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Temporal Analysis of Field, SSURGO, and LiDAR Derived Site Indices in the Southeastern U.S.

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TEMPORAL ANALYSIS OF FIELD, SSURGO, AND LIDAR DERIVEDSITE INDICES IN THE SOUTHEASTERN U.S.

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by
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Accepted by:
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Dr. Lawrence Gering
Dr. Christopher Post

ABSTRACT

Sustainable forest management requires accurate information about site index (SI, tree height at a base age). The objectives of this study were to compare site indices from field inventory data (2008-2009), Soil Survey Geographic Database (SSURGO), and Light Detection and Ranging (LiDAR, 2008), and to determine the uncertainty in the site indices from the southern part of the Clemson Experimental Forest. When LiDAR derived analysis were used to compare to SSURGO there were statistical differences for site indices for all of the tree species in this study: loblolly pine (*Pinus taeda*), scarlet oak (*Quercus coccinea*), shortleaf pine (*Pinus echinata*), white oak (*Quercus alba*), and yellow poplar (*Liriodendron tulipifera*). LiDAR has the potential to provide reliable and rapid estimates of site index variability within the soil map units. Loblolly pine and shortleaf pine had the greatest statistical differences with the LiDAR derived site indices being much larger than the SSURGO values. The results of this study indicate that a larger sample size for LiDAR is a better option to decrease variation, and that the map unit level may be the best option.

Keywords and abbreviations: basal area factor (BAF), Clemson Experimental Forest (CEF), climate change, diameter at breast height (DBH), forest inventory, Light Detection and Ranging (LiDAR), loblolly pine, site index (SI), soil inventory, Soil Survey Geographic Database (SSURGO)

DEDICATION

I would like to dedicate this thesis to Steve Ham, Sherry Dalton, Larry Grimes, and Sheila Fernandez. Without their support and help along the way, I would not have been able to get through college, or be the person that I am today.

ACKNOWLEDGMENTS

I want to express my sincere appreciation to my committee: Dr. Elena Mikhailova, Dr. Lawrence Gering, and Dr. Christopher Post for their help and support throughout this study. I wish to thank and acknowledge Benjamin Kendall and Knight Cox for providing the forest inventory cruise data for the Clemson Experimental Forest, the Anderson County Assessor's Office and the South Carolina Department of Natural Resources for the LiDAR datasets, and Dr. William Bridges for the help with the statistics. Financial support for this project was provided by Clemson University. Technical Contribution No. 6069 of the Clemson University Experiment Station.

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CHAPTER ONE

INTRODUCTION

Statement of the Problem

Soil quality is the most important factor in assessing forest productivity and forest management decisions (Hamilton, 2007). Concerns about the effects of global climate change have triggered intensive research over recent decades on the impacts of land use on biomass production in forest ecosystems (Poudel et al., 2011). The temperature increase in higher latitudes associated with global warming may stimulate forest production due to longer growing season and more favorable conditions for photosynthesis (Bergh et al., 2003; Poudel et al., 2011). Several studies predicted higher forest productivity (by 10-30% in the next 100 years), reduced length of rotation periods by 5-10 years, and increased carbon stocks (Pussinen et al., 2002; Kirilenko and Sedjo, 2007; Eggers et al., 2008; Subedi et al., 2009). Current research on climate change over the continental United States using a moisture index (Grundstein, 2009) showed that the southeastern part of the country has been getting wetter, and cooler. The question, then, is how do these combined changes affect forest productivity and site index in the Southeastern U.S.?

Literature Review

Site index (SI) is defined as the total height to which dominant trees of a given species will grow on a given site at some index age, usually 50 years in the Southeast (Hamilton, 2007). Site index is commonly used to evaluate site productivity and is provided through the SSURGO (Soil Survey Staff, 2013). The site index can be determined by two methods: 1) from the site index curves using accurate age and height measurements or 2) from the tables in the soil survey (Baker and Langdon, 2012). For example, site index for loblolly pine at age 50 can vary from 60 to 120 feet depending on soil and other site characteristics. Site index curves were developed in various time periods ranging from early 1920's to late 1980's (National Register of Site Index, 2013). Site index does not provide the measure of uncertainty due to soil, site, and climate variability.

South Carolina has diverse soil coverage. Seven of twelve soil orders occur in South Carolina: Histosols, Entisols, Inceptisols, Mollisols, Alfisols, Spodosols, and Ultisols. Lynchburg is a state soil of South Carolina (it belongs to the order of Ultisols) because it is a prime farmland and has a high site index for loblolly pine. Approximately four hundred soil series (of 21,000 soil series) occur in South Carolina. In the Southeastern U.S., soils in the Piedmont physiographic province are severely eroded and contain low quantities of soil C as a result of agricultural activity prior to 1940 (Dunn and Holladay, 1977; Richter et al., 1999). Conversion of degraded croplands to forests likely has increased terrestrial carbon stocks (Richter et al., 1999), although the magnitude of this increase and the impact of forest management on it are unclear because of the lack of long-term data and the high variability in existing soil and plant data. Impacts of land use and climate on site index are poorly understood. A previous study in the Pacific Northwest indicates LiDAR derived site indices correlate well with field site indices (Gatziolis, 2007).

Research Questions

- How reliable is the site index provided by SSURGO?
- Are site indices developed in the 1920's valid today?
- What are the ways to incorporate variability and uncertainty in the site index?
- Does climate change affect the site index in the SE of the United States?
- Can advanced techniques (e.g. SSURGO etc.) be used to evaluate and update site index in the SSURGO as needed?

Research Objectives

- Compare site indices from SSURGO to the most recent forest inventory cruise data;
- Compare site indices from SSURGO to LiDAR derived site indices;
- Conduct statistical analysis for any trends and to determine the uncertainty in the site indices.

CHAPTER TWO

MATERIALS AND METHODS

Study Area

The location for this study is the southern part, Anderson County (Figure 1) of the Clemson University Experimental Forest (CEF) in Clemson, SC (N 34° 41' 55.7", W 82° 52' 45.7") (Griffith et al., 2002). The CEF lies in the upper Piedmont region at the base of the foothills. The climate is generally mild and has four distinct seasons with annual precipitation averaging 54.01 inches with annual temperatures ranging from an average minimum temperature of 29.80°F in January to an average maximum annual temperature of 90.6°F in July (IDcide 2013). The CEF is divided into 15 divisions, which are sub-divided by compartment and then broken down to stand level. In total, the forest has more than 2,000 stands and 41 of them were used in this study (Tables 15-19). The entire forest is an intensively managed multi-use forest with research areas, natural areas, timber production areas, and wildlife managed areas. The cover type ranges from hardwood coves, upland hardwoods, mixed hardwood and pine, natural pines, to pine plantations (Forest inventory 2008-2009). The data for the study area were limited to the forest area in Anderson County. Attention was given to points that had field forest inventory (2008-2009), SSURGO, and LiDAR data (Table 1).

History of Ownership and Management

The CEF was previously eroded farm land before Clemson College began supervision of the lands in 1939 under an agreement with the federal government (Dunn and Holladay, 1977). In 1946 a forester, Norbert Goebel, was hired to manage the forestlands (Dunn and Holladay, 1977). Silvicultural practices (planting, thinning and harvests) to improve the timber production, wildlife habitat and water quality were initiated. In 1954, the project was deeded to Clemson College, due to the efforts of U.S. Senators Charlie Daniel, Strom Thurmond, State Senator Edgar Brown and Dr. George H. Aull (Dunn and Holladay, 1977).

Forest Inventory

The cruise data were gathered from the forest inventory in 2008-2009 according to field forest specification for the CEF (Table 2). It was inventoried as point-level data measured in cubic feet. The point location was determined by a resource grade GPS and previous point locations on the forest. Each point was measured on a tree level basis. At each point trees were tallied using a BAF (basal area factor) = 10 prism. For each tally tree species, diameter at breast height (DBH) (1 inch class), type of product, merchantable height, total height, the percent defect, and any comments about the tree were recorded. The trees were measured with a diameter tape and mechanical clinometer. Height measurements were obtained to the nearest foot and diameter DBH to the nearest 1-inch class (Table 2). The contractor provided the tree data for volume determinations. The points are numbered and correspond to a GPS location. Stand information was also available for the entire Clemson Experimental Forest as GIS and Excel spreadsheets. The amount of volume harvested for each stand and the date the stand was cut was also available. This allowed for any points to be nullified if stands were harvested after the 2008 LiDAR data were flown, or before the 2011 LiDAR data were flown.

Soil Inventory and Site Index from SSURGO

Soil Survey Geographic Database (SSURGO) tabular and spatial complete data were downloaded from http://soils.usda.gov/survey/geography/ssurgo/ for Anderson County, South Carolina. Site index is listed for various tree species at base age 25 or 50. The field inventory data were collected at base age 50. Therefore, this base age was used throughout the analysis. The forest inventory GIS data were used to spatially compare the SSURGO data to the study area (Figure 2). First, all the stands in the study area within Anderson County were selected using a county outline from ArcGIS and exported the file into NAD83 UTM Zone 17N meters. A “select by location” using the county outline as the source layer and selected the stands that are within the source layer was performed. The selection was then exported as a new layer. The spatial SSURGO map unit data layer was joined to the component key table by the map unit key in both attribute tables. Then the soil map unit table was joined to the forest productivity component table by the component key. The ACCESS database associated with the SSURGO data were then used and a report for site index was created and exported as an excel file. The Excel file was then edited to create one row for each map unit. The excel file was then exported to the project geodatabase as a single table and joined by the map unit symbol to the spatial

SSURGO data. Each Map unit symbol contained its own site indices for various tree species and was compared to the inventory data and LiDAR derived measurements.

Point to Plot Conversion

In order to be able to compare LiDAR to field data the point data (collected with a basal area factor (BAF) = 10 ft^2/ac prism) had to be converted to fixed radius plot data. The first step was to calculate the basal area (BA) for each inventoried tree. This was found using equation (1):

$$BA_{each\ tree} = 0.005454 * (DBH_{class})^2 \qquad (1)$$

where $BA_{each\ tree}$ is calculated in (ft^2/tree) and represents the per tree basal area for the point; and DBH_{class} (in) is the 1-inch diameter at base height (DBH) class for each tree on the point. Once $BA_{each\ tree}$ was calculated, the tree factor for each individual tree could be calculated. The equation for this calculation is:

$$F_t = \frac{F}{BA_{each\ tree}} \qquad (2)$$

where F_t is calculated in (Number of trees/ac) and represents the tree factor for each tree, F (ft^2/ac) is the BAF represented by the prism, and $BA_{each\ tree}$ is measured in (ft^2/tree). Once F was calculated for each tree, the total number of trees per acre for the entire point was calculated. This was found using the equation:

$$\frac{Trees}{acre} = \sum F_t \text{ each tree on the point} \qquad (3)$$

where $\frac{\text{Trees}}{\text{acre}}$ is calculated in (trees/ac) and represents the total number of trees per acre on a particular point, and F_t is measured in (trees/ac). The next step was to calculate the total basal area per acre for the point. This was found calculated using the equation:

$$\frac{\text{BA}}{\text{acre}} = \text{F} * \text{Number trees tallied on the point} \tag{4}$$

where $\frac{\text{BA}}{\text{acre}}$ represents the basal area per acre for the entire plot in (number of trees*ft^2/ac), and F (ft^2/ac) is the BAF of the prism used. With the $\frac{\text{BA}}{\text{acre}}$ calculated, the mean basal area for the mean tree on the plot was then calculated using the equation below:

$$\text{BA}_{\text{mean}} = \frac{\frac{\text{BA}}{\text{acre}}}{\frac{\text{Trees}}{\text{acre}}} \tag{5}$$

where BA_{mean} represents the basal area for the mean tree of a particular point in (ft^2/tree), and $\frac{\text{BA}}{\text{acre}}$ is measured in (number of trees*ft^2/ac), and $\frac{\text{Trees}}{\text{acre}}$ is measured in (number of trees/ac). After the basal area for the mean tree, calculate the DBH for the mean tree in the equation below:

$$\text{DBH}_{\text{mean}} = \sqrt{\frac{\text{BA}_{\text{mean}}}{0.005454}} \tag{6}$$

where DBH_{mean} represents the DBH for the mean tree of the point in (in), and BA_{mean} is measured in (ft^2/tree). The mean DBH was then used to calculate the radius for the plot in the equation below:

$$\text{R}_{\text{mean}} = \frac{\text{DBH}_{\text{mean}}}{\left[12 * \left(\frac{1}{33}\right)\right]} \tag{7}$$

Where R_{mean} represents the mean radius of the plot equivalent for each individual point centered at the location of the variable radius plot in (ft), and DBH_{mean} is measured in inches. The R_{mean} (ft) is then used to get the area represented by each plot in the equation below:

$$A_{mean} = \pi R_{mean}^{2} \tag{8}$$

where A_{mean} represents the average area of the plot for the average tree on the point in (ft^2), and R_{mean} is measured in (ft). All of the point-to-plot conversions were done in Excel.

Remote Sensing Data

Two LiDAR datasets flown over Anderson County, SC in 2007 and 2011 were used in this study and were collected by the South Carolina LiDAR Consortium. The first dataset (2007) was obtained from the South Carolina Department of Natural Resources, and is single return data with nominal point spacing of approximately 1.4m and was processed using Terrascan software. The second LiDAR dataset (2011) was obtained from Anderson County, SC Assessors office and had a nominal point spacing of 1.4m. This data were collected by Towill Inc. using an Optech Orion M-200 LiDAR system. The data were originally collected as waveform data and discrete pulses were extracted and provided in the dataset as up to 4 discrete returns per LiDAR pulse. Data were processed with Terrascan as well as the Terrasolid software suite.

Site Index Inventory by LiDAR

Newly flown, multi-return, LiDAR data are available for Pickens (5/2012), Anderson (8/2012) and Oconee counties (8/2012).

Anderson County LiDAR data from 2008 are already available (Figure 3).

Tree locations, heights and crown diameters were extracted from the LiDAR data using the TIFFS software package version 8.0 beta (Globalidar). This software uses the raw LAS files and tiles the raw data and filters out ground and non-ground returns. The filtered data are then used to derive a digital elevation model and canopy height model, which it subsequently uses to identify tree locations using watershed analysis techniques within Matlab based on individual tree crown structures (Chen, 2007).

The point-to-plot conversion radii were put into an Excel file and exported as a dbase file and added to ArcMap. The forest inventory spatial data were also added to ArcMap. Stands in Anderson County were added if they contained relevant information for determining LiDAR site index. The CEF points file are points corresponding with the stand data of the stands that they are in. The attribute table was joined to the Excel file based on the recognized number for the points in the CEF data and the point number in the dbase file with only matching records being kept. The new attribute table was exported to create a new shapefile. A buffer was then applied to create a polygon file with the plot radii from the point shapefile's radius (m) as the buffering distance.

LiDAR tree locations (points) were then added to ArcMap and extracted where only those trees contained inside the plots were kept. The tree locations are points that contain information on individual tree heights. Once the trees were extracted the next thing was to create an excel spreadsheet summarizing the LiDAR heights in each point and corresponding the age of the trees on the point to plot conversion and the SI species with the stand data. The summary sheet was then used to choose the proper SI species curves (Figures 4-8) to derive site indices for each point. Upland oaks (Figure 6) site index curves were used for scarlet oak.

The tallest tree on each point and the stand age were used to derive an SI from the SI Curves (interpolated/extrapolated between two curves) and added to the Excel sheet. The assumption of tree selection is that the tallest tree(s) will be the same specie as the SI specie of the stand from the CEF data. The mean and standard deviation on each LiDAR (2008) point were summarized by map unit and SI species. The procedures were repeated for the LiDAR (2011) dataset with the stand ages adjusted to the proper age. An observation was defined as a single point. The total number of points for a particular specie that were grouped together by matching criteria by map unit, stand number, or a combination of the two defined the sample size for the particular criteria.

After the plot data were summarized they were then summarized for entire map units in a similar manner. Stands were selected by their SI species from the point summary Excel file and exported as a new file. SSURGO soils map units were extracted by SI species from the point summary excel file. Each map unit within a stand was exported as an individual shapefile. Both LiDAR (2008) and LiDAR (2011) tree data were extracted by each individual map unit layer within a stand. Any stand that had trees from multiple files were selected and then merged together and exported as one file to properly select the correct amount of trees from each file. The sample from each stand was calculated as the tallest 5% of all trees, or the tallest 20, whichever was greatest. The stand age was then gathered in the same manner by the corresponding stand identification number. The height was then converted to a SI the same way as the plot data. This data was then added to its own excel file summarized by mean SI and standard deviation for each species in three ways: each stand number as its own occurrence in a map unit, each map unit within a stand, and by each map unit.

Statistical Analysis

The statistical analysis proceeded in three stages. The first stage was to calculate means and standard deviations of site indices of each species broken down by soil map unit for both plot level and soil map unit level and further break the map unit level data down by stand. The second stage was to compare the means to the SSURGO standard using a series of t-tests. The third stage was to convert R^2-values to t-values and compare using a series of t-tests. The reason for using the t-test is that it provided a direct test of the hypothesis that the mean value was different from the SSURGO in whichever direction that occurs. All calculations were performed in Excel.

CHAPTER THREE

RESULTS AND DISCUSSION

Soil Evaluation

Sixteen soil map units (soil order: Ultisols) were identified (Table 3). Map units CdB and CdC had the highest SI for loblolly pine (83 ft, base age 50). The lowest SI for loblolly pine was HwC2 (71 ft, base age 50). CdD had the highest SI for scarlet oak (81 ft, base age 50). The lowest SI for scarlet oak were map units MaC and MaE both had the lowest SI for scarlet oak (75 ft, base age 50). Map unit PaE had the highest site index for shortleaf pine (70 ft, base age 50). The lowest SI for shortleaf pine was map unit CcC2 (55 ft, base age 50). Map units MaD and MaE had the same SI for white oak (75 ft, base age 50). Map unit MaE had the highest SI for yellow poplar (96 ft, base age 50). The lowest SI for yellow poplar was map unit PaE (90 ft, base age 50).

Forest Inventory vs. SSURGO

Loblolly pine and shortleaf pine species were the only SI species at the forest inventory level that significantly differed from the SSURGO site indices. Ten out of the thirty one map unit and specie combinations were statistically different than the SSURGO site indices with 8 being higher. All the loblolly pine map units that were different were higher, and shortleaf pine was split with 2 being higher and 2 being lower (Tables 4A and 4B).

LiDAR Derived Plot Level vs. SSURGO

Almost half of the plot level LiDAR derived site indices were statistically different than the SSURGO SI (28 out of 57 total observations). The majority of the 2008 LiDAR plot map unit derived site indices were statistically different than the SSURGO site indices (16 out of 31 total observations) and occurred in each soil series. Ten out of the sixteen map unit symbols' species combinations LiDAR derived site indices were statistically lower than the SSURGO site indices occurring in all five species. The six map unit symbols that were higher occurred in loblolly pine (5 map unit symbols) and shortleaf pine (1 map unit symbol).

The 2011 LiDAR derived plot site indices were statistically different than the SSURGO site indices for all five species. The majority of the derived site indices that were statistically higher occurred mainly in loblolly pine species. Two shortleaf pine map unit symbol site indices were statistically lower with none being higher (Tables 4A and 4B) which was different than 2008. The high variability associated with using plot data can be seen in Figure 9. The variability could be caused from the small sample sizes in the plot data. Another contributing factor on the graph is all the species and all the map units are represented on the graph together.

LiDAR Derived Map Unit Level vs SSURGO

The majority of the standard deviations of the map unit level data were lower than the plot level data (Tables 4A and 4B). With the higher variability and small sample sizes in the plot level data it was necessary to take another approach and to use map unit level data which had greater sample sizes. The majority of the map unit level LiDAR derived mean site indices for the map unit symbols (2008, 2011, and 2008 and 2011 combined) were statistically higher than the SSURGO site indices and occurred in all five species across each soil series (Tables 4A and 4B). When looking at Tables 4A and 4B there were 6 combinations where LiDAR derived mean site indices were statistically lower than the SSURGO site indices. These occurred in loblolly pine (CbC and HaB), scarlet oak (MaE), and yellow poplar (CdC).

The site indices by map units were further broken down by stand within a map unit for further analysis. When loblolly SI was broken down by stand within a map unit the majority of the derived mean site indices are statistically higher than the SSURGO site indices except for map units CbC, CdC, HaB, and MaC (Tables 5A and 5B). This was different than what was summarized from Tables 4A and 4B, that CbC and HaB were the only two map units where the LiDAR derived mean site indices were statistically lower than SSURGO site indices.

Scarlet oak did not pick up any more map unit symbols that had observations indicating a statistically lower mean SI than when the map units were broken down into stands (Tables 6A and 6B). On the summary tables (Tables 4A and 4B) shortleaf pine did not have any map unit symbols with statistically lower LiDAR derived mean site indices than SSURGO site indices, but when broken down by stand within a map unit 4 map unit symbol LiDAR derived site indices (CbB, CbC, CdC, and CdD) were significantly lower than SSURGO site indices (Tables 7A and 7B).

Tables 4A, 4B, 8A, and 8B show white oak did not have any map unit symbols indicating that LiDAR derived mean site indices were statistically lower than SSURGO site indices. Yellow poplar map unit symbols broke down into stands indicated that one other LiDAR derived map unit symbol's SI was statistically lower than the SSURGO (CdD). Tables 10-14 (A and B for each) are intermediate tables showing where the numbers for Tables 4A and 4B came from. Each table is a single species.

Figure 10 shows the high variability in the relationship between SSURGO and forest inventory site indices. The variability is likely present due to the graph showing all species and all map units combined where site index is based on one tree species for one map unit where tree species have different growth patterns. Another possible contributing factor is that both are reported as one single number without a standard deviation.

There are a couple trends present. One trend is that LiDAR derived maximum heights (2008) are significantly higher than the forest inventory measured maximum heights. The model equation shows that in 2008 the LiDAR and forest inventory heights correlate well (Figure 11). Another trend is LiDAR derived maximum heights (2011) are significantly higher than the LiDAR derived maximum heights (2008) indicating growth has occurred (Figure 12). Tables 5B, 7B, and 9B show that some stands had negative growth and indicate a stand has had one of the following or combination of the following occur: the stand has been harvested, trees were lost to some sort of event, an overestimation of LiDAR derived tree heights in 2008, or an underestimation of LiDAR derived tree heights in 2011 has occurred. A contributing factor to the variability is more than likely the different growth patterns of each species (Figures 9-12).

CHAPTER FOUR

CONCLUSIONS

The objectives of this research were to compare site indices from SSURGO to the most recent forest inventory cruise data, compare site indices from SSURGO to LiDAR derived site indices, and conduct statistical analysis for any trends and to determine the uncertainty in the site indices. Site index is supposed to be static and not change. Tables 4A and 4B show the only two species that had a difference were loblolly and shortleaf pine. However, when LiDAR derived analysis was used to compare to SSURGO there were differences. There were statistical differences for site indices for all of the tree species in this study: loblolly pine, scarlet oak, shortleaf pine, white oak, and yellow poplar. This raises the question what methods can produce reliable and rapid estimates of site index?

LiDAR has the potential to provide reliable and rapid estimates of site index variability within the soil map unit (Tables 4A and 4B) unlike the field forest inventory data which provides limited and expensive data. Newly available free LiDAR data sets provide an opportunity to evaluate variability across thousands of soil map units and tree species combinations. Through the LiDAR analysis all the tree species had statistically different site indices than that recorded in SSURGO. The only way to accurately and cheaply answer the question if environmental and anthropogenic changes affect the site index in the SE of the United States is to determine tree heights and the associated variability across large spatial areas (with numerous soil map units and forest characteristics).

The only way to update and evaluate the site index is to have sufficient forest data which is possible through LiDAR analysis. Advanced genetics, different silvicultural practices, recent droughts, warmer temperatures, and other anthropogenic and environmental changes may be having an effect on SI. Even though SI is static, this study indicates there are statistical differences in SI from the LiDAR data which means that through environmental and anthropogenic changes, SI may be changing and more research is needed to understand the effects of these changes. The results of this study indicate that a larger sample size for LiDAR is a better option to decrease variation, and that the map unit level may be the best option.

There are some errors that arise using LiDAR. Ground sampling errors can occur due to dense closed canopy forests. Underestimation of tree height can also occur due to tree lean or when LiDAR returns capture the wrong tree apex. These errors are usually small (Gatziolis, 2007).

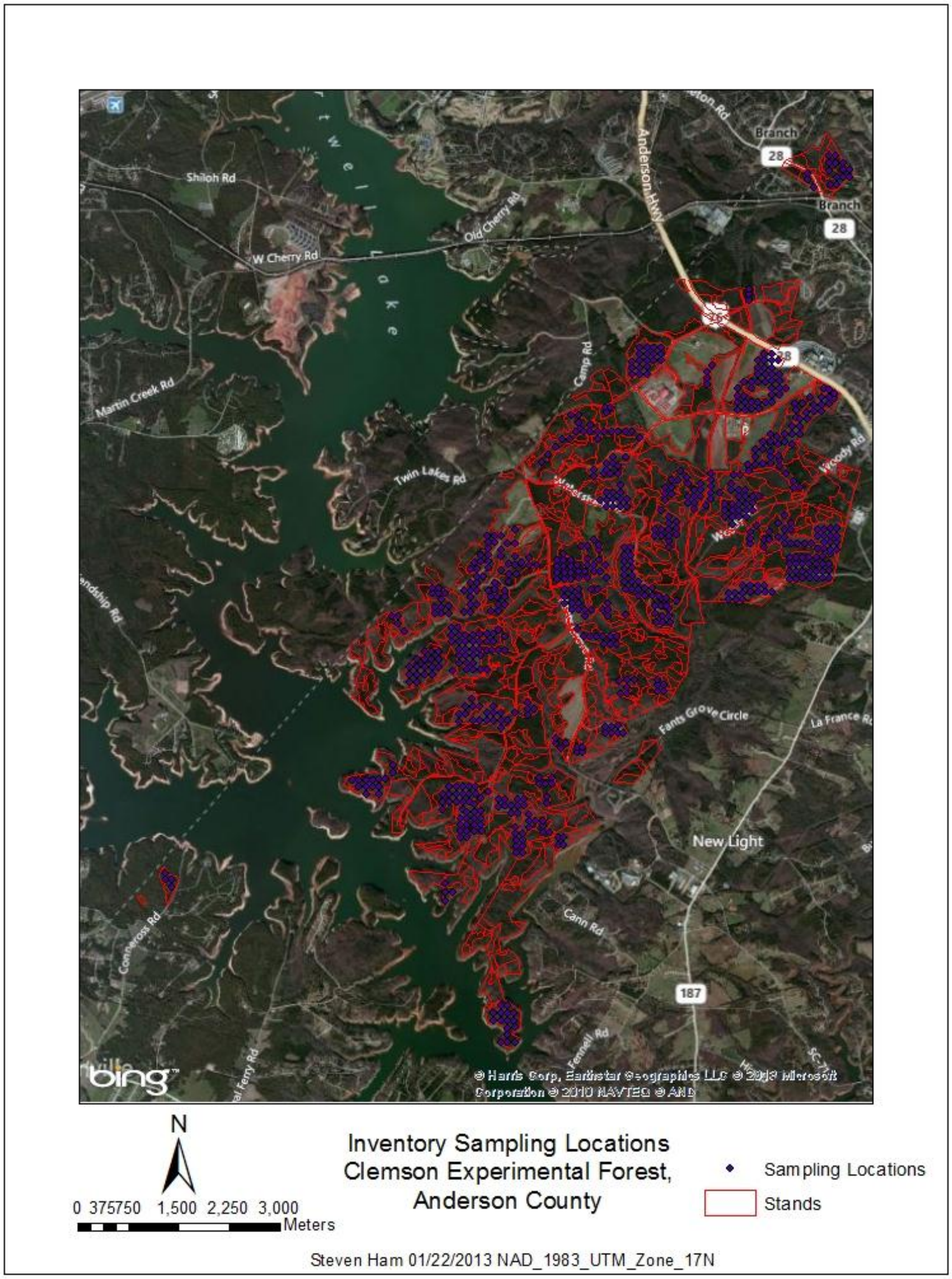


Figure 1. Map of the part of the Clemson Experimental Forest.

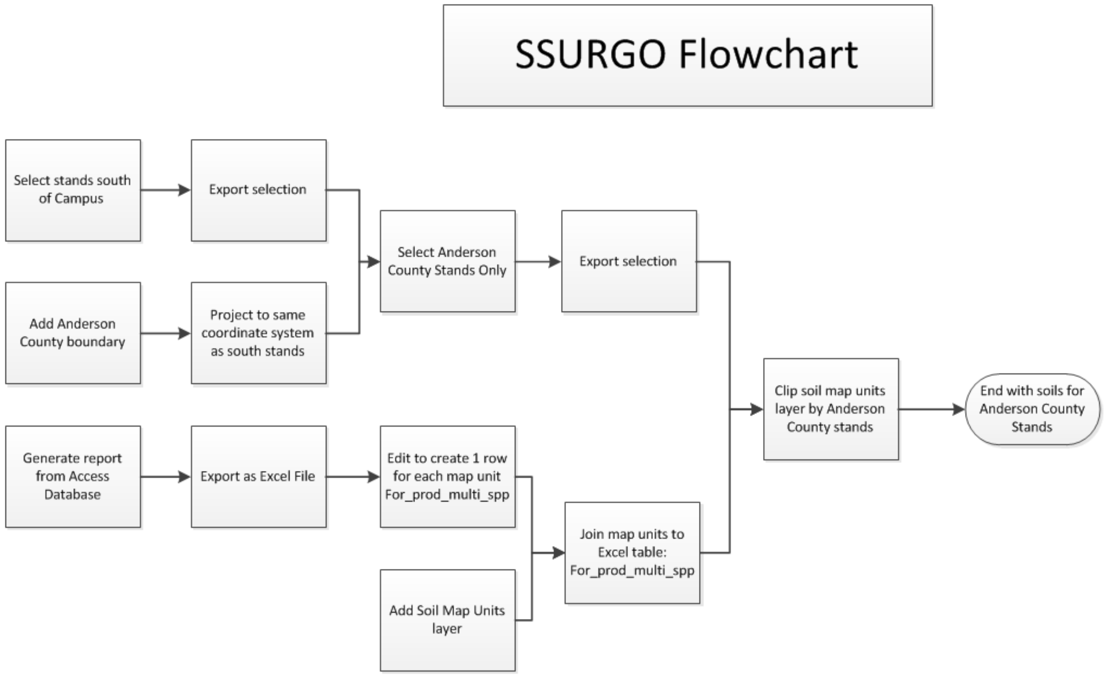


Figure 2. Process of extracting soil data for the southern part (Anderson County) of the Clemson Experimental Forest.

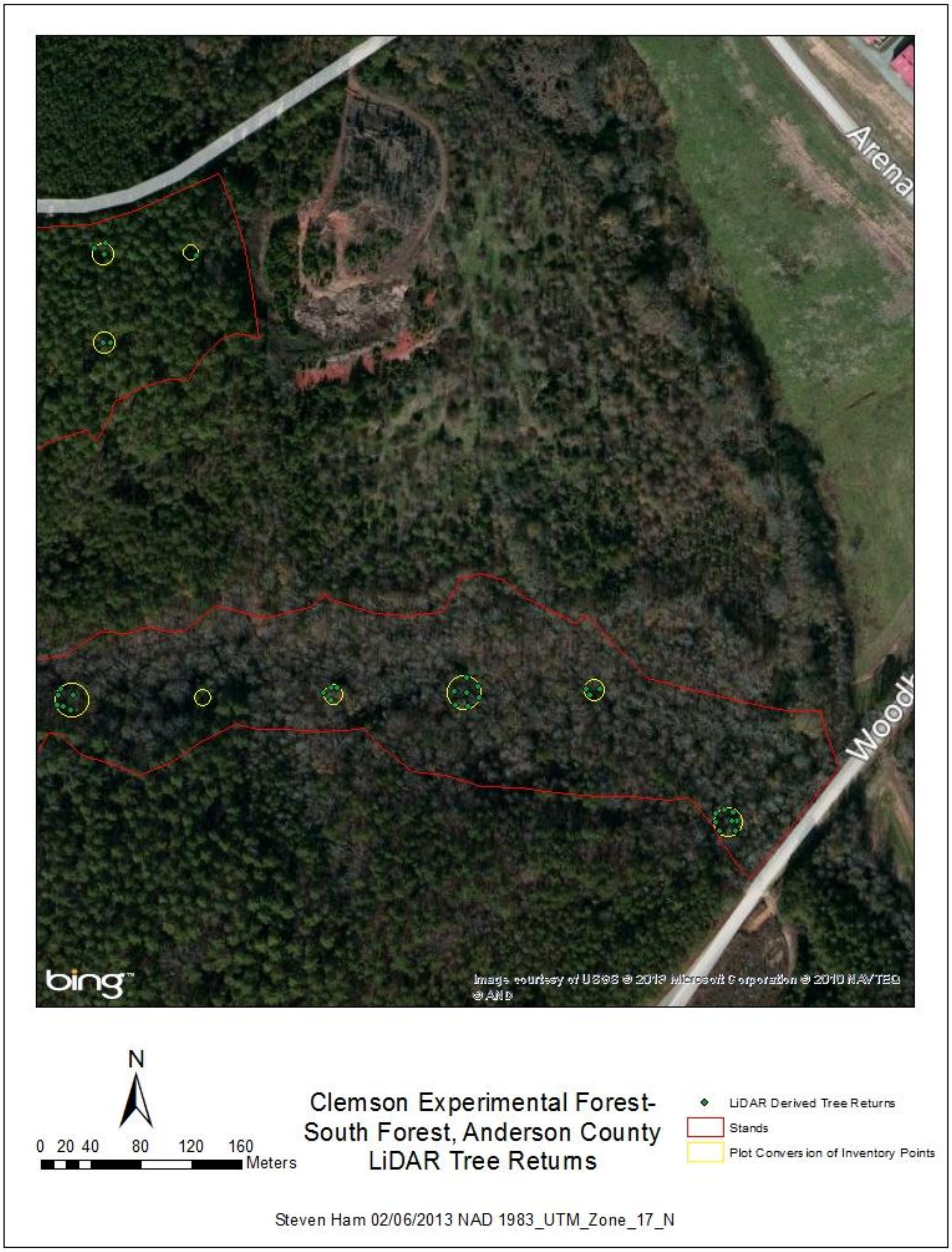
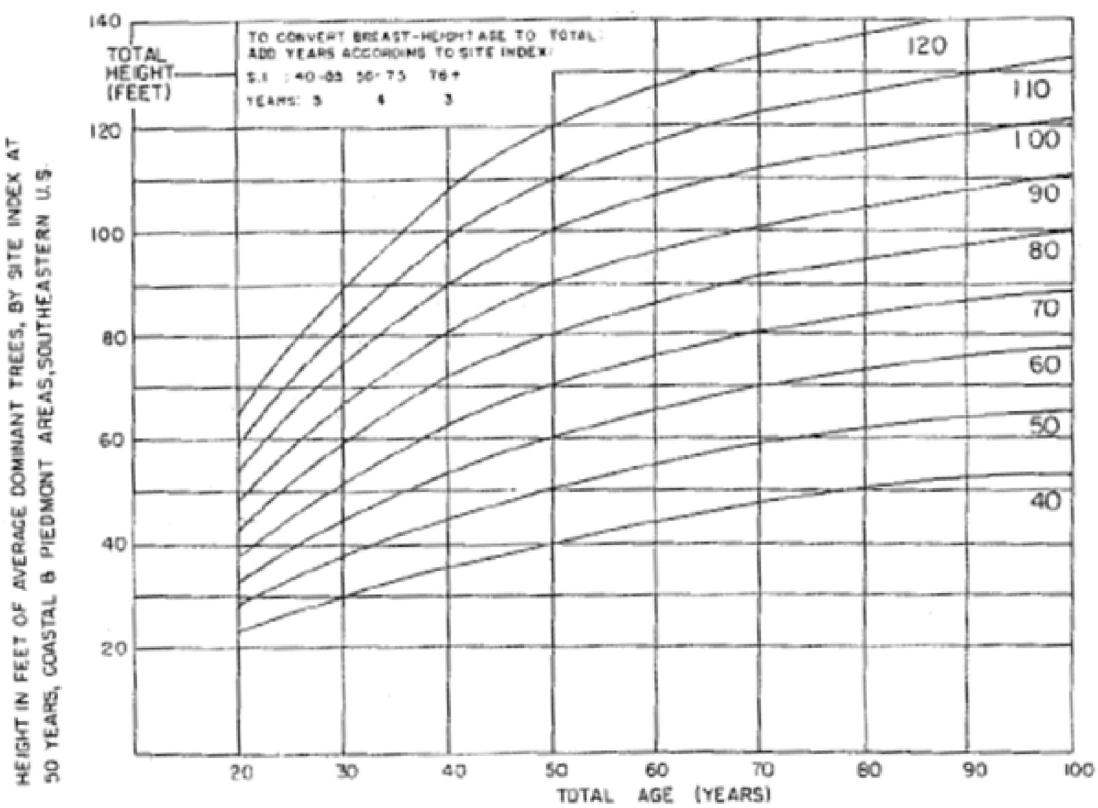


Figure 3. Clemson Experimental Forest, South Forest, Anderson County LiDAR tree returns(2008).

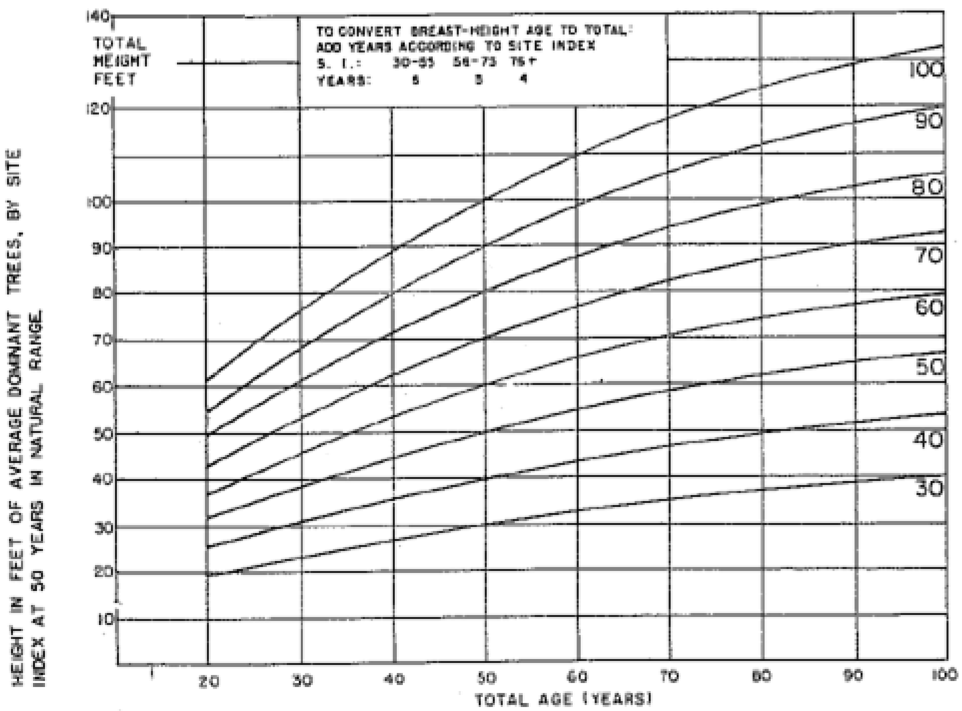
LOBLOLLY PINE



SOURCE: VOLUME, YIELD & STAND TABLES FOR SECOND-GROWTH SOUTHERN PINES, U.S.D.A. MISC PUBL. NO. 50 (1929). REVISED BY COILE & SCHUMACHER, JOURNAL OF FORESTRY, JUNE 1953.

Figure 4. Loblolly pine Site Index classes for coastal and piedmont areas of the Southeastern U.S. (adapted from Coile & Schumacher, 1953).

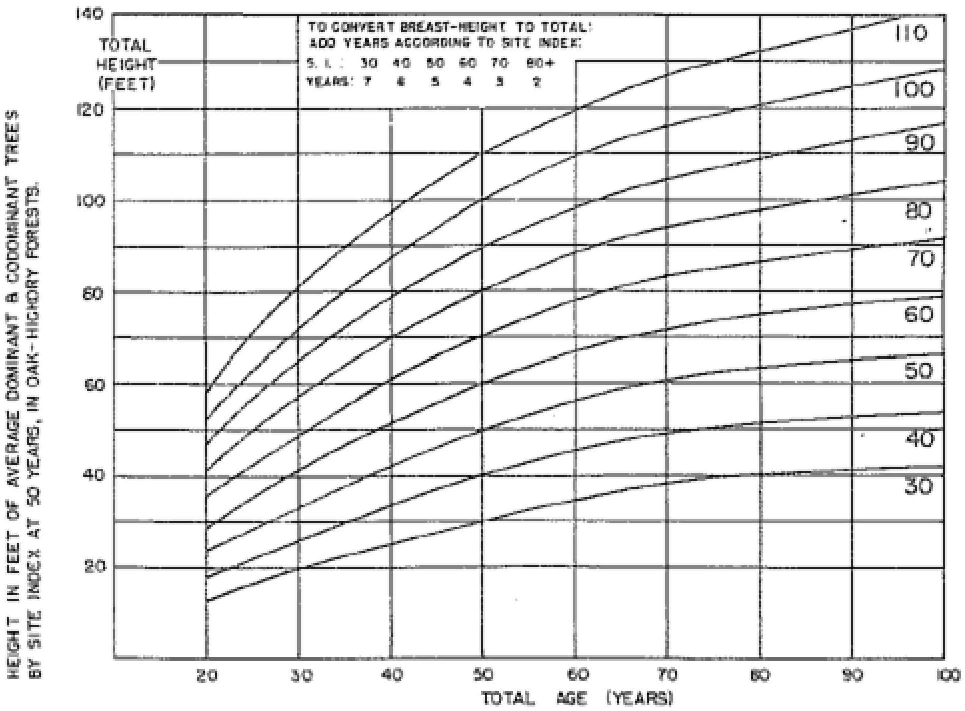
SHORTLEAF PINE



SOURCE: BASED ON HEIGHT GROWTH DATA IN U.S.D.A. PUBL. # 50 (1929), REVISED BY COILE & SCHUMACHER, JOURNAL OF FORESTRY, JUNE 1953.

Figure 5. Shortleaf pine Site Index classes in natural range (adapted from Coile & Schumacher, 1953).

UPLAND OAKS



SOURCE: G.L. SCHNUR, YIELD STAND, & VOLUME TABLES FOR EVEN-AGED UPLAND OAK FORESTS, U.S.D.A., TECH. BLL. NO. 560 (1937).
D.J. OLSON, JR., S.E. F.E.S. RESEARCH NOTES NO. 125 APRIL 1959.

Figure 6. Upland oaks Site Index classes in oak-hickory forests (adapted from Olson, 1959).

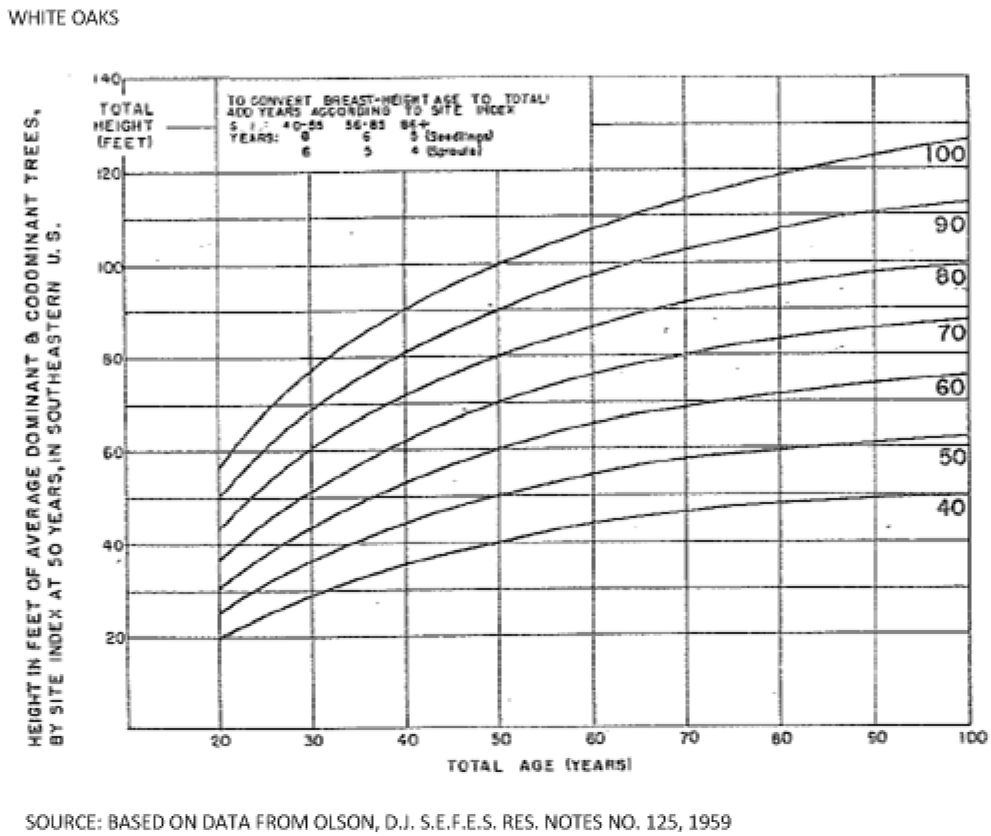
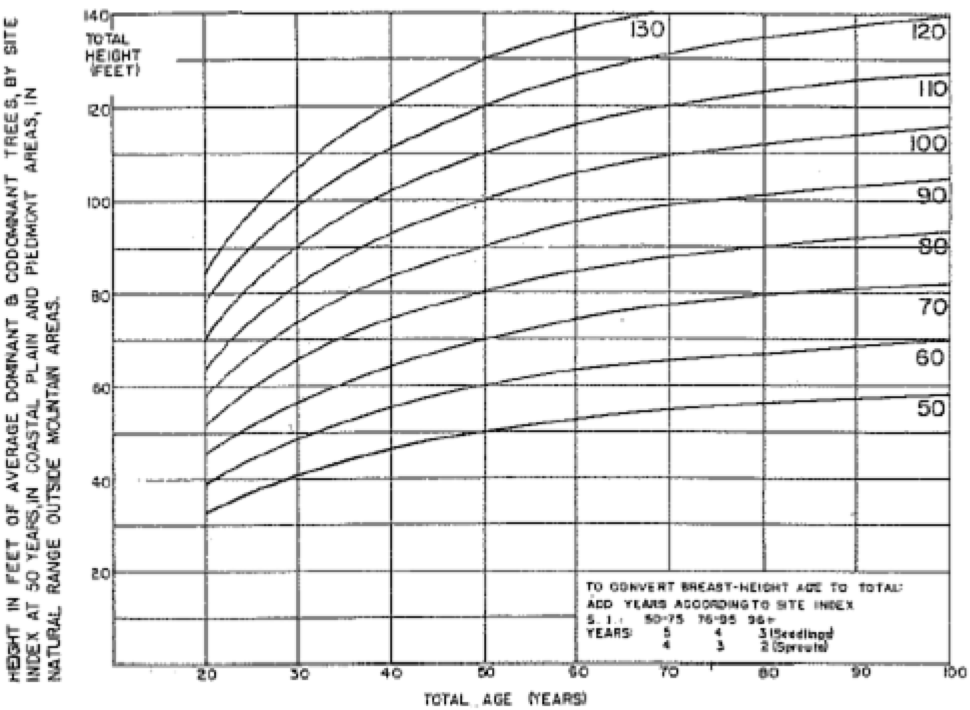


Figure 7. White oaks Site Index lasses in the Southeastern U.S. (Olson 1959).

YELLOW POPLAR



SOURCE: BECK, D.E., S.E.F.E.S. RES. NOTES NO. 180, OCT. 1962.
McCARTHY, E.F.,U.S.D.A. TECH. BULL. NO. 356, 1933.

Figure 8. Yellow polar Site Index classes for coastal and Piedmont areas, in natural range outside mountain areas (Beck, 1962).

Table 1. Spatial data sources and descriptions used in this study.

Data layer[a)]	Source	Resolution/scale
	Imagery	
LiDAR data from Anderson county, SC	SC Department of Natural Resources, 2013	1:24000 scale
	Soil	
Soil map of Anderson county, SC	Soil Survey Staff, 2013	Varies from 1:12000 to 1:63360 scale
	Forest	
Clemson Experimental Forest (SC) forest inventory field data	Cox, 2013	1:7920 scale

[a)]All data layers projected to Universal Transverse Mercator Zone 17 North (UTM Zone 17 N), North American Datum (NAD) 1983.

Table 2. Field forest inventory specifications for Clemson Experimental Forest.

Basal Factor 10 prism points to be taken in approximately 273 stands on the Clemson Experimental Forest for a total of approximately 2000 points.

Stand Maps and x, y coordinate locations for point locations in each stand to be sampled will be provided. The inventory contractor will be required to navigate to the x, y coordinate location to within 30 feet of the given position, place a flag with the point number at the point center and collect inventory data as described below.

Data required on each point will include:
1. **DATE AND CREW**
2. **STAND ID**.
3. **POINT NUMBER**
4. **LATITUDE AND LONGITUDE of POINT**
5. **COVERTYPE (general covertype represented by point, from list)**
6. **TOPOGRAPHIC POSITION of POINT (bottom, cove, lower middle, upper, ridge)**
7. **REPRODUCTION** on point. (# stems < 0.6 inch DBH. on .001 acre (3.7 ft. radius) circular plot by species group (pine, oak, yellow poplar, other).

The following information must be recorded for each tree determined to be in on the BAF 10 sampling point.

8. **TREE NUMBER** for each tree tallied on point.
9. **SPECIES** of each tree tallied. A species list with corresponding species code will be provided.
10. **DBH** of all sample trees 2 inch and greater DBH in point sample. Borderline trees must be measured for distance and diameter to determine if they are in the sample. Tree diameters must be recorded within +/- 1 inch of dbh.
11. **PRODUCT**, the highest value produce for each tree. (pulpwood, CNS, pole, sawtimber, veneer)
12. **MERCHANTABLE HEIGHT** in feet, of each merchantable size tree tallied to reflect the product assigned. (top minimum diameter by product table will be provided)
13. **TOTAL HEIGHT** in feet of each tree.
14. **PERCENT DEFECT**, for adjustment of merchantable volume estimated for each tree using a table provided.

Trees shall be tallied beginning from North and proceeding clockwise around the point. Each tally tree must be marked with a spot of paint, ink or durable crayon facing the point center.

The data collected must be provided at a minimum in DBF 4 (.dbf) database IV format, and delivered as stands are completed.

Table 3. Soil data from SSURGO database for study area (n = 302 plots).

Map unit symbol	Map unit name	Surface texture rating	Taxonomic class	Slope (%)	Tree species (number of points from field inventory, 2007-2008)	SSURGO Site Index (ft) at base age 50
CbB	Cataula	Sandy loam	Fine, kaolinitic, thermic Oxyaquic Kanhapludults	2-6	Loblolly pine (4) Shortleaf pine (20)	80 66
CbC	Cataula	Sandy loam	Fine, kaolinitic, thermic Oxyaquic Kanhapludults	6-10	Loblolly pine (4) Shortleaf pine (6)	80 66
CcC2	Cataula	Clay loam	Fine, kaolinitic, thermic Oxyaquic Kanhapludults	6-10	Shortleaf pine (5)	55
CdB	Cecil	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	2-6	Loblolly pine (5) Shortleaf pine (7)	83 69
CdC	Cecil	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	6-10	Loblolly pine (10) Shortleaf pine (29) Yellow poplar (10)	83 69 92
CdD	Cecil	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	10-15	Scarlet oak (4) Shortleaf pine (14) Yellow poplar (7)	81 69 92
CeC2	Cecil	Clay loam	Fine, kaolinitic, thermic Typic Kanhapludults	6-10, eroded	Loblolly pine (10)	72
HaB	Hiwassee	Sandy loam	Very-fine, kaolinitic, thermic Rhodic Kanhapludults	2-6	Loblolly pine (9)	85
HaC	Hiwassee	Sandy loam	Very-fine, kaolinitic, thermic Rhodic Kanhapludults	6-10	Shortleaf pine (8)	75
HaD	Hiwassee	Sandy loam	Very-fine, kaolinitic, thermic Rhodic Kanhapludults	10-15	Shortleaf pine (3)	75
HwC2	Hiwassee	Clay loam	Very-fine, kaolinitic, thermic Rhodic Kanhapludults	6-10, eroded	Loblolly pine (5)	71
MaC	Madison	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	6-10	Loblolly pine (14) Scarlet oak (8)	80 75

MaD	Madison	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	10-15	Loblolly pine (10)	80
					White oak (8)	75
MaE	Madison	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	15-25	Loblolly pine (3)	80
					Scarlet oak (12)	75
					Shortleaf pine (6)	64
					White oak (5)	75
					Yellow poplar (4)	96
PaE	Pacolet	Sandy loam	Fine, kaolinitic, thermic Typic Kanhapludults	15-25	Loblolly pine (5)	78
					Shortleaf pine (11)	70
					Yellow poplar (46)	90
PcD2	Pacolet	Clay loam	Fine, kaolinitic, thermic Typic Kanhapludults	10-15	Shortleaf pine (13)	60

Table 4A. Comparison of Site Index data from SSURGO database for study area by plot level (n = 302 plots for LiDAR 2008 data, n = 258 plots for LiDAR 2011 data).

Map unit symbol	Map unit name	Surface texture rating	Slope (%)	Tree species (number of points from field inventory with 2008 LiDAR) (number of points from field inventory with 2011 LiDAR)	SSURGO Site Index (ft) at base age 50	Field Inventory Data Site Index (ft) at base age 50, (2007-2008) Mean (std.)	LiDAR derived Site Index (ft) at base age 50 (2008) Mean (std.)	LiDAR derived Site Index (ft) at base age 50, plot data (2011) Mean (std.)
CbB	Cataula	Sandy loam	2-6	Loblolly pine (4) (4)	80	86.5(4.04)*	89.8(13.72)	80.0(28.72)
				Shortleaf pine (20) (18)	66	64.1(9.51)	70.0(17.65)	71.6(17.63)
CbC	Cataula	Sandy loam	6-10	Loblolly pine (4) (0)	80	80.0(0.00)	108.0(13.37)*	-
				Shortleaf pine (6) (6)	66	61.2(10.11)	61.7(4.32)*	66.7(12.52)
CcC2	Cataula	Clay loam	6-10	Shortleaf pine (5) (4)	55	70.8(0.45)**	74.6(28.74)	77.5(20.82)
CdB	Cecil	Sandy loam	2-6	Loblolly pine (5) (4)	83	101.2(17.44)*	110.0(18.18)*	114.5(9.00)**
				Shortleaf pine (7) (7)	69	50.0(0.00)	61.1(10.51)*	46.4(1.86)**
CdC	Cecil	Sandy loam	6-10	Loblolly pine (10) (8)	83	95.4(14.38)*	113.3(25.56)**	122.9(13.85)**
				Shortleaf pine (29) (27)	69	66.1(14.16)	57.1(13.33)**	62.1(14.07)**
				Yellow poplar (10) (9)	92	85.0(0.00)	58.1(14.54)**	69.3(12.12)**
CdD	Cecil	Sandy loam	10-15	Scarlet oak (4) (4)	81	69.0(0.00)	74.8(11.59)	81.0(6.68)
				Shortleaf pine (14) (12)	69	59.6(5.42)**	51.0(15.04)**	61.7(26.43)
				Yellow poplar (7) (7)	92	93.9(8.32)	64.6(27.01)*	74.9(25.25)
CeC2	Cecil	Clay loam	6-10, eroded	Loblolly pine (10) (10)	72	70.0(0.00)	71.1(12.87)	76.9(1.35)**
HaB	Hiwassee	Sandy loam	2-6	Loblolly pine (9) (7)	85	86.2(3.27)	67.8(26.00)*	57.3(10.77)**
HaC	Hiwassee	Sandy loam	6-10	Shortleaf pine (8) (5)	75	68.3(3.11)**	79.1(21.54)	75.0(17.13)

HaD	Hiwassee	Sandy loam	10-15	Shortleaf pine (3) (0)	75	72.0(0.00)	95.3(17.04)	-
HwC2	Hiwassee	Clay loam	6-10, eroded	Loblolly pine (5) (0)	71	90.0(0.00)	108.0(8.72)**	-
MaC	Madison	Sandy loam	6-10	Loblolly pine (14) (12)	80	92.4(8.00)**	78.0(28.47)	83.2(32.31)
				Scarlet oak (8) (4)	75	69.0(0.00)	58.5(4.63)**	74.3(13.43)
MaD	Madison	Sandy loam	10-15	Loblolly pine (10) (10)	80	94.0(8.43)**	96.8(27.37)*	99.7(26.45)*
				White oak (8) (8)	75	72.0(0.00)	70.4(7.46)	77.9(0.64)**
MaE	Madison	Sandy loam	15-25	Loblolly pine (3) (0)	80	103.3(5.77)**	103.3(15.57)	-
				Scarlet oak (12) (10)	75	70.0(0.00)	39.9(15.24)**	50.8(16.19)**
				Shortleaf pine (6) (5)	64	78.3(9.48)**	63.0(28.62)	73.4(29.77)
				White oak (5) (5)	75	72.0(0.00)	66.0(7.38)*	59.4(30.62)
				Yellow poplar (4) (4)	96	105.0(0.00)	110.8(19.97)	118.0(9.66)**
PaE	Pacolet	Sandy loam	15-25	Loblolly pine (5) (0)	78	90.0(0.00)	86.8(21.56)	-
				Shortleaf pine (11) (11)	70	70.1(5.77)	84.9(15.53)**	97.5(17.99)**
				Yellow poplar (46) (44)	90	91.3(5.80)	84.3(18.58)	86.8(19.47)
PcD2	Pacolet	Clay loam	10-15	Shortleaf pine (13) (13)	60	62.4(8.30)	59.9(19.19)	68.3(17.85)

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 4B. Comparison of Site Index data from SSURGO database for study area by map unit level (n = 20 or 5%, whichever is greatest, for each map unit within a stand for LiDAR 2008 and 2011 data).

Map unit symbol	Map unit name	Surface texture rating	Slope (%)	Tree species (number of points from field inventory with 2008 LiDAR) (number of points from field inventory with 2011 LiDAR)	SSURGO Site Index (ft) at base age 50	Field Inventory Data Site Index (ft) at base age 50, (2007-2008) Mean (std.)	LiDAR derived Site Index (ft) at base age 50, soil map unit (2008) Mean (std.)	LiDAR derived Site Index (ft) at base age 50, soil map unit (2011) Mean (std.)	LiDAR Combined derived Site Index (ft) at base age 50, soil map unit (2008 and 2011) Mean (std.)
CbB	Cataula	Sandy loam	2-6	Loblolly pine (4) (4)	80	86.5(4.04)*	101.6(15.66)**	95.6(9.84)**	98.5(13.18)**
				Shortleaf pine (20) (18)	66	64.1(9.51)	84.5(20.20)**	84.9(20.24)**	84.7(20.19)**
CbC	Cataula	Sandy loam	6-10	Loblolly pine (4) (0)	80	80.0(0.00)	125.3(2.54)**	52.6(27.45)**	92.2(40.93)*
				Shortleaf pine (6) (6)	66	61.2(10.11)	70.5(9.23)**	74.5(10.55)**	72.3(9.99)**
CcC2	Cataula	Clay loam	6-10	Shortleaf pine (5) (4)	55	70.8(0.45)**	101.0(4.53)**	100.6(5.51)**	100.8(5.02)**
CdB	Cecil	Sandy loam	2-6	Loblolly pine (5) (4)	83	101.2(17.44)*	107.4(16.01)**	110.9(17.26)**	108.9(16.58)**
				Shortleaf pine (7) (7)	69	50.0(0.00)	78.0(4.82)**	74.7(9.08)**	76.4(7.32)**
CdC	Cecil	Sandy loam	6-10	Loblolly pine (10) (8)	83	95.4(14.38)*	124.7(10.62)**	102.8(35.11)**	114.2(27.64)**
				Shortleaf pine (29) (27)	69	66.1(14.16)	80.3(11.08)**	81.7(10.38)**	81.0(10.77)**
				Yellow poplar (10) (9)	92	85.0(0.00)	81.8(6.27)**	93.9(6.06)*	87.1(8.64)**
CdD	Cecil	Sandy loam	10-15	Scarlet oak (4) (4)	81	69.0(0.00)	79.7(5.84)	87.7(3.14)**	83.2(5.79)**
				Shortleaf pine (14) (12)	69	59.6(5.42)**	91.1(11.99)**	95.1(12.08)**	92.9(12.18)**
				Yellow poplar (7) (7)	92	93.9(8.32)	100.4(9.76)**	108.1(9.92)**	103.9(10.53)**
CeC2	Cecil	Clay loam	6-10, eroded	Loblolly pine (10) (10)	72	70.0(0.00)	92.9(5.17)**	97.9(5.87)**	95.1(6.02)**
HaB	Hiwassee	Sandy loam	2-6	Loblolly pine (9) (7)	85	86.2(3.27)	87.4(19.68)	77.6(14.70)**	83.3(18.41)

HaC	Hiwassee	Sandy loam	6-10	Shortleaf pine (8) (5)	75	68.3(3.11)**	87.4(4.56)**	93.6(3.73)**	90.0(5.21)**
HaD	Hiwassee	Sandy loam	10-15	Shortleaf pine (3) (0)	75	72.0(0.00)	121.3(3.93)**	116.0(2.51)**	118.6(4.20)**
HwC2	Hiwassee	Clay loam	6-10, eroded	Loblolly pine (5) (0)	71	90.0(0.00)	119.5(2.12)**	82.0(23.17)**	101.0(24.86)**
MaC	Madison	Sandy loam	6-10	Loblolly pine (14) (12)	80	92.4(8.00)**	103.1(27.03)**	98.1(36.27)**	101.0(31.26)**
				Scarlet oak (8) (4)	75	69.0(0.00)	79.5(6.28)**	87.8(5.27)**	82.2(7.13)**
MaD	Madison	Sandy loam	10-15	Loblolly pine (10) (10)	80	94.0(8.43)**	122.0(16.52)**	121.1(21.04)**	121.6(18.71)**
				White oak (8) (8)	75	72.0(0.00)	81.8(3.97)**	91.6(4.40)**	86.0(6.38)**
MaE	Madison	Sandy loam	15-25	Loblolly pine (3) (0)	80	103.3(5.77)**	134.5(5.85)**	136.2(7.36)**	135.2(6.57)**
				Scarlet oak (12) (10)	75	70.0(0.00)	64.4(6.32)**	74.0(7.32)	68.6(8.29)**
				Shortleaf pine (6) (5)	64	78.3(9.48)**	90.4(17.73)**	90.7(13.26)**	90.5(15.76)**
				White oak (5) (5)	75	72.0(0.00)	86.9(4.21)**	93.4(4.48)**	89.5(5.36)**
				Yellow poplar (4) (4)	96	105.0(0.00)	113.1(22.37)**	126.3(5.13)**	121.0(6.86)**
PaE	Pacolet	Sandy loam	15-25	Loblolly pine (5) (0)	78	90.0(0.00)	109.3(3.74)**	91.1(2.86)**	101.2(9.69)**
				Shortleaf pine (11) (11)	70	70.1(5.77)	98.7(18.29)**	101.3(17.21)**	99.9(17.77)**
				Yellow poplar (46) (44)	90	91.3(5.80)	110.6(13.31)**	115.0(9.44)**	112.7(11.37)**
PcD2	Pacolet	Clay loam	10-15	Shortleaf pine (13) (13)	60	62.4(8.30)	81.9(11.76)**	86.6(9.51)**	83.9(11.08)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 5A. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with loblolly pine as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) Mean (std dev) (2008)
CbB	90217	83	80	412	21	66.9	10.0	30	89.8(12.77)**
	90512	90	80	187	20	101.1	4.9	39	114.1(5.01)**
CbC	90509	80	80	465	24	110.1	2.6	37	125.3(2.54)**
CdB	90315	109	83	470	24	93.1	4.3	23	128.3(4.54)**
	100429	70	83	876	44	86.9	3.1	41	95.9(3.17)**
CdC	90315	109	83	613	31	97.8	3.0	23	135.7(2.88)**
	90509	80	83	341	20	105.5	3.1	37	120.5(3.14)**
	90703	83	83	305	20	102.8	2.1	41	112.0(2.45)**
CeC2	100429	70	72	2422	122	83.9	5.2	41	92.9(5.17)**
HaB	110504	83	85	731	37	109.2	3.6	46	113.2(3.57)**
	110509	90	85	995	50	71.7	7.5	46	74.6(8.25)**
	110826	87	85	634	32	74.3	13.9	46	77.6(14.04)**
HwC2	90512	90	71	635	32	106.4	2.0	39	119.5(2.12)**
MaC	110128	92	80	931	47	68.5	6.8	47	69.5(6.92)**
	110401	100	80	906	46	82.7	5.5	25	123.8(5.10)**
	110504	83	80	507	26	96.6	3.0	46	99.5(3.26)**
	110817	80	80	406	21	96.7	4.3	24	137.3(3.67)**
MaD	110401	100	80	775	39	89.3	8.6	25	129.7(7.39)**
	110509	90	80	127	20	92.9	9.2	46	96.6(9.14)**
	110817	80	80	313	20	91.5	3.1	24	132.5(3.07)**

MaE	110101	110	80	1063	54	91.0	4.5	23	133.0(4.58)**
	110401	100	80	584	30	97.7	7.6	25	137.4(6.84)**
PaE	90512	90	78	606	31	97.3	3.9	39	109.3(3.74)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 5B. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with loblolly pine as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	Growth (3 years)	LiDAR SI (ft, base age 50) Difference	LiDAR SI (ft, base age 50) Mean (std dev) (2011)	LiDAR Combined SI (ft, base age 50) Mean (std dev) (2008 and 2011)
CbB	90217	83	80	517	26	73.4	9.4	33	6.5	3	92.8(11.80)**	91.5(12.21)**
	90512	90	80	159	20	92.4	3.9	42	-8.7	-15	99.3(4.68)**	106.7(8.91)**
CbC	90509	80	80	191	20	46.1	25.5	40	-64.1	-73	52.6(27.45)**	92.2(40.93)*
CdB	90315	109	83	399	20	97.7	4.4	26	4.5	2	130.0(4.42)**	129.1(4.52)**
	100429	70	83	632	32	90.8	17.1	44	3.9	3	98.5(9.12)**	97.0(6.42)**
CdC	90315	109	83	492	25	101.7	3.2	26	3.9	-2	133.7(3.16)**	134.8(3.14)**
	90509	80	83	182	20	48.5	15.5	40	-57.0	-66	54.4(17.79)**	87.4(35.74)
	90703	83	83	279	20	106.5	1.2	44	3.7	0	112.5(1.23)**	112.2(1.93)**
CeC2	100429	70	72	1878	94	92.8	5.7	44	8.9	5	97.9(5.87)**	95.1(6.02)**
HaB	110504	83	85	476	24	66.3	16.5	49	-42.9	-45	68.6(16.92)**	95.6(24.50)**
	110509	90	85	652	33	79.3	8.3	49	7.6	6	80.3(8.34)**	76.9(8.69)**
	110826	87	85	526	27	81.3	15.7	49	7.0	5	82.3(15.64)	79.7(14.85)**
HwC2	90512	90	71	606	31	75.9	21.7	35	-30.5	-37	82.0(23.17)**	101.0(24.86)**
MaC	110128	92	80	512	26	74.9	7.9	50	6.4	5	74.9(7.91)**	71.4(7.68)**
	110401	100	80	689	35	90.9	6.8	28	8.2	1	124.4(7.03)**	124.0(5.98)**
	110504	83	80	234	20	42.6	3.9	29	-54.1	-56	43.6(3.94)**	75.2(28.24)
	110817	80	80	299	20	101.2	2.2	27	4.5	0	137.0(1.82)**	137.1(2.89)**
MaD	110401	100	80	570	29	98.4	6.1	28	9.2	3	132.9(5.97)**	131.0(6.95)**
	110509	90	80	112	20	90.8	15.7	49	-2.1	-5	91.7(15.72)**	94.1(12.93)**
	110817	80	80	237	20	97.4	3.0	27	6.0	1	133.3(2.75)**	132.9(2.91)**

MaE	110101	110	80	803	41	96.4	2.9	57	5.5	-1	132.4(2.73)**	132.7(3.88)**
	110401	100	80	459	23	108.2	8.4	33	10.5	6	142.9(8.19)**	139.8(7.89)**
PaE	90512	90	78	490	25	85.0	2.6	34	-12.4	-18	91.1(2.86)**	101.2(9.69)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Note: A negative number in growth indicates that a stand has been harvested, trees were lost to some sort of damage, or an overestimation in 2008 or underestimation in 2011 has occurred.

Table 6A. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with scarlet oak as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) Mean (std dev) (2008)
CdD	110906	69	81	938	47	91.9	5.4	65	80.0(5.05)
MaC	110906	69	75	1590	80	91.2	6.7	65	79.5(6.28)**
MaE	110403	70	75	2790	140	77.1	6.9	70	64.4(6.32)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 6B. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with scarlet oak as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	Growth (3 years)	LiDAR SI (ft, base age 50) Difference	LiDAR SI (ft, base age 50) Mean (std dev) (2011)	LiDAR Combined SI (ft, base age 50) Mean (std dev) (2008 and 2011)
CdD	110906	69	81	677	34	101.8	3.4	68	9.9	8	87.7(3.14)**	83.2(5.79)**
MaC	110906	69	75	752	38	102.0	5.8	68	10.9	8	87.8(5.27)**	82.2(7.13)**
MaE	110403	70	75	2215	111	88.7	7.9	73	11.6	10	74.0(7.32)	68.6(8.29)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 7A. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with shortleaf pine as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) Mean (std dev) (2008)
CbB	90215	71	66	1469	74	91.0	5.2	43	98.0(5.1)**
	90301	55	66	79	20	41.2	5.5	48	42.2(5.5) **
	90419	70	66	272	20	73.4	4.1	27	100.2(4.0)**
	90918	50	66	525	27	80.0	3.5	49	81.0(3.54)**
	111306	47	66	214	20	62.5	6.6	45	66.2(6.95)
CbC	90301	55	66	841	43	66.0	3.6	48	67.0(3.56)*
	90507	70	66	566	29	80.9	7.3	50	80.9(7.29)**
	90915	47	66	137	20	62.1	7.2	49	63.1(7.22)*
CcC2	90215	71	55	268	20	94.0	5.1	43	100.9(4.90)**
	90419	70	55	286	20	74.0	4.0	27	101.1(4.25)**
CdB	90918	50	69	1026	52	77.0	4.8	49	78.0(4.82)**
CdC	90428	80	69	2113	106	73.0	10.9	40	82.5(12.22)**
	90507	70	69	59	20	74.0	5.7	50	74.0(5.68)**
	90915	47	69	248	20	67.6	5.4	49	68.6(5.42)
	90918	50	69	1249	63	80.8	4.5	49	81.8(4.53)**
	100504	70	69	360	20	81.9	3.0	78	66.5(2.48)**
	100508	55	69	616	31	78.1	3.4	55	74.1(3.51)**
	111302	60	69	176	20	81.7	3.5	35	99.0(4.01)**
	111306	47	69	508	26	81.0	6.0	45	85.4(8.16)**
CdD	90301	55	69	275	20	65.3	3.7	48	66.3(3.67)**

	111026	68	69	772	39	82.7	4.8	38	95.5(4.70)**
	111209	70	69	449	23	76.7	6.9	31	98.4(7.26)**
	111302	60	69	1830	92	80.5	4.7	35	97.7(5.16)**
	111306	47	69	626	32	73.5	3.5	45	77.3(3.66)**
HaC	90324	66	75	574	29	99.0	5.3	65	87.4(4.56)**
HaD	90101	72	75	362	20	105.7	4.6	35	121.3(3.93)**
MaE	90428	80	64	491	25	60.6	5.7	40	68.7(6.20)**
	110142	88	64	593	27	84.2	6.8	30	107.6(5.98)**
	110207	67	64	294	20	81.5	4.7	38	94.3(4.80)**
PaE	100504	70	70	329	20	85.8	3.6	78	69.5(2.95)
	111026	68	70	393	20	87.5	5.1	38	100.5(4.25)**
	111218	75	70	506	26	95.0	4.5	30	116.9(3.54)**
	111302	60	70	251	20	85.4	9.3	35	102.3(9.27)**
PcD2	90215	71	60	1098	55	85.8	6.5	43	91.8(6.98)**
	90301	55	60	1056	53	70.5	4.5	48	71.5(4.51)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 7B. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with shortleaf pine as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	Growth (3 years)	LiDAR SI (ft, base age 50) Difference	LiDAR SI (ft, base age 50) Mean (std dev) (2011)	LiDAR Combined SI (ft, base age 50) Mean (std dev) (2008 and 2011)
CbB	90215	71	66	1252	63	96.0	5.0	46	5.0	1	99.0(5.01)**	98.5(5.07)**
	90301	55	66	61	20	47.0	5.1	51	5.8	4	46.0(5.08)**	44.1(5.58)**
	90419	70	66	212	20	80.4	4.2	30	7.0	4	103.7(4.04)**	102.0(4.34)**
	90918	50	66	482	25	79.2	6.8	52	-0.8	-3	78.2(6.79)**	79.7(5.49)**
	111306	47	66	174	20	68.1	5.6	48	5.6	3	69.1(5.58)*	67.6(6.40)
CbC	90301	55	66	564	29	74.9	4.5	51	9.0	7	73.9(4.48)**	69.8(5.21)**
	90507	70	66	429	22	87.0	7.9	53	6.1	3	84.0(7.90)**	82.2(7.64)**
	90915	47	66	121	20	66.0	10.6	52	58.7	2	65.0(10.57)	64.0(8.98)
CcC2	90215	71	55	215	20	96.6	6.7	46	2.6	-1	99.8(6.98)**	100.3(5.98)**
	90419	70	55	211	20	78.0	3.3	30	4.0	0	101.4(3.50)**	101.2(3.85)**
CdB	90918	50	69	938	47	75.7	9.1	52	-1.4	-3	74.7(9.08)**	76.4(7.32)**
CdC	90428	80	69	1794	90	78.7	8.4	43	5.7	3	85.2(8.82)**	83.8(10.85)**
	90507	70	69	50	20	74.6	3.1	53	0.6	-2	71.6(3.07)**	72.8(4.67)**
	90915	47	69	213	20	67.1	5.0	52	-0.5	-3	66.1(5.00)**	67.3(5.31)*
	90918	50	69	1163	59	81.0	4.2	52	0.2	-2	80.0(5.73)**	81.0(4.46)**
	100504	70	69	260	20	88.5	2.7	81	6.7	5	71.1(2.13)**	68.8(3.28)
	100508	55	69	467	24	86.1	6.1	58	8.1	6	80.0(5.73)**	76.7(5.43)**
	111302	60	69	138	20	86.7	4.4	38	5.1	1	99.9(3.84)**	99.4(3.90)**
	111306	47	69	393	20	90.5	5.3	48	9.4	6	91.5(5.32)**	88.0(7.62)**
CdD	90301	55	69	227	20	72.4	3.5	51	7.1	5	71.4(3.45)**	68.8(4.35)

	111026	68	69	606	31	87.1	3.3	41	4.4	2	97.2(3.56)**	96.2(4.29)**
	111209	70	69	424	22	84.8	5.1	34	8.0	5	103.6(6.18)**	101.0(7.18)**
	111302	60	69	1418	71	90.1	4.9	38	9.5	5	102.6(4.72)**	99.9(5.54)**
	111306	47	69	506	26	82.1	5.9	48	8.5	6	83.1(5.86)**	79.9(5.55)**
HaC	90324	66	75	407	21	108.0	4.4	68	9.0	6	93.6(3.73)**	90.0(5.21)**
HaD	90101	72	75	279	20	103.8	3.1	38	-1.9	-5	116.0(2.51)**	118.6(4.20)**
MaE	90428	80	64	429	22	68.5	4.2	43	8.0	5	74.1(4.84)**	71.2(6.19)**
	110142	88	64	253	20	83.6	4.9	33	-0.7	-5	102.4(4.39)**	105.3(5.91)**
	110207	67	64	216	20	87.3	3.1	41	5.8	3	97.4(3.36)**	95.8(4.39)**
PaE	100504	70	70	239	20	94.0	2.6	81	8.2	6	75.7(2.11)**	72.6(4.03)**
	111026	68	70	304	20	93.4	5.5	41	5.9	3	103.8(5.57)**	102.1(5.16)**
	111218	75	70	371	20	104.4	2.3	33	9.4	4	121.3(2.05)**	118.8(3.69)**
	111302	60	70	194	20	91.9	8.4	38	6.5	2	104.6(7.92)**	103.4(8.59)**
PcD2	90215	71	60	820	41	91.5	5.6	46	5.7	3	94.5(5.61)**	93.0(6.54)**
	90301	55	60	781	40	79.5	4.4	51	8.9	7	78.5(4.40)**	74.5(5.62)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Note: A negative number in growth indicates that a stand has been harvested, trees were lost to some sort of damage, an overestimation in 2008, or an underestimation in 2011 has occurred.

Table 8A. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with white oak as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) Mean (std dev) (2008)
MaD	110710	72	75	1407	71	91.8	4.0	65	81.8(3.97)**
MaE	110710	72	75	1398	70	96.9	4.2	65	86.9(4.21)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 8B. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with white oak as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	Growth (3 years)	LiDAR SI (ft, base age 50) Difference	LiDAR SI (ft, base age 50) Mean (std dev) (2011)	LiDAR Combined SI (ft, base age 50) Mean (std dev) (2008 and 2011)
MaD	110710	72	75	1077	54	103.5	4.1	68	11.7	10	91.6(4.40)**	86.0(6.38)**
MaE	110710	72	75	903	46	105.2	4.2	68	8.3	7	93.4(4.48)**	89.5(5.36)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 9A. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with yellow poplar as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) Mean (std dev) (2008)
CdC	100503	85	92	1319	66	93.0	6.8	85	81.8(6.27)**
CdD	100414	100	92	378	22	112.9	4.3	62	106.4(4.08)**
CdD	100503	85	92	396	20	95.3	7.5	85	83.9(6.95)**
CdD	111027	102	92	1332	67	106.4	5.8	55	103.4(5.75)**
MaE	90426	105	96	542	28	113.1	5.1	45	117.2(5.28)**
PaE	90426	105	90	268	20	115.0	6.2	45	118.8(6.26)**
PaE	90707	91	90	2065	104	107.9	4.9	55	104.8(4.84)**
PaE	100229	90	90	3611	181	124.1	6.8	48	125.1(6.76)**
PaE	100310	90	90	347	20	95.9	4.0	49	96.9(3.99)**
PaE	100414	100	90	863	44	113.1	7.3	62	106.3(7.12)**
PaE	100503	85	90	2723	137	114.0	7.6	85	100.9(6.57)**
PaE	111027	102	90	679	34	104.4	3.9	55	101.4(3.92)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 9B. Comparison of Site Index soil data from SSURGO database by SSURGO Map Unit Symbol within a stand with yellow poplar as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	Growth (3 years)	LiDAR SI (ft, base age 50) Difference	LiDAR SI (ft, base age 50) Mean (std dev) (2011)	LiDAR Combined SI (ft, base age 50) Mean (std dev) (2008 and 2011)
CdC	100503	85	92	1005	51	106.9	7.5	88	13.9	12	93.9(6.06)*	87.1(8.64)**
CdD	100414	100	92	283	20	119.7	4.4	65	6.8	5	111.5(4.32)**	108.8(4.89)**
CdD	100503	85	92	296	20	105.2	6.0	88	9.9	9	92.7(5.17)	88.3(7.51)**
CdD	111027	102	92	986	50	118.9	6.1	58	12.5	10	112.9(6.00)**	107.4(7.51)**
MaE	90426	105	96	361	20	125.3	5.1	48	12.1	9	126.3(5.13)**	121.0(6.86)**
PaE	90426	105	90	173	20	121.6	3.6	48	6.6	4	122.6(3.62)**	120.7(5.41)**
PaE	90707	91	90	1565	79	115.8	3.8	58	8.0	5	109.8(3.80)**	107.0(5.06)**
PaE	100229	90	90	3435	172	123.5	7.1	51	116.8	-3	122.5(7.14)**	123.8(7.06)**
PaE	100310	90	90	333	20	94.2	3.2	52	-1.8	-4	93.2(3.18)**	95.0(4.04)**
PaE	100414	100	90	687	35	125.0	5.6	65	11.9	11	116.8(5.65)**	110.9(8.36)**
PaE	100503	85	90	2029	102	126.8	4.8	88	12.8	10	110.4(4.44)**	105.0(7.44)**
PaE	111027	102	90	494	25	112.7	4.2	58	8.2	5	106.7(4.24)**	103.7(4.80)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Note: A negative number in growth indicates that a stand has been harvested, trees were lost to some sort of damage, an overestimation in 2008, or an underestimation in 2011 has occurred.

Table 10A. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with loblolly pine as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) (2008)	LiDAR SI Std Dev (2008)	LiDAR SI (ft, base age 50) Mean (2008)
CbB	90217	83	80	412	21	66.9	10.0	30	89.8	12.8	101.6(15.66)**
	90512	90	80	187	20	101.1	4.9	39	114.1	5.0	
CbC	90509	80	80	465	24	110.1	2.6	37	125.3	2.5	125.3(2.54)**
CdB	90315	109	83	470	24	93.1	4.3	23	128.3	4.5	107.4(16.01)**
	100429	70	83	876	44	86.9	3.1	41	95.9	3.2	
CdC	90315	109	83	613	31	97.8	3.0	23	135.7	2.9	124.7(10.62)**
	90509	80	83	341	20	105.5	3.1	37	120.5	3.1	
	90703	83	83	305	20	102.8	2.1	41	112.0	2.4	
CeC2	100429	70	72	2422	122	83.9	5.2	41	92.9	5.2	92.9(5.17)**
HaB	110504	83	85	731	37	109.2	3.6	46	113.2	3.6	87.4(19.68)
	110509	90	85	995	50	71.7	7.5	46	74.6	8.2	
	110826	87	85	634	32	74.3	13.9	46	77.6	14.0	
HwC2	90512	90	71	635	32	106.4	2.0	39	119.5	2.1	119.5(2.12)**
MaC	110128	92	80	931	47	68.5	6.8	47	69.5	6.9	103.1(27.03)**
	110401	100	80	906	46	82.7	5.5	25	123.8	5.1	
	110504	83	80	507	26	96.6	3.0	46	99.5	3.3	
	110817	80	80	406	21	96.7	4.3	24	137.3	3.7	
MaD	110401	100	80	775	39	89.3	8.6	25	129.7	7.4	122.0(16.52)**
	110509	90	80	127	20	92.9	9.2	46	96.6	9.1	
	110817	80	80	313	20	91.5	3.1	24	132.5	3.1	
MaE	110101	110	80	1063	54	91.0	4.5	23	133.0	4.6	134.5(5.85)**

	110401	100	80	584	30	97.7	7.6	25	137.4	6.8	
PaE	90512	90	78	606	31	97.3	3.9	39	109.3	3.7	109.3(3.74)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 10B. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with loblolly pine as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	LiDAR SI (ft, base age 50) (2011)	LiDAR SI Std Dev (2011)	LiDAR SI (ft, base age 50) Mean (2011)	LiDAR Combined Mean SI (ft, base age 50) (2008 and 2011)
CbB	90217	83	80	517	26	73.4	9.4	33	92.8	11.8	95.6(9.84)**	98.5(13.187)**
	90512	90	80	159	20	92.4	3.9	42	99.3	4.7		
CbC	90509	80	80	191	20	46.1	25.5	40	52.6	27.5	52.6(27.45)**	92.2(40.93)*
CdB	90315	109	83	399	20	97.7	4.4	26	130.0	4.4	110.9(17.26)**	108.9(16.58)**
	100429	70	83	632	32	90.8	17.1	44	98.5	9.1		
CdC	90315	109	83	492	25	101.7	3.2	26	133.7	3.2	102.8 (35.11)**	114.2 (27.64)**
	90509	80	83	182	20	48.5	15.5	40	54.4	17.8		
	90703	83	83	279	20	106.5	1.2	44	112.5	1.2		
CeC2	100429	70	72	1878	94	92.8	5.7	44	97.9	5.9	97.9(5.87)**	95.1(6.02)**
HaB	110504	83	85	476	24	66.3	16.5	49	68.6	16.9	77.6(14.70)**	83.3(18.41)
	110509	90	85	652	33	79.3	8.3	49	80.3	8.3		
	110826	87	85	526	27	81.3	15.7	49	82.3	15.6		
HwC2	90512	90	71	606	31	75.9	21.7	35	82.0	23.2	82.0(23.17)**	101.0(24.86)**
MaC	110128	92	80	512	26	74.9	7.9	50	74.9	7.9	98.1(36.27)**	101.0(31.26)**
	110401	100	80	689	35	90.9	6.8	28	124.4	7.0		
	110504	83	80	234	20	42.6	3.9	29	43.6	3.9		
	110817	80	80	299	20	101.2	2.2	27	137.0	1.8		
MaD	110401	100	80	570	29	98.4	6.1	28	132.9	6.0	121.1(21.04)**	121.6(18.71)**
	110509	90	80	112	20	90.8	15.7	49	91.7	15.7		
	110817	80	80	237	20	97.4	3.0	27	133.3	2.8		
MaE	110101	110	80	803	41	96.4	2.9	57	132.4	2.7	136.2(7.36)**	135.2(6.57)**

	110401	100	80	459	23	108.2	8.4	33	142.9	8.2		
PaE	90512	90	78	490	25	85.0	2.6	34	91.1	2.9	91.1(2.86)**	101.2(9.69)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 11A. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with scarlet oak as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) (2008)	LiDAR SI Std Dev (2008)	LiDAR SI (ft, base age 50) Mean (2008)
CdD	110906	69	81	938	47	91.9	5.4	65	80	5.1	79.7(5.84)
MaC	110906	69	75	1590	80	91.2	6.7	65	79	6.3	79.5(6.28)**
MaE	110403	70	75	2790	140	77.1	6.9	70	64	6.3	64.4(6.32)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 11B. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with scarlet oak as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	LiDAR SI (ft, base age 50) (2011)	LiDAR SI Std Dev (2011)	LiDAR SI (ft, base age 50) Mean (2011)	LiDAR Combined Mean SI (ft, base age 50) (2008 and 2011)
CdD	110906	69	81	677	34	101.8	3.4	68	88	3.1	87.7(3.14)**	83.2(5.79)**
MaC	110906	69	75	752	38	102.0	5.8	68	88	5.3	87.8(5.27)**	82.2(7.13)**
MaE	110403	70	75	2215	111	88.7	7.9	73	74	7.3	74.0(7.32)	68.6(8.29)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 12A. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with shortleaf pine as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) (2008)	LiDAR SI Std Dev (2008)	LiDAR SI (ft, base age 50) Mean (2008)
CbB	90215	71	66	1469	74	91.0	5.2	43	98.0	5.1	84.5(20.20)**
	90301	55	66	79	20	41.2	5.5	48	42.2	5.5	
	90419	70	66	272	20	73.4	4.1	27	100.2	4.0	
	90918	50	66	525	27	80.0	3.5	49	81.0	3.5	
	111306	47	66	214	20	62.5	6.6	45	66.2	6.9	
CbC	90301	55	66	841	43	66.0	3.6	48	67.0	3.6	70.5(9.23)**
	90507	70	66	566	29	80.9	7.3	50	80.9	7.3	
	90915	47	66	137	20	62.1	7.2	49	63.1	7.2	
CcC2	90215	71	55	268	20	94.0	5.1	43	100.9	4.9	101.0(4.53)**
	90419	70	55	286	20	74.0	4.0	27	101.1	4.3	
CdB	90918	50	69	1026	52	77.0	4.8	49	78.0	4.8	78.0(4.82)**
CdC	90428	80	69	2113	106	73.0	10.9	40	82.5	12.2	80.3(11.08)**
	90507	70	69	59	20	74.0	5.7	50	74.0	5.7	
	90915	47	69	248	20	67.6	5.4	49	68.6	5.4	
	90918	50	69	1249	63	80.8	4.5	49	81.8	4.5	
	100504	70	69	360	20	81.9	3.0	78	66.5	2.5	
	100508	55	69	616	31	78.1	3.4	55	74.1	3.5	
	111302	60	69	176	20	81.7	3.5	35	99.0	4.0	
	111306	47	69	508	26	81.0	6.0	45	85.4	8.2	
CdD	90301	55	69	275	20	65.3	3.7	48	66.3	3.7	91.1(11.99)**
	111026	68	69	772	39	82.7	4.8	38	95.5	4.7	

	111209	70	69	449	23	76.7	6.9	31	98.4	7.3	
	111302	60	69	1830	92	80.5	4.7	35	97.7	5.2	
	111306	47	69	626	32	73.5	3.5	45	77.3	3.7	
HaC	90324	66	75	574	29	99.0	5.3	65	87.4	4.6	87.4(4.56)**
HaD	90101	72	75	362	20	105.7	4.6	35	121.3	3.9	121.3(3.93)**
MaE	90428	80	64	491	25	60.6	5.7	40	68.7	6.2	90.4(17.73)**
	110142	88	64	593	27	84.2	6.8	30	107.6	6.0	
	110207	67	64	294	20	81.5	4.7	38	94.3	4.8	
PaE	100504	70	70	329	20	85.8	3.6	78	69.5	2.9	
	111026	68	70	393	20	87.5	5.1	38	100.5	4.2	
	111218	75	70	506	26	95.0	4.5	30	116.9	3.5	98.7(18.29)**
	111302	60	70	251	20	85.4	9.3	35	102.3	9.3	
PcD2	90215	71	60	1098	55	85.8	6.5	43	91.8	7.0	81.9(11.76)**
	90301	55	60	1056	53	70.5	4.5	48	71.5	4.5	

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 12B. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with shortleaf pine as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	LiDAR SI (ft, base age 50) (2011)	LiDAR SI Std Dev (2011)	LiDAR SI (ft, base age 50) Mean (2011)	LiDAR Combined Mean SI (ft, base age 50)
CbB	90215	71	66	1252	63	96.0	5.0	46	99.0	5.0	84.9(20.24)**	84.7(20.19)**
	90301	55	66	61	20	47.0	5.1	51	46.0	5.1		
	90419	70	66	212	20	80.4	4.2	30	103.7	4.0		
	90918	50	66	482	25	79.2	6.8	52	78.2	6.8		
	111306	47	66	174	20	68.1	5.6	48	69.1	5.6		
CbC	90301	55	66	564	29	74.9	4.5	51	73.9	4.5	74.5(10.55)**	72.3(9.99)**
	90507	70	66	429	22	87.0	7.9	53	84.0	7.9		
	90915	47	66	121	20	66.0	10.6	52	65.0	10.6		
CcC2	90215	71	55	215	20	96.6	6.7	46	99.8	7.0	100.6(5.51)**	100.8(5.02)**
	90419	70	55	211	20	78.0	3.3	30	101.4	3.5		
CdB	90918	50	69	938	47	75.7	9.1	52	74.7	9.1	74.7(9.08)**	76.4(7.32)**
CdC	90428	80	69	1794	90	78.7	8.4	43	85.2	8.8	81.7(10.38)**	81.0(10.77)**
	90507	70	69	50	20	74.6	3.1	53	71.6	3.1		
	90915	47	69	213	20	67.1	5.0	52	66.1	5.0		
	90918	50	69	1163	59	81.0	4.2	52	80.0	4.2		
	100504	70	69	260	20	88.5	2.7	81	71.1	2.1		
	100508	55	69	467	24	86.1	6.1	58	80.0	5.7		
	111302	60	69	138	20	86.7	4.4	38	99.9	3.8		
	111306	47	69	393	20	90.5	5.3	48	91.5	5.3		
CdD	90301	55	69	227	20	72.4	3.5	51	71.4	3.5	95.1(12.08)**	92.9(12.18)**
	111026	68	69	606	31	87.1	3.3	41	97.2	3.6		

	111209	70	69	424	22	84.8	5.1	34	103.6	6.2		
	111302	60	69	1418	71	90.1	4.9	38	102.6	4.7		
	111306	47	69	506	26	82.1	5.9	48	83.1	5.9		
HaC	90324	66	75	407	21	108.0	4.4	68	93.6	3.7	93.6(3.73)**	90.0(5.21)**
HaD	90101	72	75	279	20	103.8	3.1	38	116.0	2.5	116.0(2.51)**	118.6(4.20)**
MaE	90428	80	64	429	22	68.5	4.2	43	74.1	4.8	90.7(13.26)**	90.5(15.76)**
	110142	88	64	253	20	83.6	4.9	33	102.4	4.4		
	110207	67	64	216	20	87.3	3.1	41	97.4	3.4		
PaE	100504	70	70	239	20	94.0	2.6	81	75.7	2.1		
	111026	68	70	304	20	93.4	5.5	41	103.8	5.6		
	111218	75	70	371	20	104.4	2.3	33	121.3	2.1	101.3(17.21)**	99.9(1.77)**
	111302	60	70	194	20	91.9	8.4	38	104.6	7.9		
PcD2	90215	71	60	820	41	91.5	5.6	46	94.5	5.6	86.6(9.51)**	83.9(11.08)**
	90301	55	60	781	40	79.5	4.4	51	78.5	4.4		

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 13A. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with white oak as Site Index species for the study area (2008).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) (2008)	LiDAR SI Std Dev (2008)	LiDAR SI (ft, base age 50) Mean (2008)
MaD	110710	72	75	1407	71	91.8	4.0	65	81.8	4.0	81.8(3.97)**
MaE	110710	72	75	1398	70	96.9	4.2	65	86.9	4.2	86.9(4.21)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 13B. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with white oak as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	LiDAR SI (ft, base age 50) (2011)	LiDAR SI Std Dev (2011)	LiDAR SI (ft, base age 50) Mean (2011)	LiDAR Combined Mean SI (ft, base age 50)
MaD	110710	72	75	1077	54	103.5	4.1	68	91.6	4.4	91.6(4.40)**	86.0(6.38)**
MaE	110710	72	75	903	46	105.2	4.2	68	93.4	4.5	93.4(4.48)**	89.5(5.36)**

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.

**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 14A. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with yellow poplar as Site Index species for the study area.

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2008)	LiDAR n (20 or 5% greatest) (2008)	LiDAR Mean Ht (ft) (2008)	LiDAR Std Dev (2008)	Age (2008)	LiDAR SI (ft, base age 50) (2008)	LiDAR SI Std Dev (2008)	LiDAR SI (ft, base age 50) Mean (2008)
CdC	100503	85	92	1319	66	93.0	6.8	85	82	6	81.8(6.27)**
CdD	100414	100	92	378	22	112.9	4.3	62	106	4	100.4(9.76)**
	100503	85	92	396	20	95.3	7.5	85	84	7	
	111027	102	92	1332	67	106.4	5.8	55	103	6	
MaE	90426	105	96	542	28	113.1	5.1	45	117	5	113.1(22.37)**
PaE	90426	105	90	268	20	115.0	6.2	45	119	6	110.6(13.31)**
	90707	91	90	2065	104	107.9	4.9	55	105	5	
	100229	90	90	3611	181	124.1	6.8	48	125	7	
	100310	90	90	347	20	95.9	4.0	49	96.9	4.0	
	100414	100	90	863	44	113.1	7.3	62	106.3	7.1	
	100503	85	90	2723	137	114.0	7.6	85	100.9	6.6	
	111027	102	90	679	34	104.4	3.9	55	101.4	3.9	

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

Table 14B. Comparison of Site Index soil data from SSURGO database for SSURGO Map Unit Symbol with yellow poplar as Site Index species for the study area (2008 and 2011).

Map Unit Symbol	Stand ID	Stand SI (ft, base age 50)	SSURGO SI (ft, base age 50)	LiDAR Total Number Trees (2011)	LiDAR n (20 or 5% greatest) (2011)	LiDAR Mean Ht (ft) (2011)	LiDAR Std Dev (2011)	Age (2011)	LiDAR SI (ft, base age 50) (2011)	LiDAR SI Std Dev (2011)	LiDAR SI (ft, base age 50) Mean (2011)	LiDAR Combined Mean SI (ft, base age 50)
CdC	100503	85	92	1005	51	106.9	7.5	88	93.9	6.1	93.9(6.06)*	87.1(8.64)**
CdD	100414	100	92	283	20	119.7	4.4	65	111.5	4.3	108.1(9.92)**	103.9(10.53)**
	100503	85	92	296	20	105.2	6.0	88	92.7	5.2		
	111027	102	92	986	50	118.9	6.1	58	112.9	6.0		
MaE	90426	105	96	361	20	125.3	5.1	48	126.3	5.1	126.3(5.13)**	121.0(6.86)**
PaE	90426	105	90	173	20	121.6	3.6	48	122.6	3.6	115.0(9.44)**	112.7(11.37)**
	90707	91	90	1565	79	115.8	3.8	58	109.8	3.8		
	100229	90	90	3435	172	123.5	7.1	51	122.5	7.1		
	100310	90	90	333	20	94.2	3.2	52	93.2	3.2		
	100414	100	90	687	35	125.0	5.6	65	116.8	5.6		
	100503	85	90	2029	102	126.8	4.8	88	110.4	4.4		
	111027	102	90	494	25	112.7	4.2	58	106.7	4.2		

* Indicates significantly different than SSURGO at $\alpha = 0.05$ level.
**Indicates significantly different than SSURGO at $\alpha = 0.01$ level.

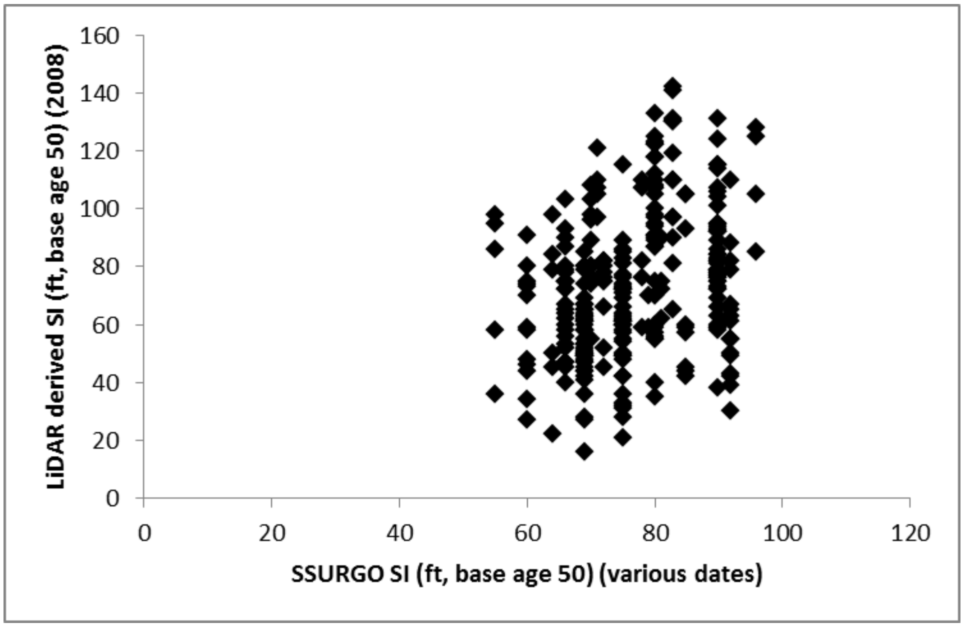


Figure 9. A plot of the LiDAR derived site index (2008) against SSURGO site index (various dates) of 302 plots.

Figure 10. A plot of the SSURGO site index (2008) against Inventory measured site index (2008) of 302 plots.

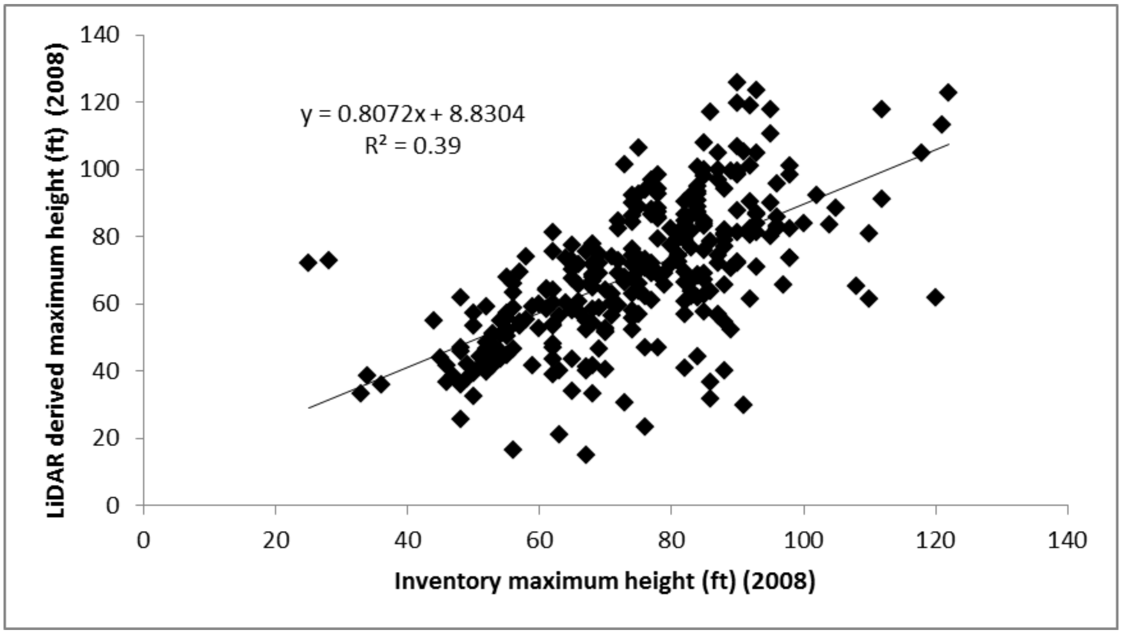


Figure 11. A plot of the LiDAR derived maximum height (2008) against Inventory (2007-2008) measured maximum height of 302 plots.

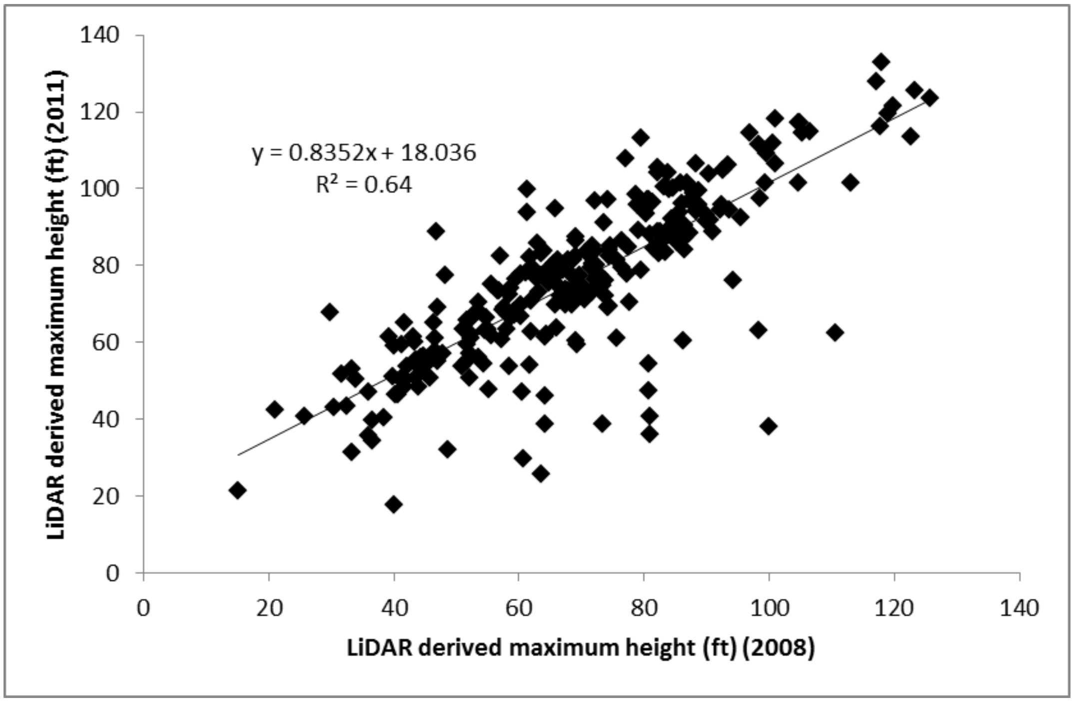


Figure 12. A plot of the LiDAR derived maximum height (2011) against LiDAR derived maximum height (2008) of 258 plots.

Table 15. Summary statistics for Figures 11 and 12.

Figure	R^2	n	t-test	t-value $\alpha = 0.05$	t-value $\alpha = 0.01$	p-value
11	0.39	302	13.84930607	1.645	2.326	<.0001
12	0.64	258	21.33333333	1.645	2.326	<.0001

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