DEFINING OLD GROWTH: IMPLICATIONS FOR MANAGEMENT[1]

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Abstract-This paper describes the USDA Forest Service Eastern old-growth definition project. Major definition elements are described using examples from the dry and dty-mesic oak-pine old-growth type. Few old-growth types approximate st-eady-state conditions and some are ephemeral on the landscape. Prescribed fire is required for the maintenance of some old-growth types. Other silvicultural tools can be used to retain some old-growth characteristics in stands managed for multiple objectives. Understanding the relationships between various types of disturbances and the living and dead components of old-growth forests is critical to their restoration and/or maintenance.

INTRODUCTION

USDA Forest Service (USFS), with the help of scientists from The Nature Conservancy (TNC), Forest Service Research and other organizations, is developing old-growth definitions for 35 forest types within the Eastern United States (U.S.). Old-growth forests were officially recognized as a resource by the USFS in 1988 and shortly thereafter, the Eastern Old-Growth Definition Project began. Initially, an old-growth task group drafted a generic definition that stated: "Old-growth forests are ecosystems distinguished by old trees and related structural attributes. Old growth encompasses the later stages of stand development that typically differ from earlier stages in a variety of characteristics which may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function." The primary objective of the project was to describe current knowledge about broad forest types and identify gaps in that knowledge.

Much of the land in the Eastern U.S. has been dramatically affected by humans, especially since the arrival of Europeans. Therefore, defining old growth in the Eastern U.S. requires a somewhat different approach than that used in parts of the U.S. where large areas of old growth exist. The definitions will vary in quantity and quality, largely because the amount of available literature and the number of existing old-growth sites vary with forest type. Nevertheless, when complete, the definitions will be useful to land managers whose objectives include either restoring or maintaining old-growth forests or incorporating certain old-growth characteristics into the management of forests with multiple objectives. Our paper describes the USFS Eastern Old-Growth Definition Project and the major elements of the old-growth definitions. We use information from the dry and dry-mesic oak-pine old-growth type to illustrate the definition process and the management implications.

OLD-GROWTH DEFINITIONS

The framework used by the old-growth task group to develop the initial list of Eastern old-growth forest types included the following parameters: 1) all natural ecosystems that contain trees in any density; 2) ecosystems with any combination of disturbance regimes, including ecosystems that contain short-lived tree species that regenerate after catastrophic disturbance; and 3) the forests, woodlands and savannahs within USFS Southern and Eastern regions and TNC's Eastern, Midwestern, and Southeastern regions. Item two represents a deviation from the perception of old growth as steady-state, self perpetuating, climax communities. Thirty-five old-growth forest types have been identified for the Eastern U.S., and approximately 24 of these have ranges that include the Southeastern U.S. Of these 24, 14 are terrestrial types and 10 are palustrine types (Table 1). These old-growth types represent broad forest types. For example, types 21 and 25 occur across most of the physiographic regions of the Eastern U.S. and include the intermediate to dry site oak-hickory and oak-pine community types, respectively.

Each old-growth definition will contain the following major elements: 1) an introduction, 2) a description of the forest type group, 3) a table of old-growth attributes, 4) a narrative of old-growth conditions, 5) a description of forest dynamics and ecosystem function, and 6) a list of representative old-growth stands.

Description of Forest Type Group

The description of the forest type group includes links or crosswalks with SAF cover types and other classification systems as well as a description of disturbance regimes, vegetation composition and distribution of the forest type. To be useful to managers, definitions must link the old-growth types to existing classification systems. Because few old-growth oak-pine stands exist in the Piedmont, a variety of

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Table I-Eastern old-growth types of the Southeastern U.S.

Old-Growth Forest Type #	Name
	Terrestrial Forests
1	Northern hardwood forests
2	Conifer-northern hardwood forests
5	Mixed mesophytic and western mesophytic forests
6	Coastal Plain upland mesic hardwood forests
21	Dry-mesic oak forests
22	Dry and xeric oak forests, woodlands, and savannahs
24	Xeric pine and pine-oak forests and woodlands
25	Dry and dry-mesic oak-pine forests
26	Upland longleaf and S.Florida slash pine
27	Seasonally wet oak-hardwood woodlands
31	Montane and allied spruce and spruce-fir forests
34	Sand pine forests and woodlands
37	Rocky, thin-soiled excessively-drained cedar woodlands
38	Barrier Island mixed forests &woodlands
	Palustrine Forests
IO	Hardwood wetland forest
12	Hardwood freshwater tidal swamps
13	River floodplain hardwood forests
I4	Cypress tupelo swamp forests
15	Tropical and subtropical wetland forests and woodlands
16	Mangrove swamps
28	Eastern riverfront forests
29	Southern wet pine forests, woodlands and savannahs
40	Atlantic white cedar forests
41	Bay forests

site/vegetation studies were examined to best assess where the old-growth oak-pine would probably develop. Several studies eliminated stands that contained pine species (Farrel and Ware 199, Kasmer and others 1984, Keever 1973, Jones 1988), while others included pine species in their attempts to define site/vegetation relationships(Golden 1979, Oosting 1942, Peet and Christensen 1980, Schafale and Weakley 1990). Both types of studies provided information relevant to the characteristics and/or distribution of old-growth oak-pine forests.

Peet (unpublished data') compiled a table of synonymous communities for the NC Piedmont from various sources including Oosting (I 942), Peet and Christensen (1980), Schafale and Weakley (1990) and others. This table and the original studies allowed us to infer which identified oak-dominated communities occupied sites where the dry and dry-mesic oak-pine type would probably occur, given sufficient canopy and/or forest floor disturbance (e.g. fire, wind and ice storms, insects). Table 2 shows approximately equivalent community types from three different classification systems that occupy the types of sites where old-growth oak-pine occurs.

Predictive ecosystem classification systems are especially valuable tools for planning and management because the variables, soil and landform characteristics in some cases, can often be incorporated in a geographical information system (GIS). National Forests and other organizations are developing various forms of these systems. Jones (I 988) sampled old-growth hardwood stands in the SC Piedmont and developed a predictive landscape ecosystem classification (LEC) system integrating landform, soil and late successional vegetation. While Jones' system predicts the late successional vegetation type from soil and landform variables, it is important to acknowledge that multiple ecological outcomes are possible on a given site unit. Different forest types will develop for each combination of soil, landform and disturbance regime. Based on descriptions of Jones' site units, literature information and our sampling, the dry and dry-mesic oak-pine type would probably develop on xeric, sub-xeric and intermediate site units (Table 3). A more intense disturbance would probably be required for pine to become established on the intermediate site unit because conditions are more favorable for hardwoods.

Old-Growth Attributes

The table of old-growth attributes includes density, basal area, number of 4 in. size classes, age and diameter of codominant and dominant trees, abundance of snags and coarse woody debris (CWD), and size and distribution of canopy gaps. Studies describing age, snags, CWD, size and distribution of canopy gaps and other descriptions of disturbance are lacking for many old-growth types (Table 4). The John de la Howe (JDLH) tract is the only stand with a complete set of attribute data. A portion of these data is shown in Table 5 to illustrate the kind of information presented in an old-growth attribute table.

Forest Dynamics and Ecosystem Function

The section on forest dynamics and ecosystem function describes ecological processes during the old-growth stage, presefflement disturbance regimes,

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Table 2. Portion of community synonymy table showing communities that correspond to the sites where the dry and dry-mesic oak-pine type may occur.

Community Synonymy for North Carolina Piedmont		
Peet and Christensen 1980	Oosting 1942	Schafale and Weakley 1990
Dry Mesotrophic - Clayey phase - Sandy phase	White oak-black oak-red oak (in part)	Dry-mesic oak hickory
Dry Oligotrophic	White oak	Dry oak-hickory
Dry Eutrophic	White oak-post oak	Basic oak-hickory

Table 3. Late successional community types, soil, and landform characteristics from the SC Piedmont LEC (Jones 1988) corresponding to site units supporting old-growth type 25.

Site Unit and Community Type	Distinguishing Soil Characteristics	Landform Description
Xeric: Post oak-black oak-and lowbush blueberry’	heavy clay subsurface horizon 12 in. from surface or bedrock within 24-36 in.	Exposed ridge flats upper slopes of any aspect
Subxeric: White oak-scarlet oak-deerberry[2]	clay or sandy clay sub-surface horizons at 12-24 in. or:	ridge flats, upper slopes of any aspect or mid-slope with a S. aspect southerly aspect
	heavy clay horiions within 12 in. of surface or bedrock within 24-36 in.	less exposed mid slopes with N. or E. aspects
Intermediate: White oak-northern red oak’-false solomon’s seal’	sandy clay loam or clay loam at 12-24 in.	mid slopes with N. or E. aspects or mid- to lower slopes with S. aspects

[1] *Vaccinium vacillans* Torrey.
[2] *Vaccinium stamineum* L.
[3] *Quercus rubra* L.
[4] *Smilacina racemosa* (L.) Desf.

Table 4. Locations of old-growth oak-pine stands showing the availability of attribute data.

Region and Site	Density	BA	4 inch’	Age[2]	DBH[2]	CWD	Gaps
Piedmont							
John de la Howe (SC)	+[4]	+	+	+	+	+	+
Duke Forest (NC)	+	+	-[5]				-
Southern Appalachians							
Scarlet Oak N.A.(NC)	+	+	+	+			
GSNP (TN) [3]		-	-	+			
Gulf Coastal Plain							
Kisatchie NF (LA)	+	+	+	-			
Ouachita Mountains							
Roaring Branch RNA (AR)	+	+	+	+	+		
Lake Winona RNA (AR)	+	+	+	+			
Hot Springs NP (AR)	+	+		+		+	

[1] Refers to number of 4 in. size classes.
[2] Age and diameter of large trees (dominants and codominants).
[3] Ongoing studies.
[4] Data available.
[5] Data not available.

successional trends and other aspects important to managing for a given type. Given the relative scarcity of old-growth in the East, using a variety of information from the past and present helps in formulating definitions of Eastern old-growth types. Examples from the dry and dry-mesic oak-pine type are used to illustrate how this varied information can be used to characterize old growth.

First, the historical distribution of oak and pine species and their response to disturbance are discussed. Then, perceptions of the presefflement composition in the Southeastern Piedmont are presented. Finally, mortality-related disturbance patterns in an old-growth oak-pine stand in the SC Piedmont are reviewed.

Historical Development of the Oak-Pine Type.
To gain a more complete understanding of the prevalence of oak-pine types in the Eastern U.S., a review of the relative importance of these two species groups on a broad time scale is useful. Upon the arrival of humans to Eastern North America 12,000 years ago (Delcourt and Delcourt 1987), plant taxa were migrating northward in latitude and upwards in elevation in response to global warming that began after the height of Wisconsin glaciation (18000 b.p.). Global warming reached its maximum approximately 6000-7000 b.p., followed by a gradual cooling period. Approximately 8000 b.p., oaks exhibited a slight decline in paleodominance in the Southeastern U.S. while southern pine dominance increased (Delcourt and Delcourt 1987). The apparent shift in relative dominance of upland oaks and southern pines during the mid-holocene interval (5000 b.p.) is believed to be the result of increased fire frequency associated with hunting practices of Native Americans. Although climatic warming, more frequent fire, and growing populations and activities of Native Americans may have affected oaks and pines differently, both species were probably in association for thousands of years. Buckner (1989) described the pine-hardwood type as a “mid-seral stage that is ephemeral on a given site and is maintained in a changing landscape mosaic where scattered disturbances re-initiate succession in a stochastic manner.”

While the role of fire and other disturbances in maintaining pines is well established, their effects on oak species are less clear because many have been viewed historically as relatively stable “climax’ species. It is now generally accepted that oaks require disturbance for successful establishment as canopy dominants. Fire is regarded as an important disturbance agent for establishing upland oaks in eastern deciduous forests (Abrams 1992, Christensen 1981, Van Lear and Watt 1993). Fire reduces competition from fire intolerant species and increases the accumulation of oak advance regeneration. Van Lear and Watt (1993) also suggest that understory fires may provide more favorable conditions for germination and seedling establishment. If sufficient oak advanced regeneration is present, canopy disturbances will promote further oak development and eventual dominance. Since oaks are more shade-tolerant than

Table 5. Portion of old-growth attribute table for old-growth oak-pine stands from the John de la Howe tract in South Carolina

Quantifiable Attribute	Value Range'	Mean
Aae of Larqe[2] Trees		
Shortleaf pine'	89-205	144
Loblolly pine	79-I 89	117
White oak	82-207	149
Hickory species	142-207	179
Post oak	101-216	144
Southern red oak	64-I 90	124
Yellow poplar	94-I 94	160
Standinq Dead I# acre-')		
Snags $\geq$ 4 in. dbh	15-69	33
Snags $\geq$ 20 in. dbh	2-16	8
Coarse Woodv Debris		
Volume (ft.[3] acre")	747-2528	1545
Mass (tons acre")	7.4-25.4	15.4
Tree Canow Structure		
Number of canopy layers	2-3	-
Percent canopy in gaps	24-80	37
Mean gap size (acres)'	.002-.503	.060

[1] For standing dead, CWD and percent canopy in gaps, range represents the range of means from areas showing different degrees of mortality.

[2] Codominant and dominant trees.

[3] Scientific names given in order shown above:/? *echinata* Miller, *P.taeda* L., *Quercus alba* L., *Carya* spp (*C. tomentosa* (Poiret) Nuttall, C. ovata (Miller) K. Koch, C. *glabra* (Miller) Sweet.), Q. *stellata* Wang., *Q. coccinea* Muenchh., Q. falcata Michaux., and *Liriodendron tulipifera* L.

[4] Canopy gaps $\leq$ 1 acre in size. Gaps exceeding 1 acre were variable sized patches of extensive pine mortality accounting for 58 percent of the total gap area.

associated pine species, they generally require smaller canopy disturbances.

Post-settlement logging and fire probably increased the oak component beyond its presefflement distribution in parts of North America, even though use of fire by Native Americans prior to settlement also favored oak establishment

This historical information provides two important points: 1) oaks and pines have been components of the eastern deciduous forest for thousands of years and shifts in their relative abundance have been related to climate changes and to fire used by aboriginal people in the past 10,000 years, and 2) the oak and pine species that dominate the dry and dry-mesic oak-pine type require disturbance to maintain their dominance.

Presettlement Forests of the Piedmont.
The composition of Southeastern Piedmont forests prior to European settlement has been characterized (Brender 1974, Nelson 1957, Peet and Christensen 1987, Plummer 1975, Skeen and others 1980, Skeen and others 1993) but no clear agreement exists. While most view pine species as minor components of the "original" forest, Nelson (1957), citing a number of sources from the 1800's, describes the original forest of the GA Piedmont as ranging from pure pine to pure hardwoods. The oak-hickory types were more abundant in the "red lands"(35-40 percent of the GA Piedmont), while shortleaf pine and post, white and red oaks occupied the "gray sandy lands"(45 percent of the

region). Pine dominated the remaining 15 percent of the Piedmont, the Elberton granitic formation. Plummer (1975) used survey records of the GA Piedmont and Blue Ridge from the settlement period, 1733-1832, to provide more specific information. Pine was especially abundant on steep slopes and upland soils of micaceous origin. Soils with higher clay content supported more post oak. The ratio of oak:pine:hickory was 53:23:8 on over one-half million acres surveyed.

Early writings by explorers and settlers, as well as early land surveys provide a general sense of the vegetation composition prior to widespread settlement by Europeans. Because this information describes conditions at a single point in time, they must be regarded with some caution. For example, Native American populations are thought to have declined dramatically from exposure to European diseases introduced by explorers 200 years prior to settlement (De Vivo 1991). Population decline would have resulted in less fire (after 1500 AD), affecting the structure and composition of forests surveyed and described at the time of settlement. Fire suppression policies of this century have also altered the composition and structure of forests. Impressions of presettlement forests that are based on present day forest composition must also be viewed with caution. It is important to acknowledge that presettlement forests were dynamic rather than static.

Mortality Patterns in an Old-Growth Piedmont Stand,

The JDLH forest tract in South Carolina is, to our knowledge, the best example of the dry and dry-mesic oak-pine type in the Piedmont. This 120-acre, 200+ year old stand of mixed oak-shortleaf-loblolly pine has recently undergone significant levels of pine mortality. The stand is located in an area disturbed to varying degrees by European settlers in the mid 1700's, abandoned just prior to 1800 and protected since. Scattered cutting has occurred in the periphery of the stand and pine has been salvaged in a few areas in more recent years.

We sampled the area systematically and eliminated plots with cut stumps or other obvious signs of human disturbance. Characterization of 0.25 acre plots was based on 4 levels of mortality, described in terms of canopy openness or percent of canopy in gaps (Figure 1): 1) low - <25% in canopy gaps; 2) intermediate - 25-50% in canopy gaps; 3) high/old - >50% in canopy gaps that formed 3 or more years prior; and 4) high/new - > 50% in canopy gaps that occurred within l-2 years prior to sample. Soils were predominantly the Cecil series with some Pacolet. Based on the LEC described by Jones (1988), most of the area was characterized as subxeric and intermediate with a few xeric sites, . Sampling was similar to that described by Shifley and others (1991), with modifications for CWD and canopy gaps. CWD was sampled using a modified version of a technique described by Van Wagner (1968) and Brown (1974). Gaps were sampled along transects that bisected the stand along plot grid lines.

Mortality in the JDLH stand was 62 percent pine, 23 percent hardwood and 15 percent pine-hardwood. Areas of low and medium levels of mortality were characterized by a relatively continuous canopy (Figure 1), broken up by variable sized canopy gaps, generally less than 0.3 acres and averaging 0.06 acre (58 ft in diameter). While, the mean gap size and range found on the low to medium mortalii areas (Table 5) was similar to that found by Clinton and others (1993) in a mature Southern Appalachian mixed oak forest, the percent of the total area in gaps at JDLH was higher. In the JDLH high mortality areas, overstory canopy openness ranged from 60-80 percent These open patches ranged in size from 0.5 to 10 acres. Almost all mortality occurred in shortleaf and loblolly pine.

Across this gradient of canopy related disturbance, certain old-growth characteristics varied considerably. Figures 2 and 3 show snag density and CWD abundance across the same mortality classes illustrated in Figure 1.

Snag density $\geq$ 4 in. dbh ranged from 15 per acre in areas of low to medium mortality to 70 per acre in areas of high mortality. In Kentucky, McComb and Muller (1983) reported from 14 to 32 snags ($\geq$ 4 in. dbh.) per acre in old-growth beech (*Fagus grandifolia* Ehrhart.) and chestnut oak (*Quercus prinus* L.) forests, respectively. Sabin (1991) reported 11 snags per acre across a range of 20-60 year old Piedmont forest types in South Carolina. Large snag density ($\geq$ 20 in. dbh) in the JDLH high mortality areas was >10 per acre compared to 0 to 3 per acre (10-35 in. dbh) in Kentucky (McComb and Muller 1983).

CWD follows the same pattern (Figure 3) except that the high-recent mortalii area had low inputs. Most recent pine mortality remained standing as snags while most of the mortality occurring 3-20 years ago was on the ground as CWD. The 25 tons acre.' of CWD in the high-old mortality class is much higher than the 8-11 tons acre-' found in several old-growth mixed oak-hardwood forests of the Eastern U.S. (Harmon and others 1986, Lang and Forman 1978, MacMillan 1981, Muller and Liu 1991). However, this quantity was less than one-half that reported for mature uneven-aged pine stands on the SC Coastal Plain following Hurricane Hugo (Myers and others 1993). Large inputs of CWD from insect-related mortality at the JDLH and large scale disturbances such as Hurricane Hugo, represent large but infrequent pulsed inputs. The dynamics of these inputs and their effects on various ecosystem processes are not well understood (Van Lear and Waldrop 1995).

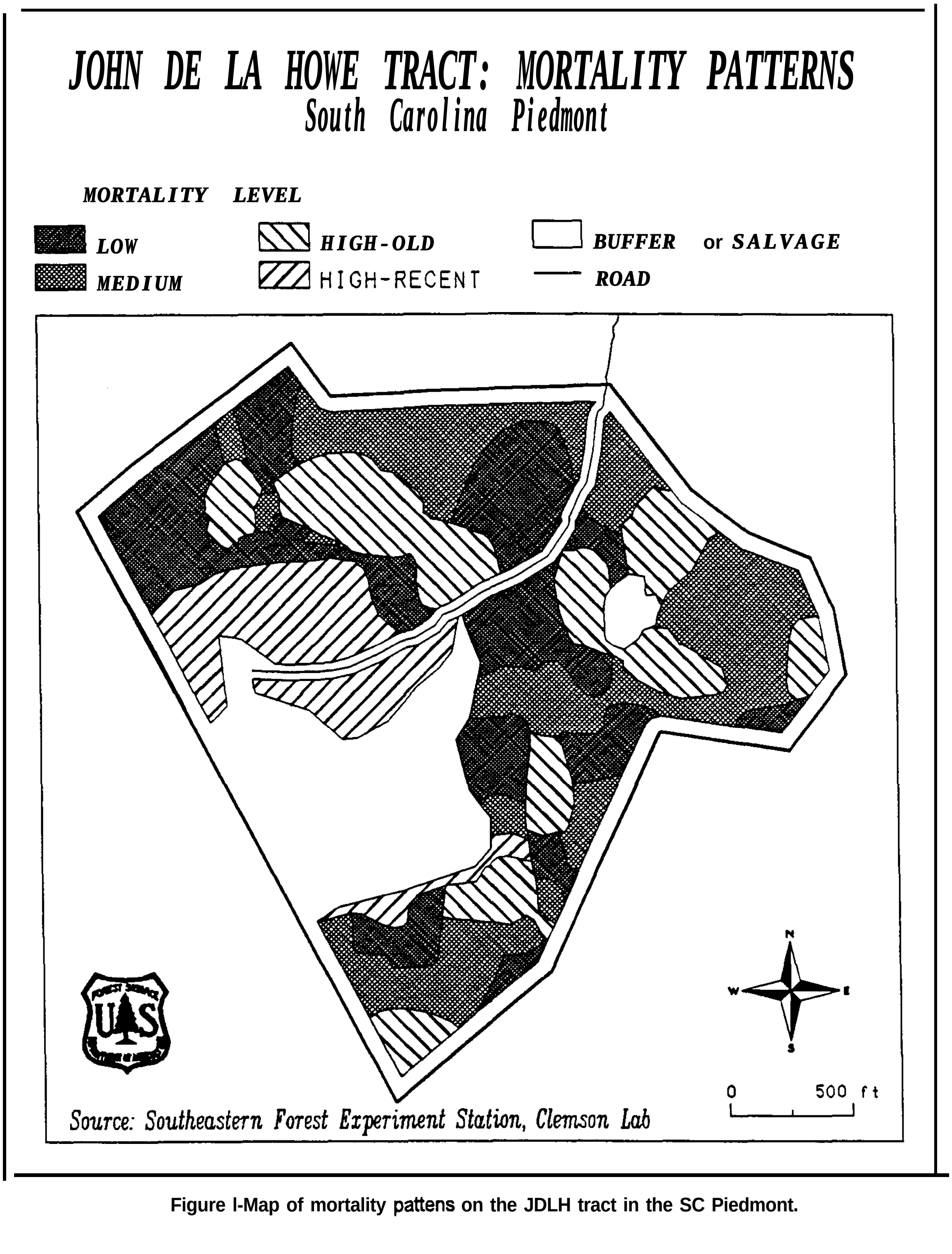

Figure l-Map of mortality pattens on the JDLH tract in the SC Piedmont.

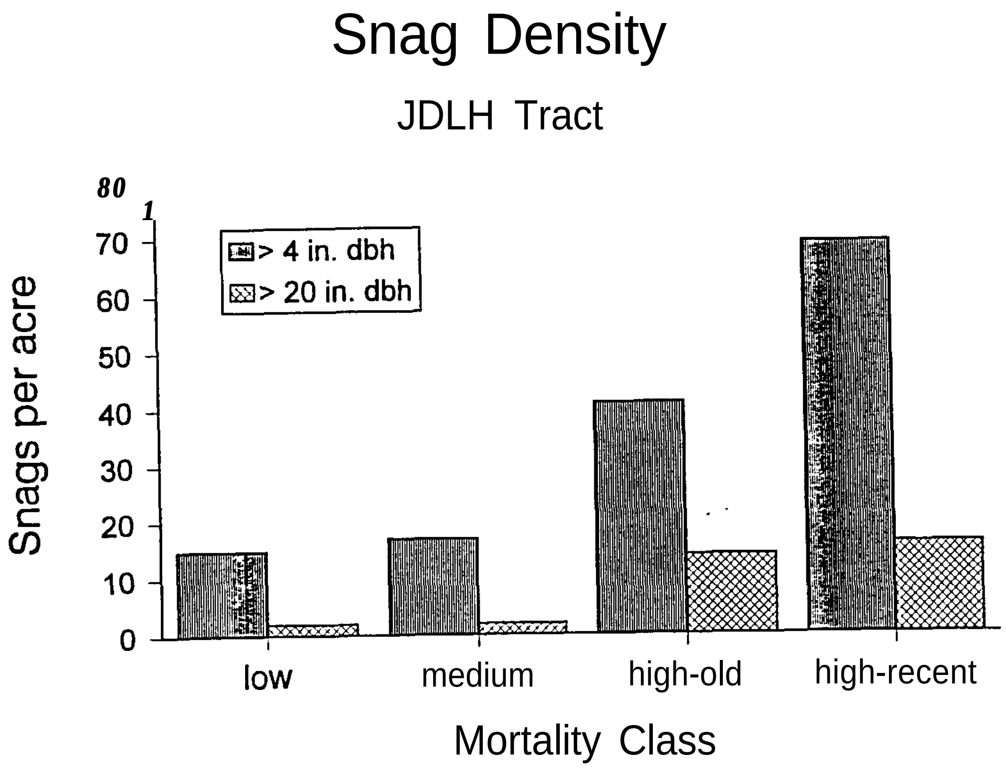

Figure 2-Snag density by dbh and mortality class for the JDLH tract.

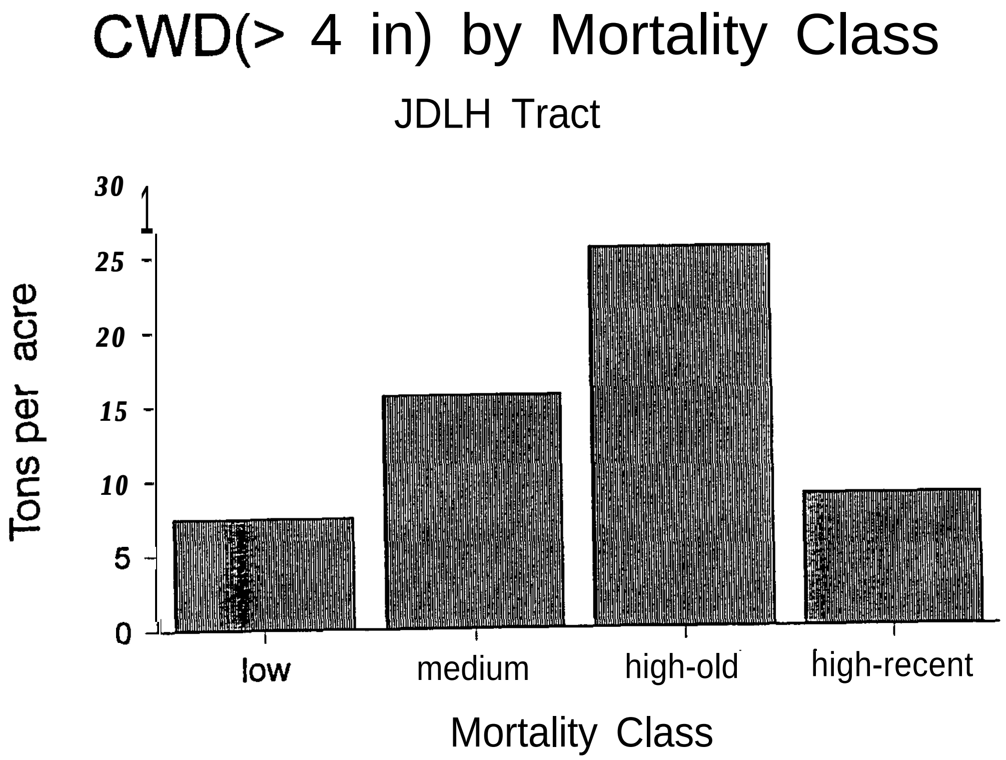

Figure 3–Coarse woody debris (tons acre-‘) by mortality class for the JDLH tract.

CWD mass and snag density in low to medium mortality areas of the JDLH corresponded to the ranges reported for old-growth forests previously cited. These similarities are temporary because pine mortality will probably increase on these sites in the near future. When most pines in the stand have succumbed to southern pine beetle (SPB), lifflleleaf disease or other pathogens, oaks and other hardwoods will assume dominance. Without forest floor disturbance, such as that caused by fire, pine species will become minor components of this stand in the future.

IMPLICATIONS FOR MANAGEMENT

We have described and, in some cases, used specific examples of the types of information contained in old-growth definitions. The historical distribution of a forest type or historical composition of a region where specific old-growth types occur, identifies what the potential old-growth types would be for a given site. A greater understanding of historical disturbance regimes as well as species response to varying levels of disturbance should clarify management options for creating and maintaining certain old-growth types on the landscape.

Generally, some old-growth definitions will reinforce acceptance of the importance of a wide range of types, scales and intensities of disturbance required to maintain certain forest types. Early concepts of old-growth forests were based on the steady-state, equilibrium view of forest dynamics. While some forest types may approximate steady-state dynamics, many types may not. A number of papers have presented alternative views of forest succession for specific types or described forest dynamics in a way that includes a wider range of disturbances as an integral component (Christensen 1988, Denslow 1985, Egler 1954, Glitzenstein and others 1986, Harper 1977, Oliver 1981, Pickett and White 1985, Platt and Schwartz 1990, Sprugel 1991, Spurr and Barnes 1973). Conceding the relative “untidiness” of forested ecosystems is critical to their wise management.

Canopy and forest floor disturbance is required to regenerate or maintain the dry and dry-mesic oak-pine type (25). Natural disturbances, such as insect related mortality, wind and storm damage, and fire may interact to provide conditions necessary for pine and oak establishment The spatial and temporal variation of disturbance over broad landscapes may cause the loss of pine in some oak-pine patches which will then become oak-mixed hardwoods. Other non-pine patches occurring on similar sites may be subjected to a combination of disturbances that support pine establishment The ephemeral nature of the oak-pine type illustrates the concept of the shifting landscape mosaic. Multiple ecological outcomes are possible for comparable sites. Acknowledging the importance of these concepts is crucial for developing long-term management strategies for large areas, especially when the land manager has multiple resource objectives.

If maintaining some old oak-pine forests is an objective, the role of insects and other pathogens that affect the composition and structure of old growth (Haack and Byler 1993) and the interaction between old growth and surrounding stands are important For example, in the Piedmont, SPB and liieleaf disease are the most serious pests affecting conifers (Belanger and others 1986). Shortleaf pine, has the widest range of the southern pines and grows on a variety of soils and is most susceptible to littleleaf or to liieleaf-SPB interactions. Risk multiplies on sites that are severely eroded and contain a high percentage of heavy plastic clays. Therefore, these sites should be avoided when managing for the dry and dry-mesic oak-pine type if maximizing the longevity of the pine component is the objective.

The impact from SPB is less in mixed pine-hardwood stands than in pure pine stands because pine continuity is interrupted by hardwoods (Belanger and others 1986, Showalter and Turchin 1993). If maintaining old-growth oak-pine on landscapes mixed with more intensively managed stands is the objective, managing for pine-hardwood mixtures rather than pine monocultures may minimize the risk and extent of insect and other disease outbreaks. When managing for old-growth oak-pine, susceptibility to SPB and other pathogens will increase as the pines reach old age. While pine mortality is to be avoided from the perspective of fiber and timber production, it is integral to the vegetation dynamics in some old-growth forests. The management challenge is to allow natural disturbance to occur in old-growth forests, while minimizing losses in surrounding stands. Separating intensively managed stands (high pine component, disease risk dependent on stand conditions) from old-growth oak-pine stands (moderate pine component, moderate to high disease risk) with pure hardwood stands or with mixed pine-hardwood stands may reduce disease-caused losses.

To protect old growth core areas from fragmentation and to produce a sustained yield of functionally dynamic old growth forests in the Interior Highlands, Guldin (1991) suggested surrounding old growth core areas with buffer stands managed under “big-tree” uneven-aged silvicultural systems. This could be accomplished through structural control-BDq[1] methodology with targets derived from existing old-growth stands (Guldin 1991). Application of silvicultural techniques (fire, timber extraction etc.) to the buffer stands would continue until the live tree composition and structure was similar to that of the target old-growth stand. After this point, significant time would elapse before these buffer stands would be considered old growth.

‘Basal area-maximum diameter-q factor method.

Retaining Old-Growth Characteristics in Managed Stands

What old-growth attributes are desirable in stands managed for multiple values? Generally, large living and dead trees (large for site), various habitats and conditions they support, and relatively continuous forest canopies are valued in old-growth forests for spiritual inspiration, aesthetics, wildlife habitats, timber, etc. Snags and downed CWD serve multiple and important ecosystem functions (Van Lear 1994, Van Lear and Waldrop 1995). What cutting practices would maintain some of these desirable characteristics and simultaneously allow for the economical harvest of commercial species?

Information is lacking on even- and uneven-aged management techniques for retaining old-growth characteristics. Modified shelterwood methods may be compatible with this goal since this method allows indefinite retention of older trees and more frequent fire (Pell, personal communication). Research on uneven-aged management and natural regeneration of shortleaf and loblolly has been conducted (Baker and others [in press]) but less is known about uneven-aged management for mixed pine-hardwood stands (Waldrop 1991). One approach might involve group-selection harvest of oaks and pines, leaving snags and "snag candidates" in and around openings. Opening size could vary but should be large enough to support pine regeneration. If pine regeneration is insufficient following logging disturbance of the forest floor, prescribed fire could be used, though burning group openings is logistically challenging. Patchy forest floor disturbance combined with a variable light regime within a given opening, as well as among different sized openings, would enhance regeneration of pines, oaks and other hardwoods. Regardless of the silvicultural system, if maintaining some old-growth characteristics is the goal, techniques that focus on retaining these characteristics are needed.

SUMMARY

Defining Eastern old growth is a complex, evolving process using limited information. Completed definitions will describe the composition and structure of live and dead components, site types and associated disturbance regimes. Definitions will also help identify old-growth and potential old-growth sites and contribute to restoration and management strategies. Few old-growth types function as steady-state climax communities. Given the stochastic nature of disturbance, some old-growth types should be viewed as ephemeral patches on the landscape. Some old growth, such as the oak-pine type, will require management to endure on the landscape.

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