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

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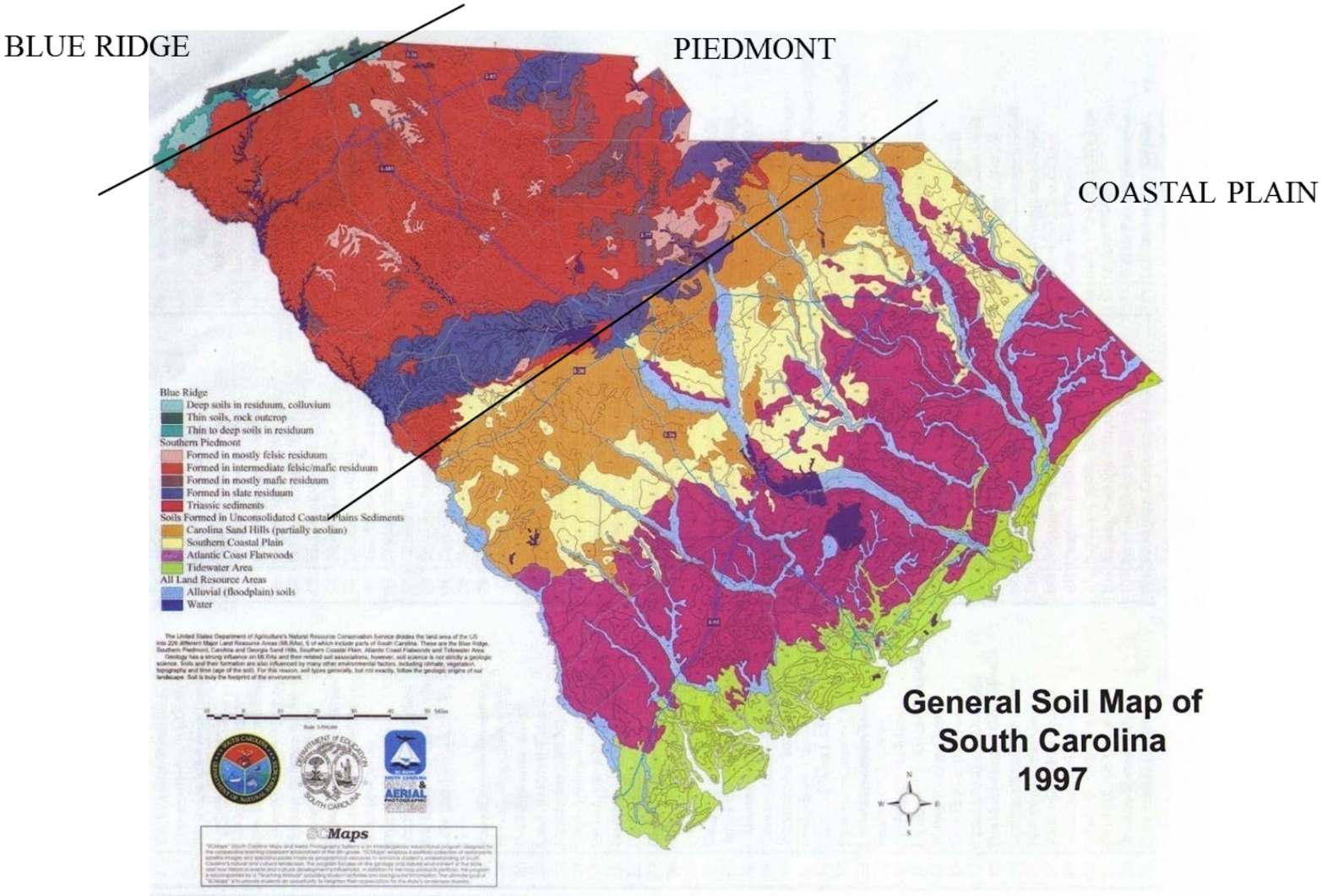
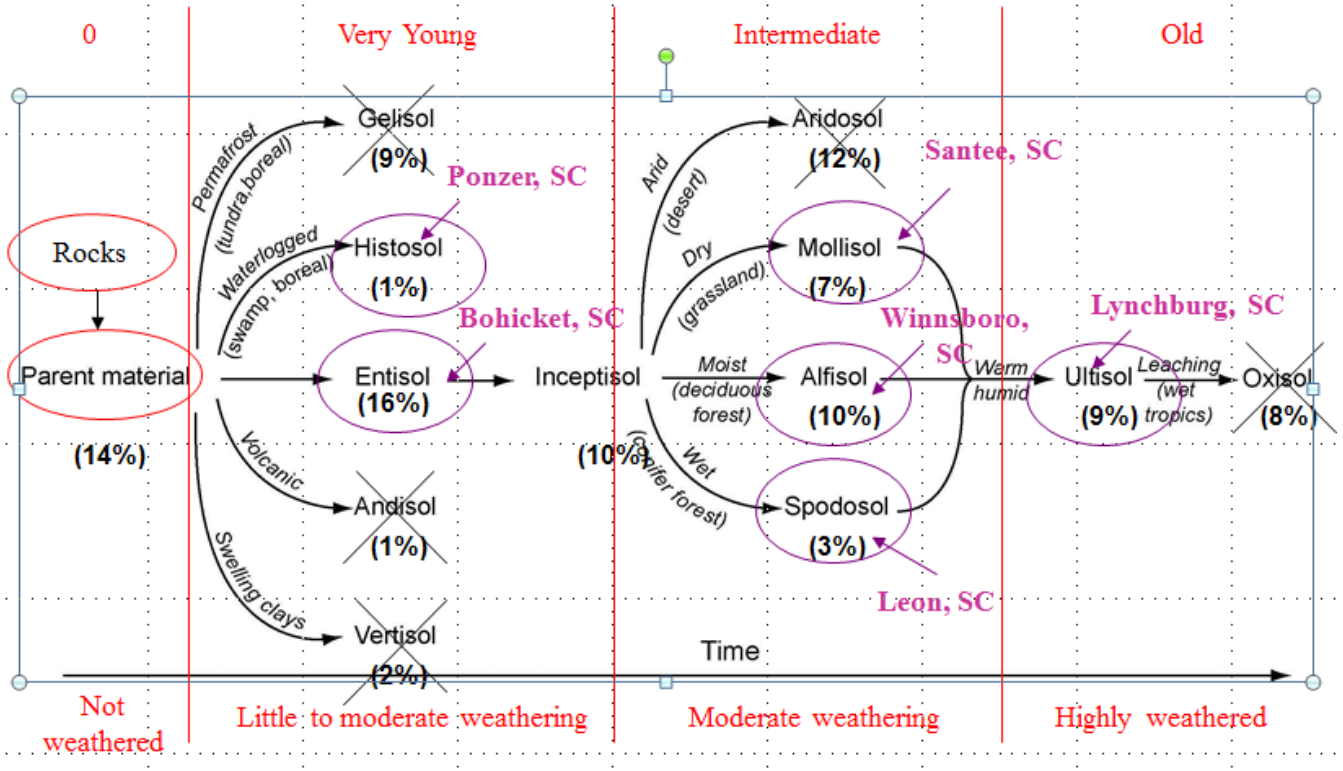
Soil Map of South Carolina



Soil Diversity in South Carolina

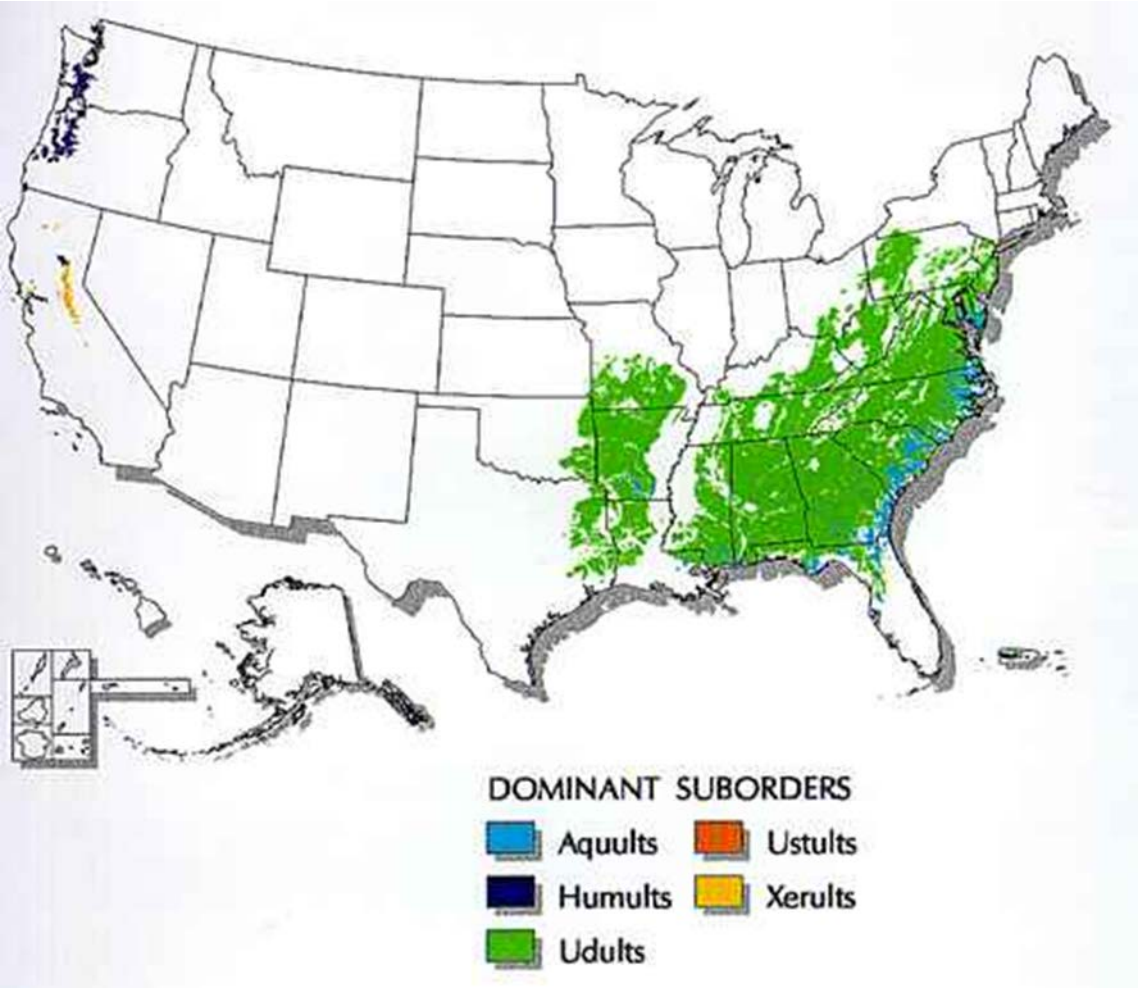
7 *out of 12 soil orders occur in SC;*

400 out of 21,000 soil series occur in SC



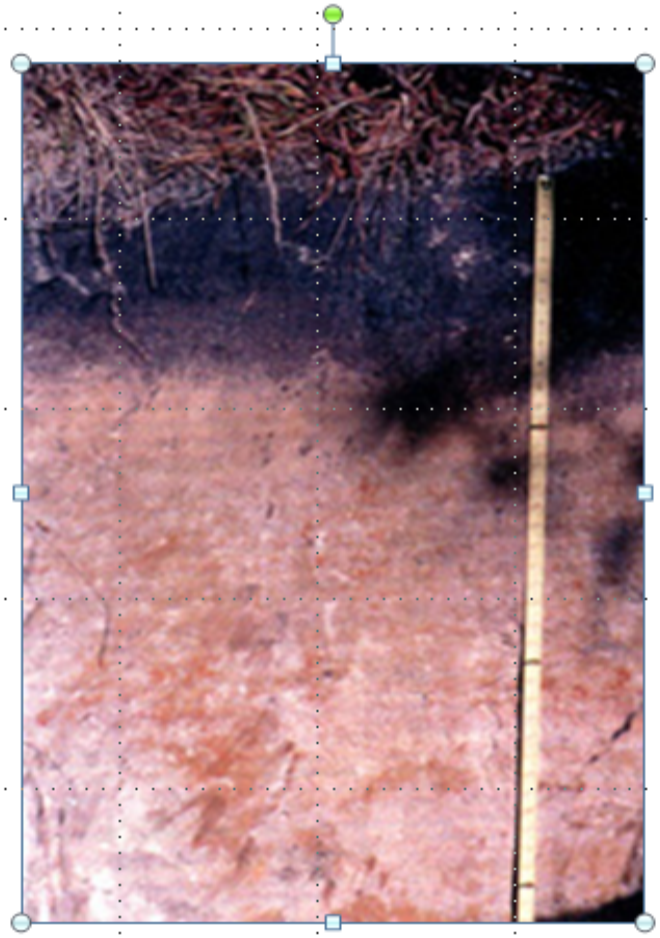
http://hcs.osu.edu:16080/osuetalks/003/Boggs%20Soil.ppt; Dennis Netoff, 1997

The Most Common Soil Order in SE is…



Source: USDA/NRCS

Lynchburg – SC State Soil



- The Lynchburg series consists of very deep, somewhat poorly drained soils that formed in sandy and loamy marine sediments.
- These soils are in shallow depressions or on broad interstream divides on the Coastal Plain. Where drained, the soils are considered prime farmland.
- Lynchburg soils have a high site index for lobolly pine.
- There are approximately 432,000 acres of Lynchburg soils in South Carolina.
- The mean annual precipitation ranges from 38 to 50 inches, and the mean annual temperature ranges from 59 to 66 degrees F.

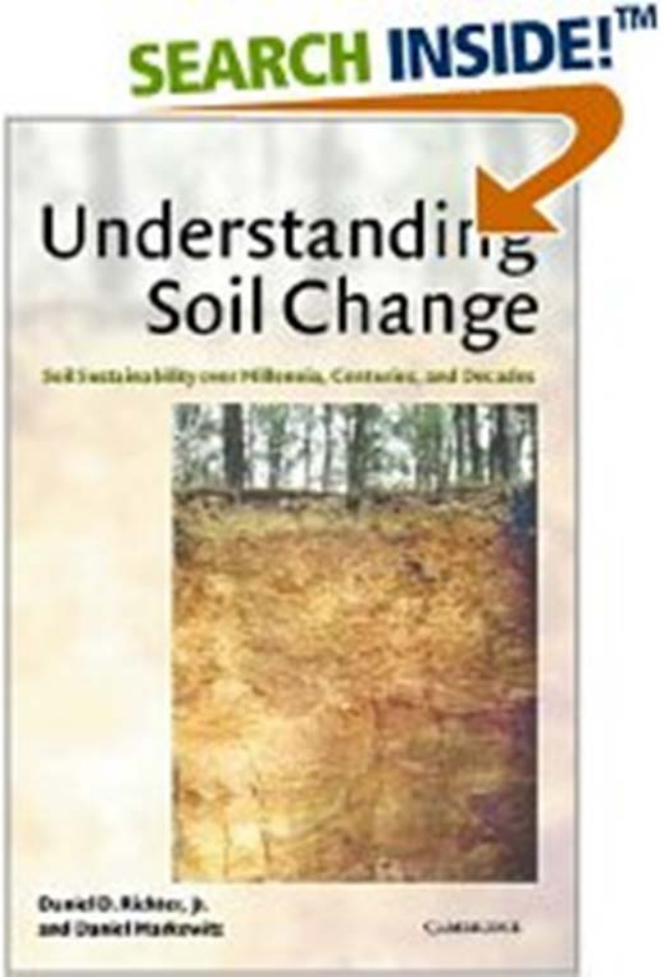
Source: USDA/NRCS

TAXONOMIC CLASS:
Fine-loamy, siliceous, semiactive, thermic Aeric Paleaquults

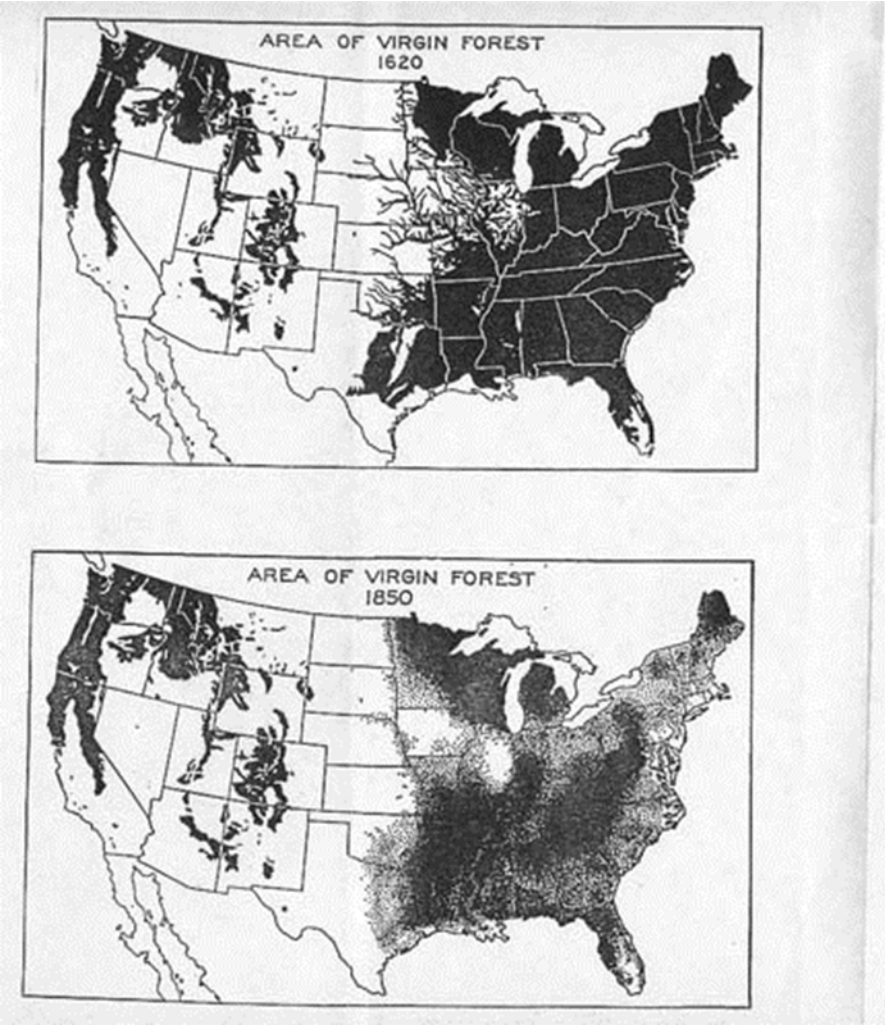
TYPICAL PEDON: Lynchburg loamy fine sand--cultivated. (Colors are for moist soil.)
Ap--0 to 6 inches; very dark gray (10YR 3/1) loamy fine sand; weak medium granular structure; very friable; common fine roots, few medium roots; very strongly acid; clear smooth boundary. (3 to 11 inches thick)
E--6 to 10 inches; light olive brown (2.5Y 5/4) loamy fine sand; weak medium subangular blocky structure; very friable; common fine roots; few fine pores; common medium distinct dark gray (10YR 4/1) iron depletions; very strongly acid; clear smooth boundary. (0 to 10 inches thick)
Bt--10 to 17 inches; light olive brown (2.5Y 5/4) sandy clay loam; weak medium subangular blocky structure; friable; common fine roots; few fine pores; few faint clay films on faces of some peds; common medium distinct light brownish gray (2.5Y 6/2) iron depletions and many medium distinct yellowish brown (10YR 5/6), and few fine medium prominent red (2.5YR 4/8) masses of oxidized iron; very strongly acid; clear wavy boundary.
Btg1--17 to 30 inches; light brownish gray (2.5Y 6/2) sandy clay loam; weak medium subangular blocky structure; friable; few fine roots; few fine pores; common faint clay films on faces of some peds; many medium prominent yellowish brown (10YR 5/6) and common medium prominent red (2.5YR 4/6) masses of oxidized iron; very strongly acid; gradual smooth boundary.
CONTINUED: Btg2--Btg3

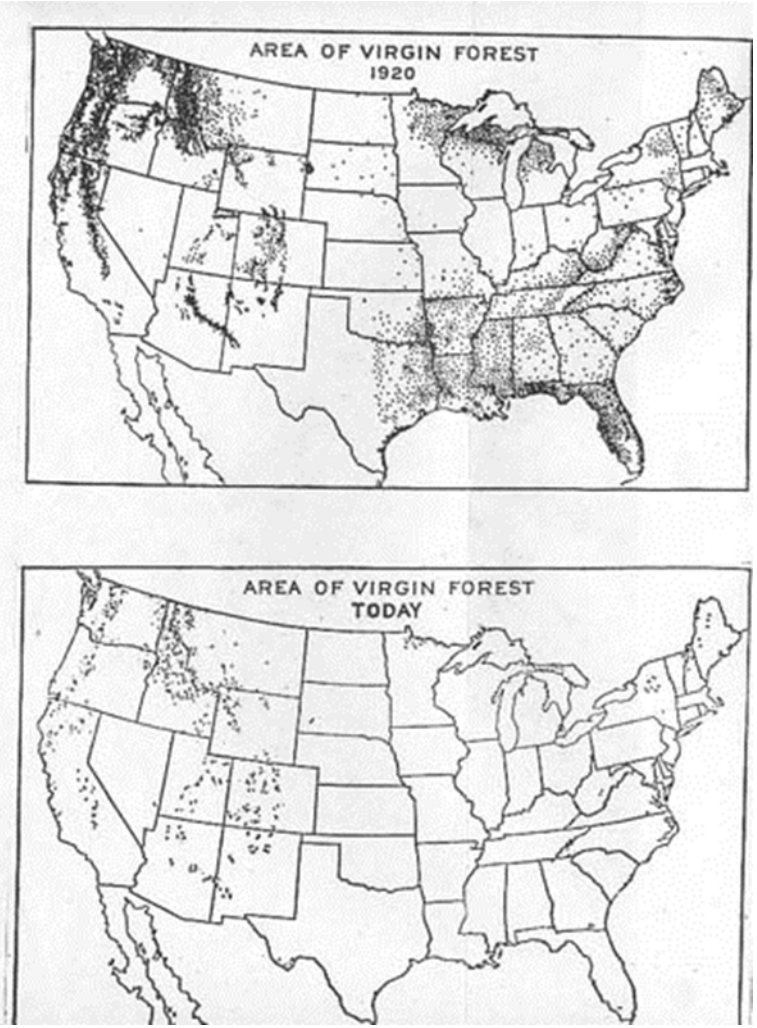
Source: USDA/NRCS

History of Soil Use in South Carolina



Deforestation



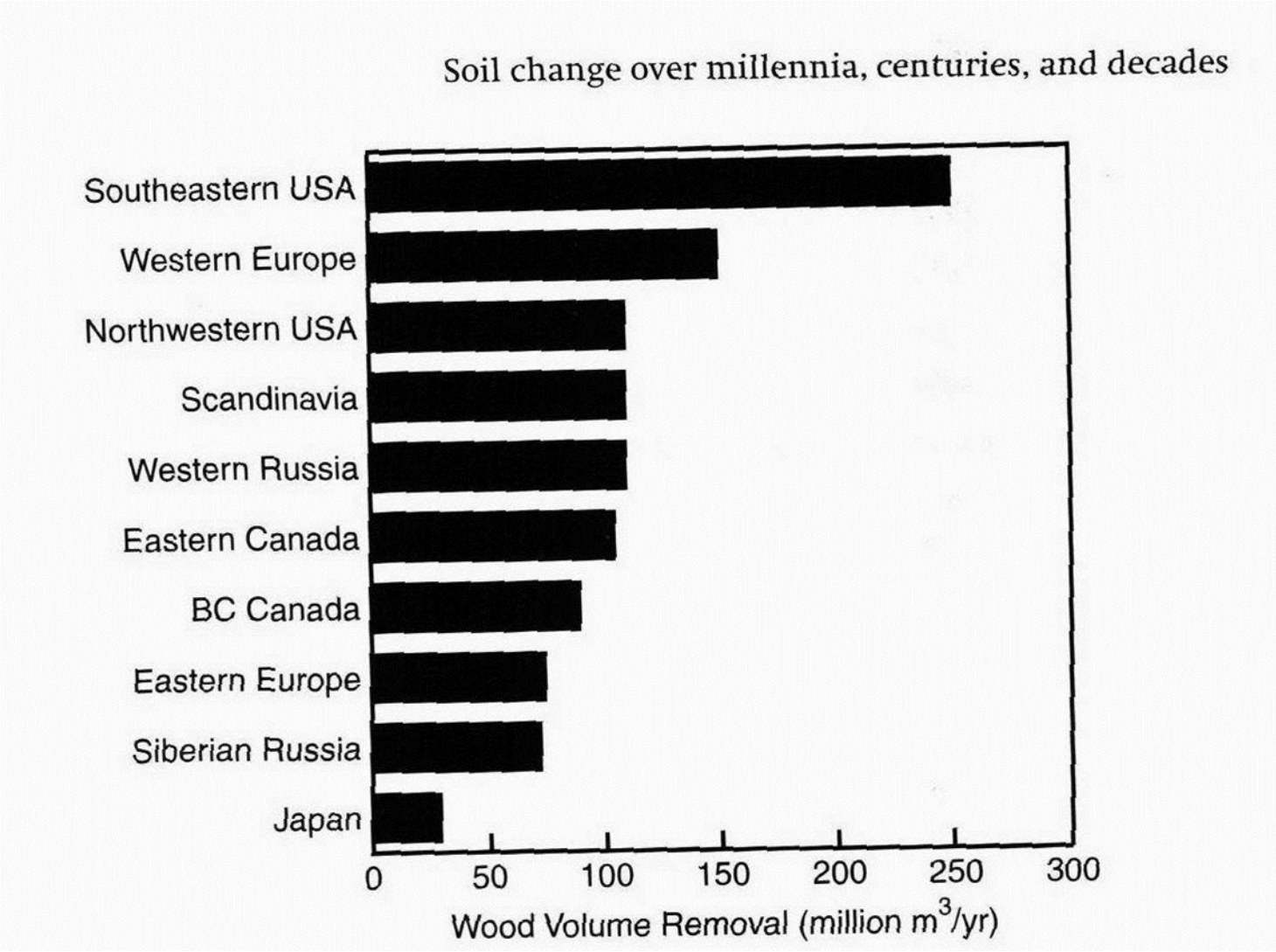


Source: Wikipedia

Land-use History and Calhoun Experimental Forest

Source: http://www.czen.org/node/263

- The Calhoun Experimental Forest was originally selected as a research site to learn how to stabilize agriculturally disturbed landforms, watersheds, and whole landscapes.
- The first director and founder of the Calhoun Forest, Dr. Lou Metz, selected the Calhoun "as the worst of the worst" and was confident if US Forest Service researchers could learn how to slow accelerated erosion, promote soil fertility, and establish forests at the Calhoun, they could do such anywhere in the South.
- Fifty years later, some gullies are still active despite the best efforts of the USFS, but most of the eroded Southern Piedmont lies beneath a blanket of green.

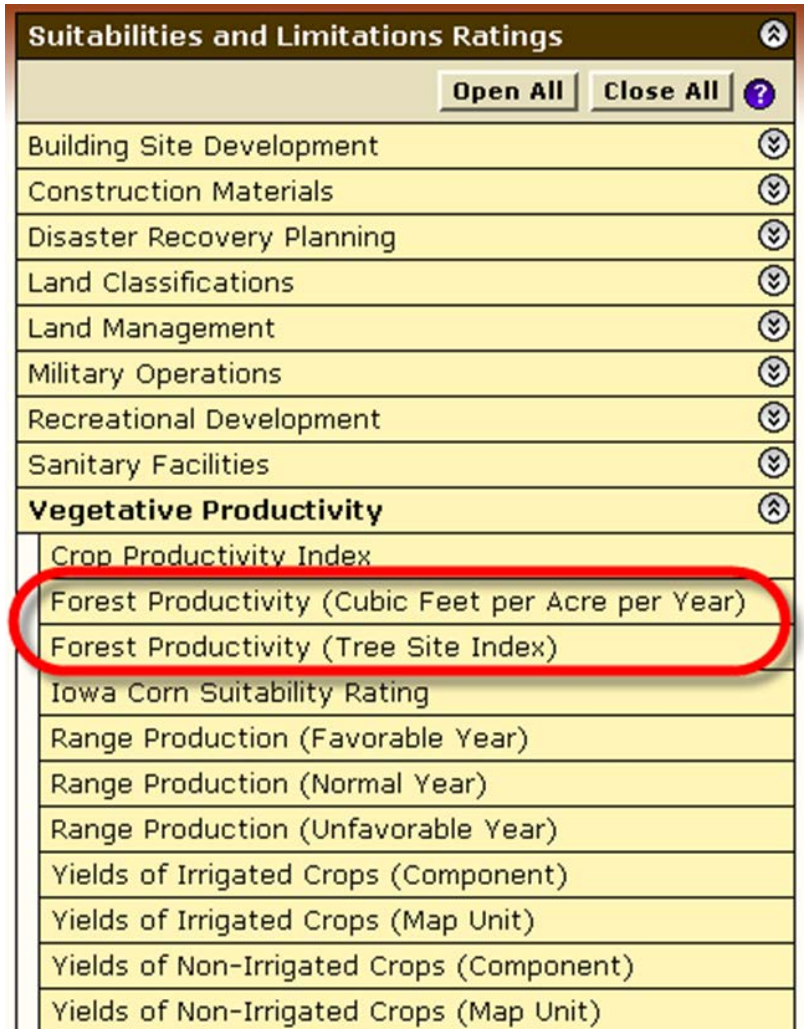


Source: Richter and Markewitz, 2001

Climate Change

- 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, 2010; Poudel et al., 2011).
- Several studies predict 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).
- 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.

Forest Soils and Web Soil Survey



Forest Soils and Site Index

"Soil quality is the most important factor in forest management decisions. Soils will determine which tree species yield the greatest timber volume, the time of harvest, and ultimately, the investment a landowner must make to yield an acceptable economic return from forest management."

Source: Woodland Owner Notes

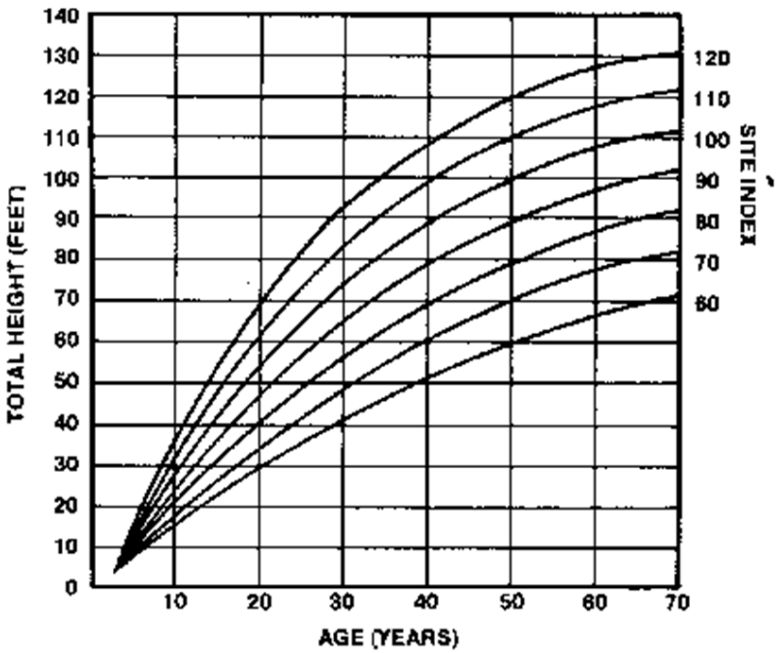
Relation of Site Index (SI) to Timber Yield of Managed Loblolly Pine

SI	Yield at Age 40	Value
70	6 MBF[1] + 26 cords[2]	$1082[3]
80	14 MBF + 37 cords	$2359
90	19 MBF + 38 cords	$3116
100	29 MBF + 36 cords	$4602

[1]Thousand board feet (International Rule) of sawtimber per acre assuming recommended thinnings are completed.
[2]Cords of pulpwood per acre removed as thinnings.
[3]Value per acre assuming $150 per MBF and $7 per cord.

Source: Woodland Owner Notes

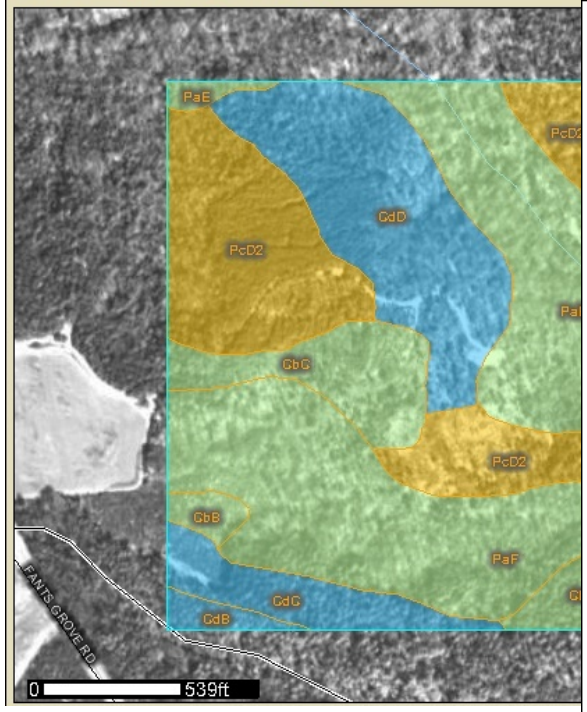
Site Index Curves



Site Index Curves for Loblolly Pine at Index Age 50 years.

- Site index (SI) is a measurement used to describe the productivity of a site. It describes sites growing well-stocked even-aged forests.
- Site index is the average height of the dominant and co-dominant trees on the site, at a given age (base age).
- Typically, the base age for loblolly pine in South Carolina is 50 years. Ultisols have a site index measured at base age 50 years for loblolly pine of 20 to 29 m (65 to 95 ft) in the Piedmont.
- The higher the SI, the higher the site productivity (trees will grow faster than on a site with a lower SI) (Baker and Langdon, 2012).

Map — Forest Productivity (Tree Site Index): loblolly pine (Coile, Schumacher 1953 (690))



Tables — Forest Productivity (Tree Site Index): loblolly pine (Coile, Schumacher 1953 (690)) — Summary By Map Unit

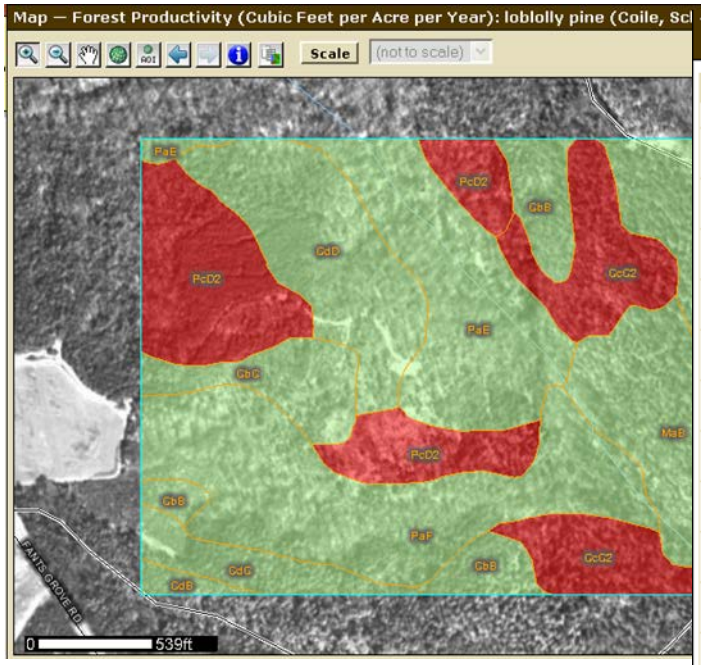
Summary by Map Unit — Anderson County, South Carolina

Map unit symbol	Map unit name	Rating (feet)	Acres in AOI	Percent of AOI
ApB	Appling sandy loam, 2 to 6 percent slopes	84	0.5	0.3%
CbB	Cataula sandy loam, 2 to 6 percent slopes	80	26.0	16.8%
CbC	Cataula sandy loam, 6 to 10 percent slopes	80	5.8	3.8%
CcC2	Cataula clay loam, 6 to 10 percent slopes, eroded	65	16.2	10.4%
CdB	Cecil sandy loam, 2 to 6 percent slopes	83	1.1	0.7%
CdC	Cecil sandy loam, 6 to 10 percent slopes	83	5.0	3.2%
CdD	Cecil sandy loam, 10 to 15 percent slopes	83	15.3	9.9%
HaB	Hiwassee sandy loam, 2 to 6 percent slopes	85	4.1	2.7%
MaB	Madison sandy loam, 2 to 6 percent slopes	80	14.2	9.2%
PaE	Pacolet sandy loam, 15 to 25 percent slopes	78	18.1	11.7%
PaF	Pacolet sandy loam, 25 to 40 percent slopes	78	25.6	16.5%
PcD2	Pacolet clay loam, 10 to 15 percent slopes, eroded	70	20.2	13.0%
Tc	Toccoa-Cartecay complex	92	2.8	1.8%
Totals for Area of Interest (AOI)			**154.8**	**100.0%**

Forest Productivity –Tree Site Index (loblolly pine)

The "site index" is the average height, in feet, that dominant and co-dominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this attribute, only the representative value is used.



Tables — Forest Productivity (Cubic Feet per Acre per Year): loblolly pine (Coile, Schumacher 1953 (690)) — Summary By Map Unit

Summary by Map Unit — Anderson County, South Carolina

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
ApB	Appling sandy loam, 2 to 6 percent slopes	114.00	0.5	0.3%
CbB	Cataula sandy loam, 2 to 6 percent slopes	114.00	26.0	16.8%
CbC	Cataula sandy loam, 6 to 10 percent slopes	114.00	5.8	3.8%
CcC2	Cataula clay loam, 6 to 10 percent slopes, eroded	86.00	16.2	10.4%
CdB	Cecil sandy loam, 2 to 6 percent slopes	114.00	1.1	0.7%
CdC	Cecil sandy loam, 6 to 10 percent slopes	114.00	5.0	3.2%
CdD	Cecil sandy loam, 10 to 15 percent slopes	114.00	15.3	9.9%
HaB	Hiwassee sandy loam, 2 to 6 percent slopes	114.00	4.1	2.7%
MaB	Madison sandy loam, 2 to 6 percent slopes	114.00	14.2	9.2%
PaE	Pacolet sandy loam, 15 to 25 percent slopes	114.00	18.1	11.7%
PaF	Pacolet sandy loam, 25 to 40 percent slopes	114.00	25.6	16.5%
PcD2	Pacolet clay loam, 10 to 15 percent slopes, eroded	86.00	20.2	13.0%
Tc	Toccoa-Cartecay complex	133.81	2.8	1.8%
Totals for Area of Interest (AOI)			**154.8**	**100.0%**

Tree: loblolly pine

Description — Forest Productivity (Cubic Feet per Acre per Year)

Forest productivity is the volume of wood fiber that is the yield likely to be produced by the most important tree species. This number, expressed as cubic feet per acre per year and calculated at the age of culmination of the mean annual increment (CMAI), indicates the amount of fiber produced in a fully stocked, even-aged, unmanaged stand.

This attribute is actually recorded as three separate values in the database. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this attribute, only the representative value is used.

National Register of Site Index Curves

National Register of Site Index Curves

Scientific Name Common Name NSPNS	Curve Number Age Base Reference	Area of Use	Age Correction Factor								
Abies amabilis Pacific silver fir ABAM	05 100TA Hoyer, Herman 1989	Entire Range	Not Needed								
Abies balsamea balsam fir ABBA	010 50TA Gevorkiantz 1956a	Northeast	**SI** **Years**	30 15	40 13	50 11	60 9	70 8			
	011 50TA Carmean, Hahn 1981	Lake States	**SI** **Years**	20 15	30 13	40 11					
	020 50TA Lloyd 1970a	Northeast	**SI** **Years**	30 15	40 13	50 11	60 9	70 8			
	030 50TA Schumacher 1926	Entire Range	**SI** **Years**	30 16	40 14	50 12	60 10	70 8	80 6	90 5	

http://esis.sc.egov.usda.gov/CustomReports/html/fsnatreg.htm

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?

Objectives of the Study

- 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.

Materials and Methods: Study Site

Clemson Experimental Forest (study site). Photo: Knight Cox.

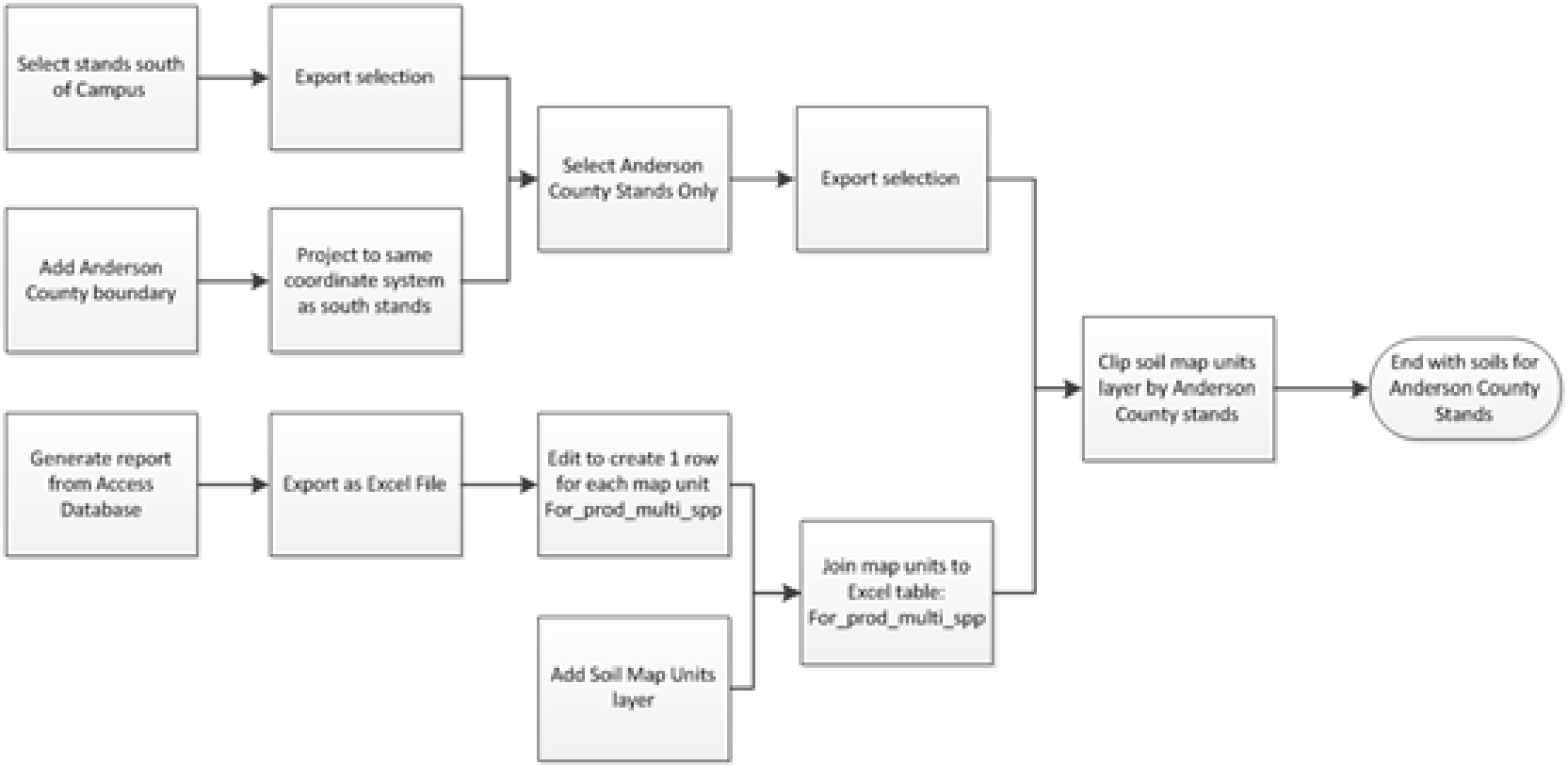
- The Clemson Experimental Forest was originally eroded farmland;
- Management began in 1939.
- Loblolly pine is the main species on the tracts along with many other pine and hardwood species.

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.

SSURGO Flowchart



RESULTS AND DISCUSSION

Soil Inventory Results

There are three soil orders within the study site : Ultisols, Entisols, and Inceptisols (Table 1).

Table 1. Soil Taxonomic Name (Soil Survey Staff, 2012).

Anderson County, South Carolina	
Soil name	**Family or higher taxonomic classification**
Appling	Fine, kaolinitic, thermic Typic Kanhapludults
Cartecay	Coarse-loamy, mixed, semiactive, nonacid, thermic Aquic Udifluvents
Cataula	Fine, kaolinitic, thermic Oxyaquic Kanhapludults
Cecil	Fine, kaolinitic, thermic Typic Kanhapludults
Chewacla	Fine-loamy, mixed, active, thermic Fluvaquentic Dystrudepts
Gwinnett	Fine, kaolinitic, thermic Rhodic Kanhapludults
Hiwassee	Very-fine, kaolinitic, thermic Rhodic Kanhapludults
Madison	Fine, kaolinitic, thermic Typic Kanhapludults
Pacolet	Fine, kaolinitic, thermic Typic Kanhapludults
Toccoa	Coarse-loamy, mixed, active, nonacid, thermic Typic Udifluvents
Urban land	
Water	
Wet spot	Coarse-loamy, mixed, semiactive, nonacid, thermic Typic Fluvaquents
Pickens County, South Carolina	
Soil name	**Family or higher taxonomic classification**
Cecil	Fine, kaolinitic, thermic Typic Kanhapludults
Hiwassee	Very-fine, kaolinitic, thermic Rhodic Kanhapludults
Pacolet	Fine, kaolinitic, thermic Typic Kanhapludults
Water	

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

* Indicates significantly different than SSURGO at α = 0.05 level.
**Indicates significantly different than SSURGO at α = 0.01 level.

Table 4. Comparison of Site Index data from SSURGO database for study area (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.)	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.)
ChB	Cataula	Sandy loam	2-6	Loblolly pine (4) (4) Shortleaf pine (20) (18)	80 66	86.5(4.04)* 64.1(9.51)	89.8(13.72) 70.0(17.65)	80.0(28.72) 71.6(17.63)	101.6(15.66)** 84.5(20.20)**	95.6(9.84)** 84.9(20.24)**	98.5(13.18)** 84.7(20.19)**
ChC	Cataula	Sandy loam	6-10	Loblolly pine (4) (0) Shortleaf pine (6) (6)	80 66	80.0(0.00) 61.2(10.11)	108.0(15.37)* 61.7(4.32)*	- 66.7(12.52)	125.3(2.54)** 70.5(9.23)**	52.6(27.45)** 74.5(10.55)**	92.2(40.93)* 72.3(9.99)**
CeC2	Cataula	Clay loam	6-10	Shortleaf pine (5) (4)	55	70.8(0.45)**	74.6(28.74)	77.5(20.82)	101.0(4.53)**	100.6(5.51)**	100.8(5.02)**
CdB	Cecil	Sandy loam	2-6	Loblolly pine (5) (4) Shortleaf pine (7) (7)	85 69	101.2(17.44)* 50.0(0.00)	110.0(18.18)* 61.1(10.51)*	114.5(9.00)** 46.4(1.86)**	107.4(16.01)** 78.0(4.82)**	110.9(17.26)** 74.7(9.08)**	108.9(16.58)** 76.4(7.32)**
CdC	Cecil	Sandy loam	6-10	Loblolly pine (10) (8) Shortleaf pine (29) (27) Yellow poplar (10) (9)	85 69 92	95.4(14.38)* 66.1(14.16) 85.0(0.00)	113.3(25.56)** 57.1(13.33)** 58.1(14.54)**	122.9(13.85)** 62.1(14.07)** 69.3(12.12)**	124.7(10.62)** 80.3(11.08)** 81.8(6.27)**	102.8(35.11)** 81.7(10.38)** 93.9(6.06)*	114.2(27.64)** 81.0(10.77)** 87.1(8.64)**
CdD	Cecil	Sandy loam	10-15	Scarlet oak (4) (4) Shortleaf pine (14) (12) Yellow poplar (7) (7)	81 69 92	69.0(0.00) 59.6(5.42)** 93.9(8.32)	74.8(11.59) 51.0(15.04)** 64.6(27.01)*	81.0(8.68) 61.7(26.43) 74.9(25.25)	79.7(5.84) 91.1(11.99)** 100.4(9.76)**	87.7(5.14)** 95.1(12.08)** 108.1(9.92)**	83.2(5.79)** 92.9(12.18)** 103.9(10.53)**
CeC2	Cecil	Clay loam	6-10, eroded	Loblolly pine (10) (10)	72	70.0(0.00)	71.1(12.87)	76.9(1.35)**	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)	67.8(26.00)*	57.5(10.77)**	87.4(19.68)	77.6(14.70)**	83.5(18.41)
HaC	Hiwassee	Sandy loam	6-10	Shortleaf pine (8) (5)	75	68.3(5.11)**	79.1(21.54)	75.0(17.13)	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)	95.3(17.04)	-	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)	108.0(8.72)**	-	119.5(2.12)**	82.0(23.17)**	101.0(24.86)**
MaC	Madison	Sandy loam	6-10	Loblolly pine (14) (12) Scarlet oak (8) (4)	80 75	92.4(8.00)** 69.0(0.00)	78.0(28.47) 58.5(4.63)**	83.2(32.31) 74.3(13.43)	105.1(27.05)** 79.5(6.28)**	98.1(36.27)** 87.8(5.27)**	101.0(31.26)** 82.2(7.13)**
MaD	Madison	Sandy	10-15	Loblolly pine (10) (10)	80	94.0(8.43)**	96.8(27.37)*	99.7(26.45)*	122.0(16.52)**	121.1(21.04)**	121.6(18.71)**

* Indicates significantly different than SSURGO at α = 0.05 level.

**Indicates significantly different than SSURGO at α = 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)**

* Indicates significantly different than SSURGO at α = 0.05 level.
**Indicates significantly different than SSURGO at α = 0.01 level.

Table 2. 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 α = 0.05 level.
**Indicates significantly different than SSURGO at α = 0.01 level.

Table 3. 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 4. 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.

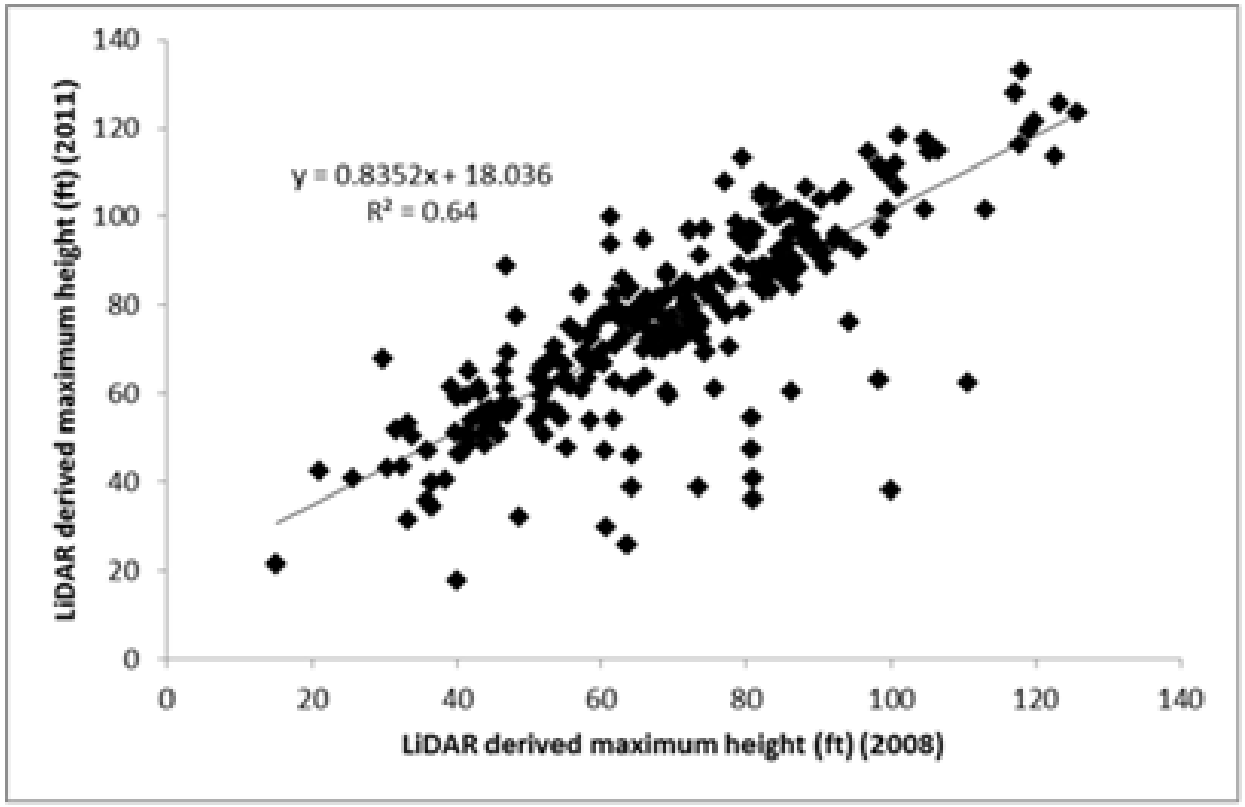


Figure 3. A plot of the LiDAR derived maximum height (2011) against LiDAR derived maximum height (2008) of 258 plots.

Conclusions

- Site indices (SI, tree height at a base age) reported in conventional soil surveys were developed many years ago and need to be re-evaluated due to environmental and climatic changes.
- Site indices from field inventory data (2008-2009), Soil Survey Geographic Database (SSURGO), and Light Detection and Ranging (LiDAR, 2008) were compared for the southern part of the Clemson Experimental Forest, South Carolina.
- Statistical differences for site indices were observed 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.

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Questions?