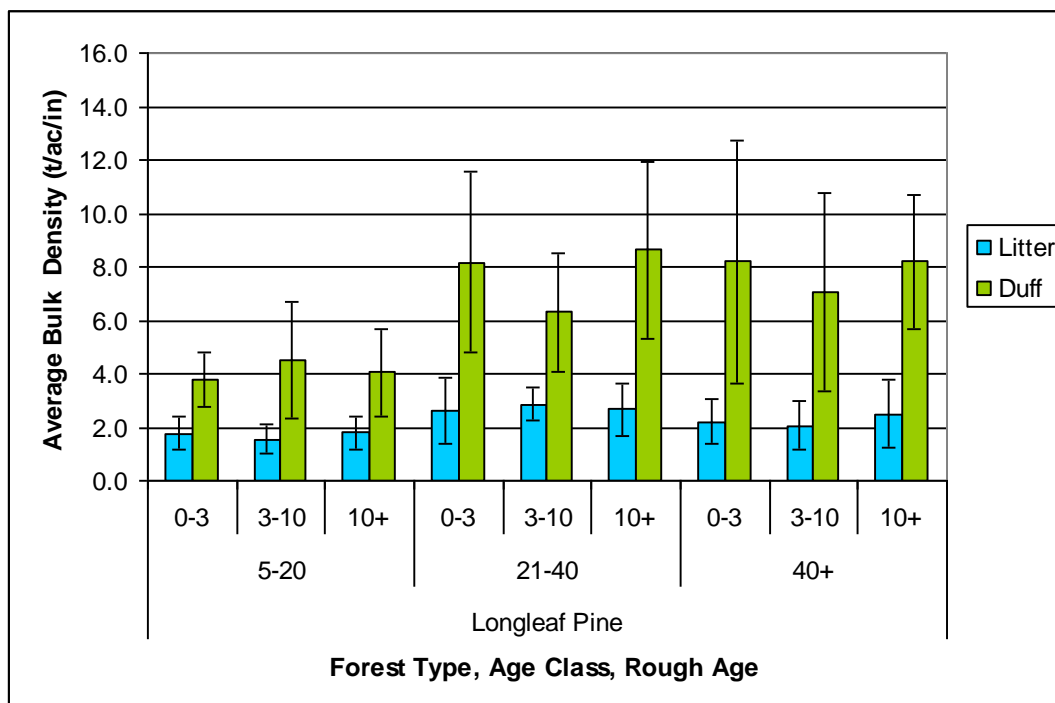| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Bulk Density (t/ac/in)	SD
Longleaf pine				202	9.1	
	Litter			124	2.3	1.0
		5-20		36	1.7	0.6
			0-3	12	1.8	0.6
			3-10	12	1.6	0.6
			10+	12	1.8	0.6
		21-40		40	2.7	0.9
			0-3	12	2.6	1.2
			3-10	16	2.9	0.6
			10+	12	2.7	1.0
		40+		48	2.3	1.0
			0-3	16	2.2	0.8
			3-10	16	2.1	0.9
			10+	16	2.5	1.3
	Duff			78	6.8	3.3
		5-20		18	4.3	1.8
			0-3	2	3.8	1.0
			3-10	10	4.5	2.2
			10+	6	4.1	1.6
		21-40		23	7.1	2.8
			0-3	5	8.2	3.4
			3-10	14	6.3	2.2
			10+	4	8.6	3.3
		40+		37	7.8	3.6
			0-3	11	8.2	4.5
			3-10	13	7.0	3.7
			10+	13	8.2	2.5

Figure D2. Longleaf pine average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

Appendix D – Bulk Density   36

Figure D3. Pine and hardwood mix average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

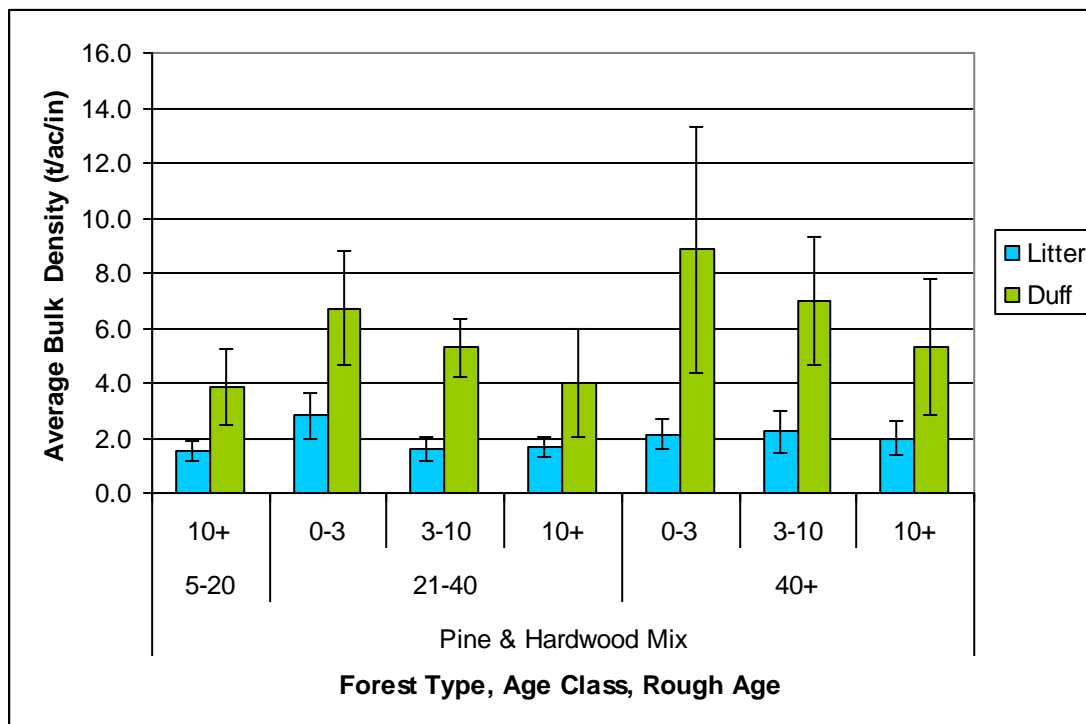| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Bulk Density (t/ac/in)	SD
Pine & Hardwood Mix				95	7.9	
	Litter			56	2.0	0.7
		5-20		8	1.5	0.4
			10+	8	1.5	0.4
		21-40		16	2.2	0.9
			0-3	8	2.8	0.8
			3-10	4	1.6	0.5
			10+	4	1.7	0.4
		40+		32	2.1	0.6
			0-3	8	2.1	0.5
			3-10	8	2.2	0.7
			10+	16	2.0	0.6
	Duff			39	5.9	2.7
		5-20		4	3.9	1.4
			10+	4	3.9	1.4
		21-40		14	5.5	2.0
			0-3	6	6.7	2.1
			3-10	4	5.3	1.1
			10+	4	4.0	2.0
		40+		21	6.5	3.1
			0-3	4	8.8	4.5
			3-10	7	7.0	2.3
			10+	10	5.3	2.5

Figure D3. Pine and hardwood mix average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

Table D4. Upland hardwood average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

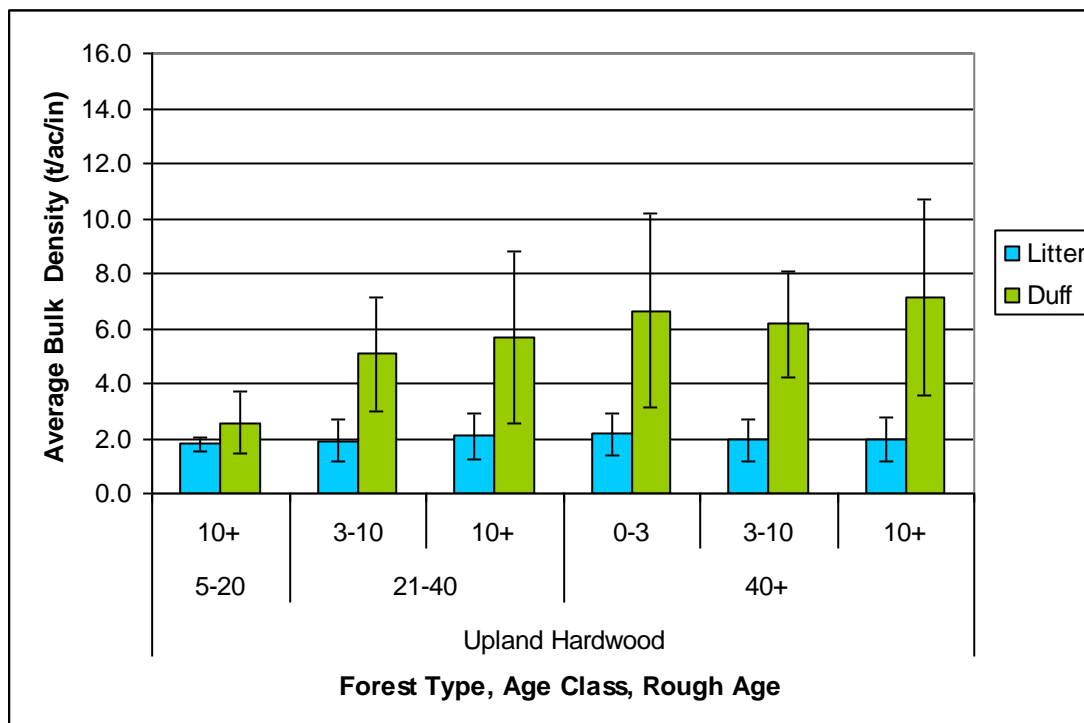| Forest Type	Sample Type	Age Class (years)	Rough Age (years)	n	Average Bulk Density (t/ac/in)	SD
Upland hardwood				133	8.0	
	Litter			84	2.0	0.8
		5-20		4	1.8	0.2
			10+	4	1.8	0.2
		21-40		28	2.0	0.8
			3-10	12	1.9	0.8
			10+	16	2.1	0.9
		40+		52	2.1	0.8
			0-3	28	2.2	0.8
			3-10	12	1.9	0.8
			10+	12	2.0	0.8
	Duff			49	6.0	3.1
		5-20		2	2.6	1.1
			10+	2	2.6	1.1
		21-40		20	5.5	2.8
			3-10	7	5.1	2.0
			10+	13	5.7	3.1
		40+		27	6.7	3.3
			0-3	15	6.6	3.5
			3-10	4	6.2	1.9
			10+	8	7.1	3.6

Figure D4. Upland hardwood average bulk density (t/ac/in) by age class (yrs) and rough age (yrs).

Figure D5. Forest type average bulk density (t/ac/in) by age class (yrs).

Forest Type	Sample Type	Age Class (years)	n	Average Bulk Density (t/ac/in)	SD
Loblolly & Slash Pine			**227**	**8.4**	
	Litter		**124**	**2.1**	**0.6**
		5-20	32	2.0	0.5
		21-40	44	2.2	0.7
		40+	48	2.2	0.7
	Duff		**103**	**6.3**	**2.9**
		5-20	27	4.6	1.5
		21-40	38	6.1	2.2
		40+	38	7.7	3.5
Longleaf Pine			**202**	**9.1**	
	Litter		**124**	**2.3**	**1.0**
		5-20	36	1.7	0.6
		21-40	40	2.7	0.9
		40+	48	2.3	1.0
	Duff		**78**	**6.8**	**3.3**
		5-20	18	4.3	1.8
		21-40	23	7.1	2.8
		40+	37	7.8	3.6
Pine & Hardwood Mix			**95**	**7.9**	
	Litter		**56**	**2.0**	**0.7**
		5-20	8	1.5	0.4
		21-40	16	2.2	0.9
		40+	32	2.1	0.6
	Duff		**39**	**5.9**	**2.7**
		5-20	4	3.9	1.4
		21-40	14	5.5	2.0
		40+	21	6.5	3.1
Upland Hardwood			**133**	**8.0**	
	Litter		**84**	**2.0**	**0.8**
		5-20	4	1.8	0.2
		21-40	28	2.0	0.8
		40+	52	2.1	0.8
	Duff		**49**	**6.0**	**3.1**
		5-20	2	2.6	1.1
		21-40	20	5.5	2.8
		40+	27	6.7	3.3

Figure D6. Forest type average bulk density (t/ac/in) by rough age (yrs).

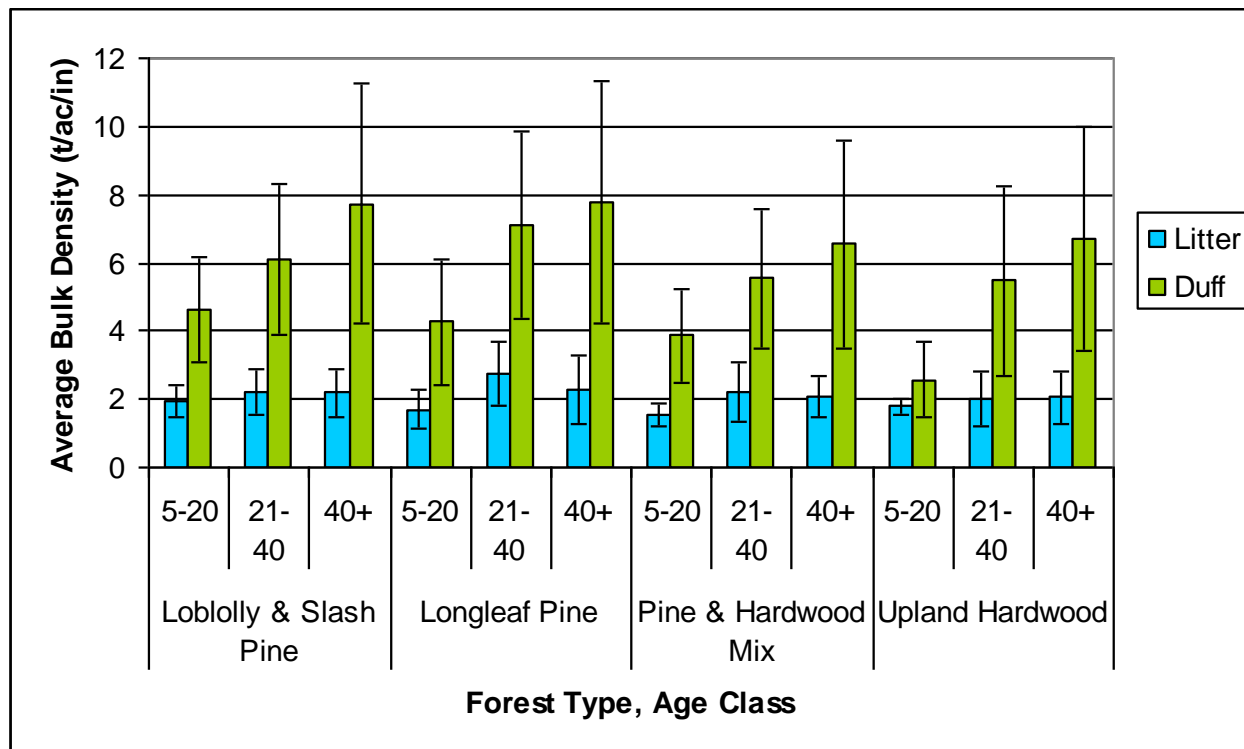| Forest Type	Sample Type	Rough Age (years)	n	Average Bulk Density (t/ac/in)	SD
Loblolly & Slash Pine			227	8.4	
	Litter		124	2.1	0.6
		0-3	28	2.1	0.7
		3-10	44	2.3	0.6
		10+	52	2.0	0.6
	Duff		103	6.3	2.9
		0-3	18	6.2	2.0
		3-10	42	6.8	3.5
		10+	43	5.9	2.5
Longleaf Pine			202	9.1	
	Litter		124	2.3	1.0
		0-3	40	2.2	1.0
		3-10	44	2.2	0.9
		10+	40	2.3	1.1
	Duff		78	6.8	3.3
		0-3	18	7.7	4.1
		3-10	37	6.1	2.9
		10+	23	7.2	3.0
Pine & Hardwood Mix			95	7.9	
	Litter		56	2.0	0.7
		0-3	16	2.5	0.8
		3-10	12	2.0	0.7
		10+	28	1.8	0.5
	Duff		39	5.9	2.7
		0-3	10	7.6	3.2
		3-10	11	6.4	2.1
		10+	18	4.7	2.2
Upland Hardwood			133	8.0	
	Litter		84	2.0	0.8
		0-3	28	2.2	0.8
		3-10	24	1.9	0.8
		10+	32	2.0	0.8
	Duff		49	6.0	3.1
		0-3	15	6.6	3.5
		3-10	11	5.5	2.0
		10+	23	5.9	3.3

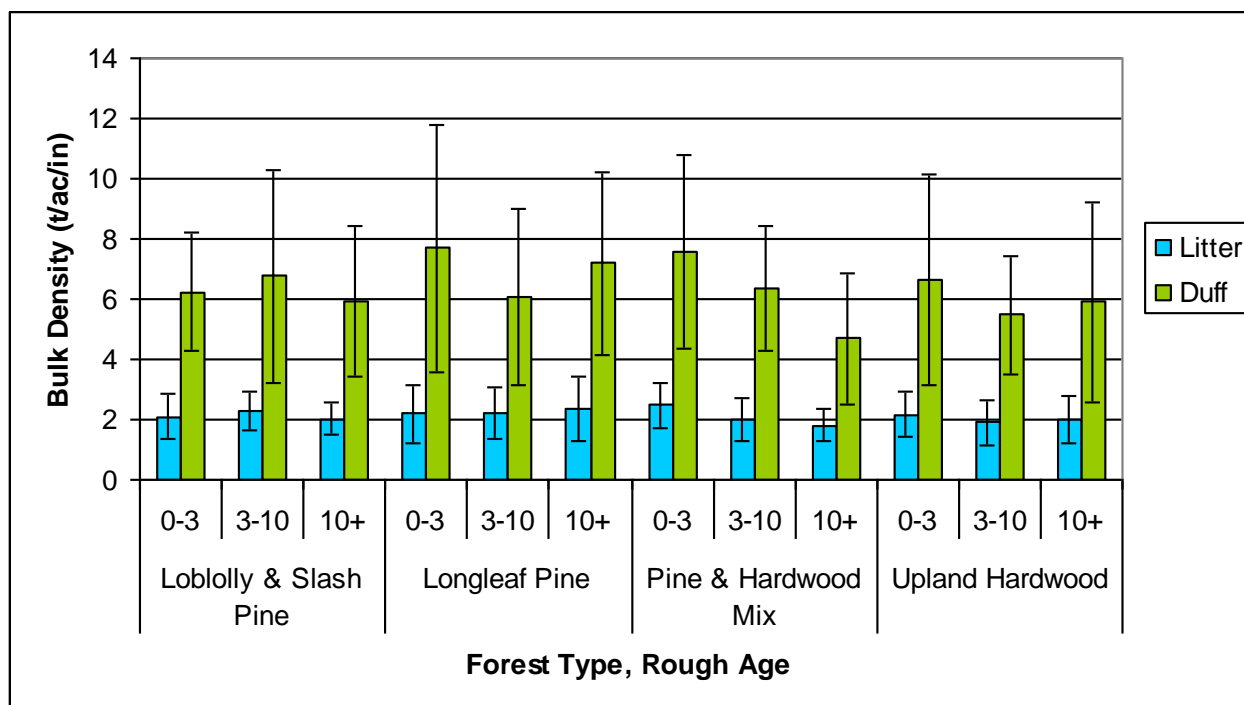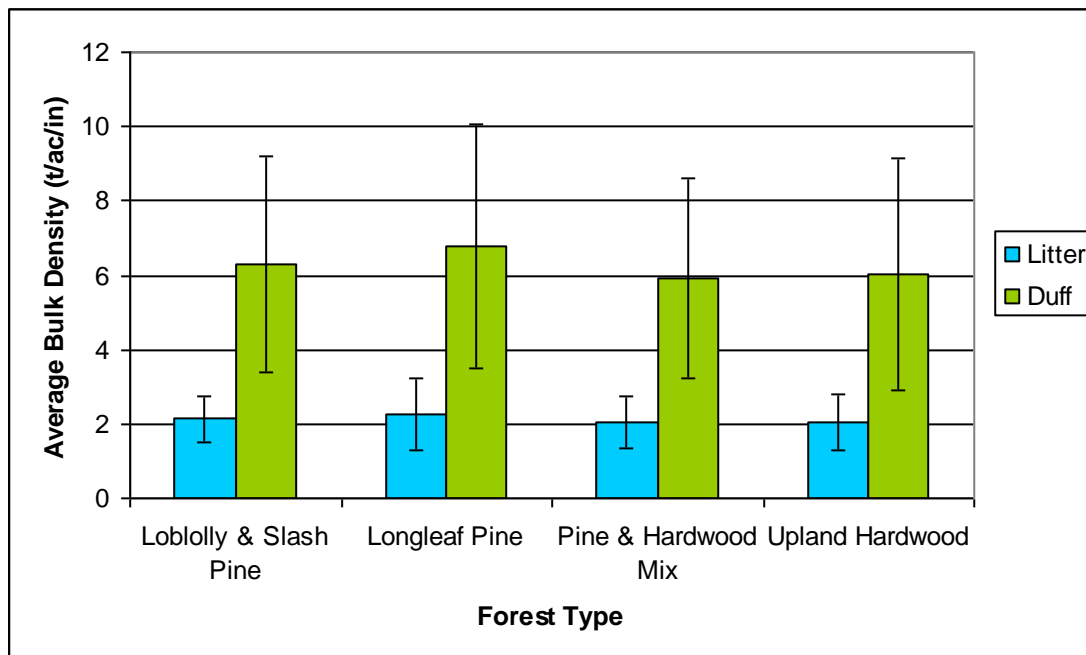**Figure D5.** Forest type average bulk density (t/ac/in) by age class (yrs).

Figure D6. Forest type average bulk density (t/ac/in) by rough age (yrs).

Table D7. Forest type average bulk density (t/ac/in).

Forest Type	Sample Type	n	Average Bulk Density (t/ac/in)	SD
Loblolly & Slash Pine		**227**	**8.4**	
	Litter	124	2.1	0.6
	Duff	103	6.3	2.9
Longleaf pine		**202**	**9.1**	
	Litter	124	2.3	1.0
	Duff	78	6.8	3.3
Pine & Hardwood Mix		**95**	**7.9**	
	Litter	56	2.0	0.7
	Duff	39	5.9	2.7
Upland hardwood		**133**	**8.0**	
	Litter	84	2.0	0.8
	Duff	49	6.0	3.1

Figure D7. Forest type average bulk density (t/ac/in).