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# A PRELIMINARY TEST OF AN ECOLOGICAL CLASSIFICATION SYSTEM FOR THE OCONEE NATIONAL FOREST USING FOREST INVENTORY AND ANALYSIS DATA

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## ABSTRACT

An ecological classification system (ECS) has been developed for use in evaluating management, conservation and restoration options for forest and wildlife resources on the Oconee National Forest. Our study was the initial evaluation of the ECS to determine if the units at each level differed in potential productivity. We used loblolly pine (*Pinus taeda*) site index from field plots inventoried by the forest inventory and analysis group of the Forest Service as a measure of productivity at each hierarchical level. The classification system performed best at the landtype level where it identified significant differences in site index between exposed slopes (82 feet) and sheltered slopes (94 feet). Results were less conclusive at the landtype association level, where no clear differences in site index were found among seven units. Results of this preliminary test suggest the ECS will be useful as a guide for diversifying forest cover composition by identifying land units that differ in environmental properties associated with productivity.

## INTRODUCTION

The USDA Forest Service adopted a policy in 1992 of using an ecological approach for management of natural resources on national forests and grasslands. To assist managers implement that policy consistently at all administrative levels throughout the agency, an eight-level hierarchical framework concept of ecological units was developed for application from national to local scales (Cleland and others 1997). Ecosystems of national and regional extent have been identified and delineated using a “top-down” method of successive stratification of large regions into subregions that represent smaller ecosystems of increasing uniformity (Cleland and others 2007). For identification of the smallest ecosystems, at landscape and local scales, however, a “bottom-up” method is commonly used where data representing environmental components and associated

vegetation are analyzed and grouped into units of similar ecological potential, productivity, and predictable response to disturbance (VanKley 1993, Hix and Pearcy 1997). Where field data are not initially available to develop a bottom-up ECS, however, a survey method based on existing knowledge of environmental relationships, especially as modeled and analyzed with a geographic information system, can be used for the initial subdivision of large areas to form smaller, tentative ecological units. Testing and validation of a survey-based ECS is highly desirable to identify units that require refinement and to gain confidence from users who did not participate in its development (Rowe and Sheard 1981, Barnes and others 1982).

The Oconee National Forest (ONF) used the survey method to develop an ECS consistent with the national ecological framework to form the basis for a large-scale assessment of opportunities for management of forest resources<sup>1</sup>. An interdisciplinary team of resource specialists used expert knowledge of environmental gradients on selected areas of the ONF represented by a range of combinations of bedrock formation, topography, and soils to identify and classify land areas with similar ecological characteristics at a range of scales<sup>2</sup>. The classification system was then applied to the entire ONF using a geographic information system to delineate polygons of similar ecological potential, each of which is hypothesized to enclose an area that differs from its neighbors. The purpose of this study was to begin the process of testing and evaluating the validity of the ONF classification. Our specific objective was to use data from an independent source to determine if the ECS identified land areas that differed in biological response. Our study is considered preliminary because it utilized a small set of existing data to test the classification for only one

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<sup>1</sup> Oconee Large Scale Assessment. Unpublished report on file. Chattahoochee-Oconee National Forests, Gainesville, Ga.

<sup>2</sup> Technical report: Process used in mapping ecological classification system units on the Oconee National Forest of the Georgia Piedmont, July 2009. Unpublished report on file. Chattahoochee-Oconee National Forests. Gainesville, Ga. 9 p.

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environmental response, forest productivity, which was not the main goal of the large scale assessment on the ONF. This study is the first part of an ongoing project to test and refine an ECS for the ONF for integration of ecological concepts with natural resource management (Sharitz and others 1992) to evaluate, for example, the effects of forest restoration on water yields in the southern Piedmont (Trimble and others 1987).

## STUDY AREA AND HIERARCHICAL ECOLOGICAL UNITS

The ONF is in the Midland Plateau-Central Uplands Subsection, one of ten ecological units that stratify the Southern Appalachian Piedmont Section into smaller areas of more uniform environments associated with climate and surficial geologic materials (Cleland and others 2007). Extending from central Alabama northeast to South Carolina, this large (11,884 miles<sup>2</sup>) subsection is a region of highly weathered metamorphic gneisses and schists that includes most of the north-central portion of Georgia (Figure 1). Much of this subsection is an exotic terrain that was accreted to the continent during formation of the Appalachian Mountains, which now forms an extensive shield-like plateau underlain by a complex of granitic gneisses and schists that vary in resistance to weathering and associated soils. Two major river systems draining the region have cut deeply into parts of the plateau surface, forming extensive areas of highly dissected topography that extend more than 50 miles north from the boundary of this subsection with the coastal plains. Harper (1930) subdivided the Piedmont physiographic province into upper and lower parts based on the amount of landscape-scale dissection associated with the major river basins. The ONF is in the highly dissected lower part of the Piedmont, where little of the original plateau surface remains. Almost all of the ONF lies off of the plateau surface, on the broad and highly eroded sides of the extensive drainage basins of the Oconee and Ocmulgee Rivers and their tributaries.

Physiography of the subsection varies, but can be generally characterized as a slightly southerly sloping, moderately to strongly dissected peneplain with few surface features. Occasional granite monadnocks are present in the northern part of the subsection and areas of strongly dissected landforms increase to the south, particularly along the east-west Fall Line transition to the coastal plains (Fenneman 1931, Burbanck and Platt 1964). Staheli (1976) found the dendritic drainage pattern of this region was consistent throughout, but differed markedly from the trellis pattern of the Schist Plains Subsection of the Piedmont farther north. Pehl and Brim (1985) show no noteworthy variation of forest habitats in the region they delineate as the Midland Plateau Region of the Piedmont and which they describe

as "...topography gently to steeply undulating, with forest vegetation associated extensively with steeper topography." Wharton (1989) identified a midland subprovince within the Piedmont (which is similar to the Midland Plateau-Central Uplands Subsection) without further subdivision, and described 14 plant communities associated with topographic and soil moisture regimes ranging from hydric river swamps to xeric bluffs.

Quantitative relationships among environmental gradients and vegetation in the lower Piedmont of Georgia are limited to studies by Cowell (1993, 1998). On a landscape scale, he found vegetative communities could be subdivided into two groups: upland and bottomland forests. Cowell found soil fertility (in the upper 4 inches) was more important than moisture (expressed by topographic position and aspect) when accounting for variation in the distribution of tree species on upland sites. Elsewhere in the broader Appalachian Piedmont region, Golden (1979) reported that composition of forest tree and shrub communities in the highly disturbed landscapes of central Alabama was associated with macroscale landscape position ranging from xeric ridgetops to subhydric stream bottoms. Working in South Carolina, Jones (1988) associated composition of old-growth forest vegetation with a moisture gradient, which he suggested was related to landform, aspect, and soil properties. Brender and Davis (1959) concluded that the effects of topography (as it affects site moisture relations) was more important than soil types in determining the rate of hardwood encroachment into pine stands in the lower Piedmont of Georgia. Considerable study, however, has been made of the unusual flora occurring on soils weathered from materials associated with two intrusive geologic formations: granite (Burbanck and Phillips 1983) and gabbro (Schmidt and Barnwell 2002). Wharton (1989) comments that effects of over 200 years of disturbance to soil and vegetation related to European settlement have largely obscured many ecological relationships but historical accounts suggest that arborescent vegetation was associated with "red land" and "gray land" soil types weathered from different types of bedrock. Nelson (1957) provides a county-level map of the "gray lands" that were usually occupied by a pine-hardwood mixture, "granitic lands" (generally near Elberton, Ga.) that were dominated consistently by pine forests, and "red lands" that supported hardwood stands before European settlement. Following almost two centuries of intensive disturbance, hardwood stands are currently found on about 18 percent of the Piedmont landscape, equally distributed between bottomlands and lower slopes of coves (Nelson and others 1957).

For our study, the Midland Plateau-Central Uplands subsection was subdivided into landtype associations (LTA) following the hierarchical structure of the national ecological framework. Seven recurring LTAs, based

primarily on composition of mapped geologic formations occurring within the proclamation boundary of the ONF, were delineated as closed polygons enclosing an area of about 1.4 million acres (Figure 1). Bedrock in this subsection is predominately a mixture of highly weathered northeast-trending bands of metamorphic granitic gneisses and schists that have formed soils that vary mostly in depth and degree of erosion. Upland soils, which make up over 90 percent of the study area, are primarily Ultisols that have a thermic temperature regime, a udic moisture regime, are well drained, highly acidic, and low in fertility. Slope gradients of upland soils range from 2 to 35 percent. Most upland soils are classified as eroded, resulting from a long period of intensive cultivation. Climate of this area is a combination of maritime and continental influences that varies little throughout the subsection. Average monthly temperatures range from 44°F in January to 80°F in July. Almost all precipitation occurs as rain, which averages 48 inches annually. The wettest month is March (5.5 inches) and the driest is October (2.8 inches). Soil moisture deficits usually occur annually during the late growing season as a result of high temperature and low precipitation and often are cumulative during successive years of below average rainfall. Elevation averages about 510 feet (range 321-711 feet) for the study area.

Six landtype (LT) units of the ECS, which occurred within all LTAs, were recognized within the three separated land areas forming the proclamation boundary of the ONF (Table 1). All LTs except one (glade) identify segments of the landscape that define a perceived moisture gradient associated with topography, ranging from dry ridges to wet stream banks. Ridges were separated into three classes: (1) Piedmont plain, (low hills atop the plateau), which occurred only slightly (65 acres) within the LT analysis area, (2) broad ridges, and (3) narrow ridges. (major land divides between tributary streams within the river basins). Slopes were stratified in two groups based on the relative amounts of solar radiation received: (1) exposed (aspects between 158° - 292°) or (2) sheltered (aspects from 293° - 157°). Riparian LTs occurred in bottomlands on sites with moisture regimes ranging from supermesic or subhydic on high floodplains to hydric beside streams. Glades are small (1 - 2 acres) "island-like" LTs occurring on nearly flat uplands underlain by gabbro rock formations that have weathered to form soils with clay B-horizons that are highly impervious to water movement (Schroeder and others 2000). These areas are typically flooded during winter and early spring, but usually experience drought during late summer when precipitation declines. Glades are sites with a unique moisture regime that varies seasonally from xeric to hydric

(Schmidt and Barnwell 2002). On the ONF glades occur as two large areas of about 4,000 acres.

Landtypes were further subdivided into landtype phases (LTP), the lowest and most homogenous level of the ECS. Thirteen units (including water) were identified, 5 of which were associated with upland sites and the others with bottomlands (Table 1). The broad ridge LT was subdivided into two LTPs: (1) broad ridge or (2) narrow ridge. Broad ridges were generally those along the ridge divides of 5th level hydrologic units, termed watersheds in the USGS classification scheme, which generally range in area from 40,000 to 250,000 acres. Narrow ridges typically followed 6th level hydrologic units (sub-watersheds) that range from 10,000 to 40,000 acres. Two LTPs associated with slopes were identified using criteria similar to that for LTs: (1) exposed and (2) sheltered. The LTP designated as upland flat was restricted to the glade LT.

Finally, LTPs were modified (LTPm) to account for the biological effects of differential soil erosion. Each LTP was assigned a code representing one of seven mapped or perceived classes of soil erosion, ranging from slight to severe, resulting in a total of 84 potential classification units. When all national forest lands were classified at the LTPm level, however, only 34 ecological units were identified. Most of the riparian LTPs were represented by a single level of erosion, such as forested wetland-slight erosion or sand levee-slight erosion. Each LTPm represents an ecological unit of varying size with sufficiently uniform physical and chemical properties that combine to form environmental conditions suitable for establishment and maintenance of a characteristic vegetative community.

## METHODS

Field data used for testing the classification were obtained from FIA through a standard data service request. Sample plots were restricted to those occurring on sites classified as forest land<sup>3</sup>. Site index (50 years) of loblolly pine on each sample plot was used as the biological response variable. Site index, a timber-related measure of site quality, was not an ideal choice of response variable considering the ecological objectives of the study, but was the best of those available in the FIA data set. Where site index had been determined for a species other than loblolly pine, it was converted to an equivalent value for loblolly pine using relationships reported by Olson and Della-Bianca (1959), Harrington (1987), and other sources.

<sup>3</sup> Forest land is an area >1 acre with at least 10 percent cover by live trees of any size or species, as defined in the Forest Inventory and Analysis Database: Database Description and Users Manual Version 4.0 for Phase2. Draft revision 3. USDA Forest Service. Forest Inventory and Analysis Program. 368 p.

A fixed-effects model analysis of variance was used to determine if the biological response variable (site index) was affected by treatments for each of the four ECS levels. A treatment consisted of the various randomly occurring combinations of environmental variables represented by the classification units within each ECS level. At the LTA level of the ECS, for example, we hypothesized that environmental variation of the Piedmont landscape affecting site index of loblolly pine would be reduced if the underlying geologic formations (see Fig. 1) were taken into account. The seven fixed categories of geology were considered as natural treatments in a completely randomized experimental design. Our null hypothesis, therefore, was that mean site index of loblolly pine did not differ among treatments (i.e. geologic groups or LTAs). Rejection of the null hypothesis resulted in non-rejection of the alternate hypothesis, which stated that mean site index differed among the LTA ecological units. Sample field data to test the hypothesis came from the LTA ecological units in which FIA plots had been placed. Similarly, the six LT ecological units were assumed to be moisture regime treatments that were sampled with randomly located FIA plots to determine if site index differed among them. Each of the four ECS levels was a separate experiment with a different set of treatments.

Sample sizes varied among treatments for each ECS level and depended on criteria used by FIA for establishing field plots and extent of the geographic area being investigated. At the large LTA level (Fig. 1), ECS units sampled with  $\geq 4$  plots were judged as adequate replication for meaningful analysis. For the LT level and below, where the study area was restricted to the smaller area of the ONF, ECS units with  $\geq 3$  field sample plots were included in the analysis. Although the minimal replication used in our study would likely result in an analysis with little power to detect real differences among treatments (Zar 1996), it was justified on the basis of increasing knowledge about the function and application of the ECS.

Bartlett's test was used to determine the homogeneity of variances of site index among units at each ECS level. A square root transformation of site index was used where necessary to achieve homogeneity of variance (Zar 1996). When the analysis of variance indicated significant differences were present among mean site index of the ECS units, Tukey's test was used to determine differences among treatments (Zar 1996). All tests of statistical significance were made at the  $P = 0.1$  level of probability. We used the increased type I error rate (probability of falsely detecting an effect) of  $P = 0.1$ , instead of the traditional  $P = 0.05$ , because of the small-size and the exploratory nature of our study.

## RESULTS

A total of 241 FIA plots were present on forest land in the study area surrounding the ONF, which was defined by delineation of the large geologic based LTAs, as shown in Figure 1. However, 63 plots were discarded because site index was missing (i.e. stand was too young for its determination) or it had been determined for a tree species that could not be converted to an equivalent value for loblolly pine, leaving 178 plots potentially available for analysis. Four of the 178 plots had been installed on sites classified as hydric bottomlands, which were discarded because of the low representation of this group of plots in the data set. The remaining 174 plots were located on sites classified as mesic uplands and were available for analysis at the LTA level of the ECS.

Analysis at the LT level of the ECS and below was restricted to the area where those smaller and more detailed ecological units had been delineated, which was only within the boundary of the ONF (Fig 1). Only 18 FIA plots had been installed in the ONF and therefore could be used for analysis of data at the LT level of the ECS and below. Classification groupings of the 18 FIA field plots were identical for analysis at the LT and LTP levels. For example, upland units at the LT and LTP levels differed only by ridge type: broad versus narrow. Because the three FIA plots were all on narrow ridges, the LTP analysis would have been identical to that for the LT; therefore it was omitted. Finally, to obtain sample sizes adequate for analysis ( $n \geq 3$ ) at the LTPm level, the 18 plots were grouped into three broad classes (low, medium, and high) of erosion instead of the seven detailed categories recognized in the ECS.

Forest type of the large study area was predominately pine (59 percent) but it varied considerably among LTAs, from 46 percent in LTA4 to 75 percent in LTA7 (Table 2). The pine type was primarily loblolly (96 percent); the oak-hickory type was classified mostly as white oak/red oak/hickory (30 percent) or mixed upland hardwoods (27 percent). Most of the oak/pine forest type (74 percent) occurred in LTA3 and LTA4, and almost half of LTA5 was classified as oak/hickory type. Among all sample plots site index was highest for four plots associated with the oak/gum and elm/ash forest types. Although those plots had been classified in the FIA data as having a mesic moisture regime, they were likely located on drier parts of very mesic and fertile floodplains.

### LANDTYPE ASSOCIATION ECOLOGICAL UNITS

Mean loblolly pine site index for the entire study area averaged 88.1 feet and ranged from an average of 83.6 feet (LTA4) to 103.1 feet (LTA7) (Table 3). Excluding LTA7,

represented by only 4 plots, variation of plot site index was wide for the other LTAs (44 - 71 feet) and particularly for three LTAs (2, 4, and 6) each of which likely (based on forest type) included a plot associated with a floodplain (Table 2). The analysis indicated significant differences ( $p < 0.02$ ) of site index were present among some or all of the seven LTAs. Site index differences were present between two groups of LTAs (Fig. 2). The Tukey Test indicated that average site index did not differ among LTA 2, LTA6, or LTA7, but it was statistically higher for LTA7 than for LTA1, LTA3, LTA4, or LTA5.

### LANDTYPE ECOLOGICAL UNITS

Only 18 of the 174 FIA plots were available for the analysis of site index for LTs delineated within the boundary of the ONF, an area of about 115,300 acres. However, an adequate number of plots for analysis ( $n \geq 3$ ) were available for only three LTs: ridges ( $n=3$ ), exposed slopes ( $n=5$ ) and sheltered slopes ( $n=10$ ). Analysis of data for the 18 plots revealed mean site index of exposed slopes (80.7 feet) was lower ( $P=0.02$ ) compared to sheltered slopes (97.1 feet) (Fig. 3). Neither of those ECS units differed in site index compared to the ridge LT, which was intermediate (93.0 feet) between exposed and sheltered slopes.

### LANDTYPE PHASE ECOLOGICAL UNITS

As explained previously, the analysis for LTPs would be identical to that for LTs, and therefore is not presented.

### LANDTYPE PHASE - MODIFIED ECOLOGICAL UNITS

The LTPm level of the classification grouped LTPs based on the severity of soil erosion. Analysis of data from 13 plots located on the three classes of soil erosion revealed no significant difference of site index of loblolly pine for sheltered slopes with high erosion (98.0 feet) compared with moderate erosion (97.6 feet) (Fig 4). Although average site index was lowest on exposed slope with moderate erosion (88.8 feet), it was not statistically different from that measured on plots located on the two sheltered slope units.

## DISCUSSION

The results of our analysis suggest that the land units delineated using the ECS define areas of differing site quality, and perhaps ecological potential, over a range of scales, from large LTAs to small LTPs. The strongest findings of the study occurred at the LT level of the ECS, where we found clear differences in site index between exposed (80.7 feet) and sheltered units (97.1 feet). We could not detect real differences in site index among ecological units at the LTPm level of the ECS, which was a measure

of soil erosion. Because soil erosion clearly affects site quality in the Georgia Piedmont (Harrington 1991) the small number of FIA plots (13) available for our analysis at the LTPm level was likely a contributing factor in our inability to demonstrate a difference in site index.

A recognized limitation of our study was use of site index, not composition of vegetation, as the biological response variable. Composition is generally used to evaluate hypothesized ecological units (Rowe and Sheard 1981). We used site index for several reasons primarily because it was available in the FIA data set and also because it is a vegetative variable that indirectly integrates physical components of ecosystems including long-term climate and soil characteristics (Spurr and Barnes 1973). Harrington (1991) in an extensive study of loblolly pine site index found the species was sensitive to many environmental variables, including those considered important to differentiate ecological units, such as climate, geology, and soil. In comparison with other Piedmont tree species, particularly hardwoods, loblolly pine is less responsive to variation in site quality (Nelson and Beaufait 1956). Our study is perhaps noteworthy because we found no references from other studies where site index of southern pines had been used to test for differences among ecoregion units. In a highly replicated, large-scale study of ponderosa pine (*P. ponderosa*) site quality in Arizona and New Mexico, Mathiasen and others (1987) found site index did not vary among seven habitat types.

Results of our preliminary study suggest the possible need for refinement of the ECS at the LTA level, which is currently based on types of bedrock. Loblolly pine site index varied little among LTAs when compared across the seven groups. Except for the exposed granitic domes and localized areas of gabbro, the mostly buried geology of the Piedmont resembles an extensive shield of gneisses and schists that have weathered differentially to form a coarse mosaic of soils with slightly varying moisture and nutrient characteristics. Unlike LTA7, which is associated with an unusual type of rock, environmental conditions associated with the other six LTAs did not result in identification of ecological units associated with detectable differences of site index for loblolly pine.

## CONCLUSIONS

In conclusion, our preliminary evaluation of the ECS developed for the ONF using a small FIA data set demonstrated a promising relationship between ecological units and environmental gradients expressed by site index of loblolly pine. An analysis using a larger data set, with

vegetation as the biological response variable, is needed to clarify and strengthen the ecological relationships at the lower levels of the ECS. Such an analysis will likely indicate the need for revision of classification units at the LTA level. This region of the Georgia Piedmont is particularly challenging for ecological classification due to lack of topographic relief and its long history of intensive past disturbance resulting in variable soil erosion. As Rowe and Sheard (1981) make clear, ecosystem classification is done not only to reduce environmental variation by stratification of land units for management planning, but also gain a better understanding of the underlying interactions among the important physical components that combine to make the ecosystems unique, which was one of the objectives for developing an ECS for the Oconee National Forest.

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**Table 1—Preliminary non-hierarchical units occurring at the landtype, landtype phase, and landtype phase-modified levels of the ecological classification system for the Oconee National Forest**

ECS levels <sup>1</sup>	Description
<b>Landtype</b>	
Piedmont plain <sup>2</sup>	Largely undissected land surface of the "original" penplain or plateau
Broad ridge	Ridges along watershed divides of 5th level hydrologic units
Narrow ridge	Ridges along watershed divides of 6th level and smaller hydrologic units
Exposed slope	Linear part of a slope below the ridge with an aspect from 158°-292°
Sheltered slope	Linear part of a slope below the ridge with an aspect from 293°-157°
Riparian	Concave land surface enclosing large streams and rivers
Glade	Flat area of a ridge associated with gabbro rock formations
<b>Landtype phase</b>	
Broad ridge	Ridges along watershed divides of 5th level hydrologic units
Narrow ridge	Ridges along watershed divides of 6th level and smaller hydrologic units
Exposed slope	Linear part of a slope below the ridge with an aspect from 158°-292°
Sheltered slope	Linear part of a slope below the ridge with an aspect from 293°-157°
Upland flat	Flat area of a ridge associated with gabbro rock formations
Others <sup>3</sup>	Concave land surfaces associated with subhydric to hydric riparian sites
<b>Landtype phase-modified<sup>4</sup></b>	
Slight	Little or no erosion
Moderate	From 25 - 50 percent of surface horizon lost
Severe	Over 50 percent of surface lost, often "gullied"

<sup>1</sup> These units are not hierarchical. They are common to all and may occur in any of the seven landtype associations within the larger Midland Plateau-Central Uplands Subsection.

<sup>2</sup> Present in a very small area (65 acres) on the ONF; it was combined with broad ridge at the LTP level.

<sup>3</sup> Land units associated with wetter parts of the landscape (forested wetland, open wetland, riparian, river floodplain, stream terrace, sand levee, upland flat, and water).

<sup>4</sup> The seven categories of erosion in the ECS (slight, slight-moderate, moderate-slight, moderate, moderate-severe, severe-moderate, and severe) were grouped into three classes for this study.

**Table 2—Distribution of FIA plots by forest type and landtype association in the Midland Plateau-Central Uplands Subsection where site index was determined for loblolly pine on sites classified as upland mesic**

Forest type	Landtype association							Total all	Per-cent	Site index
	1	2	3	4	5	6	7			
	-----Number of plots-----									
Pine	15	20	27	18	9	11	3	103	59.2	90.7
Oak/pine	1	2	7	10	-	3	-	23	13.2	84.7
Oak/hickory	5	10	8	10	8	3	-	44	25.3	82.2
Oak/gum	-	1	-	-	-	-	1	2	1.1	97.0
Elm/ash	-	-	-	1	-	1	-	2	1.1	105.5
<b>Total</b>	<b>21</b>	<b>33</b>	<b>42</b>	<b>39</b>	<b>17</b>	<b>18</b>	<b>4</b>	<b>174</b>	<b>100.0</b>	<b>88.1</b>

**Table 3—Characteristics of ecological units classified by landtype association from FIA sample plots within the Midland Plateau-Central Uplands Subsection study area of the Oconee National Forest**

Item	Landtype association <sup>1</sup>						
	1	2	3	4	5	6	7
Site Index (feet)	85.2	94.3	87.3	83.6	97.9	90.0	103.1
Basal area (feet <sup>2</sup> /acre)	124	110	100	109	98	112	129
Elevation (feet)	232	350	306	374	369	251	415
Aspect (degrees)	202	262	197	160	132	87	91
Gradient (percent)	12.0	9.8	8.0	12.0	8.4	10.2	7.0

<sup>1</sup> An 8th geologic group, aluminous schist, occurred in the subsection but was not present within the area delineated by LTAs in the proclamation boundary of the Oconee National Forest.

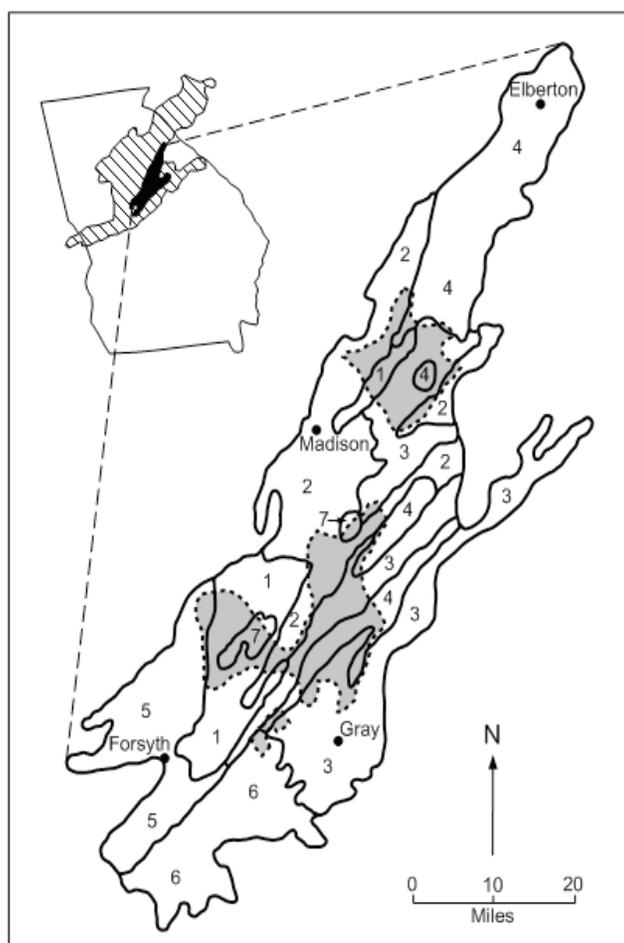


Figure 1—Extent of the Midland Plateau—Central Uplands Subsection (hatched area in small inset map) in Alabama, Georgia, and South Carolina. The study area (black overlay in Georgia) was defined by the closed polygons of seven proposed landtype associations (LTAs) that occur within the proclamation boundary of the Oconee National Forest (three gray areas in the enlarged LTA area). The LTAs (identified by a number in each polygon) represent the predominate geologic bedrock formations: 1, intermediate gneiss; 2, granitic gneiss; 3, mica schist; 4, granite; 5, biotite gneiss; 6, metamorphosed mafic; 7, mafic and ultramafic (gabbro).

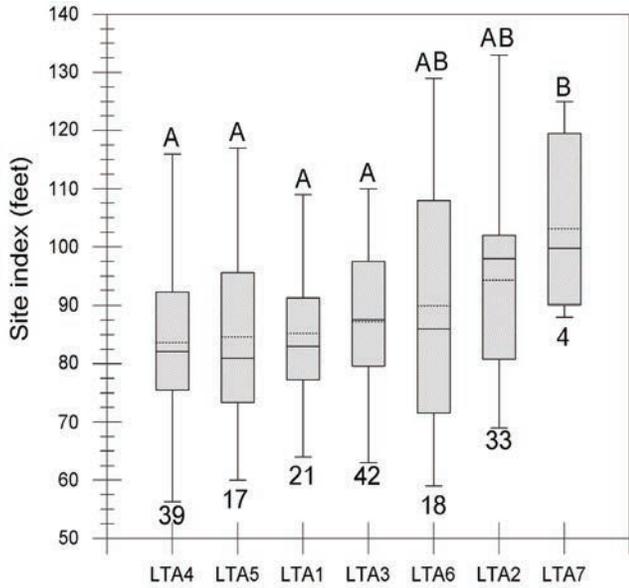


Figure 2—Box plot for loblolly pine site index by landtype association (LTA). The bottom and top of the box represent the 25th and 75th percentiles; respectively; the mean is represented by the horizontal dashed bar and the median by the solid bar in each box. The cross bars below and above each box indicate the range of site index. LTAs with the same letters are not significantly different at the 0.1 level of probability. The number of plots present in each LTA is shown below each box.

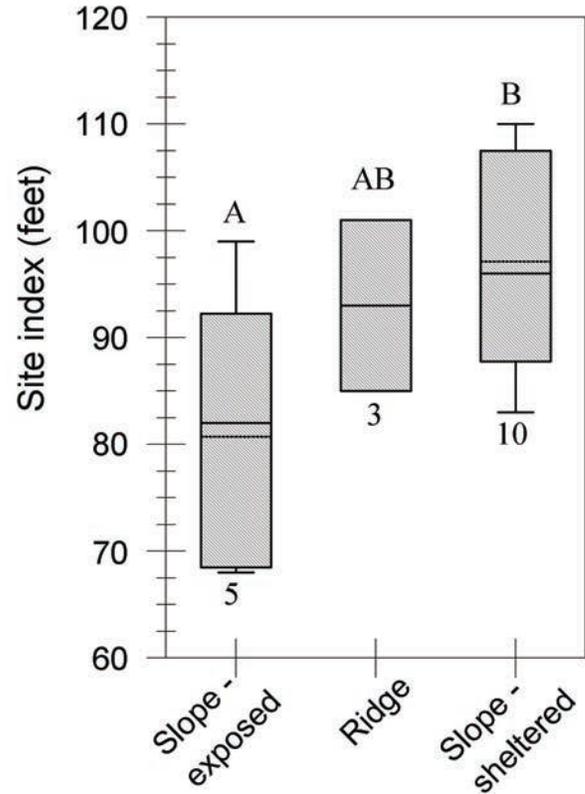


Figure 3—Box plot for loblolly pine site index by landtype and landtype phase levels of the ecological classification system (ECS) for the Oconee National Forest. The bottom and top of the box represent the 25th and 75th percentiles, respectively; the mean is represented by the horizontal dashed bar and the median by the solid bar in each box. The cross bars below and above each box indicate the range of site index. Bars with the same letters are not different at the 0.1 level of probability. Below each bar is the number of plots present in that unit of the ECS.

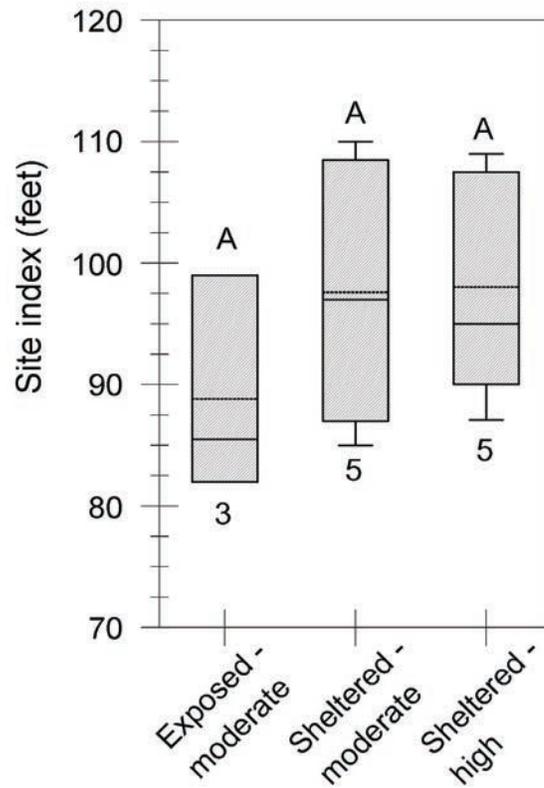


Figure 4—Box plot for loblolly pine site index by landtype phase-modified level of the ecological classification system (ECS) for the Oconee National Forest. The bottom and top of the box represent the 25th and 75th percentiles, respectively; the mean is represented by the horizontal dashed bar and the median by the solid bar in each box. The cross bars below and above each box indicate the range of site index. Bars with the same letters are not different at the 0.1 level of probability. Below each bar is the number of plots present in that unit of the ECS.