FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

Southern Research Station | General Technical Report SRS-284 | May 2026

Identifying and Managing Old-Growth Forest Communities in the National Forests and Grasslands of the Southern Region

ABOUT THE AUTHORS

Don C. Bragg (deceased), Research Forester and Project Leader, USDA Forest Service, Southern Research Station, Monticello, AR 71656

Margaret Woodbridge, Research Ecologist, USDA Forest Service, Southern Research Station, Asheville, NC 28806

Christine Martens, Science Delivery Specialist, USDA Forest Service, Southern Research Station, Asheville, NC 28806

Joanne Baggs, National Landscape Ecology Program Lead, USDA Forest Service, National Forest System, Southern Region, Atlanta, GA 30309

Mohammad Bataineh, Research Biological Scientist, USDA Forest Service, Southern Research Station, Pineville, LA 71360

J. Davis Goode, Postdoctoral Fellow, USDA Forest Service, Southern Research Station, Monticello, AR, 71656. Current affiliation: Director of Forest Programs, The Nature Conservancy in Alabama, 3700 1st Ave N., Birmingham, AL 35222

John Haffner, ORISE Research Fellow, USDA Forest Service, Southern Research Station, Asheville, NC 28806

Gary Kauffman, Botanist (retired), USDA Forest Service, National Forest System, Southern Region, Asheville, NC 28701

Chelsea Leitz, Regional Inventory, Monitoring, and Assessment Program Manager, USDA Forest Service, National Forest System, Southern Region, Atlanta, GA 30309

Amy Nathanson, Regional Vegetation Ecologist, Southern Region, USDA Forest Service, National Forest System, Southern Region, Atlanta, GA 30309

H. Allen Nicholas, USDA Forest Service, National Forest System, (retired), Atlanta, GA 30309

Eric Pfeifer, Forest Silviculturist, USDA Forest Service, National Forest System, Southern Region, Roanoke, VA 24019

Jason Rodrigue, Regional Silviculturist, USDA Forest Service, National Forest System, Southern Region, Asheville, NC 28701

Christopher M. Schalk, Research Ecologist, USDA Forest Service, Southern Research Station, Nacogdoches, TX 75965

Peter Siciliano, Regional Social Scientist, USDA Forest Service, National Forest System, Southern Region, Asheville, NC 28801

Martin Spetich, Research Forest Ecologist (retired), USDA Forest Service, Southern Research Station, Hot Springs, AR 71902

David Taylor, Forest Botanist, USDA Forest Service, National Forest System, Southern Region, Winchester, KY 40391

Matthew Trager, Regional Planner, USDA Forest Service, National Forest System, Southern Region, Tallahassee, FL 32308

* Corresponding author; margaret.woodbridge@usda.gov

PHOTO CREDITS

Cover photo: Xeric Post Oak. (USDA Forest Service photo by Don Bragg).

Unless otherwise noted, all photos, maps or other reproduced materials are from public domain sources produced by the USDA Forest Service or other Federal sources.

DISCLAIMER

The use of trade or firm names in these proceedings is for reader information and does not imply endorsement by the U.S. Department of Agriculture.

May 2026

https://doi.org/10.2737/SRS-GTR-284

Forest Service
Research & Development
Southern Research Station
General Technical Report SRS-284

Southern Research Station
200 W.T. Weaver Blvd.
Asheville, NC 28804
www.research.fs.usda.gov/srs

EXECUTIVE SUMMARY

Old-growth forests in the Southeast are diverse, highly valued, and complicated to both define and differentiate on the landscape. In this report, we review the history of forests in the region, including how old-growth has been defined, the characteristics of old-growth communities and old trees, and the values that old-growth communities provide. We also provide information for land managers to consider: threats that old-growth forests face, examples of management strategies for maintaining and restoring ecological functions, and tools for managing old-growth characteristics in mature forests. Finally, we summarize the unique characteristics of the various old-growth community types that occur in the Southern Region and even the Eastern Region. Some differences between this report and the similarly named 1997 old-growth guidance by Gaines et al. are that this report does not include any specific management direction at the plan or project level. Instead, we focus primarily on information to support identification of old-growth conditions such as land-use history, detailed descriptions of values, and clarified terminology related to old-growth conditions. We hope this report can serve as a tool to inform a more thorough understanding of the old-growth communities in the Southern Region and beyond.

Keywords: Old growth, old-growth forest, management, old-growth communities, southern forests, historical old growth, old-growth values, old-growth threats.

CONTENTS

1. INTRODUCTION . . . 1
   1.1 Past Old-Growth Guidance in the Southern Region . . . 1
   1.2 Rationale for This Revised Report . . . 2
   1.3 Scope and Limitations . . . 5
2. PAST AND PRESENT DEFINITIONS OF OLD GROWTH . . . 9
   2.1 History and Context of Describing Old Growth in the Southern Region . . . 9
   2.2 Defining Old Growth in the Late 20th and 21st Century . . . 17
   2.3 Southern Region Working Definitions for Old Growth . . . 21
3. THE NATURE OF OLD GROWTH IN THE SOUTHERN REGION . . . 26
   3.1 Characteristics of Old Trees . . . 26
   3.2 Characteristics of Old Stands in the Southeastern United States . . . 30
   3.3 Patch Size . . . 39
4. FACTORS AFFECTING OLD GROWTH IN SOUTHERN REGION NATIONAL FORESTS . . . 44
   4.1 Old-Growth Values . . . 44
   4.2 Threats and Responses . . . 55
   4.3 Methods for Inventorying and Monitoring Old-Growth Forests . . . 73
5. OVERVIEW OF OLD-GROWTH FOREST COMMUNITY TYPES . . . 80
   5.1 Relationships to Other Classification Systems . . . 81
   5.2 Geographic and Environmental Diversity in the Southern Region . . . 82
   5.3 Summary Attributes of Common Old-Growth Community Types . . . 86
6. THE OLD-GROWTH FOREST COMMUNITY TYPES OF THE SOUTHERN REGION . . . 100
   6.1 OGCT 1: Northern Hardwood Forest . . . 100
   6.2 OGCT 2: Mesic Conifer-Hardwood Forest . . . 103
   6.3 OGCT 5: Mixed Mesophytic and Western Mesophytic Forest . . . 109
   6.4 OGCT 6: Coastal Plain Upland Mesic Hardwood Forest . . . 117
   6.5 OGCT 10: Hardwood Wetland Forest . . . 122

6.6 OGCT 13: River Floodplain Hardwood Forest . . . 129
6.7 OGCT 14: Cypress-Tupelo Swamp Forest . . . 137
6.8 OGCT 21: Mesic and Dry Mesic Oak Forest . . . 142
6.9 OGCT 22: Dry and Xeric Oak Forest, Woodland, and Savanna . . . 151
6.10 OGCT 24: Xeric Pine and Pine-Oak Forest and Woodland . . . 159
6.11 OGCT 25: Dry and Dry Mesic Oak-Pine and Pine-Oak Forest and Woodland . . . 167
6.12 OGCT 26: Upland Longleaf Pine Forest, Woodland, and Savanna . . . 177
6.13 OGCT 27: Seasonally Wet Oak-Hardwood Woodland . . . 184
6.14 OGCT 28: Eastern Riverfront Forest . . . 190
6.15 OGCT 29: Southern Wet Pine Forest, Woodland, and Savanna . . . 198
6.16 OGCT 31: Montane and Allied Spruce and Spruce-Fir Forest . . . 204
REFERENCES . . . 207
GLOSSARY . . . 227
References for Glossary . . . 256
APPENDIX 1—ACRONYMS . . . 258
APPENDIX 2—SPECIES LIST BY TAXONOMIC GROUP AND SCIENTIFIC NAME . . . 259
All Sections Species List by Taxonomic Group by Scientific Name . . . 259
All Sections Species List by Taxonomic Group by Common Name . . . 268

LIST OF TABLES

Table 4.1.a—Age class, accumulation rate, carbon density, and percentage of forested area in the South-Central and Southeast regions of the United States . . . 46

Table 4.2.a—Threats and stressors for Southern Region forests: fire exclusion . . . 57

Table 4.2.b—Threats and stressors for Southern Region forests: pests and pathogens . . . 58

Table 4.2.c—Threats and stressors for Southern Region forests: nonnative invasive species . . . 59

Table 4.2.d—Threats and stressors for Southern Region forests: historical land use . . . 60

Table 4.2.e—Threats and stressors for Southern Region forests: wind or hurricane, ice or snow, and catastrophic flooding and drought . . . 61

Table 4.2.f—Threats and stressors for Southern Region forests: high severity wildfires or prescribed burns . . . 62

Table 4.2.g—Common categories of restoration and maintenance treatments by old-growth community type . . . 70

Table 4.3.a—Advantages and limitations of FSVeg for use related to old-growth community types . . . 77

Table 5.2.a—OGCTs included in Southern Region provinces . . . 84

Table 5.3.a—Example of commercially valuable species targeted during early logging operations in the southern Appalachian Mountains, specifically Great Smoky Mountains National Park. Adapted from appendix A in Yost et al. (1994) . . . 89

Table 5.3.b—Maximum age by species organized by community types in the Southeastern United States. Ages are from individuals found throughout the eastern US . . . 90

Table 5.3.c—Old-growth forest overstory age attributes by common old-growth community types (old-growth code) in the Southeastern United States . . . 94

Table 5.3.d—Operational criteria for old-growth forest identification by common old-growth community types (old-growth code) in the Southeastern United States . . . 97

Table 5.3.e—Old-growth overstory attributes by old-growth community type (old-growth code) in the Southeastern United States . . . 98

Table 5.3.f—Downed woody debris (DWD) and snag attributes by common forest types (old-growth code) in the Southeastern United States . . . 99

Table 6.1.a—The potential distribution of OGCT 1: northern hardwood forest . . . 102

Table 6.1.b—The relationship of OGCT 1: northern hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) . . . 102

Table 6.1.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 1: northern hardwood forest . . . 103

Table 6.1.d—Natural Vegetation Communities for OGCT 1: northern hardwood forest 103

Table 6.2.a—The potential distribution of OGCT 2: mesic conifer-hardwood forest 107

Table 6.2.b—The relationship of OGCT 2: mesic conifer-hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 108

Table 6.2.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 2: mesic conifer-hardwood forest 108

Table 6.2.d—Natural vegetation communities for OGCT 2: mesic conifer-hardwood forest 109

Table 6.3.a—The potential distribution of OGCT 5: mixed mesophytic and western mesophytic forest 113

Table 6.3.b—The relationship of OGCT 5: mixed mesophytic and western mesophytic forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 115

Table 6.3.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 5: mixed mesophytic and western mesophytic forest 116

Table 6.3.d—Natural vegetation communities for OGCT 5: mixed mesophytic and western mesophytic forest 116

Table 6.4.a—The potential distribution of OGCT 6: Coastal Plain upland mesic hardwood forest . . 120

Table 6.4.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 6: Coastal Plain upland mesic hardwood forest 121

Table 6.4.b—The relationship of OGCT 6: Coastal Plain upland mesic hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 121

Table 6.4.d—Natural Vegetation Communities for OGCT 6: Coastal Plain upland mesic hardwood forest 122

Table 6.5.a—The potential distribution of OGCT 10: hardwood wetland forest 125

Table 6.5.b—The relationship of OGCT 10: hardwood wetland forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 127

Table 6.5.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 10: hardwood wetland forest 128

Table 6.5.d—Natural vegetation communities for OGCT 10: hardwood wetland forest 128

Table 6.6.a—The potential distribution of OGCT 13: river floodplain hardwood forest 132

Table 6.6.b—The relationship of OGCT 13: river floodplain hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 134

Table 6.6.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 13: river floodplain hardwood forest . . . 135

Table 6.6.d—Natural Vegetation Communities for OGCT 13: river floodplain hardwood forest . . . 136

Table 6.7.a—The potential distribution of OGCT 14: cypress-tupelo swamp forest . . . 139

Table 6.7.b—The relationship of OGCT 14: cypress-tupelo swamp forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) . . . 140

Table 6.7.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 14: cypress-tupelo swamp forest . . . 140

Table 6.7.d—Natural vegetation communities for OGCT 14: cypress-tupelo swamp forest . . . 141

Table 6.8.a—The potential distribution of OGCT 21: mesic and dry mesic oak forest . . . 145

Table 6.8.b—The relationship of OGCT 21: mesic and dry mesic oak forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) . . . 148

Table 6.8.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 21: mesic and dry mesic oak forest . . . 149

Table 6.8.d—Natural vegetation communities for OGCT 21: mesic and dry mesic oak forest . . . 150

Table 6.9.a—The potential distribution of OGCT 22: dry and xeric oak forest, woodland, and savanna . . . 154

Table 6.9.b—The relationship of OGCT 22: dry and xeric oak forest, woodland, and savanna, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) . . . 157

Table 6.9.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 22: dry and xeric oak forest, woodland, and savanna . . . 158

Table 6.9.d—Natural vegetation communities for OGCT 22: dry and xeric oak forest, woodland, and savanna . . . 158

Table 6.10.a—The potential distribution of OGCT 24: xeric pine and pine-oak forest and woodland . . . 162

Table 6.10.b—The relationship of OGCT 24: xeric pine and pine-oak forest and woodland, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) . . . 164

Table 6.10.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 24: xeric pine and pine-oak forest and woodland . . . 165

Table 6.10.d—Natural vegetation communities for OGCT 24: xeric pine and pine-oak forest and woodland . . . 166

Table 6.11.a—The potential distribution of OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland . . . 171

Table 6.11.b—The relationship of OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 174

Table 6.11.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland 175

Table 6.11.d—Natural vegetation communities for OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland 176

Table 6.12.a—The potential distribution of OGCT 26: upland longleaf pine forest, woodland, and savanna 181

Table 6.12.b—The relationship of OGCT 26: upland longleaf pine forest, woodland, and savanna, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 182

Table 6.12.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 26: upland longleaf pine forest, woodland, and savanna 182

Table 6.12.d—Natural vegetation communities for OGCT 26: upland longleaf pine forest, woodland, and savanna 183

Table 6.13.a—The potential distribution of OGCT 27: seasonally wet oak-hardwood woodland . . . 186

Table 6.13.b—The relationship of OGCT 27: seasonally wet oak-hardwood woodland, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 188

Table 6.13.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 27: seasonally wet oak-hardwood woodland 189

Table 6.13.d—Natural vegetation communities for OGCT 27: seasonally wet oak-hardwood woodland 189

Table 6.14.a—The potential distribution of OGCT 28: eastern riverfront forest 193

Table 6.14.b—The relationship of OGCT 28: eastern riverfront forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 196

Table 6.14.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 28: eastern riverfront forest 197

Table 6.14.d—Natural vegetation communities for OGCT 28: eastern riverfront forest 197

Table 6.15.a—The potential distribution of OGCT 29: southern wet pine forest, woodland, and savanna 201

Table 6.15.b—The relationship of OGCT 29: southern wet pine forest, woodland, and savanna, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) 202

Table 6.15.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 29: southern wet pine forest, woodland, and savanna 202

Table 6.15.d—Natural vegetation communities for OGCT 29: southern wet pine forest, woodland, and savanna . . . 203

Table 6.16.a—The potential distribution of OGCT 31: montane and allied spruce and spruce-fir forest . . . 206

Table 6.16.b—The relationship of OGCT 31: montane and allied spruce and spruce-fir forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA) . . . 206

Table 6.16.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 31: montane and allied spruce and spruce-fir forest . . . 206

Table 6.16.d—Natural Vegetation Communities for OGCT 31: montane and allied spruce and spruce-fir forest . . . 206

LIST OF FIGURES

Figure 2.1.a—An example of a cutover and burned Forest Service land acquisition authorized by the Weeks Act in North Carolina in 1911 (USDA Forest Service photo) 13

Figure 2.1.b—Even the mountains of the Southern Region experienced extensive timber harvest and agriculture in the 19th and early 20th centuries before some of these lands became part of the National Forest System. (A) Timber harvest on the Pisgah National Forest on the slopes of Mt. Mitchell in North Carolina; many areas were clearcut followed by burning the slash, often repeatedly. (USDA Forest Service photo, negative #176383, by E.S. Shipp in 1923) (B) Large areas of mountain slopes, once cleared, were planted to crops such as corn, tobacco, and cotton, often leading to significant erosion and downstream flooding problems, Madison County, NC near the village of Marshall. (USDA Forest Service photo, negative #236411 by C.R. Hursh in 1929) (C) A grandfather and his granddaughters strip bark from a blight-killed chestnut (for tannin extraction) and cut up the decay-resistant wood to produce shingles and lumber, an example of the poverty and limited opportunities for many mountain families, Chattahoochee National Forest in northern Georgia (USDA Forest Service negative #414131 by Clint Davis in July of 1941) (D) Ducktown River basin in eastern Tennessee near the Cherokee National Forest where copper mining and smelting resulted in extensive forest loss and the denuded lands eroded. Although mining was never large scale in the eastern national forests, it could still have devastating effects. (USDA Forest Service negative #204327 by R.H. Charton in 1925) . . . 14

Figure 2.1.c—Southern Region Forest Service land acquisitions in the 1930s were often from some of the most exploited and damaged areas, including lands that had been cleared then grazed and farmed for decades. (A) A photo from the Zavalla Forest Farm Rehabilitation Project in southeastern Texas on former longleaf pine lands that are now part of the Angelina National Forest. Poor farming techniques often lead to extensive soil erosion. (USDA Forest Service negative #405009 by S.L. Frost in 1935) (B) Even more pronounced erosion problems occurred on certain soil types in northern Mississippi, leading to dramatic gullying. The area photographed would soon become part of the Holly Springs National Forest. (USDA Forest Service negative #258562 by H.G. Meginnis in 1931) (C) Even where erosion was less problematic, the absence of seed trees required widespread tree planting efforts by federal agencies. Here a Civilian Conservation Corps crew plants trees on the Catahoula unit of the Kisatchie National Forest in Louisiana. (USDA Forest Service negative #285996 by J.D Nellis in 1934) 16

Figure 3.1.a—Characteristic appearance of shortleaf pine at different life stages and ages: (A) seedlings of a few months, (B) saplings a few years old, (C) small poles approximately 30 years, (D) mature at 80 to 100 years, (E) an old shortleaf tree, likely >150 years (USDA Forest Service photos by Don Bragg) 26

Figure 3.1.b—A large bald cypress felled in 1913 in southern Georgia reported to be 8 feet d.b.h. and estimated to be 1,200 years old. (USDA Forest Service negative #17915 by Wilbur R Mattoon) 28

Figure 3.1.c—Examples of bole characteristics often found in old-growth forest types in the Southeastern United States. (A) Nearly 300-year-old loblolly pine (*Pinus taeda*) with very low bole taper (columnar or cylindrical bole); (B) spiral grain in 200-year-old post oak; (C) low bole quality in >150-year-old post oak, showing hollow (lightning scar), knobs, and spiral grain; (D) clear bole on a shortleaf pine; (E) smooth-barked, slower growing loblolly pine (background left) compared to more furrowed younger loblolly (foreground right) (USDA Forest Service photo by Don Bragg) 29

Figure 3.2.a—Downed wood, tip-up mounds, and canopy gaps are important forest structural characteristics for both wildlife and herbaceous species (USDA Forest Service photo by Margaret Woodbridge) 32

Figure 3.2.b—Old-growth rich cove forests in the southern Appalachian Mountains support diverse herbaceous understories (USDA Forest Service photo by Margaret Woodbridge) .. 35

Figure 4.1.a—(A) Acidic cove (USDA Forest Service photo by Peter Siciliano) (B) and mixed-mesophytic forests in the Joyce Kilmer Memorial Forest, Nantahala National Forest (USDA Forest Service photo by Margaret Woodbridge) 49

Figure 5.2.a—The 10 provinces within the Southern Region that contain Forest Service ranger districts 82

Figure 5.2.b—Map of the 37 sections within the Southern Region that contain Forest Service lands. 83

THE SOUTHERN REGION OLD-GROWTH TEAM MEMBERS

Southern Region

Michelle Aldridge, Planning Staff Officer

Joanne Baggs, Regional Vegetation Ecologist

Cavan Fitzsimmons, Deputy Forest Supervisor of National Forests in North Carolina

Gary Kauffman, Forest Botanist

Chad Keyser, Forest Silviculturist

Kevin Kyle, District Ranger

Chelsea Leitz, Regional Inventory, Monitoring, Assessment and Climate Change Coordinator

S. Lee Madson, Regional Planning Director

Amy Nathanson, Regional Vegetation Ecologist

H. Allen Nicholas, Retiree ACES Program

Eric Pfeifer, Forest Silviculturist

Duke Rankin, Regional Threatened and Endangered Species Program Manager

Jason Rodrigue, Regional Silviculturist, USDA-NFS Southern Region

Peter Siciliano, Regional Social Scientist

David Taylor, Forest Botanist

Matthew Trager, Regional Planner

Lorenzo Walton, Forest Silviculturist

Southern Research Station

Mohammad Bataineh, Research Biological Scientist

Don C. Bragg, Research Forester and Project Leader

J. Davis Goode, ORISE Fellow

Phillip Jordan, Wildlife Biologist

John Haffner, ORISE Fellow

Christine Martens, Science Delivery Specialist

Christopher Schalk, Research Ecologist

Martin Spetich, Research Forest Ecologist

Margaret Woodbridge, Research Ecologist

ACKNOWLEDGMENTS

This report could not have been completed without the dedication and support from countless USDA Forest Service employees. We would like to thank all those who took the time to contribute. The partnership between the Southern Research Station and the Southern Region Regional Office provided an opportunity for successful collaboration and years of productive conversations. We received excellent feedback and ideas from employees throughout the region and beyond. This input, along with supporting field visits significantly improved the content of this publication and broadened our understanding of old-growth conditions. The team especially needs to recognize and thank the following people and organizations for their support in this undertaking: Paul Arndt for his expertise, service, and dedication to the Southern Region's planning portfolio for over 40 years. Rachel Neuenfeldt, whose Middle Leader Practicum collected survey results of regional personnel that defined the key goals of this effort. The team would also like to thank Tara Keyser (USFS SRS), Rick Lint (USFS RO - Retired), Greg Hayward (USFS WO EMC - Retired), Micah Thorning (USFS RO), Emrys Treasure (USFS RO), and WO Mature and Old Growth team members.

Jim Guldin (USFS-SRS retired), Peter White, and specialists from national forests in the Southern Region provided expertise in reviewing the final manuscript. Laurel Haavik and Donna Burnett edited the final manuscript.

DEDICATION

Dedicated to Don Bragg, who will be remembered for his passion for science and the natural world. Don had a 23-year career as a research forester with the USDA Forest Service, Southern Research Station and was an expert in the silviculture of southern pines. His leadership, guidance, and mentorship in the ecology and management of pine systems in the Southern United States shaped not only this team, this report, and our understanding of old growth pine systems, but many people and works throughout the agency. The Forest Service will dearly miss Don's leadership and enthusiasm for forest history, forest ecology, and active forest management.

1. INTRODUCTION

The U.S. Department of Agriculture (USDA), Forest Service manages 193 million acres of public land in the National Forest System, approximately 144 million acres of which is forested. These forested lands vary widely in species composition, management history, and current condition. Despite this recognition, defining, identifying, and choosing appropriate management for old-growth forests presents scientific and operational challenges within the Forest Service and continues to fuel public controversy.

In this report, we provide a major revision to the past old-growth forest guidance (Gaines et al. 1997) for the Southern Region of the Forest Service. Using a synthesis of the best available scientific information from published studies and agency expertise, we first describe land-use history of national forests in the region and provide a general narrative definition of old-growth forest (for additional information on available literature, see Woodbridge et al. 2025). We then summarize the best available scientific information regarding old-growth forest values, threats, and effects of management, as well as potential methods for identifying and tracking old growth. We conclude by providing more specific descriptions of old-growth conditions for 16 forest communities in the region. The purpose of this report is to provide information when considering old-growth forests in forest planning and plan implementation throughout national forests in the region. This report does not constitute an agency decision, establish policy, or either authorize or restrict any specific land management actions.

1.1 Past Old-Growth Guidance in the Southern Region

In 1989, Chief Dale Robertson issued a formal position statement on old-growth forests that recognized their unique importance and identified distinguishing characteristics. Specifically, Chief Robertson directed the Forest Service to manage for protection of existing and future old-growth forests, to develop definitions for each forest type, and to study and inventory old-growth forests. In written testimony to Congress, the Chief encouraged “silvicultural practices that maintain or establish specific old-growth values,” indicating active management and old-growth conservation were compatible goals. However, Robertson also addressed the potential conflicts between old-growth forest protection and commercial harvest, stating that “where goals for providing old-growth values are not compatible with timber harvesting, lands will be classified as unsuitable for timber production” (Joint Hearing before the Committee on Agriculture, Nutrition, and Forestry, 101st Congress, October 25, 1989: 116). In addition to providing agency direction to conserve old-growth forests, Chief Robertson’s position statement also contributed to the development of national forest land management plans that reduced emphasis on commercial production and increased emphasis on ecosystem management.

In response to internal recognition of old-growth forest values and continued public interest, in 1997 the Forest Service’s Southern Region completed a report titled *Guidance for Conserving and Restoring Old-Growth Forest Communities on National Forests in the Southern Region* (Gaines et al. 1997). The report included descriptions of old-growth forest structure and composition based on a series of published papers focusing on major forest types in the region (Batista and Platt 1997). The 1997 guidance also provided direction for considering old-growth communities in forest planning and plan implementation. The regional old-growth guidance served as the definitive reference on the subject since its publication and was incorporated into nearly all the subsequent land management plan revisions in the region.

The 1997 Southern Region guidance adopted Chief Dale Robertson's general, narrative definition for old-growth forests and described old-growth characteristics for 16 forest community types in the Southern Region. The minimum compositional and structural attributes for forest types were designated as operational definitions. They rely on easily evaluated forest metrics but also recognize that the best available scientific information regarding old-growth forest characteristics could change over time. The operational definitions were based on age of the dominant species, stand basal area, diameter of the largest size class, and a more qualitative criterion related to disturbance history (Gaines et al. 1997: 25–26). Additionally, more detailed descriptions of community types including species composition, classification of vegetation types, and representative locations complimented these operational definitions. The guidance recommended forests conduct old-growth inventories during the land management plan revision process, allocate areas for old-growth management, and develop plan components to address issues related to old-growth. In areas identified as potential old-growth during the preliminary inventory (i.e., those that likely meet at least one old-growth criterion, usually stand age), the 1997 guidance recommended field assessment during project implementation to determine appropriate management activities and potential designation of small-sized old-growth areas.

One of the primary objectives of the 1997 guidance was to promote consistency among forest plans in the Southern Region while recognizing that on-the-ground conditions and issues related to old growth varied among national forests. Almost every land management plan revision in the region addressed old-growth issues, primarily discussing the amount of old growth desired, where old growth occurs, and how to manage it. Forests developed a range of desired conditions, goals or objectives, and standards or guidelines related to old-growth forest protection and management. Forest plans generally adopted terminology from the 1997 guidance, though some also developed alternative terms to describe forest conditions, account for uncertainty about old-growth status, and clarify management intent. Several plans spatially designated management or prescription areas intended to maintain or increase the extent of old-growth forests, whereas other plans allocated future old growth wherever it occurred for major ecosystems. Many old-growth forest designations, particularly the medium- and large-sized areas (those that were 100–2,499 acres or >2,500 acres, respectively) were allocated within management areas or congressionally protected areas where little active management is permitted, such as remote or inaccessible wetlands, Inventoried Roadless Areas, Research Natural Areas, or areas designated as Wilderness Study Areas or wilderness. Project-level requirements for old growth varied among forest plans, with some requiring surveys prior to management activities, while others referred to the 1997 guidance. Gaines et al. (1997) provided no specific direction for old-growth forest evaluation or management for projects implementing the forest plan.

1.2 Rationale for This Revised Report

The 1997 old-growth guidance addressed several important issues related to identifying and considering old-growth forest issues in land management plans. Though the 1997 guidance was interpreted somewhat differently among plans, it largely succeeded in promoting a more standardized approach to old-growth forests across the region while recognizing variation among forests. However, changing forest conditions, continued challenges regarding the management of old-growth conditions, new research, and shifts in agency priorities and direction prompted the Southern Region to revisit issues related to old-growth forests.

Changing forest conditions and stressors

The ecological, social, and economic factors affecting forest management in the Southern Region have changed during the nearly 30 years since the development of the 1997 guidance. These changes are happening in the context of shifting forest conditions, especially as stands planted in the early days of the national forests continue to mature. Large-scale analysis and futuring projects such as the Southern Forest Futures Project (Wear et al. 2013) and the *Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment* (USDA Forest Service 2023b) address forest issues across large areas and all ownerships. The trends and projections they describe are also relevant for understanding old-growth forest management on national forest land.

The Southeastern United States has the country's highest rates of forest harvest, accounting for approximately 65 percent of U.S. wood production and 10 percent of the global total of industrial roundwood (Costanza et al. 2023, Johnston et al. 2023). The vast majority of this production is from private timberland, primarily pine plantations. However, harvest from national forests is locally important and the forest products economy can influence overall land-use patterns.

In the coming decades, models suggest an increase in population and development across the South resulting in a decrease in forested land (Riitters et al. 2023, Ryan et al. 2010). Although the carbon pool of regional forests is expected to slowly increase until 2030 due to the growth of current forests, these changes in land use and harvest are expected to decrease forest carbon stocks in the south in the future (Ryan et al. 2010). These projected changes in land use and forest carbon could result in conflicting pressures on national forest land to allow more harvest or sequester more carbon in forests to compensate for the loss of private timberlands.

Although national forests are generally not subject to the direct effects of surrounding development, they face many of the same stressors as other forests. Forests in the southeast have experienced lower rates of mortality due to wildfire, drought and insects or disease than many western forests. However, these disturbances are all expected to increase in the future under nearly all climate scenarios (Robbins et al. 2024), with potential impacts throughout national forests. Additionally, forests in the Southern Region are particularly susceptible to invasion by nonnative plant species (Costanza et al. 2023) and major wind damage or flooding from hurricanes. Many public lands in the south also suffer from lack of fire, which was the primary historical disturbance in many drier forest ecosystems. Managing for resilience of national forests in the face of these stressors, including persistence of old-growth forests, requires understanding the relationship between forest conditions and the effects of past and expected future disturbances.

Defining and managing old-growth forests

The 1997 guidance succeeded in promoting Chief Robertson's general definition of old-growth forests as well as developing operational definitions for field identification in the Southern Region. In this updated report, we provide a broader regional definition of old-growth forests that accounts for variation in site conditions and history, while also providing descriptions of conditions that do not meet the definition.

Terminology used to describe older forests often implies both ecological conditions and past human activities (Wirth et al. 2009). The 1997 guidance states that “For a stand to be considered as existing old growth, no obvious evidence of past human disturbance which conflicts with the old-growth characteristics of the area should be present” (Gaines et al. 1997: 25). That direction was frequently interpreted as equating existing old-growth forest with virgin or primary forest that showed little or no evidence of human influence. As a result, many areas of disturbed or degraded old-growth forest or older second-growth forest that had clear evidence of past human disturbance were excluded from designation in preliminary inventories or project-level assessments. However, these previously excluded forests may provide important ecological functions and contain many elements—particularly old trees of appropriate species—that could be managed to maintain or promote desirable old-growth forest structure and composition. Therefore, in this revised report, a disturbance such as past land clearing is not considered by itself to be sufficient rationale to preclude a site from classification as old-growth forest if the current conditions otherwise meet the criteria for that forest type.

The 1997 guidance provided little information regarding the effects of management activities on old-growth forest conditions beyond the determination that old-growth areas recognized in forest plans were generally considered unsuitable for timber production. This designation, along with public controversy surrounding active management in old-growth areas, frequently led to preservation-focused management. Such a hands-off approach may result in degraded ecological conditions due to invasive species, atypical structure and composition, and lack of fire. Conversely, in some areas that would be recognized as old-growth forest according to definitions in this report, harvest activities have resulted in a loss of old trees and associated values. In this report, we discuss the potential effects of management activities on old-growth forests, focusing on mitigating stressors and understanding how to maintain or improve old-growth forest values.

Forest types across national forests in the Southern Region are among the most diverse temperate ecosystems in the world (Jenkins et al. 2015) and have a wide range of tree species diversity, vegetation structure, successional dynamics, and disturbance ecology. Naturally, the 16 major forest types considered in this report also vary substantially in response to common forest management practices, and our understanding of managing old-growth forests has increased substantially since the 1997 guidance was developed. Some old-growth communities may persist and appear relatively resistant to major changes for decades or centuries without human intervention (Batista and Platt 2003, Karki and Hallgren 2015). However, others would benefit from the removal of nonnative invasive plants, selective removal of trees to maintain or restore historical structure and composition, or, most commonly, application of prescribed fire at the appropriate season and interval because historically lighting-strike fires and Native American burning was disrupted (Chapman and McEwan 2016, Tuttle and White 2016). Experience and published studies have demonstrated how various management activities (including passive management) may benefit old-growth values, and in this report, we provide managers and decisionmakers with community-specific information to allow a more robust analysis of how management activities affect the ecological integrity of the region’s old-growth forests.

Regulations and policies

Although Chief Robertson's 1989 direction has influenced Forest Service management of old-growth forests, there are no federal laws or agency regulations that require specific approaches to old growth in forest planning or plan implementation. However, as a multiple-use agency required to consider a range of resources and public uses, many laws influence how the Forest Service manages old growth. For example, the Endangered Species Act of 1973 requires that the Agency contribute to the conservation and recovery of threatened or endangered species, most commonly through management of high-quality habitat that may include old-growth forests. Similarly, in areas proclaimed as wilderness or wilderness study areas under the Wilderness Act (1964), timber harvest and many other management activities are prohibited, which often protects old-growth forests (though in some cases, as described above, such protections may prevent efforts to maintain or improve forest systems). In addition to these longstanding laws, the 2012 Planning Rule is a more recently finalized regulation that affects the Forest Service's consideration of old-growth forests. The 2012 Planning Rule was enacted by USDA to direct Forest Service compliance with the National Forest Management Act (1976) through the land management planning process on April 9, 2012. This new planning rule was published in the Federal Register and replaced the previous regulations published in 1982. Whereas the 1982 rule was focused primarily on timber management (Federal Register 1982), the 2012 planning rule emphasizes ecological sustainability with an emphasis on the integrity of terrestrial and aquatic ecosystems (Federal Register 2012). The rule defines ecological integrity as the quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influences (USDA Forest Service 2012).

The planning rule states that a land management plan must contain plan components that maintain or restore the composition, structure, ecological processes, and connectivity of plan area ecosystems in a manner that promotes their ecological integrity. Although old-growth forests are not specifically mentioned in the 2012 planning rule, they contribute to key requirements of the rule, including ecological sustainability, diversity of plant and animal communities, and providing for multiple uses.

1.3 Scope and Limitations

This report has been developed specifically for the National Forest System forests and grasslands of the Southern Region. We recognize that there may be other rare forest types that do not readily fit into the 16 types described in sections 5 and 6. Additionally, there are many nonforest plant communities that provide long-term ecological value but are not addressed in this report, such as grasslands, scrub, marshes, bogs, seeps, glades, or rock outcrops; some of these communities also have notable Tribal importance, such as canebrakes and tallgrass prairie (Casey and Wynia 2010; Dinkins, N.d.). We suggest that these rare forest and nonforest communities may be treated as rare communities, some of which may be embedded in the broader old-growth forest type. Additionally, this report does not address tropical forest community types that occur in El Yunque National Forest, located in Puerto Rico's Northeast Region. The recent revision of the El Yunque National Forest land management plan, published in 2019, addressed the diverse and unique tropical forests within their ownership (USDA Forest Service 2019). However, the scope of this report is limited to the most common old-growth forest ecosystems in the region.

Within that scope, we have attempted to provide a comprehensive synthesis of old-growth forest communities and conditions in the Southern Region with the intention to inform the decision-making processes associated with planning, identification, and management activities at multiple scales. This report is intended to support national forest field managers, planners, and decisionmakers in their efforts to manage old-growth forests throughout the Southern Region. This report can be used to help inform efforts to identify old-growth for specific individual stand(s) or area(s) at the field level; it is not intended to replace the professional opinions of experienced individuals on the ground. This report is created to support a forest's analysis of determining old-growth conditions specific to the associated ecological conditions, disturbance regimes, and other associated old-growth values found there. We have intentionally provided attribute information displayed as a range of values given that any one community type can extend across multiple forests (hundreds of thousands of acres) with varying ecological conditions that can produce old-growth conditions standard to one unit, which is perhaps different from the standard found on a neighboring forest. We have also provided an updated operational definitions table with threshold values for a limited set of criteria based on the ranges found in the literature. This table is intended to be used at a regional scale, and to provide a standard set of values for a quick determination of old growth in the field. Sites that meet all of these criteria may be missing key components of old-growth forests, and sites that do not meet some (or most) of the criteria as defined in this report may actually be old growth, based on local site conditions. In short, this report is intended to help managers determine stands and areas to consider as old-growth and detail available management options.

Beyond updating information and considering new policies, this report also includes intentional changes in content and structure to reflect a shift in how we expect it to be used in land management plan revision and implementation. Most importantly, despite this report being seen as a continuation or update to the 1997 guidance, we do not include any specific management direction at the plan or project level. Instead, we focus primarily on information to support identification of old-growth conditions and understanding how agency actions or other processes may affect them. The following distinctions are among the main changes between the 1997 guidance and this report, and clearly demonstrate the change in purpose:

- Understanding the current conditions of forests managed by the Forest Service benefits greatly from considering land-use history. Therefore, we provide a detailed description of land-use history in the southeast, including the conditions of lands acquired for the Southern Region's national forests and a history of Forest Service resource management. Based on that understanding, the revised definition of old-growth forest allows for some evidence of past human disturbance if tree age, composition, and structural criteria are met.

- The 1997 guidance adopted Chief Robertson's narrative definition of old-growth forest and developed operational definitions for major forest types in the Southern Region. We define and clarify terms related to old-growth conditions that relate to their ecological conditions, uncertainty, and management intent. We have updated the operational and detailed definition tables based on the best available science, in section 5.3.
- We provide a much more detailed description of values associated with old-growth forests, including recognition of Native American cultural values and Indigenous Knowledge, in section 4.1.
- Climate and carbon science have advanced substantially since the 1997 guidance, and we incorporate considerations related to carbon stocks as well as threats posed by the likely effects of climate change.
- Plan components recommended in the 1997 guidance may still be appropriate for land management plan revisions, but we do not require or promote any specific plan content.
- Similarly, we do not include direction for project-level implementation of any particular activities related to identifying or managing old-growth forests (e.g., survey, inventory, timber suitability designation, or vegetation management), but rather include updated science to inform decisions at the appropriate scale. The 1997 guidance included both direction for plan revision as well as project-level surveys and activities, which resulted in confusion regarding which direction (i.e., land management plan or old-growth guidance) should be followed.
- The 1997 guidance directed identification of medium- and large-sized areas during plan revision and additional identification of small-sized areas during project-level surveys (Gaines et al. 1997: 15–22). That process was incorporated into most forest plans but varied in implementation and in some cases resulted in apparent contradictions between the language in forest plans and that in the 1997 guidance. Instead of prescribed designation of patches of different sizes during forest plan and project development, we provide a description of the relationships between old-growth forest values and the size and landscape context of patches of older forest (sections 3 and 4). Although there is no requirement to identify patch size, we use the terms small, medium, and large to foster a common language and provide ranges for each. Medium and large patch sizes are unchanged, minimum small patch size has increased from 1 to 10 acres.

- Forest land management plans provide a strategic framework and implementation direction for the national forests for which they are prepared. In many ways, this report updates the 1997 guidance but is not a direct replacement for it when referred to by land management plans or other documents. No part of this report triggers a need for plan revision or amendment, nor does it require changes to existing methods or rationale for field procedures used to identify old-growth forests. However, along with potential changes in national or regional direction, the information provided here may help inform plan amendments, management strategies, or changes in field inventory or management related to old-growth forests. Our revision was developed primarily because of changes in requirements for land management planning as well as recognition that both forests and our scientific understanding of old-growth forests has changed substantially since the mid-1990s when the previous guidance was prepared. Therefore, it is our intention that this information be relevant and helpful for identifying old-growth conditions and understanding the values and challenges associated with old-growth forest management in the Southern Region regardless of the outcome of any specific policy actions.

2. PAST AND PRESENT DEFINITIONS OF OLD GROWTH

Despite decades of work on the concept of old-growth forests by scientific and management communities, there is no single, universally accepted definition of old growth. Most of us have an archetypical notion of old growth, often based on historical observations that focused on the most apparent element of that forest condition: large trees and often (but not always) relatively high stand biomass. Such accounts were common among early European explorers and settlers in the Southeast and these conditions persisted well into the 19th and 20th centuries in some areas:

> These swamps and morasses [in eastern Arkansas] partly realize the idea which Europeans entertain of the primitive forest… [in these forests] the trees grow to colossal grandeur—I have seen some measuring seven, eight, and even nine feet in diameter. (Gerstaecker 1861: 177).
>
> Finer, straighter, loftier trees the world does not produce…you may ride through these ancient woods and see them as they may have stood for countless years, untouched by the hand of man…This growth of giant pines is unbroken on the route we pursued for a hundred miles or more… (Claiborne 1906, describing longleaf pine [*Pinus palustris*] in Mississippi)

The new scientific disciplines of ecology and forestry began considering what made the old-growth forest unique. For example, Ayres and Ashe (1905: 18) described the forests of the southern Appalachian Mountains as being "…wonderful in the extent, density, size, and quality of its timber trees, and the variety of their species." Although not a definition itself, their account includes attributes beyond marketable forest products that are still considered indicative of old growth in mesic environments: widespread, well-stocked (dense) forests of many different taxa, dominated by large specimens of the primary species. Despite the common focus on large, old trees and certain stand structural attributes, old-growth forests vary substantially, and the concept is more complex than people generally recognize (Wirth et al. 2009).

Views on old growth have even evolved substantially over the past quarter-century since the publication of Gaines et al. (1997). The remainder of this section will discuss some of these historical perceptions and how we have arrived at our current circumstances. We conclude this section by describing conditions and defining terms for old-growth forests in the Southern Region.

2.1 History and Context of Describing Old Growth in the Southern Region

Terminology related to old forests has changed over time as their distinctive characteristics were more widely recognized. Wirth et al. (2009) noted that the first use of the term old growth in a scientific paper was in one on mollusk communities in different forest types near Asheville, NC (Jacot 1935). Jones (1945) used old growth in lieu of virgin or climax forest in contrast to earlier scientific works by Korstian (1924) and Lutz (1930). Although the term old growth was increasingly used in the mid-1900s, alternative references such as virgin, primary, primitive, and climax were still more common well into the 1960s (Wirth et al. 2009). Beginning in the 1970s, old growth was widely adopted by the environmental movement to describe older, usually undisturbed forests (McCarthy 2019). As such, this term now has both scientific and common usage. In this section, we use terms that seem most appropriate for the forest conditions described, including many of the earlier used terms when our descriptions are based on older literature or historical documents.

Native American influences

Although scientists debate the degree and intensity of Indigenous impacts on natural communities (Abrams and Nowacki 2020, Kellett et al. 2023, Oswald et al. 2020), human presence and influences were extensive in North America and could be pronounced, especially in densely populated areas of the Southeastern United States (Foster et al. 2004, Fowler and Konopik 2007, Gremillion 2015, Munoz et al. 2014). Even though documentation of historical forest conditions is limited for many parts of North America prior to the early 1800s (many specific locations lack anything until General Land Office surveys were conducted starting after 1815), evidence of widespread and significant influences of Native Americans prior to removal can be found across the Southeastern United States. For example, the narratives of Spanish conquistador Hernando de Soto cover his 1539–1543 expedition throughout the Southeastern United States, starting in Florida and moving up through Georgia, the Carolinas, Alabama, Mississippi, Arkansas, and likely as far west as eastern Texas before exiting the region via the Mississippi River. The chronicles of de Soto's entrada are vague and not written to describe the forests and landscapes encountered, but it is clear that they traveled through well-populated country over most of their route (Young and Hoffman 1993). These were largely agrarian populations who cleared large areas to grow their crops, and also used the bounty of the forests and prairies that surrounded them to support their lifeways.

Later European explorers who returned to the lands that would eventually be known as the Southeastern United States would find more limited populations of Native Americans than de Soto, many of whom were less dependent on agriculture and more dependent on hunting and gathering. Southern landscapes were still occupied and utilized, and likely subjected to many of the same practices of their predecessors. For example, French historian and naturalist Antoine-Simon Le Page du Pratz explored much of the Lower Mississippi River Valley during the 1720s and wrote that September was the best season of the year to travel this region because during this month:

> …the meadows, the grass of which is then dry, are set on fire [by local tribes], and the ground becomes smooth, and easy to walk on: and hence it is, that at this time, clouds of smoke are seen for several days together to extend over a long track of country; sometimes to the extent of between twenty and thirty leagues in length, by two or three leagues in breadth, more or less, according as the wind sets, and is higher or lower. (Le Page du Pratz 1774: 121).

In the 1770s, botanist William Bartram explored much of the region, from the Carolinas to Florida to Alabama, and likewise reported on extensive open forests and "annual firing of the forests and plains" (Harper 1998: 142). Fellow botanist Andre Michaux noted (in Williams et al. 2020: 96) that his travels in northern Florida were rerouted due to fires set by Native Americans and American settlers:

> One has no idea in Europe of the considerable amount of woods that are annually set ablaze in America by either the Indians or by the Americans themselves. They have no other motive, either one or the other, than to have new grass come up without the dry grass of the preceding year and to hunt deer more easily and to feed the cattle.

Similar observations of frequent, widespread, and deliberately set fires in many southeastern ecosystems can be found into the early 20th century (Berry et al. 2006, Dunbar 1809, Hall 1830, Harper 1913, Hilgard 1860, Long 1889, Stoddard 1812). Johnson and Hale (2002) discuss fire history, burning traditions and agency positions around forest burning in the Southeast. These frequent fires were often set in fire-adapted forest systems, but also likely expanded the range of these forest types across the landscape.

There is abundant evidence demonstrating that most, if not all natural communities, from forests and woodlands to grasslands and aquatic habitats, have been affected by past human populations to some degree. For instance, uplands in the Coastal Plain ecoregion were heavily dominated by a single fire-adapted tree species—longleaf pine—well into the early 20th century when changing environmental conditions and human influences led to widespread conversion to other land uses and forest types (Croker 1979, Frost 2006, Hanberry et al. 2023). Recognizing the natural and anthropogenic processes that affect forest structure and composition challenge the concept of eastern old-growth forests as undisturbed and unchanging over time.

Impact of colonialism

As Europeans settled North America, displaced native inhabitants, and the American colonies emerged as a new nation, a burgeoning population resulted in a wave of settlement and exploitation across the continent. Once these new settlers arrived, forests in the South were cleared for row crop agriculture, grazed by livestock, tapped for naval stores, and eventually felled for lumber. These actions had long-term and large-scale impacts on community, landscape, and even regional vegetation dynamics.

Most early foresters held a low regard for virgin forests, considering them at best a resource that could be improved through the application of forestry science. For example, Gifford Pinchot (1898: 4) described the virgin forest as:

> … the product of centuries of struggle among the trees for the occupancy of the ground. This competition takes place between individuals of the same species, as well as between the different species, and its result determines the character of the forest. Nature does not provide for the survival of those trees alone which are of greatest use to man, or for the destruction of the valueless. The valueless species enter the contest with as much vigor as the more technically valuable, and often win in the race. [...] From a technical point of view the condition of the virgin forest is not good, because much of the land, which might be producing marketable timber, is occupied by scrubby and worthless trees.

Virtually no one in the nascent American forestry profession advocated for protection of large blocks of intact virgin forest. These forests were viewed as unproductive areas where growth barely offset the loss from decay that should be converted to fast-growing species that could be harvested on a continuous rotation (Carter 1909). This was especially true in the public land management agencies, except for the preservation-focused National Park Service. Consequently, agencies like the Forest Service continued to conduct timber harvest in the old-growth forests on their lands.

Although many of these early observers regarded the clearing of old-growth forests with alarm, others saw it as a part of manifest destiny—a realization of the changes needed to satisfy the demands of a growing nation. The first federally supported assessments of forest conditions viewed the value of these ancient forests as a resource to be extracted rather than perpetuated, with wood from old trees being the most valuable component (Hough 1878). Seen by the growing timber industry as a virtually limitless resource, the virgin (primary) forest yielded the slow-grown, usually knot-free wood desired by consumers. Those in the timber industry and those in the land business who looked to support its development (including the clearing of forests as a prelude to agriculture) knew exactly which forests were old and ripe for exploitation and which were not.

It was only in the early to mid-20th century that widespread clearing of forests across eastern North America triggered further consideration of their value. In the Southeastern United States, concern grew rapidly as the last major virgin forests were cleared and the prospects of having to shut down, move operations, or learn how to sell the much less desirable second-growth timber became an inevitability.

The radical loss of forest and changes in land use also had profound implications for a myriad of other species. For example, the regional extirpation of large ungulate herbivores such as American bison (*Bison bison*) and eastern elk (*Cervus canadensis canadensis*), near-elimination of large predators such as cougars (*Puma concolor*) and wolves (*Canis lupus rufus* or *C. rufus*), extinction of mast-consuming birds such as passenger pigeons (*Ectopistes migratorius*) and Carolina parakeet (*Conuropis carolinensis*), and introduction of pests and pathogens that have greatly reduced once-dominant tree species such as American chestnut (*Castanea dentata*) and American elm (*Ulmus americana*) have all dramatically affected forest ecosystems. Some of these anthropogenic changes to regional biodiversity even have secondary and tertiary effects such as widely fluctuating and often declining (but sometimes dramatically increasing) populations of taxa such as white-tailed deer (*Odocoileus virginianus*), songbirds, insect pollinators, and small mammals, as well as conversion of grasslands to forests and croplands, and alterations to previous fire regimes (Hanberry et al. 2020, Mueller et al. 2021).

Establishment of national forests

Most of the over 25.6 million acres of national forest lands in the Eastern United States (both the Southern and Eastern Regions) were assembled from acquisitions authorized by Federal legislation passed in the early 20th century. The majority of the 13.44 million acres of national forests in the Southern Region (USDA Forest Service 2022) was acquired after the passage of the

Weeks Act in 1911 (Williams 2003a) which allowed the Federal Government to purchase private land that “may be necessary to the regulation of the flow of navigable streams[…].” (Weeks Act 1911). Most of these purchase units were cutover lands, though some had also been farmed, often for decades (fig. 2.1.a). In parts of the southern Appalachian Mountains early purchase units (between 1911 and 1918) were a mixture of cutover, farmed, or mined lands with limited areas of intact forests; however, some of these were still virgin timber (Smith Mastran and Lowerre 1983). Williams (2003b), quoting an unpublished Forest Service report, noted that during the first 5 years of Federal management, many of the purchases in the southern Appalachian Mountains contained “high quality” (i.e., uncut virgin timber) lands, possibly accounting for 28 percent of the area.

Figure 2.1.a—An example of a cutover and burned Forest Service land acquisition authorized by the Weeks Act in North Carolina in 1911. (USDA Forest Service photo)

Between 1911 and 1924, over 2.3 million acres of watershed-protecting national forests were established in the Eastern United States through Weeks Act acquisitions. The pace of this protection received a boost in 1924 with the passage of the Clarke-McNary Act (1924), which amended the Weeks Act to allow the Federal Government to acquire lands for timber production as well as streamflow protection (NFRC 1933). This legislative change allowed the Forest Service to acquire land from many previously ineligible locations and was particularly embraced where there were few viable options for cutover and denuded areas. For example, in the late

1920s, the Kisatchie National Forest was established in Louisiana, where over 553,000 acres were acquired at an average cost of about $3.38 per acre (NFRC 1976). Most of these lands had not only been cutover and burned, but they were also grazed or farmed and often highly eroded (fig. 2.1.b). Vast areas lacked seed trees so natural regeneration was not a feasible mechanism for reforestation. To address this issue, the Forest Service planted extensively, often with offsite conifers such as slash (*Pinus elliottii*), loblolly (*P. taeda*), and eastern white pine (*P. strobus*) in the years leading up to and just after World War II. In the more eroded acquisitions, soil was

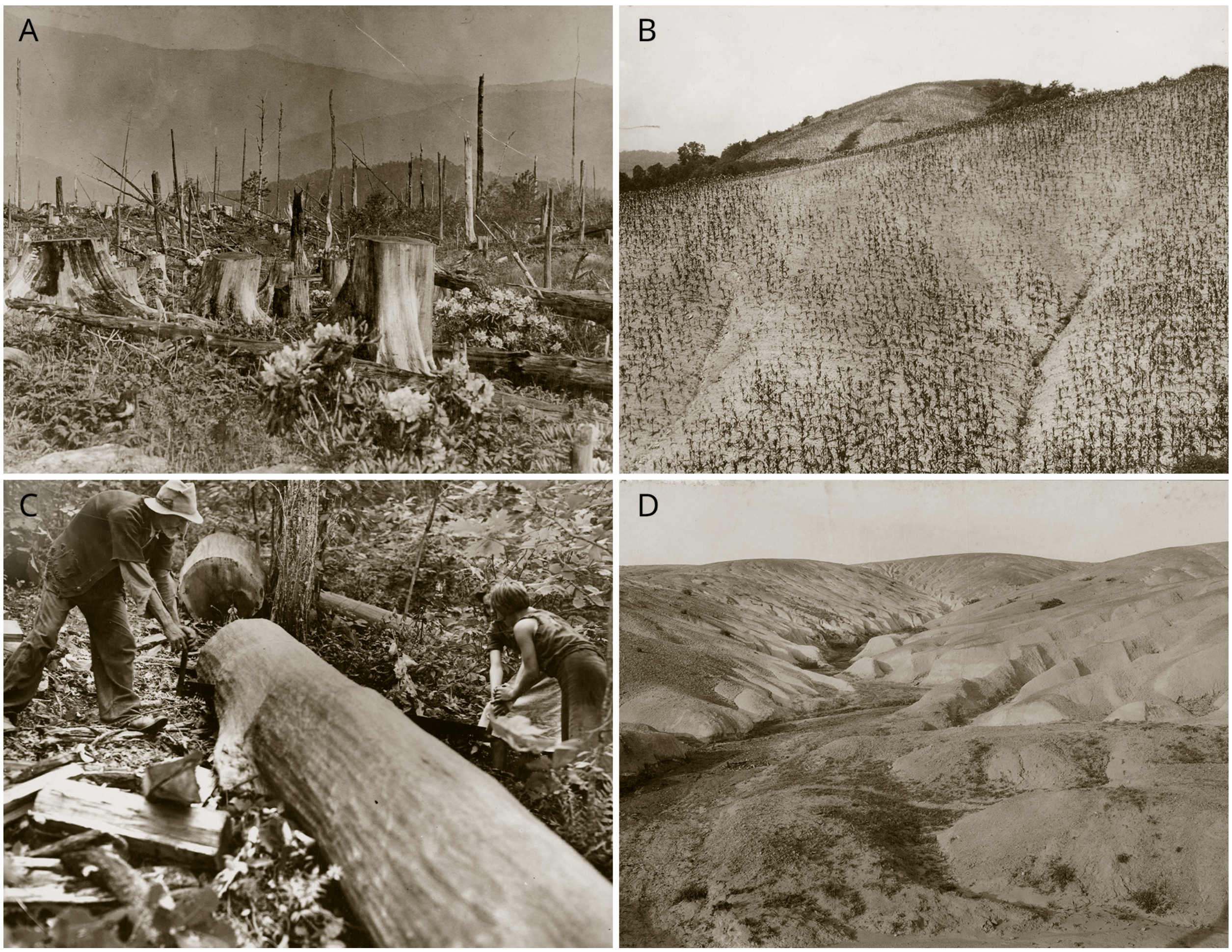

Figure 2.1.b—Even the mountains of the Southern Region experienced extensive timber harvest and agriculture in the 19th and early 20th centuries before some of these lands became part of the National Forest System. (A) Timber harvest on the Pisgah National Forest on the slopes of Mt. Mitchell in North Carolina; many areas were clearcut followed by burning the slash, often repeatedly. (USDA Forest Service photo, negative #176383, by E.S. Shipp in 1923) (B) Large areas of mountain slopes, once cleared, were planted to crops such as corn, tobacco, and cotton, often leading to significant erosion and downstream flooding problems, Madison County, NC near the village of Marshall. (USDA Forest Service photo, negative #236411 by C.R. Hursh in 1929) (C) A grandfather and his granddaughters strip bark from a blight-killed chestnut (for tannin extraction) and cut up the decay-resistant wood to produce shingles and lumber, an example of the poverty and limited opportunities for many mountain families, Chattahoochee National Forest in northern Georgia (USDA Forest Service negative #414131 by Clint Davis in July of 1941) (D) Ducktown River basin in eastern Tennessee near the Cherokee National Forest where copper mining and smelting resulted in extensive forest loss and the denuded lands eroded. Although mining was never large scale in the eastern national forests, it could still have devastating effects. (USDA Forest Service negative #204327 by R.H. Charton in 1925).

first stabilized by using ground cover and nitrogen-fixing taxa (sometimes with invasive species like kudzu [*Pueraria montana*] and sericea lespedeza [*Lespedeza cuneata*]). Species choices were often driven by the desire to halt erosion more than matching previous natural community composition.

With few exceptions, older forests were not excluded from the Forest Service's management programs. In the first decades after establishment, southern and eastern national forests used selective management approaches on mature and older forests, because this was considered the best way to produce commercial volume while retaining enough forest cover to protect desired watershed attributes. For instance, the mature pine and pine-hardwood forests of the Gulf States region (primarily Arkansas, Alabama, Louisiana, Mississippi, and eastern Texas) received selective harvests where the "…oldest timber, other things being equal, should be cut first" to remove slow growing specimens of less desirable timber species and open growing space for younger, "thriftier" (faster growing) specimens (Garver and Miller 1933: 4). The southern Appalachian national forests conducted similar forest improvement efforts in hardwood-dominated forests to manage the "defective, unmerchantable old-growth trees that impede or prevent the development of a young and vigorous stand…" (Abell et al. 1935: 2). Though there is little recorded information about the effect of these early policies on mature and old forests, it is almost certain that most of the accessible, merchantable, and otherwise unreserved stands (such as Joyce Kilmer) were partially cut to some degree. The Forest Service also worked to eliminate practices such as livestock grazing and woods-burning. The Agency claimed annual burning in the southern Appalachian Mountains declined from 30 to 50 percent of the landscape before 1911 to <0.1 percent by 1940 (USDA Forest Service 1940).

Unlike national forests of the Western and Northern United States, which contained extensive old growth when established, most Southern Region national forests were either completely denuded, newly reforested, or heavily cutover (fig. 2.1.c). Early agency policy and management practice did not provide special consideration or protection for the old forests that did exist. However, the passage of time and maturation of existing forests are starting to reverse the trend of old forest loss; the widespread denuded areas have long since been reforested, and many of those trees are now over 80 years old.

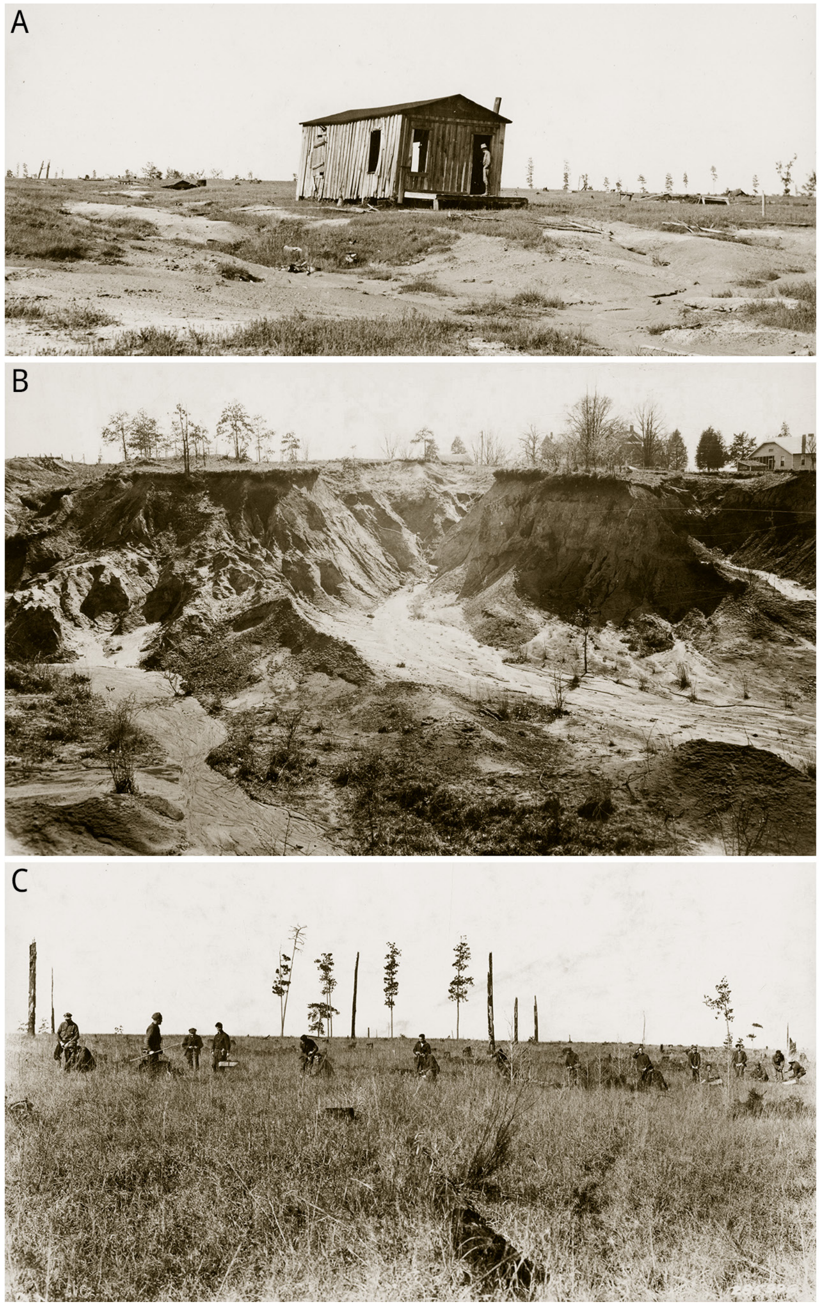

Figure 2.1.c—Southern Region Forest Service land acquisitions in the 1930s were often from some of the most exploited and damaged areas, including lands that had been cleared then grazed and farmed for decades. (A) A photo from the Zavalla Forest Farm Rehabilitation Project in southeastern Texas on former longleaf pine lands that are now part of the Angelina National Forest. Poor farming techniques often lead to extensive soil erosion. (USDA Forest Service negative #405009 by S.L. Frost in 1935) (B) Even more pronounced erosion problems occurred on certain soil types in northern Mississippi, leading to dramatic gullying. The area photographed would soon become part of the Holly Springs National Forest. (USDA Forest Service negative #258562 by H.G. Meginnis in 1931) (C) Even where erosion was less problematic, the absence of seed trees required widespread tree planting efforts by federal agencies. Here a Civilian Conservation Corps crew plants trees on the Catahoula unit of the Kisatchie National Forest in Louisiana. (USDA Forest Service negative #285996 by J.D. Nellis in 1934)

2.2 Defining Old Growth in the Late 20th and 21st Century

Current definitions and concepts regarding old growth emerged in the 1980s (Franklin et al. 1986). Although some definitions tend to be simple and brief, others can be quite lengthy, and some are both at once, such as the one for old-growth forests in the Society of American Foresters' (SAF) *Dictionary of Forestry* (Deal 2018: 127). SAF defines old growth as "The (usually) late successional stage of forest development," followed by six clarifying notes of over 250 words. Despite part of the forest condition title being old, age does not feature prominently in some definitions of old growth (including the SAF dictionary definition and associated notes).

Terms differ among various agencies, organizations, and individuals, and each source tends to develop a definition consistent with their particular perspectives or priorities. For example, the Food and Agriculture Organization of the United Nations does not define old growth but instead defines primary forest as "Naturally regenerated forests of native tree species, where there are no clearly visible indications of human activities and ecological processes are not significantly disturbed" (FAO 2023: 10). Under this definition managed forests may be included "where Indigenous Peoples and local communities engage in traditional forest stewardship and management/use activities that meet the definition."

The Sierra Club's *Glossary for Forests and Forestry Practices* (Sierra Club Forests and Climate Team 2022) defines old growth as:

> a forest that has attained great age (at least 120 years by one definition) without significant disturbance [...]. An old-growth forest is characterized by the presence of large old trees, numerous snags and woody debris, and a multilayered canopy, and that is usually in a late stage of ecological succession.

The source for the 120-year threshold is unclear.

Maloof, founder of the Old-Growth Forest Network, describes similar characteristics of old-growth forests (Maloof 2016: 16):

> The advanced age of some of the trees in an old-growth forest is important because trees change structurally with age. The most obvious change is in size. [...] Wider branches in the canopy can support more life forms: more birds, more mosses, more mammals, among others. Large limbs and wide trunks that develop hollows provide the structural diversity important to many organisms.

Many more definitions can be found in scientific and popular literature, but these examples serve to illustrate some of their similarities and differences.

Developing Forest Service old-growth definitions

In the late 1980s, new scientific understanding of the unique characteristics and value of old growth along with its rapid loss from clearcuts lead to clashes between environmental groups, logging communities, and Federal agencies. As the old-growth controversy gained prominence, the Forest Service developed a position statement on *National Forest Old-Growth Values* (USDA Forest Service 1989b). In this issuance, the agency sought to provide guidance without being overly prescriptive or formulaic. It recognized that old-growth forests vary by geography, forest type, and scale, but described generic old-growth forest characteristics by using stand-level features (such as structure, density, and composition) which are readily measured in forest inventories:

> 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. (USDA Forest Service 1989b)

This position statement further described what it considered to be the important aspects of old growth:

> The age at which old growth develops and the specific structural attributes that characterize old growth will vary widely according to forest type, climate, site conditions, and disturbance regime. Old growth in fire-dependent forest types may not differ from younger forests in the number of canopy layers or accumulation of down woody material. However, old growth is typically distinguished from younger growth by several of the following attributes:
>
> 1. Large trees for the species and site.
> 2. Wide variation in tree sizes and spacing.
> 3. Accumulations of large-sized dead standing and fallen trees that are high relative to earlier stages.
> 4. Decadence in the form of broken or deformed tops or boles and root decay.
> 5. Multiple canopy layers.
> 6. Canopy gaps and understory patchiness.

These definitions and concepts were never intended to be universal and absolute, but a starting point (and direction) for Forest Service regions to work with their respective research stations to develop old-growth definitions based on SAF forest types. Land managers could then use these definitions to conduct inventories and silvicultural treatments designed to “maintain or establish desired old-growth values” in an operational environment (USDA Forest Service 1989b).

The most substantial Forest Service action on old-growth forests in the late 20th century was the development of the Northwest Forest Plan (USDA and USDOI 1994). This regional plan amended all existing forest plans in Oregon, Washington, and northern California that were home to the northern spotted owl (*Strix occidentalis*). As part of the supporting documentation, scientists developed a lengthy report covering the issues, proposed alternatives, and management options (FEMAT 1993). The report included a glossary that provided concise and specific definitions of old growth-related aspects for the Federal lands in this region. They defined an old-growth forest in the Pacific Northwest (FEMAT 1993: IX-24) as:

> A forest stand usually at least 180-220 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees, some with broken tops and other indications of old and decaying wood (decadence); numerous large snags; and heavy accumulations of wood, including large logs on the ground.

More detailed working definitions of old-growth forests in the Pacific Northwest and other regions were developed to support planning efforts. As directed by Robertson (USDA Forest Service 1989a), each region undertook an effort to tailor the old-growth definitions for their forest types. Approaches varied among regions, because specific requirements were not provided. The Intermountain Region adapted SAF forest types by classifying them into a series of relevant environments (e.g., warm/dry versus cold/dry). They then established guidance consisting of descriptions and thresholds (minimum qualification criteria) for old growth including, but not limited to, characteristics such as tree diameter, stem density, and tree age (Hamilton 1993). The Rocky Mountain Region also developed of a set of minimum criteria (again, by SAF forest type), that were quantitative for attributes such as tree diameter, density, and age (Mehl 1992). However, in contrast to the Intermountain Region, many of the attributes were qualitative (e.g., in the case of downed dead wood, some). Additionally, attributes could be classified as required for old growth (e.g., must criteria) or indicative of the quality of old growth, but not necessarily required (Mehl 1992). The Eastern Region adopted still a different approach, choosing to consult published technical and scientific literature of older stands to develop tables of old-growth attributes such as live tree density by diameter at breast height (d.b.h.) classes, tree [stand] age by species, maximum tree diameter, percentage of canopy gaps, and standing and downed dead wood as quantitative ranges (Tyrrell et al. 1998).

The Healthy Forests Restoration Act (2003) is the only major piece of Federal legislation to specifically address old growth. Alhough not broadly defining old growth in general, this law (Section 102(e)(1)) addressed old-growth stands as appropriate for management activities when otherwise not disallowed by the Act or other applicable laws, “based on the structure and composition characteristic of the forest type.” Projects under this authority were allowed to

> …fully maintain, or contribute toward the restoration of, the structure and composition of old growth stands according to the pre-fire suppression old growth conditions characteristic of the forest type, taking into account the contribution of the stand to landscape fire adaptation and watershed health, and retaining the large trees contributing to old growth structure.

Alhough this act did not provide a detailed definition of old growth, it did reference stand structure, composition, a disturbance regime (fire), and large trees—and did not mandate that old growth was to be excluded from management. Indeed, management activities were expressly allowed (but not required) in project areas identified in whole or part as old growth to maintain and restore the structure and composition of this forest condition as it existed prior to fire suppression, consistent with an appropriately developed resource management plan.

Southern Region's 1997 guidance

The Southern Region's 1997 old-growth guidance (Gaines et al. 1997) used the original generic definition of old growth from Robertson (USDA Forest Service 1989b) and developed descriptions for 16 old-growth community types for SAF forest types found in the Region's national forests. Gaines et al. (1997) based their narratives and quantitative criteria on a review of available literature and supporting research documents or other technical sources (e.g., books, dissertations, theses, university special papers, agency reports). Most of this information was assembled from a limited number of field studies in stands recognized as old growth (see White and Lloyd 1995).

Gaines et al. (1997) also developed a set of quantitative operational definitions consisting of "a simplified set of criteria for making decisions in the field regarding a forest stand's status as old growth" (p. 4). If a field inventory for a forest stand or patch met this minimum set of criteria (age, disturbance, basal area, and tree size) it was considered existing old growth. Minimum age was based on the oldest age class present in the stand (rather than the representative stand age) and calculated as the half-life of "typical age of mortality" for dominant tree species as provided by Loehle (1988). The qualitative disturbance criteria stated "no obvious evidence of past human disturbance which conflicts with old-growth characteristics of the area should be present". Basal area was based on a single minimum value (between 10 and 40 square feet per acre), and tree size was determined by d.b.h. of the largest trees in the stand.

Gaines et al. (1997) also provided narrative definitions for future and possible old growth. Future old growth referred to forest stands or patches that did not meet one or more of the operational old-growth criteria given for existing old growth (usually age) but were designated for management that would promote transition to old growth. Possible old growth referred to forest stands that met one or more of the preliminary inventory criteria but lacked sufficient information to determine if they met the operational definition.

Additional terms have been developed to address specific old-growth management questions. For instance, the Nantahala and Pisgah National Forests Final Environmental Impact Statement (FEIS) (USDA Forest Service 2023a) eschewed the Gaines et al. (1997) terminology. It uses the terms old forest, current old growth, designated old growth network, and old forest trending landscape. The concept of possible old growth was not referenced. Forested lands that met the minimum age threshold but may or may not have other characteristics of old growth, are considered old forest according to the document. Current old growth is similar to Gaines et al. (1997); it includes forests that currently contain all the requisite old-growth characteristics (presumably, at least the four identified in Gaines et al. [1997]). The final two terms in the FEIS reflect land management categories. Forested lands in the designated old-growth network include both current (existing) old growth and future old growth. The intention is to manage these areas to become old-growth forest in the future, independent of their current condition. The old forest-trending landscape includes the designated old-growth network plus other lands outside of the network where management activities are unlikely.

2.3 Southern Region Working Definitions for Old Growth

Though we have broadened our understanding of old growth since the 1990s, these advances and additions have sometimes proven confusing, contradictory, and challenging in their implementation. Furthermore, additional legislation and policies have been developed and implemented, and public opinions have shifted considerably since 1997. As a land management agency with mandates for both multiple use management and using the best available scientific information, our definition of old growth incorporates both scientific and social perspectives, as well as an understanding of the history and current conditions of southeastern forests.

A modern framework for defining old-growth forests

Pesklevits et al. (2011) and Gray et al. (2023) have called defining old-growth forests a “wicked problem”—a seemingly intractable challenge for scientists, managers, and policymakers. Philosophers have even waded into the issue, emphasizing that “[h]ow forests are mapped in the mind will determine how forests are mapped on the ground” and thus old-growth forest definitions must be developed “with careful intentionality and critical self-awareness” (Moore and Nelson 2023). Landscape-scale studies identifying old growth on public lands in the region (Carlson 1995, Yost et al. 1994) have attempted to use a disturbance rating system to rate anthropogenic disturbance of forest stands where A rated forest stands are considered high in virgin attributes, and B+ and B ratings are moderate in virgin forest attributes, referring to forests that might have been impacted by nonnative forest pathogens, small-scale harvests, or subsistence logging. The current scientific consensus is that there is no definition or description of old growth that is universally applicable or serves as the basis for identification, protection, and management of old-growth forests (Barton and Keeton 2018, Pelz et al. 2023, Spies 2004, USDA Forest Service 2023b, Wirth et al. 2009).

Alhough some definitions seek to identify old growth by using a single measure or proxy (e.g., age, biomass, or carbon density) it is more ecologically meaningful to identify old growth by using suites of characteristics. There is a degree of agreement among many scientists and managers that most, but not all, old growth can be identified by characteristics related to dominant trees (e.g., age, size, form), stand attributes (e.g., patchiness, structure, composition) and management (e.g., type and intensity of human disturbance, evidence of natural processes). Characteristics often associated with old-growth conditions include multiaged (uneven-aged) structure, undisturbed forest floors, an average age of dominant tree species approaching half their maximum longevity, and the presence of some tree specimens approaching their maximum longevity. However, all these attributes have their own limitations and weaknesses, and some are now being called into question for their accuracy or even relevance.

For example, age is often (though not always) a metric for old growth. But what is the age of a multiaged stand? The oldest tree? The dominant or codominant trees? An average? When does a tree become old? Though typical or maximum trees lifespan is sometimes presented as reliably known (Loehle 1988), information is limited for many tree species. For some it may simply be unavailable, especially angiosperms and noncommercial taxa (Pederson et al. 2007, Zhao et al. 2018). Many of the maximum and typical lifespan ages presented in scientific and technical literature may be inaccurate (by decades or even centuries), unsupported, or vary widely with site quality. Loehle’s (1988) estimates of typical and maximum longevity for bald cypress (*Taxodium distichum*; 600 and 1,200 years, respectively) were thrown into question when precise dendrochronology showed at least two specimens in a single location along the Black River in North Carolina exceeded 2,000 years (the oldest of which was 2,624 years old) (Stahle et al. 2019). Age is certainly a factor for old-growth forests: stand-level characteristics of this stage emerge and accumulate over time. Research is needed to identify the minimum amount of time a forest community needs to allow for such development, but using age alone or as the primary criteria for old growth is questionable. Information on age and old growth from the literature review is collected in the tables found in section 5.

Others define old growth in North America as a forest condition that has maintained a continuous connection with pre-European settlement forests (Keeton 2020), suggesting that these forests have always been free from human influence. However, the notion that virgin forests were largely free from human influences prior to European arrival is antithetical to the current understanding of the history of Indigenous populations in North America. To consider a forest as truly preanthropogenic, one would need to go back at least 15,000 to 20,000 years (perhaps even more) in North America. Forests of that time period were subject to effects of the Pleistocene glaciation, under which very different environmental conditions and vegetation distributions existed (Davis 1983, Delcourt 2002). In short, the idea that old-growth forests have not been altered by human influences is contrary to our modern understanding of the long history of human societies in North America and their effects on the environment.

Overall, we find that Robertson's general definition of old-growth forests remains relevant despite decades of scientific study and public attention to these systems:

> Old-growth forests are systems 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 (USDA Forest Service 1989b).

The most basic definition of old growth is a forest or woodland community whose overstory has a preponderance of sufficiently old, site-appropriate trees. Based on that requirement, we also find that the operational definitions for forest types in the Southern Region from Gaines et al. (1997) as modified in section 5 are reasonable criteria for identifying old growth in the field. However, it is important to note that old-growth stands may be heterogeneous within a particular forest type due to geographic variation, disturbance history, soil or hydrological conditions, or biological interactions (e.g., deer browse, insect pests, nonnative invasive plants, and more).

Regional terms related to old growth

In addition to Robertson's general definition above, the following terms are also defined to support a common language for old growth and related conditions. Some of these terms are the same as those proposed by Gaines et al. (1997), but we have slightly revised the definitions to balance continuity of past terms with incorporation of current understanding of old-growth forests and national forest management. By directly addressing questions related to forest condition, management objectives and uncertainty, we hope that these terms can reduce confusion and disagreement when describing old growth and related conditions.

1. Existing old growth (alternatively current old growth or just old-growth forest)—a known or recognized area of old-growth forest that meets or exceeds the criteria in table 5.3.c—Operational criteria for old-growth forest identification by common old-growth community types (old-growth code) in the Southeastern United States for its community type. This definition is largely consistent with how it was defined by the USDA Forest Service (2023a) and earlier by what Gaines et al. (1997) operationally termed existing old growth. However, we have augmented the descriptions of forest types and allow for greater evidence of past disturbance in existing old growth, so the stands that this term describes may differ from the past. This term does not imply management intention but does require sufficient information to confidently show that the relevant criteria are met (referenced in section 5). Existing old growth may be quite heterogeneous and still meet the definition, as described in the common conditions below:

    - A patch or stand of existing old-growth forest of natural origin and generally good condition that meets all the criteria for current old growth and does not show clearly visible indications of human activities that would significantly disturb ecological processes (FAO 2023) and lacks other evidence of environmental degradation (e.g., widespread presence of nonnative invasive species).

    - A forest condition when there is evidence of past land clearing, but the current stand attributes nevertheless meet criteria for that forest type (i.e., the age, size, and basal area of the oldest trees meets or exceeds the thresholds in table 5.3.c). Given the extensive logging history of the Southeast, naturally or anthropogenically reforested lands often provide many of the ecological functions of old growth on the landscape. Additionally, higher quality secondary old-growth forests often provide current and future representation and redundancy in areas where remnant primary old growth is rare or absent.

    - A patch or stand of existing old-growth forest that has been actively treated to improve upon (or at least not detract from) its old-growth characteristics for restoration purposes by using any number of silvicultural interventions, including (but not restricted to) prescribed fire, underplantings, focused tree removals or deadenings, mastication, or herbicide or mechanical removals of undesired species. To meet the definition of old growth, the current stand attributes must meet criteria for that forest type (i.e., the age, size, and basal area of the oldest trees meets or exceeds the thresholds in table 5.3.c).

- A patch or stand of existing old-growth forest that has been negatively affected by past management actions, or inaction, to the extent that its ecological condition is substantially decreased, though it still meets the criteria of tree age and structure for the forest type. Typically, unless severely degraded, restoration treatments (e.g., elimination of nonnative invasive species, reintroduction of fire or midstory thinnings, supplemental planting or seeding of trees, shrubs, or forbs) can at least partially restore the integrity of degraded old growth.

2. Future old growth—a stand of maturing or older forest or woodland that is administratively designated for management to promote old-growth characteristics or will lead to passive development of old-growth attributes over time due to its administrative designation. These areas may meet some or none of the criteria to be considered existing old-growth forest or may have insufficient information to make that determination. Examples of future old growth are often found in declared research natural areas, wilderness areas, scenic or special botanical areas, or any other management area where there is a stated objective or desired condition of meeting old-growth criteria in the future.

3. Possible old growth—a patch or stand of older forest or woodland that is known or believed to meet at least one criterion required to be identified as existing old growth. That is, identification of possible old growth is based on incomplete information but does not suggest any current or future management intentions or designations. Gaines et al. (1997) stated that such patches or stands should be examined more thoroughly to determine if these demonstrated characteristics (e.g., a FSVeg [Field sampled vegetation] stand age at or above the age criterion; minimal nonnative invasive tree species; if not directly aged, abundant sign of older trees and stand conditions; USDA Forest Service 2015) reach or exceed the requirements for old growth. We do not provide direction on how to manage possible old growth beyond noting that such areas may, in fact, be existing old growth. Therefore, uncertainty regarding this status may need to be resolved prior to implementing management activities, depending on land management plan components regarding old growth management.

What is not old-growth forest

Despite considerable variability in vegetation structure and composition both within and among old-growth forest types, it is also important to note characteristics that do not meet the Southern Region definition for old-growth forest:

- Old growth is a forest condition that exists at a scale larger than a single old tree and generally larger than a small group of old trees, even if those specimens are very old. We do not claim that single or small groups of old trees are without value, only that they are not an old-growth forest and that ecological functions and values generally increase with patch size.

- Old-growth forests, regardless of size, must be overwhelmingly dominated by overstories of native and site-appropriate tree species. We do not include stands of nonnative or offsite tree species, even if they are quite old, in our definition of old-growth forest. If native, site-appropriate overstory trees were planted, this planting should have been done long enough ago and subjected to past management activities such that limited or no evidence of that planting remains (e.g., rows of even-spaced trees or furrowed ground).

- Forest areas that experience mass mortality from insects, disease, fire, or other large-scale disturbance are not considered old growth unless the remaining living trees are sufficient to meet the criteria for that forest type. For example, if a hurricane kills most or all of the overstory of an old-growth longleaf pine forest such that the area no longer meets the age, basal area, or diameter criteria, then that area is no longer considered old-growth forest. Such areas may retain considerable ecological value, particularly if the understory is in good condition and multiple age classes of the overstory tree species survive.

- Administrative designations, such as old growth or late successional management areas allocated through land management planning, are not sufficient to identify stands within those areas as old growth. These land allocations may indicate management objectives or desired conditions, but do not convey old-growth status to stands that do not otherwise meet the general and forest type criteria to be considered old-growth forest. Conversely, old-growth forest may certainly exist in land management designations that do not specifically address old-growth conservation and management.

The above limitations are meant to refine our understanding of old growth and help agency staff and the public understand why certain types of forest conditions may or may not meet old-growth criteria. However, this short list is not meant to be either exhaustive or absolute, and there may be valid arguments against these disqualifications in particular situations.

3. THE NATURE OF OLD GROWTH IN THE SOUTHERN REGION

Old-growth forests of the Southern Region share some similarities with old-growth forests in other regions of the world, but also have many differences that would keep a global definition from being applicable. This section discusses individual tree characteristics (for example, visual and physiological differences between young and older trees) and stand level characteristics (e.g., canopy cover and species diversity). These characteristics interact to play vital parts in old-growth forests, and in some cases other age classes, but not all are easy to measure operationally. Though we discuss characteristics of old trees, these features must be considered in a stand and landscape context—an old-growth forest is more than a single old tree.

3.1 Characteristics of Old Trees

Just as in any living organism (López-Otín et al. 2013, Thomas 2013), trees go through an aging process that alters their appearance. For example, shortleaf pine (*Pinus echinata*) germinants are virtually identical in their appearance, and there is little difference between 5-year-old saplings or 30-year-old poles, but over time, differences in growth and damage patterns start to accumulate. As the trees mature, they become both increasingly unique and increasingly aged in their appearance (fig. 3.1.a). Someone with an experienced eye for shortleaf pine will recognize this species at all of these life stages.

Pederson (2010) outlines six characteristics for old trees in eastern deciduous forests. 1) smooth or balding bark; 2) low stem taper; 3) high stem sinuosity; 4) crowns comprised of few, large-diameter, twisting limbs; 5) low crown volume; and 6) a low ratio of leaf area to trunk volume. These characteristics vary by species (see Pederson 2010) and the likelihood the tree is old increases with the number of characteristics present; possessing a single characteristic suggestive of old age does not necessarily mean a tree is actually old. Notably, these characteristics do not include tree size, and in many cases the oldest trees were not the largest.

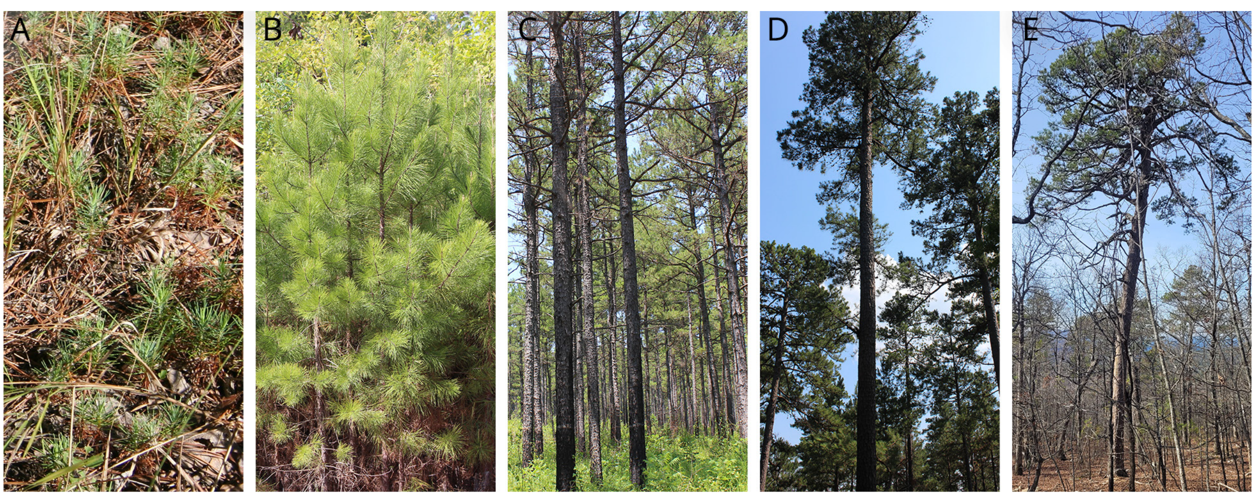

Figure 3.1.a—Characteristic appearance of shortleaf pine at different life stages and ages: (A) seedlings of a few months, (B) saplings a few years old, (C) small poles approximately 30 years, (D) mature at 80 to 100 years, (E) an old shortleaf tree, likely >150 years. (USDA Forest Service photos by Don Bragg)

Tree size and age

Because trees "create a structure that can progressively be expanded" over an extended time to compete for necessary resources (e.g., light, water, nutrients) (Lanner 2002), people have long associated tree size with tree age. Indeed, most old-growth definitions include it in their descriptions; some provide a minimum diameter (or more rarely, height) threshold for consideration, and others suggest a more qualitative statement, such as having large trees for the species and site under consideration (Robertson 1990).

There is a relationship between tree size and tree age if site conditions are held as a constant, and exogenous factors (such as disturbances) do not impose limitations. Trees grow from a tiny seedling (or sprout) until they reach a specimen-based maximum size for the particular environment. This is a fundamental principle for the forestry concept of site index, which establishes curves estimating tree size (height) as a function of age based on species and site quality (more productive sites have taller trees and, presumably, higher stand volumes) (Skovsgaard and Vanclay 2008). This concept is important for understanding old growth in the Southern Region, where pronounced gradients of site productivity (related to factors such as soil moisture availability, aspect and elevation, stoniness, and soil chemistry) are common. Whittaker (1956) clearly documented trends in tree size as a function of these gradients in the Great Smoky Mountains, with sheltered mesic sites producing the largest canopy trees and exposed xeric sites the smallest. Bald cypress (*Taxodium distichum*) develops into the largest of the southern tree species on the most favorable sites, with diameters sometimes exceeding 8 to 10 feet above the buttress, and heights of over 130 feet at 500 to 800 years (Mattoon 1915). However, the oldest dendrochronologically documented bald cypress (in excess of 2,000 and up to 2,600 years old) growing in a nutrient poor North Carolina river are much more modest in size (Stahle et al. 2019).

Research shows that large trees can play an outsized role in certain ecosystem attributes and functions, including carbon storage (Lindenmayer and Laurance 2017), but at least some of these contributions can be diminished by the loss of woody biomass from decay or crown loss through mortality or breakage (Hauck et al. 2023). Regardless of maximum tree diameter, it is important to note that within a seemingly homogeneous stand, trees of similar diameter may be vastly different ages for a given species. Very localized microsites (e.g., seeps or rock outcrops) can produce either very favorable or unfavorable growing conditions. For some shade-tolerant species such as eastern hemlock (*Tsuga canadensis*) and blackgum (*Nyssa sylvatica*) smaller diameter trees may be older than expected due to suppression from competition over years or decades.

Tree size and potential bias in historical accounts

Many early accounts of southeastern forests describe virgin forests as dominated by large trees. There is some relationship between tree size and age, but translating historical narratives into guidelines for management is difficult. Pictures of spectacularly large trees felled during the lumbering era's Big Cut continue to influence our current perspectives on old growth (fig. 3.1.b). However, even in an era where these superlative specimens were more common, they were more the exception than the rule. Most veteran trees of years past, though appreciably larger than most of those found in the woods of today, were not exceptionally large. Photographers, past and present, tend to take pictures of exceptional trees and stands. It is far more likely to see a picture of a 5-foot diameter cherrybark oak (*Quercus pagoda*) in a fertile bottomland site that may only be 100 years old than a 6-inch diameter post oak (*Quercus stellata*) on a xeric rocky ridge that may be over 300 years old.

Figure 3.1.b—A large bald cypress felled in 1913 in southern Georgia reported to be 8 feet d.b.h. and estimated to be 1,200 years old. (USDA Forest Service negative #17915 by Wilbur R. Mattoon)

Detailed analysis of the limited quantitative information available suggests that most virgin forests, though they tended to have big trees for the site, were not dominated by extremely large individuals. The General Land Office (GLO) public land surveys, which have the most extensive documentation of forest condition information preceding widespread lumbering and land clearing, are not ideal for describing representative tree size (diameter) distributions because of likely surveyor biases against using very large (or very small) trees to witness corners. For example, though GLO surveys for different forest types in Arkansas reported some very large diameter (over 5 feet) trees of various species, the vast majority (>90 percent) of witness trees were between 5 and 30 inches in diameter. Less than 1 percent of the thousands of witness trees used exceeded 50 inches in diameter (Bragg 2003, 2005, 2023; Bragg and Bragg 2016).

Early inventories of virgin forests also showed a preponderance of modest-diameter trees with limited numbers of very large specimens. Early working plans developed by Forest Service staff for various timber companies across the South often included size class distributions by the major timber species. Olmsted (1902) inventoried almost 1,750 acres of virgin pine lands (uplands) in the Upper West Gulf Coastal Plain of southern Arkansas. These areas included canopy dominant trees of 150+ years on fair to good quality sites. In that assessment, the maximum size class for loblolly (*Pinus taeda*) and shortleaf pines was only 36 inches. Trees over 28 inches d.b.h. were uncommon, averaging <1 tree per acre that size or larger. In his overview of shortleaf pine, Olmsted also mentioned that trees >40 inches d.b.h. were very rare. Sherrard (1903) reported similar size distributions in the longleaf pine dominated flatwoods of eastern South Carolina. None of the stands he evaluated had longleaf, slash, or loblolly pine >36 inches d.b.h.; only the cypress swamp lands had gums (*Nyssa* spp., possibly *Liquidambar styraciflua*) and cypress that exceeded that threshold (the cypress reached 50 inches d.b.h.). Though historical data cannot paint a complete picture of tree size distribution, it seems likely that there was a diversity of tree sizes in primary forests of the Southeast and very large trees did not necessarily dominate old-growth stands.

Form and bole characteristics

The main trunk of a tree (the bole) changes over time from physiological processes and interactions with the surrounding environment. This includes local climate, weather, soil, and moisture conditions, as well as disturbances. There are several bole characteristics that are often, but not always, associated with old trees and can be particularly common in increasingly aged specimens. These characteristics (taper, spiral grain, defects and cavities, and bark patterns; fig. 3.1.c) can be quantified, but are often qualitatively considered (e.g., presence/absence). Bole taper is the change in diameter of the main stem of the tree from its base towards the crown. Typically, boles decrease in thickness from ground level upwards; the rate of this decrease can help determine the age of many species. Generally, younger (but not seedling or sapling) trees tend to have more taper than older specimens because of a greater growth rate and proportionally higher amount of live crown. Similarly, open-grown trees also tend to be more prominently tapered (Larson 1963). Old trees are often referred to as columnar, with their taper more like a cylinder than a cone. Some systems for estimating bole volume from stem diameter provide different form factors (the ratio between d.b.h. and a point further up the bole) for trees depending on whether they are from old- or second-growth stands. Mesavage and Girard (1946) provided form-class averages for second-growth versus old-growth southern pines (*Pinus* spp., subgenus *Pinus*), white oaks (*Quercus* spp., subgenus *Leucobalanus*), and yellow-poplar (*Liriodendron tulipifera*), where trees in old-growth stands were assumed to have less tapered, more cylindrical boles.

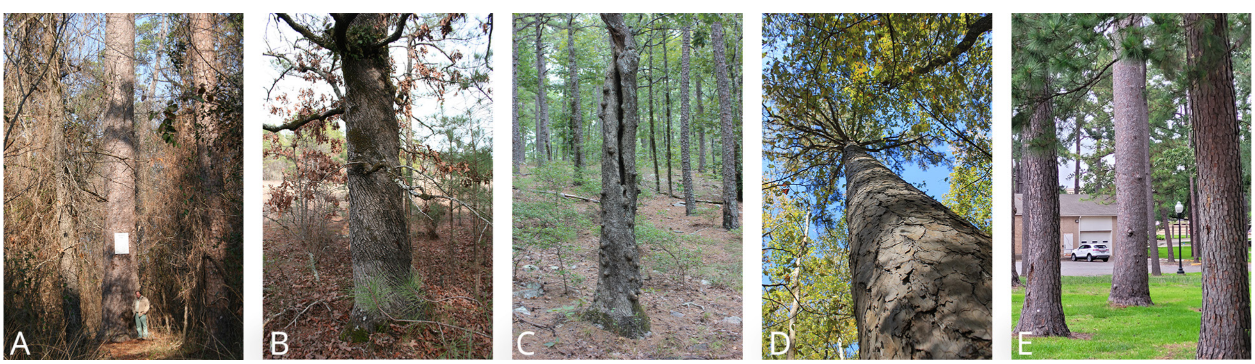

Figure 3.1.c—Examples of bole characteristics often found in old-growth forest types in the Southeastern United States. (A) Nearly 300-year-old loblolly pine (*Pinus taeda*) with very low bole taper (columnar or cylindrical bole); (B) spiral grain in 200-year-old post oak; (C) low bole quality in >150-year-old post oak, showing hollow (lightning scar), knobs, and spiral grain; (D) clear bole on a shortleaf pine; (E) smooth-barked, slower growing loblolly pine (background left) compared to more furrowed younger loblolly (foreground right). (USDA Forest Service photo by Don Bragg)

3.2 Characteristics of Old Stands in the Southeastern United States

As a forest ages in the absence of catastrophic disturbance, succession, autogenic, and exogenic processes lead to identifiable and even predictable conditions indicating a shift from young, to mature, to older forest. These changes are an aggregation of environmental cues, such as growing conditions, and internal dynamics, such as falling trees. Mortality in individual trees creates small patches that influence the subsequent growth of the forest and may be retained in the legacy of vegetation patterns (Bače et al. 2015). This history and combination of factors, also referred to as continuity, is what leads to old-growth conditions. This section explores regionally specific examples of these traits, conditions, and natural resource values provided by old-growth forests and information to help managers with the prioritization of these values and conditions.

Stand age and canopy structure

Young forests, recovering from large-scale stand-replacing disturbances are typically characterized by a single structural layer and age class. The crowns of young to moderately mature trees in these stands tend to look very similar. As trees age, physical damage, disease, foliar, and growth pattern changes accumulate (sometimes gradually, sometimes abruptly), leading to an increasingly unique crown shapes (Bond 2000, Ishii and McDowell 2002). Collectively, this means that as a stand of trees ages, canopy structure becomes more diverse and complex. As the canopy trees grow, additional layers will develop due to vertical stratification from differences in tree growth rates (Oliver and Larson 1996). Gaps from individual tree mortality and other localized or low severity disturbances (e.g., low severity fire, ice storms) will also determine canopy structure and complexity. Midstory and shrub layers may change composition and density among sites within the same community type due to differences in frequency and intensity of fire. Age diversity of old growth will vary based on geographic location, community type, and disturbance regime. For example, the few remaining examples of montane longleaf pine forests exhibit several distinct age classes, with some individuals exceeding 225 years (Varner et al. 1999), and old-growth southern Appalachian mixed-mesophytic forests may exhibit irregular age structure sustained by small-scale partial canopy disturbance (Lorimer 1980).

Tree species diversity

High tree species diversity is frequently associated with older, less disturbed (especially less managed) stands (Hinkle et al. 1993), although this is more common for mesic stands with fewer frequent or large-scale disturbances. However, old-growth ecosystems are not necessarily the seral stage with the highest diversity. Even in rich, productive sites tree species richness may peak in mid-successional conditions and drop as shade-intolerant and mid-tolerant trees are replaced by shade-tolerant species, although other measures of species diversity may increase (Clebsch and Busing 1989). Like many attributes of old-growth forests, the relationship between tree species diversity and stand age varies among community types and site conditions, as well as past management activities or disturbance.

Abundant tip-up mounds

Tip-up mounds, which are piles of earth produced when a tree is toppled by the wind from root failure, are often associated with older stands (Plotkin et al. 2017). Typically, the larger the tree, the larger the rootwad and associated mound. Large rootwads can persist for decades before erosion and bioturbation reduce their pile of soil to the forest floor and the adjoining pit fills in. Tip-up mounds create unique microtopography utilized by both tree and understory species. For example. Kern et al. (2019) found that seedlings for lighter seeded and browse-sensitive tree species were more commonly found on mounds than pits and adjacent undisturbed areas after a blowdown disturbance. Similarly, Plotkin et al. (2017) reported that early and mid-successional tree species were disproportionately found on mounds. Accumulation of tip-ups over time leading to pit and mound topography suggest minimal soil disturbance by humans. Forest clearing and agriculture in the 18th and 19th centuries, including plowing or grazing, eliminated much of the pit and mound topography across the landscape (Plotkin et al. 2017). Although abundant tip-ups can imply an extended absence of anthropogenic disturbance (i.e., farming), it is also possible that a single wind event lasting minutes or hours can topple enough trees to almost instantaneously create extensive pit and mound topography in forests of almost any age.

Snags and downed woody debris

Old-growth forests often contain more snags and downed wood than other successional stages, with a higher diversity of size and decay classes. Additionally, old-growth stands in some hardwood-dominated forests of the Central United States have about twice as many trees with at least one cavity per unit area as mature second-growth forests (Fan et al. 2003). Snags, downed wood, and cavity trees are critical for many species. However, as with many old-growth characteristics, snags and downed wood conditions vary drastically by community type. For example, many dominant forest types in the Southeast burned frequently and are less likely to maintain downed wood regardless of age; in these ecosystems, abundant downed wood could even indicate degraded conditions due to fire suppression.

Structural characteristics of old growth differ from areas with a history of intensive human disturbance, and also differ based on their landscape position or community type. For example, old-growth forests in Great Smoky Mountains National Park maintain greater overall and highly decayed downed deadwood volume than forests that were previously settled or clearcut (Webster and Jenkins 2005). The size of downed deadwood also varies, with large-diameter downed deadwood being more common in old growth (Webster and Jenkins 2005). Downed deadwood does vary within old-growth forests, with the greatest levels found on more mesic sites or higher elevations and very low levels in old-growth pine forests found along ridges (Webster and Jenkins 2005). Recovery of deadwood distributions observed in southern Appalachian old-growth forests required over a century following early clearcutting techniques (Webster and Jenkins 2005).

Botanical and wildlife characteristics

Old-growth forests, and the characteristics described previously, play an important role in supporting unique wildlife and botanical species assemblages. Though many species associated with old growth are also found in mature forests, they may exhibit differences in population dynamics (Jackson et al. 2013). Therefore, an important function of old growth is supporting healthy and abundant populations of wildlife and herbaceous species. Researchers have identified additional old-growth obligate species since 1997. Old-growth forests provide habitat in the form of microtopographic variability, which includes unique germination substrate (McGee and Birmingham 1997), temperature and soil moisture (Vose and Bolstad

2007), pit-and-mound microtopography, and downed wood (Plotkin et al. 2017; fig. 3.2.a). Additionally, structurally variable standing deadwood (e.g., large snags) (Rosenberg et al. 1988, Webster and Jenkins 2005), individual tree architectural characteristics, tree-layer diversity, midstory composition and structure, and community-specific disturbance regimes meet habitat requirements for a variety of wildlife and herbaceous species. Variability in soil chemistry and nutrient dynamics (Fraterrigo et al. 2005), bark characteristics (Snell et al. 2003), evapotranspiration rates (Oishi et al. 2020), fuel bed loading and composition (McMinn et al. 1993, Muller and Martin 1983), and canopy gaps (Himes and Rentch 2013) support unique species assemblages.

Figure 3.2.a—Downed wood, tip-up mounds, and canopy gaps are important forest structural characteristics for both wildlife and herbaceous species. (USDA Forest Service photo by Margaret Woodbridge)

Due to differences in research effort, we have a better understanding of the wildlife and botanical resources of some old-growth community types than others. For example, more empirical and observational studies have been conducted in the old-growth community types associated with the southern Appalachian Mountains compared to the alluvial floodplain of the Mississippi Delta. Moreover, within the southern Appalachian Mountains, research has focused more on mesic systems (e.g., rich cove forests) than more xeric or nutrient-deficient sites. Old growth that occurs across the various topographic, soil, and nutrient conditions across the region supports distinctive wildlife and plant communities that respond differently to past disturbances (Woodbridge 2020), in part because those different communities were subject to a different suite of historic disturbances. The examples below represent scientific studies from several forest types that occur in the Southern Region, but there may be important wildlife and botanical values in other old-growth forest communities.

Structural characteristics of old-growth forests can provide important wildlife habitat for a variety of species. For example, increased bat activity in old growth and mature stands is associated with greater numbers of forest openings compared to mid-successional stands (Loeb and O'Keefe 2006). In contrast, most bats used second-growth forest to a greater extent than old-growth forest in eastern Kentucky (Avilla et al. 2022, Conley 2011). Snags, hollow trees, and cavities, which occur in greater numbers in old growth for many forest types, also provide important habitat for bat roosting and maternity activities (Loeb and O'Keefe 2006). This more general association also extends to species-specific responses: Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) and southeastern myotis (*Myotis austroriparius*) are associated with old-growth bottomland hardwood forest. Old-growth cypress-gum swamp forests provide both roosting and foraging habitat for Rafinesque's big-eared bats (Clark 2003, Gooding and Langford 2004, Loeb et al 2011, Trousdale 2011) and both species prefer large-diameter trees and trees with larger cavity volumes for roosting (Fleming and Jones 2013). These bottomland forests are especially important to those two bat species in winter months (Scherman et al. 2022). Other species also prefer larger trees: northern flying squirrels (*Glaucomys sabrinus coloratus*) prefer larger, taller trees for nesting, and old-growth nesting sites have greater amounts of downed wood, potentially due to the increased density of fungal colonies (Hackett and Pagels 2003). These structural attributes are important given that rotation length of forests managed for timber production often only cover 10-40 percent of the potential stand development period for a similar old-growth community, and, consequently, many structural attributes are absent or not fully developed (Bauhus et al. 2009).

The cerulean warbler (*Setophaga cerulea*) was long considered a mature forest or sometimes old-growth forest bird (Hamel 2000, Nicholson 2004). Research in the last 25 to 30 years indicates key structural elements such as super canopy trees and gaps with dense saplings are important (Hamel and Rosenberg 2007, Nicholson 2004). These attributes are commonly found in old-growth forests, but cerulean warblers will use managed stands that mimic that structure (Hamel and Rosenberg 2007). Ovenbirds (*Seiurus aurocapilla*) are often considered old-growth forest species, but again key structural elements are important, not necessarily old age of the forest (Hamel 1992). The red-cockaded woodpecker (*Leuconotopicus borealis*) is well known for its use of old-growth southern yellow pines (shortleaf pine, slash pine [*Pinus elliottii*], longleaf pine [*Pinus palustris*], pitch pine [*Pinus rigida*], loblolly pine, rarely Virginia pine [*Pinus virginiana*] and potentially Table Mountain pine [*Pinus pungens*]). In the old-growth condition, these pines develop red heart rot (*Porodaedalea pini*), facilitating the excavation of cavities, which are used for nesting.

Several understudied taxonomic groups include species dependent on old growth. Traylor et. al (2022) found that the saproxylic eastern ironclad beetle (*Phellopsis obcordata*) was restricted to inside or near old-growth forests. This species is likely limited by the lack of continuous deadwood habitat through time, with old growth acting as refugia during the wide-scale human disturbances that occurred in the early 1900s (Traylor et al. 2022). In contrast, older secondary forests support similar species richness of litter-inhabiting beetles compared to old growth (Caterino et al. 2017). The federally endangered spruce-fir moss spider (*Microhexura montivaga*) is restricted to areas of rock outcrops and boulders in old Fraser fir (*Abies fraseri*) or fir-dominated spruce-fir forests (Diggins and Ford 2021, USFWS 2014). This species exhibits very specific habitat requirements and is found in humid, well-drained moss or liverwort mats on shaded areas of rock outcrops and boulders (Fridell 2001). The vulnerable southern Appalachian endemic, Rugel's ragwort (*Rugelia nudicaulis*), is also associated with high-elevation old-growth spruce-fir forests in Great Smoky Mountains National Park (Woodbridge 2020). Kalisz and Dotson (1989) found a strong association of some native earthworm species to relatively undisturbed forests, including old growth, but none restricted to old growth in eastern Kentucky. They found little evidence of invasive earthworm species outside heavily disturbed forests, a finding supported by Kalisz and Wood (1995). Kalisz and Wood (1995) also indicated that within approximately 50 m (164 feet) of severe disturbance (removal of forest and replacement with other cover, vegetative or otherwise), native earthworm populations tended to drop out, even if in high-quality forests.

Old-growth forests maintain unique conditions that provide important habitat for wildlife species (Herrera et al. 2025). For example, there is evidence that southern Appalachian woodland salamander communities are substantially changed and slow to recover following disturbances such as clearcutting (Ford et al. 2002, Petranka et al. 1994). In Appalachian cove hardwood forests, salamander richness and diversity are greatest in stands that are at least 120 years old (Petranka et al. 1994). To maintain or conserve salamander habitat, the authors' recommendation is to avoid creating landscapes dominated by early and mid-successional forests, particularly in areas around headwater streams.

Old-growth forests in the southern Appalachian Mountains support greater herbaceous plant richness and diversity compared to mature forests with a history of harvesting (Bunn et al. 2010, Woodbridge et al. 2020, Wyatt and Silman 2010; fig. 3.2.b). Additionally, Wyatt and Silman (2010) found that most herbaceous communities in the southern Appalachian Mountains have yet to recover from the widespread clearcutting that occurred in the late 1800s and early 1900s. These unlogged southern Appalachian forests also support herbaceous species that require decades of disturbance-free periods to colonize and become compositionally stable over time (e.g., spring ephemerals that leaf out in early spring and die back prior to canopy closure, and summer green species, that can leaf out before, during or after canopy closure, but retain their leaves throughout the summer) (Wyatt and Silman 2010). Although many herbaceous species are also found in mature forests, old-growth composition and structure enhances the population health and compositional stability. In many cases, there is evidence that dispersal limitation drives the observed delay in recovery—especially in rich cove forests, which support diverse spring ephemeral communities (Wyatt and Silman 2010). For example, Matlock (1994), working just outside the region in the piedmont of Delaware and Pennsylvania, found a number of species spread by ants or through spores in old regrowth forests but not in younger regrowth forests. The same was true for some species without obvious dispersal mechanisms. These species were more likely to be present if the forest patch was closer to other patches with the species than farther away. McCarthy (2014) discusses microsite affinity of many herbaceous species and the limited usefulness of individual species as old-growth indicators. Rather, he suggests employing a suite of herbaceous species as indicators.

Figure 3.2.b—Old-growth rich cove forests in the southern Appalachian Mountains support diverse herbaceous understories. (USDA Forest Service photo by Margaret Woodbridge)

Other taxonomic groups exhibit an affinity towards old growth due to limited dispersal. Douglas (2011) found land snail species diversity and abundance were higher in old-growth forests compared with second-growth forests in the Cumberland Plateau area of Kentucky; sites had similar diversity (different species) across disturbance histories in the Inner Bluegrass. No species in any of the three areas were perfect indicators of either old-growth or second-growth forest, but of 70 species found, 21 species did show an affinity for old growth, 18 of them micro-snails. The micro-snail ice thorn (*Carychium exile*) was strongly, but not exclusively, associated with old-growth forests in the Cumberland Plateau and Pine Mountain sites. He also found some indication that the degree of disturbance contributed to differences between forest conditions. There is additional evidence that micro-snail diversity, richness, and abundance are greater in old-growth forests in Kentucky. This is likely due to their size, limited mobility, and propensity to spend their entire lives at one locality due to a lack of migratory behavior (Douglas et al. 2013). The authors recommend that forest managers consider low-impact management strategies that protect existing patches of old-growth forests when managing for this taxonomic group (Douglas et al. 2013).

The natural resource values of old growth vary by community type. These values often differ based on the composition, structure, and function of the forest. For example, steep microenvironmental gradients associated with southern Appalachian old growth facilitate resource niche differentiation and in turn greater species richness and diversity in herbaceous communities (Bratton 1976). Elliott et al. (2014) found that herbaceous community assembly, including the presence and abundance of species, is heavily influenced by past disturbance. In dry-xeric, fire-adapted old-growth communities, herbaceous layer assembly is influenced by historical harvesting and consistent or inconsistent application of low-intensity surface fire.

For example, older longleaf pine forests without a history of logging have been found to support greater herbaceous richness, cover, and diversity compared to those with a history of harvesting and herbicide application (Brudvig et al. 2013).

Old-growth forests support healthy lichen (Tripp et al. 2019), fungal (Smith et al. 2002), and slime mold (Snell et al. 2003) populations that play an essential role in the ecological integrity of old-growth communities. Lichen biodiversity has a strong positive correlation with less disturbed forests in the southern Appalachian Mountains, regardless of size, reproductive mode, or growth form (Tripp et al. 2019). In general, large species of foliose and pendulous fruticose lichens are more likely to depend on late-successional to old-growth forests than other species (Lapin 2005). Some lichens require large-diameter trees with complex bark patterns, such as thick fissures, which develop over decades (McDonald et al. 2017). Certain bark-dwelling lichen species are restricted to very mature individuals of specific tree species: hot dots (*Arthonia kermesina*) on red spruce, and old birch spots (*Arthopyrenia betulicola*) and sterling lips (*Graphis sterlingiana*) on yellow birch (*Betula alleghaniensis*) (Allen and Lendemer 2016). In high-elevation spruce-fir forests, old-growth obligate lichen species, such as hot dots, require old-growth characteristics such as an abundance of downed woody debris (McMinn et al. 1993). Studies have also shown that lichen richness is greater on the oldest and largest trees, indicating a positive correlation with tree diameter (Wigle et al. 2021), or possibly slower expansion of bark as compared to smaller, younger trees.

Bryophyte studies, including mosses and liverworts, in old growth are primarily from Europe and northern North America, especially in conifer systems. Cooper-Ellis (1998) compared the bryophyte flora of second-growth and old-growth forests of western Massachusetts in sugar maple (*Acer saccharum*)-beech (*Fagus grandifolia*)-yellow birch and eastern hemlock-yellow birch communities. She found approximately twice as many species in the old-growth areas as in the second-growth areas. Although 24 species occurred only in old-growth forests and 7 species occurred only in second-growth forests, sample size did not allow for the determination of statistical significance. She also found twice as many species and greater species richness on trunks and bases of trees in old-growth forests than in second-growth forests. Sugar maple hosted approximately 1.4 times as many species on a trunk of a given diameter in old-growth forests as in second-growth forests across diameters. Bark characteristics, humidity differences, and time for colonization may be contributing to the differences. In the Adirondacks of New York McGee and Kimmerer (2002) found a greater percentage of bryophytes associated with mesophytic conditions and a greater presence of calciphiles. These species were not exclusive in old growth but were limited by the presence of large or old, thick-barked trees. Rubino and Vis (2001) observed that of 11 substrates identified, decorticated logs (logs without bark) were the most species-rich substrate on north slopes of an old-growth southern Ohio forest. Bare soil and decorticated logs were equally species-rich on south-facing slopes.

Some fungi, bacteria, and related organisms may be restricted to old-growth forests. Available fungal diversity comparisons between old-growth and second-growth forests are from the Pacific Northwest and Europe. In the Pacific Northwest, Smith et al. (2000, 2002) identified changes in fungi associated with different seral stages of Douglas fir (*Pseudotsuga menziesii*). Species dropped out and others moved in as forests aged. Some species and genera were found only in old-growth forests (Smith et al. 2002). More work is needed to determine if a similar relationship is present in the Southeastern United States.

Old-growth forests provide high-quality habitat for threatened and endangered species, as well as critical habitat to enhance the population health of numerous wildlife species. The red-cockaded woodpecker (*Leuconotopicus borealis*), for example, benefits greatly from old-growth longleaf pine composition and structure. This woodpecker excavates nesting cavities in large, widely spaced longleaf pine that are more likely to contain heart-rot fungus, which develops in older longleaf pine individuals (Hooper et al. 1991). This woodpecker species once thrived in longleaf pine old-growth forests, and managers are now emulating old-growth conditions by creating artificial cavities to help ensure the population health of this species (Copeyon et al. 1991). The threatened southeastern American kestrel (*Falco sparverius paulus*) also benefits from old-growth longleaf pine composition and structure, and nests in abandoned red-cockaded woodpecker cavities (Gault et al. 2004). Additionally, older pine trees support greater arthropod abundance (Hooper et al. 1996); arthropods are an important food source for many bird species.

The number of old-growth obligate species could be higher than we think. Although its status is often debated, the ivory-billed woodpecker (*Campephilus principalis*) required old-growth bottomland hardwood composition and structure (Mitchell et al. 2009). Additionally, Bachman's warbler (*Vermivora bachmanii*) may have been dependent on seasonally flooded swamp forests (Remsen 1986).

Many wildlife species that thrive in old-growth longleaf pine forests require an open midstory and diverse herbaceous layer. These characteristics are maintained by frequent fire and include the characteristic open-forest conditions not exclusive to longleaf pine systems, but also oak savannas, woodlands, and mixed pine-oak forests that support unique avian species assemblages. Some old-growth communities have also been found to support a greater abundance of wildlife species. For example, old-growth bottomland hardwood forests support greater numbers of swamp rabbits (*Sylvilagus aquaticus*), white-tailed deer (*Odocoileus virginianus*), and other small mammals (Smith and Zollner 2001). The authors outline many of the structural and compositional characteristics of old-growth bottomland forests important for wildlife that are absent even in older second-growth or mature stands.

Old-growth forest communities are crucial for maintaining genetic diversity in the Southeastern United States (Hamrick et al. 2006). There is evidence that harvesting can reduce genetic diversity in old-growth eastern white pine (*Pinus strobus*). Studies have shown that the removal of 75 percent of trees in two stands decreased genetic diversity (loss of approximately 25 percent of alleles and approximately 40 to 50 percent of latent genetic potential) (Buchert et al. 1997, Rajora et al. 2000). Similarly, older red spruce (*Picea rubens*) forests play an important role in preserving genetic diversity and reproductive fitness, particularly when forested areas are large (Mosseler et al. 2003). However, some tree species have been able to maintain genetic diversity in previously logged populations such as Florida slash pine (*Pinus elliottii* var. *densa*) in endangered pine rockland habitat (Williams et al. 2007). In addition to preserving the genetic diversity of tree species, old growth also conserves the genetic diversity of herbaceous understory species. A higher proportion of the genetic diversity of herbaceous understory species is found in several old-growth forest types such as the longleaf pine-wiregrass savannah and oak-hickory-pine forests (Hamrick et al. 2006).

Air, water, and soil

Old-growth forests provide additional ecosystem services including enhanced water, air, and soil quality (NCSSF 2008), compared to young or mature stands with a history of anthropogenic disturbance. Old-growth forests can filter out harmful particulate pollution and absorb greenhouse gasses. There is evidence that the soils in these old-growth forests have greater moisture-holding capacity, more organic matter, and other beneficial soil properties than young forests or extensively logged forests, which in turn support diverse and abundant herbaceous assemblages (Small and McCarthy 2005). Unique slime mold species can also be found in undisturbed old-growth forest soils (Cavender and Kawabe 1989). In some circumstances, old-growth forests can regulate the hydrologic cycle by providing enhanced groundwater filtration and storage capacity as well as filtering sediment to reduce sediment loads in adjacent streams and rivers. Additionally, old-growth forests adjacent to streams have been found to regulate water temperatures and provide downed woody debris input that enhances the habitat suitability of certain fish species, such as trout (*Oncorhynchus mykiss*, *Salmo trutta*, and *Salvelinus frontinalis*) in the southern Appalachian Mountains (Flebbe and Dolloff 1995). Studies have found that old-growth forest streams maintain nearly 170 times the amount of wood biomass and nearly 20 times the number of debris dams compared to adjacent streams found in forests logged 75 years prior (Valett et al. 2002). In southern Appalachian deciduous hardwood forests, it may take 300 years or more for large woody debris conditions to return to predisturbance levels (Webster et al. 1992).

Old-growth forest streams differ from second-growth forest streams in terms of nutrient and sediment conditions. Second-growth forest streams have less fine-grained sediment, which affects the stream bed conditions and can impact wildlife habitat (e.g., surface area and bed permeability) (Valett et al. 2002). Valett et al. (2002) also found greater epilithic organic matter in old-growth streams, which suggests a more biologically active stream-bottom environment. Nutrient conditions also differ in old-growth streams. For example, inorganic phosphate uptake was greater in streams draining old-growth forests (Valett et al. 2002). Additionally, the movement of water outside of streams in old-growth forests differs, with lower stand-level transpiration and subcanopy evapotranspiration, and greater interception, in a 200-year-old stand compared to a 35-year-old stand (Oishi et al. 2020). These differences were due in part to changes in composition, branch architecture, and bark texture in old-growth forests.

There is some evidence that soils in old-growth forests differ from those in younger or more disturbed stands. For instance, in older eastern oak (*Quercus* spp.) stands, soil nitrogen levels were greater and soil nutrient conditions are more strongly linked to herbaceous richness (Small and McCarthy 2005). However, this pattern may not be consistent across all forest types (Gilliam et al. 2005). Additionally, soil carbon and nitrogen were approximately two times greater in old-growth forests compared to 85- and 20-year-old stands in the southern Appalachian Mountains (Vose and Bolstad 2007). This was accompanied by lower soil temperatures and higher soil moisture in the old-growth stands (Vose and Bolstad 2007).

3.3 Patch Size

The concept of patch size has both scale and contextual components. As conventionally defined, forest patches and stands are tree-dominated areas with defined borders and a degree of internal consistency. Patches are usually determined by species composition, tree size, and recent disturbance history, but can also include elements of stocking (tree density) and site condition. In terms of context, a patch can be a component of a larger scale aggregation that is likewise spatially defined and internally consistent (e.g., a forested area in an agricultural landscape or a management unit of a larger property). Patches can also be defined from the perspectives of organisms that respond to them—for instance an individual tree can be a patch to an insect, whereas a patch for a black bear could be an area of several square miles. Keeton (2020) argues that the defining characteristic of old-growth forests in the Eastern United States is their ecological complexity. For example, canopy structure changes over time as individual overstory trees die, creating overlapping gaps and dead wood, which increases habitat complexity that can then support more species (Jones 1945). Given the parameters of scale, context, and ecological complexity, how small can a patch be that may still be considered old growth?

Current understanding of the intricacies of old-growth ecology provides insight, but not firm values, for minimum patch size. A single tree does not constitute an old-growth forest, because a forest is far more than an individual organism. An old-growth forest is comprised of a collection of individual trees of sufficient age to have the characteristics and contributions to desired system properties. Additionally, patterns and processes of old-growth forest ecosystems rely on interactions among trees and the other elements (biotic and abiotic) of the community through time. These interactions include canopy structuring, understory dynamics, soil processes and microclimate as well as microbial, fungal, and faunal associates. An isolated old tree may have sufficient quality and characteristics to justify special protections (e.g., aesthetics; cultural or historical values; propagule source for scarce tree species; cavities or roosts; refugium for age-dependent cohabitants such as lichens, mosses, invertebrates, small mammals, and amphibians). However, such actions for specific trees can be addressed outside of the determination of stand- or patch-level classification of old-growth forest.

A small patch (sometimes called a grove) consisting of a limited number of sufficiently old trees may only partially function as an old-growth forest. This grove may have dozens of old trees, yet fail to produce environmental conditions adequate to support the rest of the community associated with old-growth forests of that type in that area. Adequate conditions may include a minimum distance from large areas of structurally different forest, a full suite of microhabitats associated with any particular group of species, or a well-represented compliment of snags and large, downed trees. Again, a forest is rarely comprised of a single patch, but rather a collection of patches defined by age, history, composition, and shared dynamics. Even larger areas of old-growth forest tend to be characterized by the presence of cohorts of patches (e.g., young and old gaps; groups of canopy trees dominated by a particular species or set of species associates) that combined create a diverse and complex ecosystem. Similar to isolated old trees, groves may be designated as resources worth preserving or actively managing to maintain or enhance the desired characteristic(s) even if they are not fully functioning as old-growth forests. They may have significance as a local landmark or a point of community or familial pride, or provide other social, scientific, or ecological values.

Historical considerations for patch size and old-growth characteristics

Units of old growth are not uniform in size across the landscape of any one forest or region. On Forest Service land, current distribution of forest types and ages are largely a product of past management, both before and after agency ownership. Forests with difficult access, or forests containing what was considered lower value species at the time, were more likely to persist to current day uncut or with relatively little post-European settlement disturbance. For example, the remoteness and ruggedness of the Appalachian Mountains meant larger blocks of old-growth forest persisted to the current day, compared with the less remote and rugged coastal plain. Ownership patterns also contribute to remnant old-growth patch size. In practice, old-growth patch size distribution across the region varies by forest and broad physiographic region (Gaines et al. 1997: 15–16).

Given the land-use history of the Southern Region, it is important to understand how long it might take for a forest to regain some or most of its old-growth characteristics. Duffy and Meier (1992) found that 87 years is insufficient time for clearcuts to recover the understory richness and cover associated with similar old-growth forests. They also suggest that understory cover and richness are unlikely to recover within 40 to 150 years of harvest, potentially leading to additional loss of species diversity in managed stands. Woodbridge (2020) also found that understory richness does not recover after 70 to 100+ years following clearcutting, but recovery varies by landscape position. Several mechanisms may be responsible for this lack of recovery, including dispersal limitation, slow growth rates, and lack of structural characteristics that support herbaceous species, such as canopy gaps and microtopography. Stands meeting minimum old-growth age under guidance in Gaines et al. (1997) may not support the herbaceous layers found in old-growth stands that have not experienced clearcutting (Woodbridge 2020), and we have not established criteria for defining old growth based on understory characteristics.

Patch size and ecosystem function

Gaines et al. (1997: 16–18) designated three broad sizes of old-growth patches: large (>1011.7 ha [2,500 acres]), medium (40.5–1011.3 ha [100–2,499 acres]) and small (0.4–40.1 ha [1–99 acres]). Larger areas were considered more desirable, because these are generally more resilient to large-scale weather or fire events. Smaller areas were intended to provide representation of old-growth community types in short supply and to provide stepping stones between large- and medium-sized old-growth areas (Gaines et al. 1997: 18).

Literature identifying a minimum functional size for old growth is sparse. Martin (1975) described Lilley Cornett Woods (257 acres [104 ha]), an old-growth mixed mesophytic forest in eastern Kentucky, as a stable forest system. Martin (1992), after additional work addressing disturbance, suggested that for mixed mesophytic forests, a minimum of 100 ha (247 acres) is the required size to maintain old-growth characteristics on the site based on average expected disturbance from wind and tree death from disease and aging. As the site included nine distinct communities (many recognized in the current update document as old-growth community types) arranged on the landscape based largely on topographic position and aspect (Martin 1975), his size recommendation does take into account at some level, differences in disturbances (primarily wind, but likely also drought) in hollows versus ridgetops and upper slopes.

Ridgetops and upper slopes are more exposed and tend to receive greater wind damage than lower slopes and hollows. The minimum size for old-growth communities in these situations (i.e., spanning a range of elevation and soil conditions) may need to be larger than 100 ha to maintain the full suite of characteristics and values.

Relevance to species

At least one lichen, lungwort (*Lobaria pulmonaria*) is associated with old-growth forests in the Eastern United States (Sillet et al. 2000). Scheidegger et al. (2012) and Jüriado et al. (2011) investigated the population genetic structure of the species in Europe and concluded that larger blocks of relatively undisturbed old-growth forests best preserved genetic diversity. However, Sillet et al. (2000) showed that this species, at least in the Pacific Northwest, was as capable of establishment and growth from transplants in clearcuts and young forests as it was in old-growth forests. In some cases, transplanted organisms grew with less vigor in old growth than in younger forests. Nonetheless, the dispersal of propagules (soredia) may be a limiting factor. It is not known if this species will establish in second-growth eastern forests from soredia. Close proximity of old-growth stands, or possibly later successional stands with key attributes such as bark texture associated with age (Ranius et al. 2008) may be required. Most research is from the Pacific Northwest and Europe (Lapin 2005).

Small patches inherently have larger edge to interior area ratios than larger patches. There is limited buffering from outside influences, especially with patches in younger forest or nonforest matrices. Small patches tend to be more subject to invasion by nonnative invasive plant species. Small patches near residential areas (large or small) may be more subject to incursion from domestic cats (*Felis catus*) and dogs (*Canis familiaris*), but remote areas are not immune to their effects (Ogan and Jurek 1997, Van't Woudt 1990, Young et al. 2011). Additionally, moisture and humidity levels are more easily changed when the interior is closer to the edge. Mosses, liverworts, lichens, and land snails may be adversely affected by those changes. Leckie et al. (2000) looked at an old-growth American beech-sugar maple forest in Quebec and found species in the seed bank absent in the aboveground vegetation. Most were nonforest, light-seeded species blown in or carried in from nearby modified landscapes or forest edges. The implication is that small patches are more prone to the inclusion of nonforest species if in isolated positions. Many spring flora species in aboveground vegetation did not express as seedlings in the germination tests. The review in Lapin (2005) suggests that this is not uncommon with spring wildflower species, depending on year-to-year seed production and vegetation reproduction. The implication is that if species are removed through disturbance, they no longer occur on the site until seeds are brought in by some mechanism.

Small patches may help maintain key ecosystem elements. Cortese et al. (2023) report that using soil from old-growth hardwood forest patches in the Northeastern United States improved growth of eastern white pine and eastern hemlock in second-growth forest. Old-growth forest soil contained arbuscular mycorrhizae absent in adjacent secondary forests. There was evidence a single or few tree remnants from old-growth forests could support the mycorrhizae in the context of surrounding younger forests. The findings of Matlock (1994) and Duffy and Meier (1992) also suggest that small patch stepping stones could be important for maintaining and spreading some herbaceous species, an idea also supported by Meier et al. (1995).

Small patches may be important for providing representative old-growth conditions for forest communities that are proportionally under-represented on the landscape. An example encountered in mountain areas of the Southeast is floodplain forest. Floodplains provided relatively easily cleared flat land suitable for homesteading, including building sites and farming. Proportionately, less old-growth floodplain forest remains than upland forest. The spatial patterns of disturbance and topographic positions also impact patch size, and old-growth floodplain forests are more likely to be in small patches than large patches.

Small patches as rare communities

It is important to distinguish among different types of small patches of old growth. Some are remnants of what may have been much larger areas of a given community type, whereas others represent small patches of old growth that can be characteristic of their landscape context. For instance, many unique wetland, barren, outcrop, cliff, or hilltop sites can be found across the Southern United States. These sites, some less than an acre (0.4 ha) in size, can represent functional microsystems stocked with ancient trees even when embedded in a landscape of younger forests of different composition. Forest communities that typically occur in small patch size are best treated and managed as rare communities, not old growth, that may or may not be embedded in old-growth community types. Even though some, such as Atlantic White Cedar (*Chamaecyparis thyoides*) forest, have been recognized as an old-growth community type (White and Lloyd 1995), we treat them as rare communities. Some may represent intermediate successional stages and some may be limited in size by specific environmental characteristics. Specific management direction may be required to maintain the communities. Regardless, these were identified by the classification team and removed from the list of old-growth community types. In section 6, we list these examples along with rare communities such as mountain bogs, sphagnum seeps, and canebrakes under the 16 old-growth community types where they may occur as embedded communities.

Old-growth patch size in the Southern Region

Managers and planners in the Southern Region have struggled with implementing the small patch guidance in Gaines et al. (1997). Agency personnel and external parties have raised questions about what qualifies as a small patch and which parcels to manage as old growth. There is no indication that the previous guidance intended for forests to keep track of every single small patch of old growth or old trees across the landscape.

Small patches may be beneficial for creating old-growth networks, especially for species restricted to old-growth forest conditions. The intent is to create corridors and pockets of appropriate habitat to allow movement across the landscape. They may serve as stepping stones or refugia for old-growth associated species. Isolated small patches of old growth may not be viable in the long term, but still may provide important old-growth values. A single storm, catastrophic fire event, disease, or insect outbreak could remove most or all of the old-growth characteristics associated with the patch, but multiple small patches could provide resilience to such disturbances across the forest.

Due to the limited information on historical patch sizes, the fact that different old-growth community types likely have different minimum patch sizes, and that the relative size of a patch differs based on an organism's perspective, choosing thresholds for patch size is difficult.

To foster a common language for talking about old growth, we define patch size similarly to Gaines et al. (1997), but do not recommend numbers of any particular patch size nor inclusion of all patch sizes. Local planning efforts will make those determinations. In the absence of other criteria such as land management plans, old-growth areas may be considered as small, medium, and large-sized patches according to the following criteria:

- Small patches: 10–99 acres (4–40.1 ha)
- Medium patches: 100–2,499 acres (40.5–1011.3 ha)
- Large patches: ≥2,500 acres (≥1011.7 ha)

The low end of the minimum was increased from 1 to 10 acres, to align with minimum stand sizes for the FSVeg database, based on the *Silviculture Handbook*, Supplement R8-2409.17-201 (USDA Forest Service 2009). Although we are tiering to information regarding stand size from the *Silviculture Handbook*, an old-growth patch may be a component or inclusion within a larger stand. We recognize that in some cases the minimum size will not be able to capture all structural, compositional, and functional characteristics of an old-growth community type. Additionally, there may be individual trees or groves that contain important biological legacies that do not make the minimum patch size for old growth. The presence of single old trees or groves within stands may be an important consideration for management but are not considered small patches for connectivity or function. We do not recommend any particular patch size for old-growth designation or management. However, best available science suggests larger units of old growth tend to be more stable, more resistant to stochastic events, and provide greater microhabitats and redundancy of those habits than smaller units. There may be value in aggregating various smaller old-growth community type patches (stands or inclusions) into larger old-growth units where possible to provide a greater opportunity of interaction among various old-growth community types, reduce subtle to stark transitions between types (Bratton 1976), and benefit organisms that use various community types, as well as the abiotic processes that work within them. Additionally, for some forest types in some locations, it may be the case that only small patches of old growth (or even areas less than the 10-acre minimum) remain on the landscape. In those cases, achieving representation of old-growth community types and resilience across the forest may warrant conservation of small areas even if they do not meet the area criterion and may not individually provide the functions and values we associate with larger areas of old-growth forest. Therefore, managers can identify and consider appropriate management of various patch sizes of old growth.

4. FACTORS AFFECTING OLD GROWTH IN SOUTHERN REGION NATIONAL FORESTS

In section 2, we described land-use history in the Southern Region and incorporated an understanding of that history into a general narrative definition of old-growth forest. However, it is challenging to fully capture the ecological and social characteristics associated with the term old-growth forest in a simple definition, or even a relatively complex one (O'Brien et al. 2021, Pesklevits et al. 2011, Wirth et al. 2009). In this section, we further explore several considerations for identifying, evaluating, monitoring, and managing old-growth forests in the region.

The 1997 guidance stated that "Old growth should be considered in the context of a wide array of possible vegetative/habitat conditions, resource objectives, scientific values, and social/cultural values" (Gaines et al. 1997: 12), but that document only briefly described a limited set of old-growth forest values. In section 4.1, we expand on both the level of detail and range of values considered. Although the applicability of these values depends on site-specific information as well as social context, the summary we present should nevertheless demonstrate the importance of old-growth forests and the resources that may be affected if old-growth forest conditions are degraded or lost.

Old-growth conditions for most forest types have been dramatically reduced across the region due to development, land-use changes (particularly on private lands), and timber harvest. In section 4.2 we describe ongoing threats to remaining old-growth forests in the Southern Region, including extreme weather events, insects and disease, and certain forest management practices, including alteration of natural fire regimes. Later in section 4.2 we describe how silvicultural practices (or lack thereof) can maintain, restore, and promote future old-growth conditions. This overview of management activities and their effects is based on scientific studies and experience managing to perpetuate old-growth forest values and at least partially counter some threats and stressors that adversely affect old-growth forests.

Section 4 concludes with a discussion of methods that may be used to identify and monitor old-growth forests. Specifically, section 4.3 describes procedures, potential advantages, and limitations of using remote sensing, FIA data, and FSVeg data to estimate the spatial extent of old-growth forests and evaluate changes over time. Other methods such as aerial photography interpretation and field surveys are also considered, and rather than endorsing any single method we conclude that the most appropriate methods for inventorying and monitoring old-growth forests will depend on the specific questions and the spatial and temporal scale of the assessment.

4.1 Old-Growth Values

To support old-growth management decisionmaking and the development of old-growth policy, it is critical to understand the values associated with old-growth forest communities. Often referred to as ecosystem services or functions, these values include biotic, abiotic, and social aspects (Barndt et al. 2023). Since the previous guidance was published in 1997, our scientific understanding and social awareness of the numerous values associated with and supported by old growth has evolved and expanded (Frelich and Reich 2003; Gilhen-Baker et al. 2022; Owen et al. 2009). These values are often discussed more broadly as they relate to a range of forest communities, but this section provides important contextual linkages to old-growth forest communities and provides specific examples and information relevant to the Southern Region. Specifically, this section outlines examples of the socioeconomic, cultural, spiritual, scientific, and educational values of old growth, as well as the interrelated nature of these values (see Moyer et al. (2008) for an example of old-growth values based on focus group and survey data). Managers and planners can consider maintaining or enhancing these old-growth values when restoring or conserving old-growth communities; conversely, the potential adverse effects of management activities on old-growth forests can be more rigorously analyzed by explicitly recognizing how a range of values will be affected.

Values related to climate change and carbon dynamics

Climate change and associated stressors pose a significant threat to old-growth forests along with associated services and values. Carbon sequestration and storage is an important value associated with old-growth forests and is important for reaching global climate goals. From 1911 to 2012, more carbon was added to hardwood products than was released through the decay of those products (Loeffler et al. 2014). If hardwood products continue to be manufactured to last, this trend should continue.

Carbon sequestration rates vary with climate, nitrogen deposition, site productivity, disturbance history, and forest type (Barndt et al. 2023, Barnett et al. 2023, Magnani et al. 2007, Van Tuyl et al. 2005). Forest age is also a critical factor (Keeton 2018, Pregitzer and Euskirchen, 2004). Although younger forests accumulate more carbon than older forests, younger forests' respiratory demands and postdisturbance decomposition rates are also high (Carey et al. 2001, Pregitzer and Euskirchen 2004). Old-growth forests can continue to accumulate carbon at an advanced age and are not necessarily carbon neutral, as was commonly posited (Keeton 2018, Luyssaert et al. 2008). From a functional perspective, carbon stocks have even been used to define old-growth forests. For example, Barnett et al. (2023) defined old growth as the age when those forests reach 95 percent of the maximum carbon from both live and dead biomass in a given forest type.

Forest carbon can be broken into the following three carbon pools: 1) aboveground biomass including both living and dead tree components (tree stems, branches, leaves, coarse woody debris, forest floor litter, and more), 2) belowground biomass (tree roots), and 3) soil carbon. Belowground and soil carbon pools can be more substantial than the aboveground pool (Pregitzer and Euskirchen 2004), but most forest carbon estimates quantify the aboveground component only.

Within an ecoregion, aboveground carbon stores vary with structure, composition, and site productivity. Carbon accumulation and stock estimates for the aboveground live tree component were tabulated by stand age and region for the conterminous United States (Hoover and Smith 2023). For the oldest age class, 120 or more years in the East and 300 or more years in the West, most carbon stock values were between 75 and 100 tons of carbon/ha (Hoover and Smith 2023). The Southern Region was divided into a South-Central region and a Southeast region (table 4.1.a). The highest accumulation rates for the South-Central region were in the 0–20-year and the 120+ year age classes and the highest carbon density was in the 120+ year age class with the next highest carbon density in the 81–120-year age class. In the Southeast region, the highest carbon accumulation rates were in the 0–20-year age class, followed by the 81–120-year age class, with the 120+ year age class coming in third. The highest carbon density for the Southeast region was in the 120+ year age class followed by the 81–120-year and then the 61–81-year age classes. However, in both regions, the 120+ year age class represented 1 percent or <1 percent of the forested area. Clearly, older forests (>60 years) provide an opportunity for carbon storage across the Southern Region with accumulation rates varying by structure, composition, site productivity, and management objectives.

Table 4.1.a—Age class, accumulation rate, carbon density, and percentage of forested area in the South-Central and Southeast regions of the United States

Region	Age class (years)	Accumulation rate (tC/ha/year)	Carbon density (tC/ha)	Forested area (%)
South-Central	**0–20**	2.41	22.4	27
	21–40	0.52	54.1	23
	41–60	0.37	61.8	22
	61–80	0.11	74.3	21
	81–120	0.04	85.0	7
	120+	1.33	92.5	<1
Southeast	**0–20**	2.03	22.1	28
	21–40	0.29	57.4	26
	41–60	0.49	69.0	16
	61–80	0.45	85.9	16
	81–120	0.77	97.4	13
	120+	0.57	99.2	1

South-Central region: Kentucky, Tennessee, Arkansas, Oklahoma, Texas, Louisiana, Mississippi, and Alabama.
Southeast region: Virginia, North Carolina, South Carolina, Georgia, and Florida.
tC = tons of carbon.
Adapted from Hoover and Smith (2023).

Hardwood and softwood forests appear to have similar aboveground live tree carbon stock density that increases consistently across forest types with age class (Hoover and Smith 2023). However, Hoover and Smith (2023) found that the magnitude of age-related decline in aboveground live tree carbon accumulation appears to be forest-type dependent. Softwood forests accumulate carbon at higher rates than hardwood stands when young, but that accumulation rate declines with age. Hardwood stands show a less drastic decline in carbon accumulation with age than softwood stands (Hoover and Smith 2023). Uncertainty regarding forest-type specific, age-related declines in carbon accumulation remains high, however, due to the small sample size of the older age classes. Forest type and origin affect the relationship between structural diversity and aboveground carbon storage with a positive association for planted conifer forests but not for planted mixed forests (Crockett et al. 2023). In natural origin forests, structural diversity is positively linked with aboveground carbon storage regardless of forest type (Crockett et al. 2023). This implies that enhancing structural diversity may increase aboveground carbon storage.

Within a forest type, carbon accumulation rates are higher on better quality sites. Site quality may accelerate or delay achieving the structural conditions associated with old growth (Larson et al. 2008). Low site quality may reduce the utility of old-growth structure-based delineation criteria (Gray et al. 2023). Fraser et al. (2023) found that carbon in old-growth forests of the Central Hardwood Region generally increases with forest productivity, but stochastic events (e.g., ice storms, wildfires) can cause substantial variations. Aboveground carbon in these forests can range from 120 to 177 tC/ha in areas with high forest productivity, and 93 to 117 tC/ha in areas of low forest productivity (Fraser et al. 2023). Both aboveground and belowground carbon pools increased over the 20-year study period by 7 percent. Over the same period, the downed deadwood carbon pool increased by 5 percent (0.4 ± 0.7 tC/ha), and the standing dead tree carbon pool increased by 7 percent (0.3 ± 0.7 tC/ha). That study was unique in that it also measured the living and dead portion of the belowground root carbon component. Live root carbon increased by 4 percent (1.0 ± 0.3 tC/ha), and the dead root carbon pool increased by 68 percent (0.3 ± 0.1 tC/ha).

A study conducted in Indiana investigated the dry weight biomass of an old-growth forest (Spetich and Parker 1998). They found that in 1926, dry weight of living biomass for the study area was 154 Mg/ha, which had increased to 211 Mg/ha by 1981. Biomass of dead trees was 1 Mg/ha/year from 1977 through 1981; 4 Mg/ha/year from 1982 through 1986; and 3 Mg/ha/year from 1987 through 1992. The biomass of trees that died between 1976 and 1992 was greatest for mid-seral species. The living biomass of dominant early to mid-seral species was declining while that of late-seral species was increasing. In 1926, the biomass of trees 10 to 25 cm (3.9 to 9.8 inches) d.b.h. consisted of 14 percent oak species (*Quercus* spp.) and 12 percent sugar maple (*Acer saccharum*). By 1992, biomass in this diameter range consisted of 1 percent oak species and 43 percent sugar maple.

These studies that provided fine-scale estimates of carbon and biomass in old-growth forests (Fraser et al. 2023, Spetich and Parker 1998) conducted intensive field measurements of sites across both space and time. However, many large-scale efforts to quantify carbon stocks or identify old-growth forests (Barnett et al. 2023, Hoover and Smith 2023) rely on readily available Forest Inventory and Analysis (FIA) data. Unfortunately, FIA data only includes information on aboveground biomass, and fails to account for other carbon pools (i.e., belowground biomass and soil carbon) within these forests. Thus, we note the limitations of the available data and the challenge of quantifying the other forest carbon pools. It is likely that relying solely on FIA data will underestimate carbon stocks in old-growth forests.

Socioeconomic values

Wood and other forest products

Old-growth forests also provide values related to timber extraction and other forest products. Although the conservation of old growth prioritizes the social and biological values and limits intensive harvesting, there may be high-value forest products provided by old-growth forests to consider within the broader suite of values supported by old-growth forest communities. Although most areas allocated to old-growth conservation will not be suitable for timber production, these areas often contain other valuable forest products.

Management activities aiming to restore old growth likely will prioritize the retention of trees with high merchantable value. However, in some situations, it could be economically viable to carry out commercial thinning or other stand improvement activities to help promote the desired species composition. Old-growth forests have unique characteristics that make the wood products derived from them distinct from those managed under alternative scenarios. For example, old-growth longleaf pine (*Pinus palustris*) has significantly greater wood density compared to loblolly pine (*Pinus taeda*) deliberately managed on short rotations. The wood products derived from old-growth forests also have unique physical characteristics, such as birds-eye grain distortions in sugar maple, that make these products desirable for certain uses, such as furniture or other finished wood products (Bragg et al. 1997).

In addition to timber-specific products, old growth provides other extractable nontimber forest products. For example, old-growth forests have been found to support a greater richness of mushrooms (Smith et al. 2002). The accumulation of downed woody debris, often observed in old growth, helps to increase the abundance of bryophytes, including log moss (e.g., *Hypnum imponens*, *H. curvifolium*, *Thuidium delicatulum*). This type of moss is often extracted as a nontimber forest product used in plant nursery settings. American ginseng (e.g., *Panax quinquefolius*) is another botanical resource often found in greater abundance in southern old-growth forests. Chandler and McGraw (2015) found that American ginseng population stability benefits from harvesting techniques that mimic old-growth structures in the southern Appalachian Mountains.

Recreational values

Recreation is a key consideration when assessing the value of old-growth forests, both from a socioeconomic and individual perspective. People living near or visiting these forests from afar are interested in the various recreational opportunities they offer. Activities such as tourism and local recreation provide regional ecological identity as well as important economic benefits to the Southeast.

As in many forest communities, activities such as nature watching, hunting, camping, hiking, birding, and wildlife and wildflower photography are extremely common across areas of old growth. Although these activities are not specifically reliant on old-growth forest communities, the relationship between them and recreational activities in the Southeast is important to consider. Many of these communities are found adjacent to major hiking trails like the Appalachian Trail and other historic or scenic trails that belong to the National Trails System, providing hikers with direct access to areas of old growth that are more remote. Wilderness areas that contain old growth are particularly beneficial for public land users because they are removed from urbanized settings. Thus, old-growth ecotourism is a natural byproduct of regional backpacking and thruhiking, especially in more remote regions. In addition, many rural and underserved mountain communities adjacent to these trails are economically supported through ecotourism. Hiking towns located near old-growth forests rely heavily on backpacking as an economic input. This aspect of old-growth recreation, along with others such as game hunting, are important economic drivers for many communities in the Southeast.

Visitation to the Joyce Kilmer Memorial Forest, located in the Nantahala National Forest, is a regional case study of old-growth recreation (fig. 4.1.a). This forest is located on the ancestral homelands of the Eastern Band of Cherokee Indians, who were its original stewards and continue to carry many familial ties to these forested lands (specifically the local Snowbird Community). As a part of the Joyce Kilmer-Slickrock Wilderness and only accessible by foot, the Joyce Kilmer Memorial Forest is a prime example of old-growth ecotourism and offers a succinct view of the recreational benefits that these forests provide.

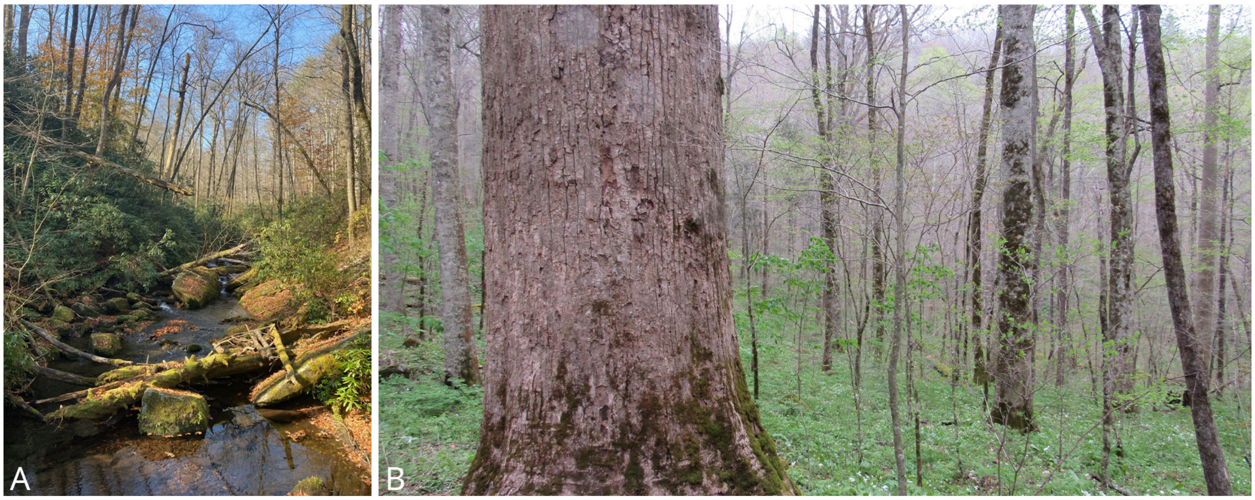

Figure 4.1.a—(A) Acidic cove (USDA Forest Service photo by Peter Siciliano) (B) and mixed-mesophytic forests in the Joyce Kilmer Memorial Forest, Nantahala National Forest. (USDA Forest Service photo by Margaret Woodbridge)

Although recreation can be a significant value inherent to old-growth forests, it is also important to note the negative impacts recreational activities can have on natural areas. These adverse effects can be particularly detrimental to old-growth communities given the delicacy of certain species present on the landscape.

Ecological impacts of humans present in old-growth landscapes

Human interaction with any natural area can lead to pest, disease, and weed or nonnative species introduction, regardless of local ecology and species structure. Further, unmanaged human use of natural areas can have deleterious ecological consequences, specifically activities such as offtrail hiking, dispersed camping, off highway vehicles use, mountain biking, and plant foraging. These impacts could be more pronounced in areas such as the Joyce Kilmer Memorial Forest, given its heavy usage and its distinction as one of the most publicly accessible examples of old growth in the region. It is important that all recreational activities in old-growth areas comply with relevant Forest Service guidelines, particularly those where sensitive, threatened, or endangered species are present. In addition, subsequent impacts could stem from developmental encroachment from surrounding communities onto national forest land, especially should such development bring added recreational pressures (e.g., mountain biking trails, ski areas).

Social impacts of humans present in old-growth landscapes

In the specific case of old-growth forests, many recreationists perceive these landscapes to induce feelings removal, idealizing them as hallowed spaces beyond human influence and impacts. As a result, excess human presence could detract from these perceptions for forest users, particularly if old-growth recreation is encouraged in specific areas (in contrast to it simply being allowed). Other visual examples of human influence, such as trash, tree carvings, or offtrail activity, could further damage this aesthetic appeal of old-growth landscapes. Excess human presence could also impact expected wildlife species in old-growth forests; some may adjust to increased human traffic (e.g., certain bird species), but many solitary mammals, such as American black bears (*Ursus americanus*), might avoid the additional noise and disturbances created by forest users.

Educational values

Old-growth communities provide unique educational opportunities for students of all ages by providing an outdoor classroom to teach basic ecological principles and to demonstrate examples of natural history. Old-growth forests serve as a field-based, experiential learning environment to advance educational opportunities. Field trips to old-growth forests inspire young future natural resource managers. For example, cross-sections collected from old-growth trees with rings dated to historical events provide important perspectives on the longevity and ecological importance of old growth. They also instill a strong conservation ethic in those who experience old growth firsthand. Furthermore, rudimentary field-based activities can be developed to enhance the appreciation of the diversity and species richness that is unique to old-growth forests. Students can learn and appreciate the compositional and structural differences that distinguish old growth from forests in other stages of development. Old growth can also contribute to other educational fields including art, storytelling, and writing. These educational values inherent to old growth merit consideration because they can serve as an invaluable source of inspiration to future natural resource managers, writers, and artists.

Sociocultural, Historical, and Indigenous Values

Spiritual and emotional values

> "...the magnificence of ancient trees has been a source of inspiration to cultures worldwide and continues to be a deeply engrained part of our very identity of human beings." (Gilhen-Baker et al. 2022).

> "Trees are as close to immortality as the rest of us will ever come." Karen Joy Fowler in the novel *Sarah Canary*, 2004, Penguin Publishing Group.

The quotes above highlight the importance of considering cultural and spiritual values when managing old-growth forests. These forests have long captured human attention, with old and ancient trees being perceived as possessing spiritual qualities and sacredness (Gray et al. 2023, Pesklevits et al. 2011). Although not the only ecological marker of old-growth forests, old trees garner a sense of wonder, being seen as sources of wisdom, life, and longevity (Blicharska and Mikusiński 2014) and as "belonging to a separate and special class of being that transcends the normal plane of existence" (Cannon et al. 2022: 1). Because people's cultural and spiritual values toward old-growth forests are complex and often very regionally or community-specific, it is important to address what these values look like for southeastern forests.

It is important to recognize that the social values of forests do not easily conform to western scientific definitions of old growth. These differences can make it difficult to assess the importance of old growth across different regions of the country. In particular, socioemotional dimensions of old growth become even more important to consider in forests with adjacent or embedded communities. Where local economies and cultures are tied to old-growth forests, it is vital to examine these individual connections. These ties are not always as tangible and conspicuous as the economic values addressed in the preceding section, yet are crucial to evaluate in the context of management and decisionmaking.

Many people find that old-growth forests hold significant spiritual value (Moore 2007). Whether these individuals are forest users, community members, or recreational users, they can attain religious experiences or rejuvenation from solitude in nature in any of the old-growth forest community types. It is also common for these forest communities to engender a sense of wonder and imagination that holds important values beyond that of ecological significance and ventures into more human-centric qualities: symbols of well-being, family, inspiration, medicine, and “even life itself” (Gilhen-Baker et al. 2022). Even if these spiritual qualities do not have a specific cultural or religious tie to forest users, they seem to be a common human experience shared by observers of ancient forests, particularly examples of broad, towering trees that evoke a sense of ecological or forest idealism.

In addition to spiritual values, the emotional values associated with old-growth forests are important management considerations (Vosick et al. 2007). Although the range of emotions when exposed to the natural world are as varied as the people who experience them, many of these values seem to point towards a sense of balance, ecological uniqueness, or separation from a human-influenced past. When considering old-growth forest communities, the distinction between nature and anthropogenic change can easily become an ecological identity. Old-growth forests provide emotional relief from feelings associated with extractive natural resource practices; instead, observers are presented with “an ecosystem state that offers people a visual and emotional feast” (Kimmins 2003, Pesklevits et al. 2011). This dichotomy is a very emotionally compelling feature of old-growth forests, because they have seemingly defied recent exploitative human influence, allowing them to be observed in their natural state.

Regional significance can often underpin the emotional values that inform public and research attitudes regarding the preservation of old-growth forests. Despite not having visited southeastern forests, individuals appreciate their idyllic nature and prominent historical image. Both public and scientific communities derive existence values from regional old-growth communities (Gray et al. 2023). The simple knowledge that these forests exist and are being recognized for their uniqueness is a key sentimental value for many with a biospheric value orientation. In other words, there is emotional value in just knowing that old-growth communities, in addition to old trees, in the Southeastern United States are being discussed, researched, and conserved.

Historical values

Because of the extended length of time required for old-growth forests to develop, the historical values associated with these forests are important to note. Aged forest communities are perceived to have a special connection to the past; old trees seem to carry a sense of knowledge and are personified as having an “awareness of history, change, and persistence” (Cannon et al. 2022: 1). These values interlink old-growth communities to the regional history of an area, especially as old-growth forests often contain historical and archeological sites because of their longevity and low record of disturbance over time.

In the Southern Region, many old-growth forests continue to resemble the forests first encountered by European colonizers, especially the cathedral-like qualities of these early stands (NCSSF 2008). Although early human history in some bottomland forests is somewhat unknown due to the colonial impacts of warfare and the introduction of European diseases, archeological evidence shows that human presence in some areas of southern old-growth dates as far back as 10,000 years (NPS 2024). Across the Southeast, these early inhabitants include numerous indigenous groups, many of whom continue to inhabit, steward, and manage these regional lands. In addition, many enslaved peoples sought refuge in southern bottomland forests—some in old-growth cypress (*Taxodium distichum*) floodplain forests. Known as Maroons, these communities differentiated themselves from other slave runaways by forming permanent settlements, rather than continuing on to pursue freedom elsewhere or returning to plantations either voluntarily or through capture (Lockley 2021). Many individual Maroon communities subsisted in bottomland and cypress floodplain old growth individually or in collaboration with local Native American Groups for many decades.

Along with these qualitative historical values, old-growth forests also preserve valuable quantitative history. Hundreds of years of climate and fire trends are preserved dendrochronologically in regions of old growth, providing vital insights into previous regional conditions, trends, and environmental pressures. This information can also provide clarity on species structure, density, and composition at given points in time, helping to draw out differences between species establishment and expansion (in contrast to them simply surviving under harsh conditions). These data are particularly valuable in regions such as the Southeastern United States, where fire regimes have played such an ecologically significant role (Stambaugh et al. 2020).

Cultural values

Old-growth forests have substantial cultural significance for many local communities. Many cultures globally revere old trees as spiritual beings, perceiving them as bearing links to divine or otherworldly spaces, or more specifically, to a shared living memory and connections to ancestral figures (Blicharska and Mikusiński 2014). However, it is important to recognize that the concept of old growth is a western scientific construct that does not necessarily represent Indigenous worldviews or align with cultural interactions with forests (Dongoske et al. 2015, Johnson et al. 2021, Long et al. 2016). Native American communities, who were the original stewards of old-growth forests, value the health of the environment as reflecting the health of the people tied to it; the emphasis here is largely holistic, focusing on the totality of ages and species present in a given ecosystem (Yazzie 2007).

The Southern Region is home to 57 federally recognized tribes, numerous State-recognized tribes, and unaffiliated communities who hold diverse cultural values related to forests. Place-based Indigenous cultural values around forests are frequently manifested through stewardship practices (Turner et al. 2009, Wickham et al. 2022). Many of these Indigenous nations have actively shaped forests for millennia in their homelands, including interacting with or managing old-growth forests. Indigenous management practices within longleaf pine and oak-hickory (*Carya* spp.)-chestnut (*Castanea dentata*) systems included the use of fire to foster ecosystem health while promoting trees, plants, and wildlife that provided food, medicine, shelter, spiritual connection, and more (Davis 2021, Fowler and Konopik 2007, Hanberry et al. 2018a, Stambaugh et al. 2011). Given the longstanding reciprocal connections between Indigenous peoples and forests, it is essential to include tribal relations in decisionmaking related to old-growth forests. The incorporation of Tribal values, priorities, and Indigenous Knowledge is paramount in any Forest Service old-growth management decision. These efforts include considerations related to land stewardship, nontimber forest products (e.g., culturally significant plants and trees), traditional cultural sites, recreation, or other management considerations. The tribes themselves are collaborators and decisionmakers. Best practices for Tribal relations may include:

1. **Recognize Diverse Tribal Values:** When considering and planning for old growth, units can consider how old growth intersects with sacred sites, historic properties, traditional cultural uses, or other tribal interests. Such situations represent shared opportunities for conservation and management of old growth and cultural interests.

2. **Early Engagement:** Early tribal engagement in the planning process can inform how old-growth species and their habitat can best be managed to serve mutual interests between tribes and the Forest Service. This early engagement is important not only when there are known interests in the area but it can also identify additional tribal interests that the Forest Service may not already be aware of. Tribal engagement in this vein goes beyond requirements for tribal consultation and represents opportunities for costewardship, as well as early and proactive coordination with tribes to increase collaboration and strengthen relationships, leading to better project and resource outcomes. Through joint Secretarial Order, policy is codified to facilitate agreements with Tribes to collaborate in the co-stewardship of Federal lands and waters (Joint Secretarial Order No. 3403).

3. **Tribal Contributions to Old-Growth Forest Conditions:** For millennia, Native Americans have actively engaged in management practices that fostered and maintained old-growth conditions. These reciprocal relationships with forests are grounded in ethics of reciprocity, and accountability to future generations, and can provide vital insights as the Forest Service considers how to best support old-growth forests into the future.

4. **Indigenous Knowledge:** Indigenous Knowledge should be considered and included in Federal decisionmaking as directed by the White House Office of Science and Technology Policy and the White House Council on Environmental Quality jointly released new government-wide guidance and an accompanying implementation memorandum for Federal Agencies on recognizing and including Indigenous Knowledge in Federal research, policy, and decision making (OSTP 2021). Indigenous Knowledge is recognized as more than western science and specifically is intended to include other

ways of knowing including (but not limited to) traditional ecological knowledge, native science, Indigenous ways of knowing, and local knowledge (OSTP 2021).

5. **Data Sensitivity:** As noted in the White House Memorandum, The Forest Service recognizes engagement with Indigenous Knowledge should be only through relationships with Tribal Nations and Native communities and in a manner that respects the rights of knowledge holders to control access to their knowledge, to grant or withhold permission, and to dictate the terms of its application. It further recognizes that, should Tribal Nations and Native communities decide to share Indigenous Knowledge and otherwise collaborate with the Forest Service, the Forest Service should ensure that the application of that knowledge and complementary collaborative efforts benefit Tribal Nations, and Native communities.

Research and scientific values

Old-growth forests provide researchers with valuable opportunities to gain a deeper understanding of ecological processes, to test the principles of stand dynamics and development, refine methodologies, and assess prevailing theories. The scientific value of old growth is considered the contribution of old growth to the theoretical advancement of ecological knowledge. Although these two values are often viewed as similar, there are important distinctions between them to be carefully considered.

The compositional diversity and structural complexity of old-growth forests offer valuable data that can be used to refine and assess the accuracy of community-level models and other stand prediction models. Martin (1992) states that old-growth forests, “are invaluable because they provide the controls against which to best test hypotheses about younger, successional forests and forests actively managed for specific products or purposes.” Thus, datasets collected from old-growth systems can be used as benchmarks upon which to assess restoration treatments in younger stands. Old-growth forests serve as sites for monitoring natural processes of disturbance and development over longer temporal scales that often exceed funding cycles or the lifetimes of decisionmakers, scientists, and resource managers. With uncertainty surrounding climate-induced altered disturbance regimes and forest threats, old growth could be used to benchmark patterns of survival, recovery, and altered plant community assembly.

Permanent plots that have been frequently measured provide the most reliable data for investigating stand dynamics. However, many old-growth community types are unstudied or have only been examined briefly, and such data are often not available. Additionally, some old-growth communities that are well-documented over space and time (e.g., the Lilley Cornett Woods, KY) do not necessarily represent the full range of conditions of similar forest types found in other locations. For example, old-growth communities adjacent to major research institutes have likely received more study. In the absence of long-term studies, dendrochronology can be useful in providing information on the establishment and disturbance history, and stand dynamics of old-growth forests, as well as in reconstructing historical climate and weather patterns. Tree growth rings provide a permanent record of the effects of climate on tree growth as well as a record of disturbances caused by fire, drought, or insects. Tree-ring samples can be extracted from live trees and downed dead wood to increase the temporal scale of reconstructed chronologies. Historical materials such as photographs can provide important context for management and planning in old-growth restoration plans. The historical inventories and rudimentary case studies conducted prior to widespread harvesting provide important baseline conditions against which current restoration and management can be assessed.

Novel research techniques have been developed to identify and monitor old-growth conditions that can be applied in other forests at various stages of development. For example, the accuracy of terrestrial LiDAR techniques can be refined by scanning larger diameter trees that are more commonly found in old growth (Dassot et al. 2011). By collecting data from old growth, we can enhance the predictive ability and inferential capability of spatial models of resource competition, niche differentiation, and other spatially explicit biotic and abiotic interactions (Seidl et al. 2012). Additionally, old growth has been used to develop suitability models that can identify the likelihood of old growth extent based on soils, topography, and other abiotic factors (Stahle and Chaney 1994).

Old-growth forests are valuable for their contribution to research, including their role in the development of forest ecological theory. The long-lived nature of old-growth communities enables examination of various biotic and abiotic processes and patterns, which either support or contradict well-established ecological paradigms. For example, various conceptual models of forest development have been established over time (Oliver and Larson 1996, Palik et al. 2020), and the availability of old growth is critical in evaluating models of forest development. Furthermore, old growth can be used to supplement theories related to forest resilience (Falk et al. 2022), alternative stable states (Nowacki and Abrams 2008), ecological climax (Frelich and Reich 2003), and niche differentiation and spatial scaling (Busing and White 1997), among others. Thus, it is important to consider the value of old growth in the development of ecological knowledge, methodologies, and techniques.

4.2 Threats and Responses

Southern regional threats

The 16 old-growth community types (OGCT) in the Southern Region are described in sections 5 and 6 with ranges of key parameters for each community type. Threats to old-growth forests in the Southeast vary geographically. The impacts of these threats on an existing old-growth community depend on the conditions present at the time of disturbance and the intensity of the disturbance. Threats to one community may not be threats to another community because it depends on ability to impact structure, composition, connectivity, and continuity, and the capacity for intervention that exists locally. For example:

- Hurricanes are more likely to impact old-growth communities based on the distance from the Gulf of Mexico or the Atlantic Ocean.
- Lack of fire and its contribution to mesophication (Nowacki and Abrams 2008) is likely to impact upland oak, mixed pine-oak, and xeric pine OGCTs to greater degrees than already mesic OGCTs or lowland pine OGCTs (Woodbridge and Dovciak 2022).

- Where mesophication is occurring across a large part of the Southern Region, the invading mesic species may differ depending on the ecological system (Alexander et al. 2021, Flatley et al. 2015).
- Within a functioning old-growth pine community, southern pine beetle (*Dendroctonus frontalis*) plays a part in regeneration dynamics and nutrient recycling. However, southern pine beetle at outbreak levels moving from mature, overstocked, closed canopy pine forest adjacent to an OGCT may have dire impacts (Clarke and Nowak 2009).

Some amount of disturbance is desired within an OGCT at the scale and intensity appropriate to maintain community function, composition, and competitive dynamics (regeneration dynamics) (Hilbert and Wiensczyk 2007). However, some old-growth forests are unique in that they may also require the absence of major natural disturbances to develop key attributes (Bauhus et al. 2009). Intact and functioning old-growth landscapes likely contain, and are desired to have, a variety of seral classes present at an appropriate scale and pattern (e.g., often heterogeneously dispersed) for the OGCT (Bauhus et al. 2009). When disturbances impact an OGCT at a scale or intensity that is outside the community's range of variation for disturbances, key community functions may be interrupted and could take decades to restore. This concern is highlighted when considering global climate changes and projections that indicate wider fluctuations in historic disturbance patterns in the Southeast (Melillo et al. 2014). The potential for increased intensity and changes in return intervals of disturbance events may significantly alter community composition, structure, or its ability to connect to adjacent communities.

When OGCTs are catastrophically disturbed (past their ability for self-maintenance), national forest land managers are faced with options that are not always desirable or easily implementable because of resource constraints, the values discussed previously, and existing Forest Land Management and Resource Plans (Forest Plans). Where eastern national forest ownerships are large enough, other tracts of mature forest may be managed towards replacement of the disturbed OGCT. In cases where national forest ownership is smaller or more fragmented, similar OGCT conditions may be identified within a system of planned redundancy. Alternatively, the disturbed community may continue to be managed as an old-growth community because it includes biological legacies important to the system. Other portions of the community may also remain intact from an old-growth perspective (e.g., canopy destroyed but herbaceous layer intact). Historically, landscapes had old-growth attributes moving in space and time (e.g., as a result of both large- and small-scale events) (Butler 2014) across the landscape, therefore the current management of old-growth presence in place poses challenges.

In addition to climate change, human disturbance (e.g., activities, development) can influence old-growth conditions or its development. This is especially true of southeastern forests, where a long history of intensive use has created variation in land ownership patterns, travel corridors, suburban development, and a complex wildland-urban interface (Butler et al. 2018, Crosby et al. 2020, Tuttle and White 2016, Woodbridge and Dovciak 2022). Where forests are adjacent to population clusters, feral dogs (*Canis familiaris*) and cats (*Felis catus*) may cause disruption in the establishment and function of expected small mammal, bird, and herptile populations. These anthropogenic influences on southeastern landscapes disrupt natural ecosystems' continuity, affecting past and future processes. In some cases, these disruptions require additional intervention in existing and future OGCTs to ensure landscape-level processes endure. For example, prescribed fire can be used to replicate the historic landscape-level fires caused by lightning, and deer management can help restore understory diversity and recruitment that has been affected by increased browsing pressure.

Threats and stressors by community types

Tables 4.2.a to 4.2.f provide threats and stressors specifics for six groups: fire exclusion, pests and pathogens, nonnative invasive species (NNIS), historical land use, climatic occurrences (wind, drought, catastrophic flooding, or other events), and wildfires. Each group identifies the likely old-growth community type to be impacted with possible management considerations and outcomes. These tables were compiled based on information from a literature review (Woodbridge et al. 2025) and consultation with forest subject matter experts. They are not all inclusive and may apply to other age classes beyond old-growth forests as well as other community types.

Table 4.2.a—Threats and stressors for Southern Region forests: fire exclusion

Threat specifics	Old-growth types	Threat dynamic	Potential management for restoration and maintenance	Management outcome
Infrequent or no fire	Longleaf-upland (26), wet (29)	Homogenization of plant community; more difficult to burn with loss of fine fuels such as wiregrass	Restore fire returns to 1–3 years, primarily growing season burns; may require more frequent fire or silvicultural treatments (thinning or density reduction harvest), or both during restoration phase	Restoration of diverse fire-adapted grasses, in particular wiregrass and muhly grasses, and herb layer; maintaining savanna structure with open midstory and shrub layer; increase in pollinators
Infrequent or no fire	Xeric pine-oak (24)	Homogenization of plant community; more difficult to burn with loss of fine fuels such as wiregrass	Restore fire returns to 3–7 years including occasional growing season burns; may require more frequent fire and silvicultural treatments (thinning or density reduction harvest), or both during restoration phase	Maintenance of woodland structure, maintaining and regenerating pine component; increase in fire-adapted herbs and grasses; pollinator diversity
Infrequent or no fire	Dry oak (22), dry mesic oak (21), dry and dry mesic oak-pine (25)	Homogenization of plant community; more difficult to burn with loss of fine fuels; loss of understory diversity	Restore fire returns to 5–10 years; may require more frequent fire or silvicultural treatments (thinning or density reduction harvest), or both during restoration phase	Maintenance of woodland structure with more open understory; oak component maintained and regenerating; scattered tall and low shrub layer; diverse grasses, herbs, and pollinators
Infrequent or no fire	Wet oak-hardwood woodland (27)	In the absence of fire, increased canopy density with mesic species dominance	Restore fire return interval to 5–10 years; may require more frequent fire or silvicultural treatments (thinning or density reduction harvest), or both during restoration phase	Open woodland structure; less dominance by mesic species

Table 4.2.b—Threats and stressors for Southern Region forests: pests and pathogens

Threat specifics	Old-growth types	Threat dynamic	Potential management for restoration and maintenance	Management outcome
Balsam woolly adelgid (*Adelges piceae*)	Spruce-fir (31)	Loss of older Fraser fir component; greater increase in deciduous tree component; increase in understory evergreen layer; change in associated plants and wildlife species	Release or plant Fraser fir or red spruce, or both	Maintain patches of Fraser fir as an integral component in old-growth community
Hemlock woolly adelgid (*Adelges tsugae*) , emerald ash borer (*Agrilus planipennis*)	Northern hardwoods (1, 2), mixed mesophytic (5)	Loss of older eastern hemlock and ash component; increase in midstory evergreen rhododendron density; loss of associated pollinators and wildlife species	Treat with integrated pest management protocol, including chemical soil drench or injections on high conservation value trees; replant red spruce to replace eastern hemlock if appropriate; replant other tree species in appropriate sites	Maintain patches of eastern hemlock or ash species as an integral component in old-growth community
Southern pine beetle (*Dendroctonus frontalis*), engraver beetles (*Ips* spp.)	Longleaf types (26, 29), xeric pine oak (24), dry and dry mesic oak-pine (25)	Loss of various yellow pines in different pine habitats; change in fire dynamics; increase in more aggressive fire intolerant species	Treat or reduce threat with silvicultural treatment	Reduce large outbreaks, maintaining pine component with lower stem density, reducing future outbreak risk
Spongy moth (*Lymantria dispar*), oak decline	Dry oak (22), dry mesic oak (22), mixed oak (24)	Loss of multiple oak species; change in beneficial insect and wildlife species; change in fire dynamics; increase in more aggressive fire intolerant species	Treat or reduce threat with silvicultural treatment	Reduce large outbreaks, maintaining oak component with lower stem density, reducing future outbreak risk
Laurel wilt disease (*Harringtonia lauricola*)	Mixed mesophytic (5), Coastal plain upland mesic hardwood (6), hardwood wetland (10), cypress-tupelo (*Nyssa* spp.) swamp (14), dry mesic oak (22), dry and dry mesic oak-pine (25), dry and mesic longleaf (26), seasonally wet oak-hardwood woodland (27), wet longleaf (29)	Loss of trees and shrubs, including one federally listed species within the *Lauraceae* family; loss of associated pollinators	Implement appropriate integrated pest management practices to reduce disease risk; plant appropriate *Lauraceae* species	Reduce disease incidence and increase members of *Lauraceae* family

Table 4.2.c—Threats and stressors for Southern Region forests: nonnative invasive species

Threat specifics	Old-growth types	Threat dynamic	Potential management for restoration and maintenance	Management outcome
NNIS are diverse and new species continue to establish; species on the Federal noxious weed list species are more common in coastal plain forests, but additional species such as Japanese knotweed (*Polygonum cuspidatum*) or kudzu (*Pueraria montana*) can also be highly impactful	All OGCTs are vulnerable to NNIS; natural and anthropogenic disturbances may exacerbate the establishment and spread of NNIS in these forests; examples include wind and snow or ice damage, wildfire and prescribed fire, and harvest operations	Decrease in diversity, particularly associated herbaceous and nonvascular plants, reducing potential for pollinators; can disrupt disturbance dynamics including fire in fire-adapted types; can impact soil chemistry and associated mycoflora	Work with APHIS for rapid control (reduce or eradicate) of Federal noxious plant infestations; prioritize management areas with species-appropriate herbicide or management to reduce or eradicate NNIS populations, particularly prior to vegetation management	Reduction in NNIS populations; increase in native plants, particularly smaller herbs; where applicable, reduction in risk of high intensity wildfires
Wild boar	All OGCTs may be impacted by wild boar; the following are especially vulnerable to wild boar damage: northern hardwood (1), conifer-northern hardwood (2), mixed mesophytic (5), coastal plain upland mesic hardwood (6), hardwood wetland (10), river floodplain (13), eastern riverfront (28), wet longleaf (29), spruce-fir (31)	Impacts to plants associated with seeps, streamside zones, wetter portions of the landscape, or embedded small, rare plant communities	Trap and remove wild boar; replant with appropriate native plants in impacted areas if necessary	Recovery of wetland-associated species, including many small, rare plant habitats

NNIS = nonnative invasive species; OGCT = old-growth community type; APHIS = Animal and Plant Health Inspection Service.

Table 4.2.d—Threats and stressors for Southern Region forests: historical land use

Threat specifics	Old-growth types	Threat dynamic	Potential management for restoration and maintenance	Management outcome
Historical intensive harvest: mesic	Northern hardwoods (1, 2), spruce-fir (31), mixed mesophytic (5)	Reduction in overstory canopy presence or abundance of desired species; change in leaf litter with influence on community processes	Plant red spruce in OGCT 1 and 2, Fraser fir in OGCT 31, and appropriate hardwoods in OGCT 5	Increase in appropriate canopy species; potential increase in lichen and bryophyte bark epiphytes including old-growth associates for high elevation sites; increase in pollinators
Historical intensive harvest or fire exclusion: xeric/ submesic	Dry mesic oak (21), dry oak (22), xeric pine-oak (24), dry and dry mesic oak-pine (25), upland longleaf pine (26), wet longleaf pine (29)	Loss of associated canopy species, typically pines, or dominance by more competitive canopy species, such as loblolly pine, white pine, red maple, and associated fire-adapted herbaceous flora which can often influence ability to successfully burn	Thinning or uneven age harvest (irregular even aged in certain instances) of uncharacteristic species; replant pines and associated herbaceous flora, in particular grasses and legumes in appropriate sites following harvest or active fire management	Reestablish appropriate canopy species and herbs; increase in associated pollinators; restore ability to burn at appropriate intervals and intensities
Historical medicinal herb extensive harvest	Northern hardwoods (1, 2), mixed mesophytic (5)	Loss of economically valuable herbs and shrubs and associated flora and fauna, including pollinators	Plant heavily harvested medicinal plants such as American ginseng; educate public on medicinal plant importance and impacts from overcollection and poaching	Increase or introduce populations of medicinals; increase in associated pollinators
Canebrake habitat loss from farming, more intensive logging, and maintaining open bottomland sites	Hardwood wetland (10), river floodplain (13), wet oak-hardwood woodland (27), eastern riverfront (28)	Loss of giant cane abundance with impacts to associated flora and fauna, including pollinators	Reintroduce giant cane in appropriate microsites within OGCTs; collaborate with tribes to educate public on cultural significance	Increase in giant cane abundance; increase in associated flora and fauna; potential filtering of flooding inputs in appropriate types
Loss or decline of native species composition due to extensive historical logging, inappropriate herbicides, or mechanical treatments	Northern hardwood (1), conifer-northern hardwood (2), mixed mesophytic (5), coastal plain upland mesic hardwood (6), dry mesic oak (21), dry oak (22), xeric pine-oak (24), dry and dry mesic oak-pine (25), upland longleaf pine (26), wet oak-hardwood woodland (27), wet longleaf pine (29), spruce-fir (31)	Loss of site-appropriate community species, including trees, shrubs, and herbs; with decline of associated pollinators; disruption of ecological process within selected communities	Reintroduce or augment native species across appropriate OGCTs; control competing vegetation with mechanical or herbicide release, reestablish prescribed burns to restore and maintain planted fire-adapted species	Establish appropriate species, increasing associated pollinators; improved ecological relationships and processes
Changes in hydrology	Hardwood wetland (10), cypress tupelo (14), wet oak-hardwood woodland (27), wet longleaf pine (29)	Modified flooding regime, loss of flood-adapted vegetation, drying of pocosin	Correct hydrology; plant species that have been lost or reduced in abundance; may require more disturbance than other potential management activities, thus increasing risk of nonnative plant invasion	Restoration of flooding regime; increase in associated species and pollinators; lower risk of high-intensity wildfire in pocosins

OGCT = old-growth community type.

Table 4.2.e—Threats and stressors for Southern Region forests: wind or hurricane, ice or snow, and catastrophic flooding and drought

Threat specifics	Old-growth types	Threat dynamic	Potential management for restoration and maintenance	Management outcome
Wind or hurricane: creation of large or small patch openings	All OGCTs	Complete or partial loss of trees within an affected plant community; variable size gap creation could lead to greater herbaceous diversity (could be positive or negative effect); large threat of NNIS plant invasion	Review sites, determine appropriate management (including no action) such as planting in smaller patch openings; monitor for and treat NNIS	Restore old-growth process within areas with smaller openings; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage
Ice or snow: creation of large or small patch openings	All OGCTs	Complete or partial loss of trees within an affected plant community; variable size gap creation could lead to greater herbaceous diversity (could be positive or negative effect); large threat of NNIS plant invasion	Review sites, determine appropriate management (including no action) such as planting in smaller patch openings; monitor for and treat NNIS	Restore old-growth process within areas with smaller openings; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage
Catastrophic flooding: creation of large or small patch openings	Primarily riverine or wet flat OGCTs, but not limited to them	Complete or partial loss of trees within an affected plant community; variable size gap creation could lead to greater herbaceous diversity (could be positive or negative effect); large threat of NNIS plant invasion	Review sites, determine appropriate management (including no action) such as planting in smaller patch openings; monitor for and treat NNIS	Restore old-growth process within areas with smaller openings; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage
Catastrophic flooding: salination of soils	Riverine or wet flats OGCTs near the coast or brackish waters	Complete or partial loss of trees and other plants within an affected plant community; variable size gap creation could lead to greater herbaceous diversity (could be positive or negative effect); large threat of NNIS plant invasion	Review sites, determine appropriate management (including no action) such as planting acceptable but salt tolerant species in patch openings; monitor for and treat NNIS	Restore old-growth process within areas with smaller openings; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage or managed for other salt tolerant species
Catastrophic flooding: loss of soil and underlying unconsolidated rock	Primarily riverine or wet flat OGCTs, but not limited to them	Complete or partial loss of soil and underlying unconsolidated rock along with all supported vegetation; large threat of NNIS plant invasion	Review sites, determine appropriate management (including no action) such as planting in small patches if possible; monitor for and treat NNIS; remediate soil and water resource concerns	Restore old-growth process within areas with smaller openings; remediate soil and water concerns in large openings
Drought: creation of large or small patch openings	Primarily in upland OGCTs, but not limited to them	Complete or partial loss of trees and other plants within an affected plant community; may affect some species more than others; variable size gap creation could lead to greater herbaceous diversity (could be positive or negative effect); large threat of NNIS plant invasion	Review sites, determine appropriate management (including no action) such as planting in small patches if possible; monitor for and treat NNIS	Restore old-growth process within areas with smaller openings; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage

OGCT = old-growth community type; NNIS = nonnative invasive species.

Table 4.2.f—Threats and stressors for Southern Region forests: high severity wildfires or prescribed burns

Threat specifics	Old-growth types	Threat dynamic	Potential management for restoration and maintenance	Management outcome
Creation of large or small patch openings	Dry mesic oak (21), dry oak (22), xeric pine-oak (24), dry and dry mesic oak-pine (25)	Crown fires could replace old growth with early seral habitat within large or scattered size patches; could lead to greater fragmentation with smaller openings; larger openings could lead to disruption of old-growth characteristics; high risk of plant NNIS invasion; change in burn dynamics with possible high intensity from downed trees or invasive plants such as cogongrass or Chinese silver grass (*Miscanthus sinensis*)	Review sites, determine appropriate management such as planting vegetation (trees or forbs, or both); management to reduce accumulated downed fuels, or salvage harvest if road access is available; monitor for NNIS and treat	Restore old-growth processes, such as disturbance regimes and structural attributes within areas with smaller patches; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage
Creation of large or small patch openings	Upland longleaf pine (26), wet longleaf pine (29)	Crown fire could replace old growth with early seral habitat within large or scattered size patches; could lead to greater fragmentation with smaller openings; larger openings could lead to disruption of old-growth characteristics; high risk of plant NNIS invasion; change in burn dynamics with possible high intensity from downed trees or invasive plants such as cogongrass (*Imperata cylindrica*); loss of occupied red-cockaded woodpecker (*Leuconotopicus borealis*) trees	Review sites, determine appropriate management such as planting vegetation (trees or forbs, or both); management to reduce accumulated downed fuels, or salvage harvest if road access is available; monitor for NNIS and treat; install red-cockaded woodpecker inserts if appropriate	Restore old-growth process within areas with smaller patches; evaluate old-growth sites with large openings to determine if they still qualify as old growth or if they should be managed as an earlier seral stage

NNIS = nonnative invasive species.

Climate change

Forests offset nearly 13 percent of the national gross greenhouse gas emissions, sequestering 216 million tons of carbon in 2021 (Ramseur 2023). Aboveground biomass accounted for 59 percent of the sequestered carbon, and forest-derived products accounted for 13 percent. However, climate directly influences forests, determining or affecting species composition, productivity, and disturbances. Forests, and in particular old-growth forests will face significant consequences from climate change and associated stressors. Climate change can cause a decrease in the capacity of forests to store carbon, alter disturbance regimes (such as increased insect and pathogen outbreaks), increase fire severity and intensity, and change forest structure, demography, and function—all of which can have impacts to ecosystem services (Vose et al. 2012). Stochastic events attributed to climate change can also have varied effects on total carbon and carbon pools in old-growth forests. The allocation or rate of biomass to different carbon pools is dependent on the severity of the disturbance, forest type, or site productivity (Hicke et al. 2012). Disturbances can shift aboveground carbon pools from live wood to deadwood, resulting in a carbon sink (Keeton 2018). For example, Fraser et al. (2023) found that in one site overstory carbon increased by 20 percent in response to damage from an ice storm.

Forests in the Southern Region are predicted to experience increased climate-related vulnerabilities. Certain ecoregions within the Southern Region have experienced over 80 percent of their area transitioning into conditions representative of other ecoregions. Examples include the outer Coastal Plain and the southeastern mixed forests (Dobrowski et al. 2021). Over 90 percent of the Western Gulf Coastal Plain and the Mississippi Alluvial Plain are projected to face a similar transition. Such changes in ecoregions could lead to high risks of species loss, especially for forests within the Gulf Coastal Plain (Mori et al. 2021). We examined potential impacts of climate change and other global changes on old-growth forests in the Southern Region based on studies that have examined these threats on southern forests. Though these studies may not be explicitly focused on old growth, they serve to inform the potential threats to these forests.

Decades of fire exclusion in increasingly dense forests, especially where prescribed fire and forest thinning have not occurred, coupled with increasing air temperatures, may result in extreme fire behavior. This poses an increased risk to communities and carbon storage. In Forest Service managed land over half of the old-growth forested area is within congressionally designated wilderness and inventoried roadless areas (Barndt et al. 2023). Wildfire potential is projected to increase from low and moderate to moderate and high by the end of the 21st century in the Southern United States (Liu et al. 2010). The lengthening of fire seasons, coupled with conditions conducive to extreme fire behavior and difficulty of control, will add to the existing wildfire crisis.

The rate of decomposition increases with increasing temperatures (Dash et al. 2019). However, it is challenging to understand the dynamics of decomposition rates and their impact on soil carbon stocks (Davidson and Janssens 2006), especially because of the balance between decomposition rate and input of plant carbon (Dash et al. 2019). Coarse and fine woody debris present in forest ecosystems contribute significantly to carbon stocks, but the contribution varies significantly with latitude (Woodall and Liknes 2008). Southern forests have the lowest stocks of carbon in woody debris (Woodall and Liknes 2008). It is also important to note that rising temperatures may increase the decomposition rate in these forests. For example, Fraser et al. (2023) monitored 10 old-growth sites over a 20-year period and observed that only 1 site did not accumulate carbon, which they attributed to increased decomposition of woody debris at that site.

In a synthesis of the science regarding forest carbon, Ryan et al. (2010) identified several strategies to reduce the rate of carbon entering the atmosphere. They include afforestation, planting more trees in urban areas, better utilization of wood for fuel in place of fossil fuels, carbon storage in forest products, and using wood instead of steel and concrete. Concrete and steel manufacturing releases more CO_2 than wood processing. They also suggest several forest management practices that could result in better long-term carbon sequestration such as increasing harvest interval or decreasing harvest intensity or both, improving silviculture practices, rapid regeneration, and thinning forests to reduce the probability of carbon loss from fire. They emphasize that any action to reduce carbon emissions should be started as soon as possible.

Maintaining and enhancing complexity is also important to accelerate the development of old-growth conditions and mitigate carbon losses. Maintaining complexity is associated with resilience, which provides for safeguarding and enhancing carbon stores. Disturbance plays an important role in regulating carbon dynamics. It is important to balance adaptation and mitigation strategies. For example, it may be necessary to enhance age-class distribution across the landscape and manage for multiage stands to create areas with higher accumulation rates and simultaneously enhance structural and compositional complexity. Carefully planned partial harvests in pine-hardwood stands could help maintain carbon stock with greater potential for live tree carbon increment while fostering structural and compositional complexity (Bataineh 2020).

Forest assisted migration (FAM)

To help existing forests adapt to a changing climate and reduce their vulnerability to the future stresses associated with these rapid changes, many have suggested planting tree species and other forest genotypes that will survive in future conditions (Clark et al. 2021, Nagel et al. 2017, Palik et al. 2022, Royo et al. 2023). These plantings aim to offset the potential loss of locally native species because the rate of climate change is expected to outpace the natural migration rate of tree species (Royo et al. 2023). As the climate changes, current species assemblages could become unstable and more susceptible to insect, disease, heat, and water stresses, leading to higher mortality rates (Dale et al. 2001). However, it is essential to carefully select species that can make the transition from current to future conditions, because species that are only adapted to future climate conditions may not necessarily be well-suited to current conditions (McKenney et al. 2009).

Forest managers will need to consider several aspects of FAM when planning for future forests. To make informed decisions for adaptable species resource managers will need to consider factors that are likely to impact their local forests such as temperature fluctuations, heat stress, fluctuations in precipitation, and water deficits. However, the current availability of nursery stock with sufficient diversity to address FAM is lacking (Clark et al. 2023). The intensity of climate change will also impact the usefulness of FAM. For instance, a simulation of a forest landscape in northern Wisconsin indicated that FAM could maintain forests under mild climate change but was problematic under extreme climate change scenarios (Gustafson et al. 2023). FAM will likely be only one part of a multipronged approach in planning the future of Eastern U.S. forests. A priority for FAM is to increase diversity and quantity of nursery stock in order to meet FAM needs now and into the future.

Considerations for high elevation communities: The distribution and persistence of tree species across a region are the result of the interactions between topography and climate, which create suitable microclimates (Dobrowski 2011). In the Eastern United States, species in high elevation forests are at higher risk of decline compared to lower elevation forests (Rogers et al. 2017). Aspect and elevation in montane areas interact to produce suitable microclimates. However, for species adapted to high altitude habitats, the availability of these microclimates is limited due to reduced available areas upslope for migration (Bell et al. 2014). Because of the complexity of montane habitats, it is essential to develop fine-grained geospatial models to identify suitable areas to aid forest managers in FAM efforts (Hannah et al. 2014, Maxwell and Scheller 2020) or projected declines of montane species (Koo et al. 2015). For example, red spruce (*Picea rubens*) is predicted to decline in the southern Appalachian Mountains based on climate change projections (Koo et al. 2015). However, there are currently no models explicitly developed to predict the response or refugia of old-growth montane communities to climate change in the Southeastern United States.

Management considerations in old-growth forests

Using silvicultural methods to develop, restore, or maintain attributes or functions within existing old-growth communities may be challenging in its practice and acceptance. Many definitions of old growth refer to forests that have not experienced human intervention for a long time (Bauhus et al. 2009), and silviculture is a human-applied art and science (Maloof 2019). However, it is now recognized that human influences on forested landscapes are far reaching (Davis 1993) and maintenance of structural, compositional, and functional diversity within forests cannot solely rely on late successional forests present in reserves (Bauhus et al. 2009, Chapman and McEwan 2016, Flatley et al. 2015). Additionally, silviculture can contribute to the development of old-growth characteristics in second-growth stands or degraded old growth. This is an important consideration given the increased recognition of the importance of old-growth communities and their generally limited existence currently in the Eastern United States (Bauhus et al. 2009, D’Amato and Catanzaro 2022, Hilbert and Wiensczyk 2007).

The Forest Service and Department of the Interior, Bureau of Land Management consider both active and passive management important to conserving old-growth communities, especially when many old-growth forests are currently vulnerable to decline or departure from desired conditions due to climate change, past management history, and current trajectories of forest development, such as mesophication and homogenization of age and structure (Edmondson 2019, USDA Forest Service 2023c).

Passive management

Passive management is a decision to retain a forest community without the intention of forest management in the future (Catanzaro and D’Amato 2022, D’Amato and Catanzaro 2007, Hilbert and Wiensczyk 2007). This management choice allows time, biological growth, ecological succession, and currently occurring natural disturbance, including insects and diseases, to influence community conditions (Catanzaro and D’Amato 2022, D’Amato and Catanzaro 2007).

Use of the passive management strategy for existing old growth often leads to the standard approach of excluding all or some portion of management from existing old growth (Hilbert and Wiensczyk 2007). This management strategy is most effective when used on old-growth communities that are less vulnerable in their current condition (USDA Forest Service 2023c). Of the 16 OGCTs identified in the Southern Region, the degree of vulnerability varies by forest and location, so deciding to manage passively is a site-specific decision.

To determine old-growth management options, it is important to assess factors (i.e., hazards, benefits) that influence local conditions. The decision to passively manage an old-growth community is ideally a formal decision that occurs during the diagnosis phase of the land management process (USDA Forest Service 2023c). The impact of a passive approach is analyzed during effects analysis and, where appropriate, is tracked for future monitoring. In some OGCTs simply excluding silvicultural activities may result in alterations to a community's ecological integrity; this is especially relevant for community types with high rates of natural disturbance (Hilbert and Wiensczyk 2007, Spies et al. 2006). In other cases, natural seed dispersal and local disturbances were found to have the potential to restore some desired old-growth characteristics (Bragg and Shelton 2014, Farge 2018, Scheff 2012).

The decision to utilize a passive strategy acknowledges that the current conditions are either desirable, indicating high ecological integrity within the community, or that there has been a departure and the community is on a trajectory towards developing into a new OGCT or facing further degradation in the future. The decision documents that current condition is consistent with the appropriate old-growth characteristics or a novel OGCT or a degraded one is more desirable than a regenerated or restored future OGCT.

Active management

Active management is intentional planning and implementation of silvicultural activities to maintain or restore existing old growth or develop old-growth characteristics in second- or third-growth forests. Utilizing active management for developing old growth requires that silvicultural strategies maintain or increase old-growth attributes or functions (Bauhus et al. 2009).

Active management is not a tool to create new old-growth forests (D'Amato and Catanzaro 2007, 2022) but can be used to develop or maintain existing old-growth characteristics or reset a community towards future old-growth conditions. Active management for developing old-growth characteristics exists on a continuum (D'Amato and Catanzaro 2022: 23). This ranges from maintenance activities, such as maintaining appropriate fire return intervals within an OGCT (in comparison to passive maintenance of fire suppression), to harvest aimed at creating structural conditions or species compositions in second-growth forests that support the development of old-growth characteristics. However, there are differences in the way management actions can be categorized. For example, Bauhus et al. (2009) identified three categories for potential silvicultural interventions in old growth after considering whether old-growth community goals are being met with existing passively managed areas. These categories are: 1) current old growth resulting from the long-term absence of large-scale disturbances; 2) current old growth that is at risk of losing key attributes or is being subject to disturbances outside the natural range of frequency or intensity; 3) second- or third-growth forests that have been managed to achieve commercial objectives. In cases where old-growth forests are needed and appropriate harvest methods are allowed based on land management plan allocations, there is an opportunity to create or enhance certain old-growth characteristics while supplying harvested trees to local markets. This can also create potential funding for additional restoration or maintenance activities.

Spatial scale and connectivity

Old growth and characteristics of old growth in mature stands provide benefits at both the landscape and stand or community level (see section 4.1). Understanding OGCTs at both scales helps us understand the local condition of these communities and their contribution to the OGCT's overall health, function, and redundancy across a larger context. At a fine scale, the objective of silviculture is to manage old-growth attributes. At the landscape scale, the spatial and temporal arrangement of existing old growth, its connectivity, the surrounding landscape attributes, and natural disturbance patterns become more apparent (Hilbert and Wiensczyk 2007).

Within the National Forest System, landscape-scale analysis is more likely to occur at the Land and Resource Management (Forest Plan) Planning level compared to the individual project level. During forest plan revision, it is important to analyze existing old growth, land management allocations, natural disturbance patterns, and landscape ecology principles amongst other needs. The process of assessing old-growth communities or characteristics at the landscape level requires tradeoffs and is sometimes political in nature (Bauhus et al. 2009). When considering old-growth characteristics at the landscape or stand level, management can aim to promote biodiversity by creating the heterogeneous structures within stands, based on the structures appropriate for a given OGCT, and across ecosystems (Bauhus et al. 2009, Hammond et al. 2016).

Benefits, challenges, and risks of active management

Active and passive management of old growth and second-growth stands present a unique set of desirable outcomes, difficulties faced during project or forest planning, and risks to resource conditions. Silvicultural practices have the potential to maintain or restore desirable old-growth conditions, but thorough consideration will ideally also be given to tradeoffs associated with directing ecological succession and manipulating structural, compositional, and stocking conditions in old-growth forests. Tradeoffs of benefits and challenges or risks vary across space and time and can be taken under consideration with site-specific environmental analysis, diagnoses, and prescriptions. Some of the most important benefits and advantages of active management to maintain or restore old growth include the following:

- Faster development of old-growth characteristics in old-growth or second-growth stands than would have occurred in the absence of applying silvicultural treatments (D'Amato and Catanzaro 2022, Lorimer and Frelich 1994, Scheff 2012, Schuler et al. 2002). This can occur via accelerated growth of remaining trees, improved physiological vigor and resistance to damage agents and associated mortality, or the expedited creation of structural characteristics, canopy gaps, large woody debris, and other old-growth elements.

- Maintenance or restoration of desired characteristics that historically required particular disturbance types or regimes to persist, but which are presently absent or substantially altered (Butler et al. 2018).

- Restoration of desired characteristics that have departed from past states (Hanberry et al. 2018a,b; Lorimer and Frelich 1994), often for reasons other than changes in historic disturbance regimes (e.g., the loss of American chestnut or eastern hemlock).

- Emulation of natural disturbances to utilize system capacities for adaptation and resilience (Hilbert and Wiensczyk 2007).

- Simultaneous promotion of old-growth attributes while meeting other social and economic management goals (Bauhus et al. 2009, Brunswig et al. 2016, Keeton 2006, Scheff 2012).

Restoration and management of old-growth characteristics through the intentional application of silvicultural practices can be associated with various challenges encountered during project planning and implementation, as well as risks of failing to attain desired characteristics or inflicting excessive damage. Important difficulties or risks faced by old-growth forest managers during project planning and implementation include:

- Social controversy arising from active management implications on revenue and employment (e.g., wood products or recreation), Indigenous people's rights, intrinsic values, and public perceptions (Hilbert and Wiensczyk 2007; section 4.1: Sociocultural, historical, and Indigenous values).
- Limited information or data describing structural, compositional, and functional characteristics for some old-growth communities (Hilbert and Wiensczyk 2007).
- Limited information at relatively large (multistand and larger) scales. Much of the research to date has been at a stand or individual community level (Hilbert and Wiensczyk 2007).
- A poor understanding of old-growth biodiversity, which can constrain the development of desired conditions and a comprehensive understanding of predicted effects resulting from management (Hilbert and Wiensczyk 2007).
- Risks associated with timber harvest, yarding, or other ground-disturbing activities that can include residual stand damage, soil disturbance, NNIS establishment or spread, and other undesired human impacts (Kleinman et al. 2017). Potential damage to old-growth characteristics is particularly important when such elements take decades or centuries to develop.

Overview of maintenance and restoration options for Southern Region old-growth community types

The intensity of management options for OGCTs ideally will vary based on the current condition of the community, its present and future threats, land management plan objectives, and available treatment options (Keeton 2006). Data and relevant scientific information can support decisions to treat old growth.

Treatments focused on meeting restoration objectives can be considered under the following two scenarios:

1. Treatments to improve the condition of existing old-growth communities. Proposed treatments to reasonably assure the progression towards Forest Plan desired conditions for old growth or higher ecological integrity within the degraded community by addressing departures within existing community characteristics (altered composition, structure, function, or process).

2. Treatments to develop future old-growth conditions in existing second- or third-growth forests. Within previously regenerated and maturing forests, silvicultural treatments may be proposed to develop desired characteristics where they currently do not exist in preparation for these communities to replace, enhance, expand, or connect existing OGCTs. Forest Plan desired conditions and objectives may be used to guide the development of characteristics. Mature stands selected for this goal should have the potential within their current development trajectory to satisfactorily possess and sustain future OGCT characteristics.

In either case, proposed treatments are typically guided by Forest Plan desired conditions. In both restoration scenarios, time is also an important factor in the development of conditions, and managers limit their expectations to accurately reflect what is possible in a single treatment (Lorimer and Frelich 1994). Additionally, when considering potential treatment options in existing old growth, it is important to weigh the feasibility of addressing a departed condition and the potential for successful restoration or gains in ecological integrity. Decision options to defer treatment are typically included in the analysis because they help to identify a departed OGCT and its projected condition into the future.

Section 5 provides restoration and maintenance activity options to achieve certain desired conditions in each OGCT. Due to the similarities in desired characteristics of old-growth communities and the disturbances present in the Southern Region, potential restoration treatments can be categorized based on their influence. Although many restoration activities can be used for different OGCTs, certain communities are more likely to benefit from specific treatments (table 4.2.g). Generally, proposed treatments may be combined to maximize benefits and address multiple community characteristics. In many cases, restoration and maintenance activities are essentially the same and differ only in the intensity of the action. The general assumption is that restoration activities may be more intensive than maintenance activities once desired conditions are present.

In many cases, similar treatments can guide either mature forest or existing old growth towards reaching old-growth related desired conditions. This is especially important when considering the landscape surrounding existing old growth or the strategic placement of future old growth. The prioritization of treatment recommendations and examples can overlap where it is possible to get the most benefit within the scope of old-growth management objectives (Keeton 2006).

Table 4.2.g—Common categories of restoration and maintenance treatments by old-growth community type

Treatment	Restoration	Maintenance
Composition modification or maintenance	5, 6, 21, 22, 24, 26,	5, 14, 21, 22, 24, 25, 26
Composition protection	2, 5, 13, 14, 28	1, 2, 5, 10
Structural modification or maintenance	1, 5, 6, 10, 13, 21, 22, 24, 25, 26, 27, 31	21, 22, 24, 25
Planting	1, 2, 5, 6, 13, 21, 22, 24, 25, 26, 27, 28, 31	5, 14, 29
Prescribed fire	6 [a], 21, 22, 24, 25, 26, 27, 29	6 [a], 21, 22, 24, 25, 26, 27, 29
Treatment of NNIS	1, 2, 5, 6, 10, 13, 25, 27, 28	1, 2, 5, 6, 10, 13, 14, 21, 22, 25, 26, 27, 28, 29
Soil and water restoration	10, 13, 14, 28, 29	6, 10, 13, 28
Monitoring	All	All

Refer to the introduction of sections 5 and 6 for a complete listing of the OGCT numbers listed in this table.

This table provides some benefit/risk considerations for active restoration in old growth, which could also apply to moving mature forest towards old growth. Benefit/risk ratios are not consistent across OGCTs nor even across units of the same OGCT. Managers may consider a variety of biological and social factors for each managed unit and across the landscape.

[a] Control of fire is an important restoration and maintenance activity.

NNIS = nonnative invasive species.

Composition modification or maintenance

This includes treatments designed to modify or restore existing species composition within some portion of the OGCT community (Bragg 2010). These treatments may occur within the overstory, midstory, or ground layers and address herbaceous or woody vegetation. They may overlap with other restoration treatments like planting, prescribed fire, NNIS, composition protection, and structural modification. During maintenance, treatments strive to keep the existing composition intact and ensure that desirable regeneration of the community is developing. Treatments may be commercial or noncommercial, chemical, or mechanical.

Example:

- Removal of red maple (*Acer rubrum*) encroachment within oak-pine dominated communities resulting from fire suppression (Crosby et al. 2020).

Composition protection

This can be used in concert with composition modification or is a stand-alone treatment. These species-specific or even tree-specific treatments usually address forest health issues that threaten to decrease the species diversity of an OGCT. They can occur during the restoration and maintenance phase of management and target the understory, midstory, or overstory. Because of the cost and intensity of these treatments the decision to implement composition protection within an OGCT needs to be committed and well-coordinated with monitoring. A typical example is pesticide treatment.

Example:

- Using insecticides to treat hemlock woolly adelgid or emerald ash borer in the northern hardwood OGCT.

Structure modification or maintenance

Structure modification has applicability across many Southern Region OGCTs. Its need relates to the historic suppression of disturbances (e.g., fire) and overlaps with composition modification in that the departures in structure may contain undesirable species. This treatment category is also widely applicable to second- and third-growth forests identified for further development of old-growth characteristics (Keeton 2006, Scheff 2012, Schuler et al. 2002). This treatment can also re-establish desirable structural conditions in rare communities, forest or otherwise, embedded in an OGCT. It may also protect desired conditions (e.g., reduction in southern pine beetle hazard, Turchin et al. 1999), including both horizontal and vertical structural conditions. Structural maintenance continues restoration-type treatments where needed. Treatments may be commercial or noncommercial, chemical or mechanical.

Examples:

- Commercial or noncommercial thinning to reduce stand density, restore woodland conditions, and reduce southern pine beetle hazard in a dry and dry mesic oak-pine and pine-oak forest and woodland OGCT.
- Reducing woody encroachment around a sphagnum (*Sphagnum* spp.) bog embedded in a hardwood wetland forest old-growth community.
- Adding gaps and thinning in a dense red spruce forest adjacent to an old-growth community, promoting understory development, birch (*Betula* spp.) recruitment, structural variability, and connected northern flying squirrel (*Glaucomys sabrinus coloratus*) habitat (Schuler et al. 2002).

Planting

Planting activities are compatible with many other restoration and maintenance activities and across numerous OGCTs. Planting is generalized here because it may refer to planting a variety of species, both woody and herbaceous, to maintain or increase the species diversity of an OGCT. In many cases planting may result in the reintroduction of a species that was lost from a past disturbance. Planting can also enhance community conditions and increase integrity or facilitate regeneration of key community components while the OGCTs functions are also being restored.

Examples:

- Introduce red spruce along high-elevation northern hardwood old-growth riparian areas after the loss of eastern hemlock.
- Planting wire grass plugs before restoring the fire return interval in an old-growth longleaf pine community.
- Cluster planting oak species in an old-growth dry mesic oak community being transitioned back to a woodland structure by using thinning and prescribed fire.

Prescribed fire

Where appropriate ecologically, fire is a cornerstone restoration and maintenance treatment in Southern Region OGCTs (Bragg 2016, Burton 2009, Cipollini et al. 2019, Goode et al. 2023, Kush et al. 2004, Varner et al. 1999). This treatment is well integrated with other activities and has the potential to magnify other restoration treatments when timing and conditions are favorable. This tool can be limited in effectiveness based on the length of its absence from the community and the conditions that have since developed. Other limitations include prescribed fire-appropriate windows and constraints based on risk to adjacent human infrastructure and populations.

Example:

- Restoring fire in a long unburnt longleaf old-growth community to reduce woody encroachment and rejuvenate the wiregrass understory.

Treatment of NNIS

Critical due to today's global economy and human interaction with nature is a treatment to prevent the establishment of or damage by NNIS. Treatments may be used to prevent the establishment of plants, insects, or animals that would reduce desired conditions or ecological integrity within OGCTs. Planning for NNIS treatments is also important when other restoration treatments are planned, roads are nearby, and OGCTs are highly desirable recreationally. There is overlap with this restoration and maintenance activity and composition protection, and treatment of NNIS is likely to be beneficial across all Southern Region OGCTs.

Examples:

- Control of wild boar (*Sus scrofa*) within a rich cove OGCT to reduce impacts on American ginseng and other herbaceous plants, invertebrates, and herptiles.
- Removing Japanese barberry (*Berberis thunbergii*) from the understory of a mesic oak OGCT.

Soil and water restoration

As noted in five of the most hydrologically connected OGCTs, restoration of impacted hydrologic function and soil conditions are important in the hardwood wetland forest (10) river floodplain hardwood forest (13), cypress tupelo swamp forest (14), and southern wet pine forest, woodland, savannah (29). For these communities, hydrologic and soil conditions are principal contributors to the characteristics and function of the community. Where past damage has occurred, restoration efforts may contribute to improved resilience and ecological integrity (Engstrom et al. 2022). Preserving hydrologic and soil conditions should be a priority when maintenance activities are being planned and implemented. It is important to note that hydrologic and soil conditions are also important in the other Southern Region OGCTs and especially in rare and embedded communities, including nonforested and some forested types.

Examples:

- Repairing or removing nearby ditching to restore appropriate water tables in a southern wet pine forest OGCT.
- Removing a low water dam upstream from a river floodplain hardwood forest OGCT to restore periodic flooding events.

Monitoring

Though not a restoration or maintenance activity in itself, monitoring is important across all OGCTs. Understanding the existing conditions within old-growth communities and their changes over time is a key goal with monitoring. Monitoring can also help determine the need for restoration and maintenance activities, as well as assess how well these activities are maintaining or improving old-growth composition, structure, function, and connectivity (Moore and Conroy 2006). Amended Forest Plans in the Southern Region may contain monitoring elements that examine old-growth conditions at appropriate scales.

4.3 Methods for Inventorying and Monitoring Old-Growth Forests

Public land managers have been challenged to classify, map, and inventory existing vegetation and potential natural vegetation to support the development of land management plans, project-level decisions, and monitoring at various scales. Given the past land-use history in the Southern Region, it has been difficult to identify old-growth locations because of the typically small, disbursed nature of old-growth occurrences. We expect remote sensing will be used in tandem with field validation protocols to determine the existence and condition of old-growth forests.

As of the publication of this report, conserving and developing old-growth conditions typically requires using numerous inventory and mapping tools applied at various scales. These tools help identify existing old growth and mature stands with development potential to augment the old-growth base and support planning and monitoring requirements. This section provides an overview of some of the available tools and their limitations to support and meet inventory desires. Across the Southern Region, various inventory protocols exist to identify old-growth conditions at various scales and new methodology is being researched. Gathering data to understand existing old-growth conditions should also align with USDA guidance on classification, mapping, and inventory of these communities (Nelson et al. 2015). It is also important to consider that the accuracy of measuring the age of trees through coring can vary based on the method used to analyze samples, especially in diffuse-porous species (Phipps 1985).

Remote sensing and LiDAR data

Field-based methods to inventory and monitor old-growth forests can be time- and cost-prohibitive, so remote sensing approaches offer a complementary approach to address inventory or monitoring needs. In forestry and ecology applications, remote sensing is the collection of data by using sensors attached to satellites or aircraft. These sensors use passive or active forms of energy to collect imagery that can be used to derive conditions related to forest structure, disturbance, and topography. Various types of remote sensing technologies are currently in use, each with strengths and weaknesses. Some of the earliest remote-sensing data is aerial photography, which in some places is available as far back as the 1930s. Aerial photography continues to be collected today and is used extensively in forestry to make management decisions and monitor change over time. More recent long-term remote sensing data sets are derived from government-funded satellite missions. For example, data collected by the nine LANDSAT missions spans from 1984 to the present and is collected at 30-m spatial resolution with a revisit interval of 8 days. As of 2015, the Sentinel-2 satellite collects similar data but with a spatial resolution as low as 10 m for some bands and a revisit interval of 5 days. These satellites collect information based on selected bands of the electromagnetic spectrum. Because of the frequency of repeated data collection, satellite imagery can be used for detecting changes in vegetation characteristics. For example, multispectral imagery-derived metrics such as the Normalized Difference Vegetation Index (NDVI) and the Normalized Burn Ratio (NBR) have been used extensively to assess and monitor overall vegetation health and fire severity, respectively, for well over a decade. The relatively short return interval of some satellites provides a means to rapidly assess forest conditions at many spatial scales. As a result, these data have been used to develop products such as the Landscape Change Monitoring System (LCMS) (Healey et al. 2018, Housman et al. 2022), which leverages LANDSAT data to monitor landscape change across the United States. Additionally, data derived from satellite imagery has proven useful for identifying and monitoring forest composition and change, as seen in the development of Gradient Nearest Neighbor (GNN) analysis (Ohmann and Gregory 2002, Ohman et al. 2011), BIGMAP (Bell et al. 2022, Wilson et al. 2018), TreeMap (Riley et al. 2021), and LANDFIRE (USDA and USDOI 2022). These are just a handful of examples of how satellite data is being used. There are many other examples of how these data have been used operationally for decisionmaking by Federal, State, and local governments; nongovernmental organizations; academia; private industry; and more with new approaches and applications coming online all the time.

More recently, land managers have started to leverage remotely sensed data derived from LiDAR (light detection and ranging). Currently, LiDAR data are often collected by fixed-wing aircraft sensors that emit pulsed laser light to the Earth's surface. However, terrestrial LiDAR, collected by sensors attached to drones, backpacks, and now cell phones and tablets, is rapidly becoming more commonplace. Terrestrial LiDAR is commonly used to obtain three-dimensional measurements of forest structure and is also used for other forestry applications such as engineering. The resulting data can provide fine-resolution products (sometimes submeter). The pulse of light emitted from airborne sensors can detect objects both above and on the Earth's surface, and one emitted light pulse can register on the sensor as one or multiple returns depending on the number of objects in its path (e.g., tree canopy, ground surface). The data produced is a cloud of elevation points. The first return typically indicates canopy height, and the last return typically indicates the bare Earth surface. LiDAR data are used extensively to develop digital elevation models (DEM). Brecheisen et al. (2019) were able to use a high-resolution DEM combined with microtopographic terrain analyses to identify areas with low human disturbance, areas lacking rill erosion from poor agricultural practices and without terraces and roads. Additionally, canopy height models (CHM) can be calculated using the difference between the digital surface model (DSM) (calculated from the first return) and the

DEM. Other forest structural metrics can also be calculated from LiDAR data, including canopy gap characteristics, individual tree location, and tree height. In conjunction with ground plot data, LiDAR can be used to generate metrics such as quadratic mean diameter and basal area. Additionally, LiDAR data can be used to differentiate between conifer and broadleaved tree species (Kim et al. 2009), calculate leaf area index (Wang et al. 2020), and identify snags and horizontal coarse woody debris (Jarron et al. 2021).

A wide variety of applications have been developed to visualize, analyze, and create thematic maps by using remotely sensed data. ArcGIS Pro (ESRI 2024) can process LiDAR-derived point cloud data and train pixel-based classification algorithms, among other spatially explicit geoprocessing capabilities. FUSION was developed by the Forest Service to visualize and analyze LiDAR data and is often used to model canopy cover and canopy closure. Open-source software and applications, such as R and Google Earth Engine remove cost barriers to remote sensing analysis. Numerous packages have been developed recently and more will continue to be developed, with specific applications based on desired data products. Technology and methods for analyzing remotely sensed data continue to evolve.

There are distinct advantages and limitations associated with the various remote sensing methods. For example, satellite data is collected frequently, so it is well-suited to detect changes in forest composition over large spatial scales and time frames (depending on how long the satellites have been in service). However, it is limited in assessing forest structure. LiDAR is collected at very fine (sometimes submeter) resolution and can be processed to derive various metrics of stand structure, but does not have a designated return interval at present. Both techniques may not gather all the relevant information used to describe and monitor old-growth communities, especially plant composition in the understory. The various remote sensing approaches may be able to identify areas that are more or less likely to have old-growth communities and monitor old-growth stand dynamics, including disturbance impacts. The Pacific Northwest Region has used remote sensing data extensively to estimate the extent and location of northern spotted owl habitat, a species associated with old-growth forests (Ackers et al. 2015). Other organizations have also used remotely sensed data to identify and classify mature forests at national scales (DellaSala et al. 2022) by using canopy cover, canopy height, and aboveground biomass as a proxy for older or mature forest.

There are additional caveats to consider when using remote sensing to assess or estimate old-growth conditions across gradients of site productivity, especially in the diverse landscapes of the Southern Region. For example, pine plantations that are intensively managed to maximize economic benefits and rapid biomass accumulation, or other planted stands, may inaccurately be classified as old growth when identified using remote sensing approaches. Areas that have been converted from historical community types, such as longleaf to loblolly pine plantations, may have many of the same structural characteristics as the original ecosystem but lack the desired species composition. Identifying old-growth forests on xeric, nutrient-deficient sites that support small-statured trees with relatively little biomass may also be challenging using remote sensing approaches. Validating remotely sensed products with field-based techniques is likely to provide the most accurate portrayal of the location and condition of old-growth forests.

Forest Inventory and Analysis data

The Forest Service FIA program provides a statistically rigorous, national-scale dataset available to the public. This dataset is the only comprehensive, consistent field data of U.S. forests. It consists of a systematic sampling network of more than 140,000 forested plots spanning the entire country, which are resampled on a regular basis (Bechtold et al. 2005, Burrill et al. 2021, Westfall et al. 2022).

The FIA sampling design consists of collecting a wide array of information including diameter and species for all trees >1-inch d.b.h., stand age, site index, slope, aspect, information on seedlings, and downed woody material. Evidence of disturbance (e.g., fire, insects, disease, wind) or treatment (e.g., tree removal, site prep, natural or artificial regeneration) are recorded. Additionally, the database contains many estimates generated from site measurements including volume, biomass, and above and belowground carbon. However, species-specific information on shrubs, forbs, and graminoids is not collected on all FIA plots.

FIA data has been used to estimate and characterize old-growth forests nationally (Pelz et al. 2023) and regionally (Ducey et al. 2013, Herrera et al. 2025). National Forest System (NFS) regional old-growth definitions have been applied to FIA data for NFS forested lands (Pelz et al. 2023). The authors used regional criteria for estimating old-growth status based on NFS definitions, assessments, and related documents. These definitions focused on structural characteristics of forests that were available via FIA data such as minimum abundance of large live trees, tree or stand age, basal area, and dead large tree density. The authors estimate approximately 10 million ha of old growth across all NFS forests.

It is important to consider several limitations of FIA data when estimating old-growth forests. The structural metrics and the plot density sampled via FIA do not capture fine-scale spatial heterogeneity (Gray et al. 2023), which is the spatial scale at which old growth currently occurs across much of the United States (FIA plot density is approximately one plot per 2,400 ha [6,000 acres]). Furthermore, the small size of FIA plots limits the ability of FIA data to capture horizontal spatial heterogeneity or low-density characteristics (e.g., gaps or infrequent large trees—important old-growth characteristics for many forest types) (Gray et al. 2023). Despite these limitations, FIA provides a dataset that can be used to estimate and monitor old growth at the landscape scale, using criteria that can be updated as definitions are refined over time. It is important to note that the utility of FIA data at the project and stand scale may be limited and require other data sources. Gray et al. (2023) summarized this well: "Identifying mature and old growth forests in a stand management context will likely require additional measurements, adjustments to criteria at local scales, and incorporation of social and traditional knowledge within a consistent definition framework."

Old growth or older forests have also been estimated based on biomass or accumulated carbon. Barnett et al. (2023) defined old-growth characteristics as occurring at the age when the density of total forest carbon stored in live and dead biomass reached 95 percent of the maximum as referenced in section 4.2. DellaSala et al. (2022) spatially depicted mature forests by using remote sensing datasets for canopy cover, canopy height, and aboveground biomass as a proxy for mature forests. Unsurprisingly, old-growth area estimates on Federal land from Barnett et al. (2023), Pelz et al. (2023), and DellaSala et al. (2022) did not match. Spatial and nonspatial estimates of old growth will differ based on how old growth is defined, and each can be useful depending on the intended application. These definitions may change as our understanding of old-growth characteristics and how to incorporate them into plot-based and remotely sensed data improves over time.

Field sampled vegetation (FSVeg)

Within the Forest Service, FSVeg is a nationally supported database and FSVeg Spatial is a nationally supported summarization system for vegetation inventory collection processes, including common stand exam (CSE). FSVeg is flexible and can contain plot vegetation data from field surveys such as FIA data, stand exams, inventories, and regeneration surveys. Data stored can include information about trees, understory, cover, and downed woody material. FSVeg Spatial stores vegetation inventory collection information and their locations within vegetation polygons (stands). FSVeg Spatial also summarizes standard and user-defined attributes at the vegetation polygon (stand) level to support vegetation analysis. FSVeg and FSVeg Spatial may be designed to gather, store, and summarize existing condition information related to the 16 old-growth community types and their attributes identified in the Southern Region (table 4.3.a). As with every database, there are limitations and gaps. Within FSVeg, "the limitations of "aggregation" involve concerns about data currency, quality assurance, plot selection, measurement protocol, plot design, cost, and statistical implications involving stand selection" (USDA Forest Service 2015).

Table 4.3.a—Advantages and limitations of FSVeg for use related to old-growth community types

Advantages of using FSVeg for OGCTs	Limitations of using FSVeg for OGCTs
CSE, FSVeg, and FSVeg Spatial are nationally supported through Natural Resource Manager (NRM).	FSVeg is based on vegetation polygons (stands) to collect, store, and summarize collected attributes. These polygons may not align with the scale of existing old-growth communities on the landscape (i.e., FSVeg polygons are typically larger than the Southern Region's old-growth patches), and summary statistics may not reflect the heterogeneity of a polygon.
The system is flexible and capable of accommodating a wide array of attributes during data gathering, storage, and summarization.	Use of FSVeg requires learning the system and how to set it up to meet objectives. Managing spatial data requires using a GIS platform and is dependent on the skill levels of users.
Reports from FSVeg and attribute tables summarized in FSVeg Spatial are customizable at the region, forest, or district level.	Up front office work is required to delineate vegetation polygons, calculate sample intensity, and define protocols. After field work is completed, data needs to be uploaded into FSVeg to manage polygons and be summarized in FSVeg Spatial.
Data from FSVeg can be downloaded, input into the Forest Vegetation Simulator (FVS) or the FSVeg Spatial data analyzer, or both, to develop a model of planned activities, changes over time, and analyze proposed management alternatives.	A protocol to utilize FSVeg as an inventory for old growth will need to be established and field verified prior to use.

OGCTs = old-growth community types; CSE = common stand exam; GIS = geographic information system.

Old-growth characteristics and FSVeg/FSVeg Spatial

The attributes of OGCTs vary among community type and across locations within the region. Attributes that best describe existing conditions within OGCTs may include, but are not limited to: d.b.h., tree height, tree age, diversity of understory conditions, snags and downed wood, and structural heterogeneity. In most cases, these attributes are used in some combination to fully understand the development of old-growth conditions on the site. The Southern Region has developed a companion document for using FSVeg to track attributes and document the presence of OGCTs.

The original 1997 guidance (Gaines et al. 1997) included recommendations to track the presence of OGCTs on Southern Region national forests in continuous inventory of stand conditions (CISC) through two means. Those recommendation options continued to be available when CISC was rolled into FSVeg in the early 2000s. Option 1 is the legacy option for tracking old growth, starting within CISC and made available within FSVeg, and option 2 was initiated with the creation of FSVeg. These two options are as follows:

1. Use of 99 as the second two digits in the three-digit Southern Region land-class codes (e.g., 599 or 899). This tracking allowed for land-class allocation decisions made at the forest plan or project level to be tracked in FSVeg. Using the second two digits allowed these decisions to be identified and tracked within the overarching land-class scheme that reported requirements for timber suitability according to the National Forest Management Act (1976). This tracking method did not necessarily indicate that conditions present within those polygons (stands) were currently old growth. Instead, it assumed that part of the national forest landscape had the potential to trend toward old-growth conditions over time. This assumption and process were consistent with the inventory process recommended in the 1997 old-growth guidance (Gaines et al. 1997).

2. Within the FSVeg Spatial polygon attributes window, programmers created a locals tab to capture old-growth-related attributes and other regionally specific information. The 16-character string field named OLD_GROWTH was intended to identify actual polygons (stands) within FSVeg that contained old-growth characteristics. This field could be entered for stands (or groups of stands) during an FSVeg spatial editor session when the stands were selected.

In both cases, the two FSVeg tracking options (originally in CISC) were adopted to varying degrees by the national forests in the Southern Region, resulting in incomplete and inconsistent old-growth information within FSVeg. The transition from the CISC database to FSVeg, which occurred after the development of the original Southern Region old-growth guidance (Gaines et al. 1997), likely contributed to a lack of understanding of how old-growth was to be tracked in FSVeg. This ultimately resulted in lower-than-desired use across the region.

The two original options for tracking old growth in the 1997 guidance (Gaines et al. 1997) did not include details related to OGCT community attributes, their existing condition on the landscape, and desired future conditions. Currently, existing CSE inventory data usually does not collect all the attribute information necessary to determine if a stand or community meets the old-growth descriptions in this report. The historical reasons for this include 1) such data is more time consuming (i.e., more expensive) to gather, and 2) typically not needed for silviculture prescriptions related to compositional or structural restoration, wildlife, and other forest health objectives. If FSVeg Spatial will store data about old growth in the Southern Region, efforts can be made to retain historical information from previously identified old-growth areas, update it, and collect and add any information that was not documented in the past. Stands identified as old growth through past inventories or land management decisions can be included.

Due to the complex nature of old growth in the Southeast and the land-use history, identification of old-growth locations in the Southern Region presents many challenges. As we have identified, there are countless ways to inventory and track OGCTs. Moving forward, we anticipate that a combination of remotely sensed data, FIA inventories and field plots, and field validation protocols will be essential in determining the existence and conditions of old-growth areas at various scales as we develop strategies to conserve and manage them.

5. OVERVIEW OF OLD-GROWTH FOREST COMMUNITY TYPES

Based on information provided by Southern Research Station scientists and national forest land managers, the Southern Region has created new or updated descriptions for old-growth forest community types to replace those in Gaines et al. (1997). These old-growth types cover a 13-State area where Forest Service ranger districts are present. The descriptions and other information in the following section are intended to help national forest managers identify and describe the current and desired future condition of old growth during forest and district-level projects. However, it is important to note that individual old-growth community types are broad, and considerable variation can occur within them. Plant community classification is not static and can be amended with new inYformation and a more complete field review. Therefore, variations can and will occur within the old-growth types across the very diverse Southern Region landscape.

These descriptions only address old-growth forest communities in the continental United States. We acknowledge that other old-growth communities such as prairies and coastal bogs exist and are of high ecological importance but describing them is beyond the scope of this report. There are also species significant to tribes that can be considered old-growth communities (Casey and Wynia 2010, Dinkins, n.d.), such as canebrakes and tall prairie grasses (e.g., *Andropogon gerardii*, *Panicum virgatum*, and *Sorghastrum nutans*.). Where nonforest old-growth communities abut old-growth forest, managers are encouraged to consider management options that benefit both. We did not include rare forest communities, such as bay forests or Atlantic white cedar (*Chamaecyparis thyoides*) forests, in our classification. We also acknowledge that typically short-lived forest types such as pond pine (*Pinus serotina*) are not included. Tropical forest community types, which occur in El Yunque National Forest in northeast Puerto Rico, are also not included but are addressed in the forest's land management plan (USDA Forest Service 2019). Lastly, we acknowledge that not all stands of old-growth forest will fit neatly into one of the 16 types. We suggest managers choose the type that best fits their specific site, the existing long-term species mix, and management options that may reasonably be implemented in the stand. Though we provide examples of where these communities can be found, they may extend beyond the administrative or ecological boundaries mentioned.

This section is designed to be a companion to the following sections in this report. Each OGCT description is self-contained and includes descriptive information about the community and its subtypes, disturbances, and threats. General, but not exhaustive examples of restoration or maintenance actions are included for management consideration. Each OGCT also includes examples of representative communities that approximate desired conditions for some, or all, of the attributes included in the Southern Region working old-growth definition. Later portions of each OGCT contain ecological classification information down to the national forest district, and suggested crosswalks to some of the most common forest-type classification systems. These classification systems may be national, regional, or subregional in extent, and may or may not have a spatial component.

5.1 Relationships to Other Classification Systems

All OGCTs include forest classification systems from Southern Region FSVeg, Society of American Foresters (Eyre 1980), and FIA (Bechtold and Patterson 2005). These classification systems describe current vegetation and focus primarily on tree composition with limited information on understory vegetation.

The following vegetation classification systems and community descriptions encompass the entire Southern Region, and are included in all OGCT descriptions:

- U.S. National Vegetation Classification (USNVC) systems (USNVC 2022) incorporates information about understory and herbaceous layers in addition to tree composition and includes a hierarchy of classification levels from coarse to fine scales.
- NatureServe Ecological Systems (Comer et al. 2003-present) incorporates information about understory and herbaceous layers and includes a hierarchy of classification levels from coarse to fine scales. Ecological Systems are linked to the USNVC systems, and the two are similar, but not identical. NatureServe's Ecological Systems are depicted spatially for the continental United States.
- LANDFIRE's biophysical settings (USDOI and USDA 2016) are a nationwide spatial representation of the vegetation that may have been dominant on the landscape prior to European settlement, and are based on NatureServe's Ecological Systems.

The following classification systems and community descriptions do not span the entire Southern Region but are included where appropriate:

- Ecological zones describe and spatially depict potential natural vegetation using NatureServe's systems and are modeled by using digital elevation model derivatives and extensive plot data. Mapping has been completed across both private and public lands within the north Atlantic Coastal Plain (Simon 2014, 2019), the north Piedmont (Simon 2011a, 2013), the central and southern Appalachian Mountains (Simon 2011a,b; 2016; Simon et al. 2005), and the Cumberland Mountains (Simon 2023).
- Florida Natural Areas Inventory is a hierarchical classification system of 81 natural communities, and is intended to depict "the original, natural biological associations of Florida" (FNAI 2010).
- Terrestrial Ecological Unit Inventory (USDA Forest Service 2005) is a hierarchical approach to classifying, mapping, and describing ecosystems based on biotic and abiotic factors that drive ecosystem formation. Within the Southern Region, it is currently used by the National Forests and Grasslands in Texas.

5.2 Geographic and Environmental Diversity in the Southern Region

Forest Service lands in the Southern Region extend across 10 provinces (Figure 5.2.a) and 37 sections (USDA Forest Service 2025, Figure 5.2.b). Environmental gradients across this area are extremely varied. For example, some OGCTs are found in areas exceeding 6,000 feet in elevation in the Blue Ridge Mountains section in the Appalachians (335E), and others are found near sea level within the Atlantic or Gulf Coastal Plain sections (345I, 345J, 345K, 345L) (Figure 5.2.b).

The 16 communities listed in table 5.2.a can be delineated by three broad classes of moisture conditions: wet, mesic, and dry mesic to xeric. A given province may contain more than one moisture class. As a result, some OGCTs have a large range that occurs across most of the provinces.

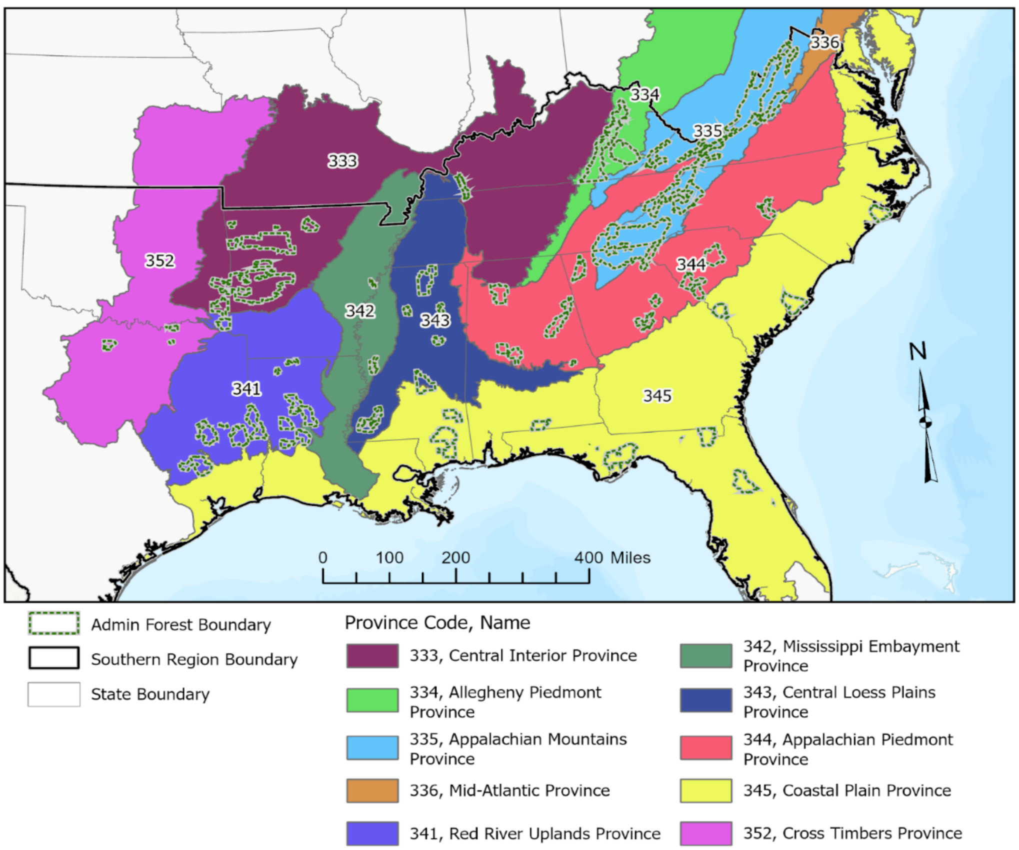

Figure 5.2.a—The 10 provinces within the Southern Region that contain Forest Service ranger districts.

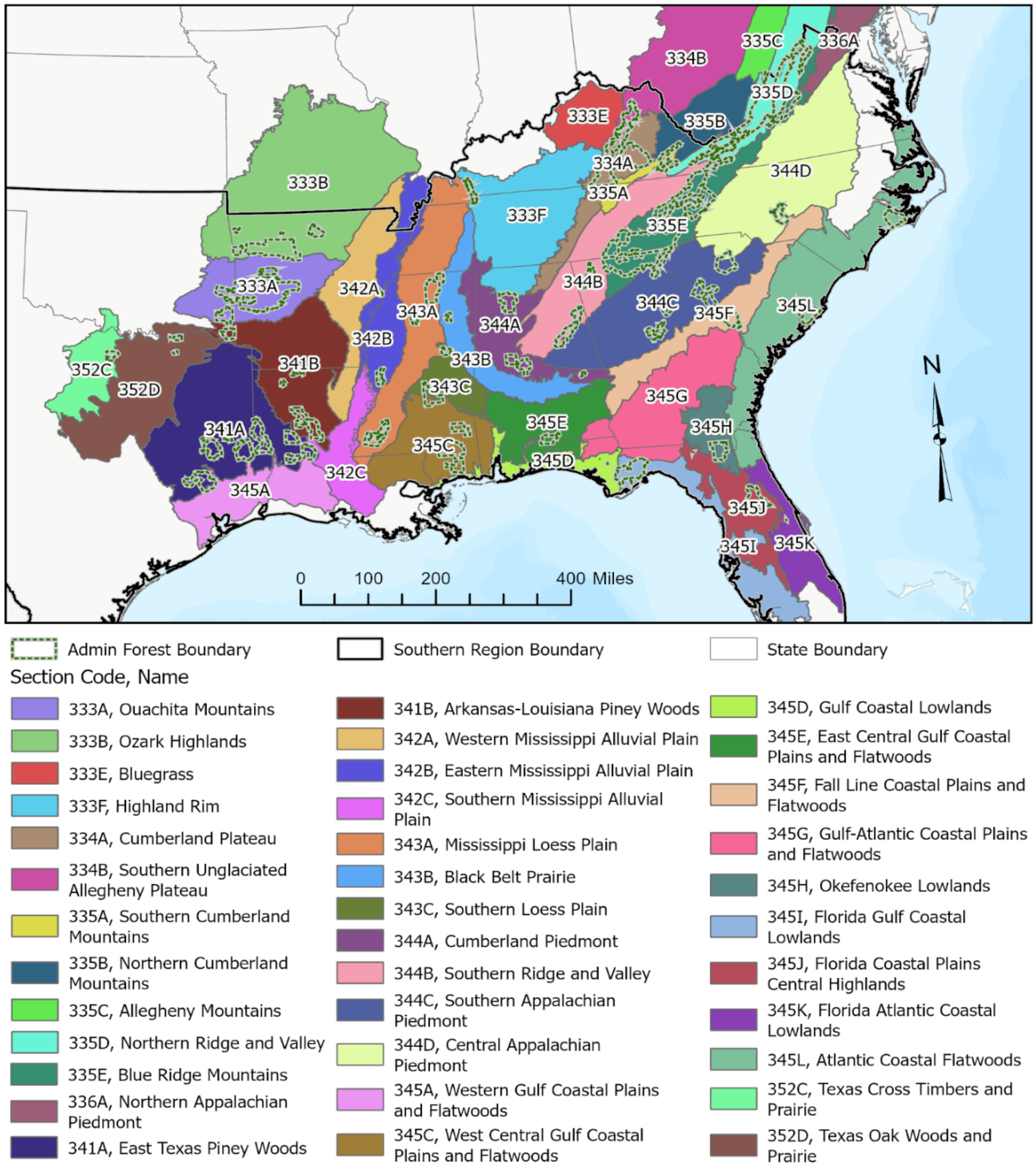

Figure 5.2.b—Map of the 37 sections within the Southern Region that contain Forest Service lands.

Table 5.2.a—OGCTs included in Southern Region provinces

OGCT number	OGCT name	Province
1	Northern hardwood forest	335
2	Mesic conifer hardwood forest	334, 335, 336, 344
5	Mixed mesophytic and western mesophytic forest	333, 334, 335, 336, 342
6	Coastal Plain upland mesic hardwood forest	341, 343, 345
10	Hardwood wetland forest	334, 335, 341, 342,343, 344, 345
13	River floodplain hardwood forest	341, 342, 343, 344, 345, 333, 334, 335
14	Cypress-tupelo swamp forest	341, 342, 343, 344, 345
21	Mesic and dry mesic oak forest	333, 334, 335, 336, 341, 342, 343, 344, 345
22	Dry and xeric oak forest, woodland, and savanna	333, 334, 335, 336, 341,343, 344, 345
24	Xeric pine and pine-oak forest and woodland	333, 334, 335, 336, 341, 344, 345
25	Dry and dry mesic oak-pine and pine-oak forest and woodland	333, 334, 335, 336, 341, 342, 343, 344, 345
26	Upland longleaf pine forest, woodland, and savanna	341, 343, 344, 345
27	Seasonally wet oak-hardwood woodland	333, 341, 342, 343, 344, 345
28	Eastern riverfront forest	333, 334, 335, 336, 341, 342, 343, 344, 345, 352
29	Southern wet pine forest, woodland, and savanna	341, 343, 344, 345
31	Montane and allied spruce and spruce-fir forests	335

OGCT = old-growth community type. Province names: 333 = Central Interior; 334 = Allegheny Piedmont; 335 = Appalachian Mountains; 336 = Mid-Atlantic; 341 = Red River Uplands; 342 = Mississippi Embayment; 343 = Central Loess Plains; 344 = Appalachian Piedmont; 345 = Coastal Plain; 352 = Cross Timbers.

The wettest portions of the landscapes include four types of forest: hardwood wetland forest (type 10), cypress (*Taxodium distichum*, *T. ascendens*)-tupelo (*Nyssa biflora*) swamp forest (type 14), wet oak-hardwood woodland (type 27), and southern wet pine (type 29). Except for the wet pine type, these wet old-growth habitats are small and less frequently encountered within the Southern Region. Hardwood wetland forest (type 10) can occur in nonriverine sites over a broad number of provinces, from the Blue Ridge to the Coastal Plain, but are uncommon and limited in size. In contrast, cypress-tupelo swamp forests (type 14) are limited to the Coastal Plain and occur in depressions that are frequently flooded. Seasonally wet oak-hardwood woodlands (type 27) can also be found in depressions or bottomland positions, but they are only seasonally wet, thus having more oak and hardwood diversity. Southern wet pine forests (type 29) include wetter longleaf pine (*Pinus palustris*) subtypes, pond pine, slash pine (*P. elliottii*), and pocosins occurring over the extent of the Coastal Plain provinces.

The mesic group includes a variety of old-growth forest types. The most geographically restricted old-growth type within the mesic group is montane spruce (*Picea rubens*) and spruce-fir (*Abies fraseri*) forest (type 31), which is only found in the Blue Ridge portion of the Central Appalachian Province. The northern hardwood forest (type 1) is found within more protected higher elevation concave slopes and also occurs in the Blue Ridge and the northern portion of the Ridge and Valley ecoregion. The mesic conifer-hardwood forest (type 2) also may occur in these areas, but at lower elevations on protected slopes over a greater area. Three subtypes have been delineated within the mesic conifer-hardwood OGCT, differentiated by the associated conifer species, primarily red spruce or primarily eastern hemlock (*Tsuga canadensis*) and the relative amount of eastern hemlock present. The three subtypes often have a dense evergreen *Rhododendron* layer limiting herbaceous layer diversity. In comparison, type 1 has a more open understory with much greater herbaceous diversity. The red spruce subtype often transitions to type 31. In contrast, type 1 often transitions to mixed mesophytic and western mesophytic forests (type 5), which occur within lower elevation concave slopes. OGCT 5 can occur within the Blue Ridge, Ridge and Valley, the Appalachian and Cumberland Plateaus, the Interior Highlands, and the Mississippi Plateau. This broad type often has the largest diameter trees and the greatest diversity in the understory. Within the inner and outer Coastal Plain, upland mesic hardwood forests (type 6) occur in the more protected, less fire-frequent portion of the landscape. Two remaining old-growth types within the broad mesic grouping include river floodplain hardwood forest (type 13), and eastern riverfront forest (type 28). Both types are scattered across a very broad range, potentially across all the provinces. They primarily differ in their topographic position; those next to rivers are type 13, versus those farther removed from streams and rivers, which are type 28. The former is more frequently impacted by recurring flooding, and the latter less so. Oaks (*Quercus* spp.) tend to be more common overstory species in OGCT 28.

The xeric and dry mesic groups primarily consist of a variety of oak and pine forests. These groups cover the largest portion of the Southern Region and include the types most adapted to fire. Differences can be delineated in the distributions of pines and oaks as well as the degree of dryness of habitats.

Xeric pine-oak (type 24), a pine-dominated type, occurs on the most xeric sites. This type includes two subtypes, one with a potentially diverse group of pines including pitch pine (*P. rigida*), Table Mountain pine (*P. pungens*), Virginia pine (*P. virginiana*), and shortleaf pine, (*P. echinata*), and the other subtype contains shortleaf pine. The former subtype occurs east of the Mississippi River from the Blue Ridge and Cumberland Mountains into the piedmont and the Atlantic and Gulf Coastal Plains. The latter shortleaf pine subtype occurs west of the Mississippi River, primarily within the Ozark Highlands and Ouachita Mountains. The other dominant pine type, the upland longleaf pine (type 26), occurs across much of the Coastal Plain and lower piedmont. A variety of separate subtypes occur within this longleaf type defined by soil moisture content and associated vegetation.

The xeric and dry mesic group also includes oak-dominated types. Xeric oak (type 22) is similar to xeric pine-oak (type 24). However, in type 22, pine is present as a relatively minor component. There are two subtypes, which are separated geographically. The coastal type is found next to longleaf or slash pine communities and includes small-statured oaks such as turkey oak (*Quercus laevis*) or bluejack oak (*Q. incana*). The other subtype occurs outside the Coastal Plain across much of the Southern Region, both east and west of the Mississippi River. Both dry and dry mesic oak-pine and pine-oak (type 25) and mesic and dry mesic oak (type 21) occur in more submesic sites and are typically dominated by oaks. Type 21 does not have greater than 25 percent pine dominance. Type 21 has two subtypes, high-elevation red oak, and mesic and dry mesic oak. High-elevation red oak (*Quercus rubra*) is restricted to the Blue Ridge. Mesic and dry mesic oak is found from mid and lower mountain sites to the Piedmont and Coastal Plain across the extent of the Southern Region. In contrast, type 25 can be codominant with pines, particularly shortleaf pine. This type has a broad range from mountainous slopes to scattered uplands in the piedmont and coastal plains. It is often adjacent to the drier type 24.

5.3 Summary Attributes of Common Old-Growth Community Types

In an effort to support field identification, the old-growth team created a summary database of key characteristics for common OGCTs available in the literature. Describing old growth quantitatively is a difficult task. The authors spent extensive time discussing the results of the literature review (Woodbridge et al. 2025) and how to interpret available data. Stand age was a particularly challenging concept. How does one describe the age of a multicohort stand? How many old trees must be present (and in what density) to make the stand old? When there is a wide range of values represented in the literature for a given characteristic, how should we choose a single value as a cutoff?

The characteristics discussed below can be used to make a determination of potential old growth in the field. We acknowledge that there may be sites that could be considered old growth that do not meet all of the criteria. The expert opinion of managers familiar with local communities may suggest different old-growth conditions, or unique conditions may result in old growth occurring outside our listed parameters (e.g., extreme edaphic conditions resulting in particularly stunted trees). We also acknowledge that a site that meets all these criteria may not be good quality or condition (e.g., invasive species are present and extensive). Finally, the Southern Region encompasses large environmental gradients. The most appropriate criteria for a specific OGCT may differ based on where it is found. These thresholds represent a summary for the entire Southern Region. If they seem inappropriate for local conditions, consider reviewing the ranges represented in the tables in this section or the database.

As stated in section 2, the most basic definition of old growth is a forest or woodland community whose overstory contains a minimum density of sufficiently old, site-appropriate trees. The operational definitions employed by Gaines et al. (1997), modified in this section, constitute criteria for identifying and delineating old-growth forests in the field. Determination of old-growth status can be made drawing upon the estimated age of the oldest age class present in the stand, minimum basal area, and tree size (stem d.b.h.). If inventory procedures indicate that a stand (or within-stand inclusion patch) meet minimum age, density, and tree size requirements, then the area may be considered old growth.

We retained the basic characteristics utilized by Gaines et al. (1997; age, density, and basal area), for two reasons: 1) age is a foundational characteristic of old-growth communities, and 2) in addition to tree size and density, is commonly sampled. Many foresters are also familiar with sampling procedures used to estimate these characteristics. We also updated the estimates of the given characteristics in several ways:

- We accumulated data from a variety of sources, both from recent literature and historical sources. For a detailed annotation of the vast majority of the sources used, see Woodbridge et al. (2025) and the old-growth literature database (Woodbridge, in press).
- We created subtypes to reflect additional variation for some OGCTs. These subtypes represent distinct, discernable variations in vegetation, which nonetheless on a broad scale can be considered part of a single OGCT. These are highlighted to help land managers determine the OGCT in which they are working.

- We added additional metrics beyond live trees, including characteristics related to the herbaceous layer and dead wood.
- We worked to outline the variation observed within OGCTs found across the region. Tables throughout this section represent a summary of an expansive compendium of available literature for the majority of communities for which data were reported.

Subjectivity, bias, and other limitations inherent to sampling

Experience over several decades has shown that identifying or delineating old-growth communities can be contentious and fraught with disagreements related to definitions. Complexities associated with spatial or temporal scale, disturbance regimes, and the presence of nonnative species or damage agents are some of the most important, but by no means only, reasons that people may disagree on the acre-by-acre old-growth status in a forest. Several points warrant consideration when evaluating the summary characteristics included in the tables throughout this section.

Even when agreement exists over the precise definition of an old-growth community, determining or delineating old-growth status can be complicated by a number of additional factors. When working to sample old-growth forests, as with many aspects of ecology and forestry, managers encounter a variety of challenges when attempting to balance time, resources, practicality, sample error, accuracy, and precision. Despite the obvious utility of tree-age data, for example, it is rarely—if ever—feasible to core every tree with an increment-borer on every acre for every planned management project. Practical limitations necessitate a sampling scheme and associated inferences as well as potential sample error. Data may be systematically and objectively collected and reported, but subjectivity and human judgement often still underlay data evaluation and development of forest management diagnoses and prescriptions. To take one obvious example, the acceptability of sampling intensity, confidence intervals, or sample error is an inherently arbitrary determination, about which reasonable parties may disagree. Sampling schemes may also reasonably or appropriately show bias in favor of emphasized characteristics. One such example with relevance to old growth involves estimating stand age by sampling oldest trees based on unique form and bark characteristics rather than stem d.b.h. (e.g., section 3.1). Though managers may accept a certain degree of subjectivity in evaluating data, they should nevertheless strive for consistency, transparency, and sound rationale. This is essential to consider when evaluating the data summarized below, and when determining a sampling approach.

Bias may also be represented in stands that were sampled. Large and charismatic trees may have been sought, or more frequently considered old growth, but large tree size is not always indicative of old growth. For example, the pineywoods of central Alabama had longleaf pine that were typically 15 inches in d.b.h. and 150 years old; 30-inch d.b.h. longleaf were about 300 years old (Reed 1905). Some longleaf and loblolly pines in this tract exceeded 40 inches d.b.h. (one loblolly reached 65 inches d.b.h.) and tuliptrees (*Liriodendron tulipifera*) were found >50 inches d.b.h., but specimens >30 inches d.b.h. were rare for all species (Reed 1905). A small (5-acre) mixed 150-year-old pine and hardwood stand on a poorly drained site in eastern Texas had loblolly pine up to 33 inches d.b.h., but on average less than one pine per acre exceeded 30 inches d.b.h. (Zon 1905), a pattern reported in other studies (Schwarz 1907). We pulled information from the available data, but recognize that the stands studied likely do not represent an unbiased sample of old-growth communities across the landscape. In short, we accumulated the best available data, but there is a need for more extensive, statistically robust sampling of old growth.

Departures from historic conditions

Determination of old-growth status can be further complicated by departures from historic disturbance regimes or damage agents and associated structural or compositional conditions. It may not be possible or reasonable to assign old-growth status to a forest where such status may not be retained over time or is otherwise ecologically distinct from prevailing historical conditions at the site. For example, fire suppression has likely increased density and changed the composition of communities that experienced more frequent or intense fire prior to widespread suppression. Alternatively, stands where the fire regime has been maintained are less likely to have as much dead wood, which has a much shorter presence on the landscape with regular burning (regardless of stand age). Community types that adapted alongside regular or severe disturbance regimes may be less likely to maintain higher densities of old trees, coarse woody debris, and uneven-aged structure, regardless of the state of current, fire-suppressed examples (Carlson 1995, Yost et al. 1994).

Additionally, invasive pests and pathogens have changed stands. Often forests are not as old as expected because of invasive species. For example, many red oak-dominated forests once had a large proportion of chestnut. The widescale loss of American chestnut (*Castanea dentata*), a dominant long-lived species, removed a large portion of old trees from forest communities. These stands would likely contain many older trees if chestnut was still present as a canopy species, but only the younger cohort of oak remains. Balsam woolly adelgid (*Adelges piceae*) has also drastically changed the age, density, basal area, and maximum tree diameters of stands with Fraser fir (McManamay et al. 2011). A similar trend is being observed with the death of eastern hemlock from hemlock woolly adelgid (*Adelges tsugae*).

Gaines et al. (1997) stated that “To many people interested in old-growth issues, past human disturbance is important in determining an area’s status as existing old growth.” They go on to note that “the acceptable level of past human disturbance can prove difficult to quantify.” We agree that past human disturbance is difficult to quantify and note that humans have been an integral part of landscapes in the Southeast well before European colonization (see section 2.1). Additionally, as much of the land base for Southern Region forests was cutover and frequently farmed (see section 2.1), removing areas with any past human disturbance from old-growth consideration could severely limit areas where old growth could occur. We put forward a qualitative description for whether human disturbance precludes designation as old growth: for a stand to be considered existing old growth, little to no obvious evidence of past human disturbance which conflicts with old-growth characteristics should be present. Evidence conflicting with old-growth characteristics may include dominance by early successional trees, or large, old roadbeds or logging cables. Alternatively, the presence of commercially valuable tree species, especially if they are old or large, is evidence that commercial logging and other human disturbance was less likely in the area of interest (e.g., large black cherry (*Prunus serotina*) in a northern hardwood stand, Yost et al. 1994; see table 5.3.a for additional examples).

Human activities, in particular those that maintain characteristics consistent with old growth, should not immediately disqualify an area as existing old growth. Examples of these activities may include commercial thinnings, midstory treatments, prescribed fire, or interpretive trails.

Table 5.3.a—Example of commercially valuable species targeted during early logging operations in the southern Appalachian Mountains, specifically Great Smoky Mountains National Park. Adapted from appendix A in Yost et al. (1994)

Species	Lumber	Chemical/acid	Pulpwood	Tannin
American chestnut	x	x	x	–
American beech	x	–	x	–
Ash species	x	–	x	–
Basswood	x	x	x	–
Birch species	x	–	x	–
Black cherry	x	–	x	–
Eastern hemlock	–	x	x	x
Hickory	x	–	x	–
Magnolia species	x	x	x	–
Chestnut oak	x	x	x	x
Red oak group	x	–	x	–
White oak group	x	–	x	–
Pine spp.	x	–	x	–
Red maple	x	x	x	–
Red spruce	–	x	x	–
Silverbell	x	–	x	–
Sugar maple	x	–	x	–
Tuliptree	x	x	x	–
Yellow buckeye	x	–	x	–

x = species were used for listed products, though not by all timber companies operating within Great Smoky Mountains National Park.

Age-related considerations

A foundational element of old-growth inventory involves measuring or assessing defining characteristics. Most of the time managers can only measure some features of interest. In many cases, the central feature of old growth is age and the associated biotic and abiotic features (e.g., well-developed soil or herbaceous layers, large decayed wood) that have developed over long time scales—often but not always in the absence of severe disturbance. However, many of those features are difficult to quantify, which is partly why tree age has been a popular means of classifying old growth. Tree size is easier to measure than tree rings, which themselves are easier to count than it is to assess the herb or fungal components of a system. Despite its importance in old growth as a concept, and the commonality of its use to identify old growth, cohort or stand age is often a difficult metric to assess, particularly for uneven-aged stands.

Most of the old-growth stands in the literature we reviewed were multiaged. Multiage or uneven-age stand structures were common historically and remain so today, though there are exceptions and this can vary by community type. Even in an account of a longleaf stand from 1909, age classes were described as having fine-scale spatial variation and patchiness across the landscape:

> The longleaf pine is found in pure stands but seldom even-aged. Although an extremely intolerant tree, which will thrive best in even-aged stands, the natural form of this forest constantly trends toward small, even-aged groups of a few hundred square feet (Chapman 1909).

As a result of spatial and temporal variation of tree establishment and mortality or survival, the age of many old-growth stands is often complicated to both measure and describe. Although we do not consider individual old trees to represent old growth, we recognize the variety of ages observed in old-growth stands. Keeping this in mind, evaluating the age of older trees in a stand necessitates either extensive coring or some other accurate evaluation of those trees likely to be relatively old. We recommend choosing species that are prone to long life and individuals that maintain characteristics associated with advanced age. Table 5.3.b summarizes species potential age, and those species from each forest type that may be good candidates for coring.

Table 5.3.b—Maximum age by species organized by community types in the Southeastern United States. Ages are from individuals found throughout the eastern US

Category	Old-growth community type	Subtypes	Tree species	Maximum age
Hydric	**Hardwood wetland forest**	**No subtypes**	*Acer rubrum*	300
			Liquidambar styraciflua [1]	350
			Quercus pagoda [1]	300
			Quercus phellos	–
			Quercus palustris [1]	300
			Quercus michauxii	–
	Cypress-tupelo swamp forest	**No subtypes**	*Taxodium distichum*	2,624
			Taxodium ascendens	417
			Nyssa aquatica [1]	300
	Seasonally wet oak-hardwood woodland	**No subtypes**	*Quercus lyrata*	218
			Quercus phellos	–
			Pinus taeda	246
			Quercus laurifolia	–
	Southern wet pine forest, woodland, and savanna	**No subtypes**	*Pinus palustris*	458
			Pinus serotina	–
			Pinus elliottii [2]	250

Table 5.3.b—Maximum age by species organized by community types in the Southeastern United States. Ages are from individuals found throughout the eastern US (continued)

Category	Old-growth community type	Subtypes	Tree species	Maximum age
Mesic	**Northern hardwood forest**	**No subtypes**	*Betula alleghaniensis*	387
			Acer saccharum	330
			Fagus grandifolia	246
	Mesic conifer-hardwood forest	**Hemlock-hardwood**	*Tsuga canadensis*	555
			Betula alleghaniensis	387
			Betula lenta	361
			Acer saccharum	330
		Red spruce-northern hardwood	*Picea rubens*	445
			Betula alleghaniensis	387
			Acer saccharum	330
			Fagus grandifolia	246
		Acidic cove	*Liriodendron tulipifera*	509
			Betula lenta	361
			Quercus rubra	326
			Quercus montana	427
			Acer rubrum	300
	Montane and allied spruce and spruce-fir forest	**No subtypes**	*Picea rubens*	445
			Abies fraseri [2]	170
			Betula alleghaniensis	387
			Sorbus americana	–
	Mixed mesophytic and western mesophytic forests	**Western mesophytic forests**	*Quercus alba*	464
			Acer saccharum	330
			Carya ovata	354
			Quercus rubra	326
		Mixed mesophytic forests	*Liriodendron tulipifera*	509
			Tilia americana [1]	242
			Aesculus flava	410
			Acer saccharum	330
			Fagus grandifolia	246
	Coastal Plain upland mesic hardwood forest	**No subtypes**	*Fagus grandifolia*	246
			Nyssa biflora [3]	679
			Quercus michauxii [1]	200
			Magnolia grandiflora [2]	120

Table 5.3.b—Maximum age by species organized by community types in the Southeastern United States. Ages are from individuals found throughout the eastern US (continued)

Category	Old-growth community type	Subtypes	Tree species	Maximum age
Mesic (continued)	**River floodplain hardwood forest**	**No subtypes**	*Fraxinus* spp.	–
			Platanus occidentalis	412
			Liquidambar styraciflua [1]	350
			Acer saccharinum [1]	200
			Acer negundo	–
	Eastern riverfront forest	**No subtypes**	*Platanus occidentalis*	412
			Betula nigra [1]	156
			Populus deltoides [1]	200
			Prunus serotina [1]	300
			Acer saccharinum	–
Xeric	**Dry mesic oak forest**	**Mesic and dry mesic oak forest**	*Quercus alba*	464
			Quercus rubra	326
			Quercus montana	427
			Fagus grandifolia	246
			Quercus velutina	257
		High elevation red oak	*Quercus rubra*	326
			Castanea dentata	270
	Dry and xeric oak forest, woodland, and savanna	**Mountains and piedmont**	*Quercus velutina*	257
			Quercus stellata	395
			Quercus montana	427
			Quercus coccinea	212
		Xeric longleaf pine or oak barrens	*Quercus alba*	464
			Quercus falcata	141
			Quercus laevis	–
			Quercus incana	–
			Quercus stellata	395
			Pinus palustris	458

Table 5.3.b—Maximum age by species organized by community types in the Southeastern United States. Ages are from individuals found throughout the eastern US (continued)

Category	Old-growth community type	Subtypes	Tree species	Maximum age
Xeric (continued)	**Xeric pine and pine-oak forest and woodland**	**Xeric pine and pine-oak in mountains and piedmont**	*Pinus rigida*	398
			Quercus montana	427
			Pinus virginiana	126
			Pinus echinata	324
			Pinus pungens	271
			Quercus coccinea	212
		Shortleaf pine and chestnut oak west of Mississippi	*Pinus echinata*	324
			Quercus stellata	395
			Quercus coccinea	212
			Quercus falcata	141
	Dry and dry mesic oak-pine and pine-oak forest	**No subtypes**	*Quercus alba*	464
			Pinus echinata	324
			Quercus velutina	257
			Pinus virginiana	126
			Quercus montana	427
			Pinus rigida	398
	Upland longleaf pine forest, woodland, and savanna	**Mesic longleaf pine flatwoods**	*Pinus palustris*	458
			Pinus taeda	246
			Pinus echinata	324
		Dry mesic loamy longleaf pine woodland	*Pinus palustris*	458
			Quercus falcata	141
			Quercus margarettae	234
		Xeric longleaf pine woodland	*Pinus palustris*	458
			Quercus laevis	–
			Quercus incana	–
		Mountain/piedmont longleaf pine woodland	*Pinus palustris*	458
			Pinus echinata	324

– = a typical to frequent species of the old-growth community type, but maximum age data are not present in the reference.

Maximum age values are from the Eastern OLDLIST (2025) database unless otherwise noted.

As old-growth community type community inventory information is gathered from the literature, updates to the specific attributes will be reflected in the updated old-growth database.

[1] From Hayek (2019).

[2] From Loehle (1988).

[3] Value used for *Nyssa sylvatica* from Sperduto et al. (2000) via Abrams (2007).

Defining old growth in terms of the minimum age of the oldest age class requires a definition of age class or cohort. Extreme definitions may assume an age class to consist of a single tree in a stand, or, in the case of Gaines et al. (1997), ≥30 trees per acre (tpa) in hardwood old-growth types. We assessed hundreds of studies where stand ages were reported, and, ideally, where age classes or regeneration cohorts may have been quantitatively defined (e.g., >6 tpa, or >10 percent of total stocking with <10 percent age variation across the class).

Given the strongly uneven-aged nature of the majority of the stands summarized, and that some OGCTs have low stand density (low tpa), we summarized age data for OGCTs in four ways, recognizing no single age value accurately represents the complexity of tree ages present in a stand (table 5.3.c). This table allows managers to see the variation in minimum age of oldest age class by using various density cutoffs to define the cohort of oldest trees within the stand.

Table 5.3.c—Old-growth forest overstory age attributes by common old-growth community types (old-growth code) in the Southeastern United States

Category	Old-growth community types	Subtypes	Old-growth code	Age of oldest trees	Minimum age: oldest age class	Minimum age: 6 trees per acre (15 trees/ha)	Minimum age: 12 trees per acre (30 trees/ha)
Hydric	**Hardwood wetland forest**	No subtype delineated	10	–	–	–	–
	Cypress-tupelo swamp forest	No subtype delineated	14	670 (200–800)	340 (170–500)	220 (60–380)	670 (200–800)
	Seasonally wet oak-hardwood woodland	No subtype delineated	27	140 (80–200)	–	–	140 (80–200)
	Southern wet pine forest, woodland, and savanna	No subtype delineated	29	100 (60–150)	–	–	100 (60–150)
Mesic	**Northern hardwood forest**	No subtype delineated	1	420 (420–420)	140 (100–180)	–	–
	Mesic conifer-hardwood forest	Hemlock-northern hardwood forest	2a	340 (150–500)	220 (150–270)	210 (130–290)	170 (50–250)
		Acidic cove	2b	–	260 (230–290)	220 (220–220)	170 (170–170)
		Red spruce-northern hardwood forest	2c	250 (190–300)	–	190 (170–200)	130 (130–130)
	Montane and allied spruce and spruce-fir forest	No subtype delineated	31	220 (170–260)	170 (110–210)	220 (170–260)	220 (170–260)
	Mixed mesophytic and western mesophytic forests	Western mesophytic forests	5a	250 (210–300)	–	–	–
		Mixed mesophytic forests	5b	270 (100–410)	200 (130–300)	180 (100–230)	140 (120–160)
		Undetermined	5	240 (240–240)	–	170 (170–170)	150 (150–150)
	Coastal plain upland mesic hardwood forest	No subtype delineated	6	240 (160–300)	190 (110–250)	–	–
	River floodplain hardwood forest	No subtype delineated	13	120 (120–120)	60 (60–60)	–	–
	Eastern riverfront forest	No subtype delineated	28	420 (420–420)	140 (100–180)	–	–

Table 5.3.c—Old-growth forest overstory age attributes by common old-growth community types (old-growth code) in the Southeastern United States (continued)

Category	Old-growth community types	Subtypes	Old-growth code	Age of oldest trees	Minimum age: oldest age class	Minimum age: 6 trees per acre (15 trees/ha)	Minimum age: 12 trees per acre (30 trees/ha)
Xeric	**Dry mesic oak forest**	Mesic and dry mesic oak forest	21a	240 (120–350)	200 (130–290)	170 (110–220)	130 (80–190)
		High elevation red oak	21b	270 (270–270)	220 (220–220)	180 (180–180)	130 (130–130)
	Dry and xeric oak forest, woodland, and savanna	Mountains and piedmont	22a	240 (90–350)	250 (140–340)	190 (120–270)	140 (70–220)
		Xeric longleaf pine or oak barrens	22b	220 (210–240)	140 (120–160)	170 (160–190)	70 (60–70)
	Xeric pine and pine-oak forest and woodland	Xeric pine/pine-oak in mountains/ piedmont	24a	200 (130–320)	140 (90–190)	170 (130–200)	140 (90–190)
		Shortleaf pine and chestnut oak west of Mississippi	24b	170 (80–250)	110 (70–150)	150 (150–160)	140 (120–150)
	Dry and dry mesic oak-pine and pine-oak forest	No subtype delineated	25	270 (170–360)	120 (70–180)	–	–
	Upland longleaf pine forest, woodland, and savanna	Dry mesic/mesic longleaf flatwoods and woodlands	26ab	250 (160–450)	130 (100–190)	–	–
		Xeric longleaf pine woodland	26c	–	100 (100–100)	350 (350–350)	310 (310–310)
		Mountain/piedmont woodland	26d	220 (150–260)	160 (90–200)	140 (120–160)	100 (80–140)
		Undetermined	26	320 (210–400)	120 (100–140)	–	–

– = no data.

First number in last four columns is the mean value for all relevant studies; values in parentheses are minimum and maximum observed values. Ranges represent differences in tree species composition and site quality or environmental condition, including variation in disturbance history, elevation, topography, slope, aspect, and soil. Additionally, this variation may also represent sampling bias, because this is a summation of a variety of sources (e.g., more dramatic stands with large trees may have been more likely to be sampled). This may be more pronounced in old-growth community types that contain more stunted examples with smaller trees. Additionally, in fire-adapted systems, recent fire suppression may also bias values.

Age of oldest trees are data on the oldest tree that was aged in each stand.

Minimum age: oldest age class, minimum age with 6 trees per acre, and minimum age with 12 trees per acre were estimated using available tree age data.

The values summarized in this table were derived from a literature review where values were obtained from relevant studies. Not all columns have values because of the lack of applicable data in the reviewed studies.

For studies where quantitative definitions did not exist but tree establishment dates were reported, we subjectively determined oldest age class by using professional judgement, and assigned a minimum age for that class. When authors suggested a given cutoff for the oldest age class in the data they summarized, we generally selected that value. In general, we erred towards including fewer trees within the oldest age class, and therefore a higher minimum age, as a conservative rule of thumb. These lower density values, in other words, using fewer trees per unit area to determine an age cutoff also increased our sample size, because many studies only aged a small subset of trees. As a complement to this subjectively estimated age class, we used density as an alternate determination for an oldest age class cutoff. We also evaluated minimum age of the oldest age class using two potential density cutoffs: 6 and 12 trees per acre. Our work retains consistency with Gaines et al. (1997) with respect to the age-related attribute utilized: minimum age of the oldest age class for some minimum of trees per acre that constitute an age class. We also build upon that of Gaines et al. (1997) by more explicitly and methodically considering and connecting minimum age and density and size attributes reported in research literature for various community types and a number of possible threshold densities for stand age classes (table 5.3.c) for additional evaluation and consideration by local managers and other users of this report.

For the studies we assessed, minimum age of the oldest age class typically displayed a negative relationship with the minimum number of trees required to constitute an age class. If age class was defined as ≥12 trees per acre, ages for the oldest age class tended to be lower.

Based on our literature review, managers can use an oldest age class cutoff where at least six trees per acre meet that cutoff. However, local users of this report may consider other data to make site-specific determinations. Managers working in old growth may want to determine which value, or suite of values, is most appropriate given the stand they are working in and objectives of the project.

Table 5.3.d provides this report's operational definition for identifying old growth. Table 5.5 provides the minimum age for the oldest age class for each old-growth forest community type. This criterion would be applicable to both even- and uneven-aged stands. The old-growth operational values (table 5.5) use basal area for trees >4 inches d.b.h., but table 5.3.e contains additional information on basal area and trees per acre for OGCTs including ranges, and how they differ based on minimum diameter cutoffs. Some studies included basal area for different diameter classes or all diameter classes.

Because old-growth communities consist of more than just the overstory trees, we looked for measures of species richness and dead wood in the literature. The appendix (in production) provides ranges for herbaceous species richness, where available, for each OGCT. This information does not list which species might be expected or designate good condition within an OGCT, but may help assess whether species diversity is within expected ranges. Details on tree and herb species associated with each OGCT are found in section 6. Snags and downed wood are an important component of old-growth communities, though the size and distribution vary by OGCT and associated disturbance regimes. Table 5.3.f summarizes information about snags and downed wood by OGCT, where information was available. Downed woody debris and snags are the mean from the reviewed references of the amount of coarse woody debris in each stand per unit area.

Table 5.3.d—Operational criteria for old-growth forest identification by common old-growth community types (old-growth code) in the Southeastern United States

Category	Old-growth community types	Subtypes	Old-growth code	Minimum age: oldest age class (years)	Basal area (ft^2 per acre) >4 inches d.b.h.	D.b.h. of largest trees (inches)
Hydric	**Hardwood wetland forest**	No subtype delineated	10	150	117	45
	Cypress-tupelo swamp forest	No subtype delineated	14	220	81	20
	Seasonally wet oak-hardwood woodland	No subtype delineated	27	120	479	40
	Southern wet pine forest, woodland, and savanna	No subtype delineated	29	120	–	20
Mesic	**Northern hardwood forest**	No subtype delineated	1	140	115	23
	Mesic conifer-hardwood forest	Hemlock-northern hardwood forest	2a	130	87	24
		Acidic cove	2b	170	–	23
		Red spruce-northern hardwood forest	2c	130	–	19
	Montane and allied spruce and spruce-fir forest	No subtype delineated	31	190	135	15
	Mixed mesophytic and western mesophytic forests	Western mesophytic forests	5a	–	83	26
		Mixed mesophytic forests	5b	130	112	13
		Undetermined	5	–	105	28
	Coastal Plain upland mesic hardwood forest	No subtype delineated	6	150	115	9
	River floodplain hardwood forest	No subtype delineated	13	190	87	24
	Eastern riverfront forest	No subtype delineated	28	90	161	25
Xeric	**Dry mesic oak forest**	Mesic and dry mesic oak forest	21a	130	78	13
		High elevation red oak	21b	130	176	23
	Dry and xeric oak forest, woodland, and savanna	Mountains and piedmont	22a	140	83	21
		xeric longleaf pine or oak barrens	22b	70	77	21
	Xeric pine and pine-oak forest and woodland	Xeric pine and pine-oak in mountains and piedmont	24a	140	–	15
		Shortleaf pine and chestnut oak west of Mississippi	24b	110	80	11
	Dry and dry mesic oak-pine and pine-oak forest	No subtype delineated	25	120	65	11
	Upland longleaf pine forest, woodland, and savanna	Dry mesic/mesic longleaf flatwoods and woodlands	26ab	150	58	29
		Xeric longleaf pine woodland	26c	100	23	30
		Mountain/piedmont longleaf pine woodland	26d	100	36	22

– = no data.

The minimum age of the oldest age class is the mean value of the age of the youngest tree within the oldest age cohort. The mean basal area for trees >4 inches d.b.h. was reported. The d.b.h. of largest trees is the mean value of the d.b.h. of the largest reported tree in the stands sampled. The values summarized in this table were derived from a literature review where values were obtained from relevant studies. For additional information on variation or other characteristics by old-growth community type, see additional tables in section 5.

Table 5.3.e—Old-growth overstory attributes by old-growth community type (old-growth code) in the Southeastern United States

Category	Old-growth code	D.b.h. of largest trees (inches)	Basal area (ft^2 per acre) >4 inches d.b.h.	Tree density (trees per acre) >4 inches d.b.h.	Basal area (ft^2 per acre) >2 inches d.b.h.	Tree density (trees per acre) >2 inches d.b.h.	>x inches	Basal area (ft^2 per acre) >x inches d.b.h.	Tree density (trees per acre) >x inches d.b.h.
Hydric	**10**	59 (45–73)	125 (117–133)	126 (126–127)	–	–	10	102	41
	14	52 (20–144)	272 (81–494)	217 (90–266)	80	–	20	251 (48–384)	36 (12–73)
	27	43 (40–45)	1,254 (479–2,302)	125 (40–205)	–	–	13	25	34 (34–34)
	29	30 (20–48)	–	74 (18–138)	–	–	12	73 (73–73)	30
Mesic	**1**	29 (23–44)	143 (115–170)	320 (320–320)	156 (107–204)	434 (239–576)	20	129 (129–129)	23 (12–34)
	2a	49 (24–142)	152 (87–227)	151 (68–272)	270 (162–366)	260 (138–494)	10	314 (311–318)	266 (261–271)
	2b	40 (23–65)	–	–	378 (167–486)	251 (179–358)	–	–	–
	2c	22 (19–24)	–	–	228 (155–300)	498 (352–643)	–	–	–
	31	30 (15–48)	200 (135–329)	226 (98–565)	179 (7–329)	387 (61–1267)	0	203 (151–245)	744 (287-2,258)
	5a	39 (26–57)	108 (83–131)	196 (98–334)	160 (139–182)	251 (213–289)	12	92 (73–111)	52 (49–55)
	5b	41 (13–72)	155 (112–335)	170 (55–404)	192 (154–257)	277 (195–384)	10	817 (112–3,239)	168 (20–279)
	6	28 (9–50)	141 (115–171)	151 (123–182)	217 (178–256)	–	20	71 (52–105)	21 (16–28)
	13	38 (24–60)	160 (87–234)	158 (89–251)	191 (160–222)	377 (248–506)	13	21 (19–23)	19 (13–26)
	28	44 (25–72)	190 (161–218)	108 (32–179)	–	–	–	–	39 (32–44)
Xeric	**21a**	30 (13–67)	126 (78–157)	251 (189–381)	174 (132–231)	307 (227–519)	0	124 (96–139)	602 (267–1,052)
	21b	28 (23–33)	176	201 (201–201)	155 (118–193)	275 (194–356)	0	105	1076
	22a	24 (21–25)	110 (83–157)	176 (91–317)	154 (133–180)	333 (283–372)	8	–	19 (15–24)
	22b	25 (21–28)	86 (77–95)	189 (128–251)	–	–	–	–	–
	24a	20 (15–25)	–	–	119 (69–254)	387 (206–569)	–	–	–
	24b	27 (11–37)	113 (80–140)	100 (65–121)	104 (94–115)	625	12	45	22
	25	61 (11–156)	98 (65–148)	394 (44–556)	99 (62–136)	262 (82–442)	20	31 (0–71)	15 (0–40)
	26ab	36 (29–40)	60 (58–62)	–	–	–	–	–	30 (25–36)
	26c	32 (30–34)	23 (23–23)	–	–	104	–	–	–
	26d	39 (22–71)	46 (36–57)	118 (115–121)	78	355	–	–	–
	26	37 (18–83)	48 (0–110)	35 (0–100)	109 (70–148)	65 (0–167)	6	126	128

– = no data.

First number in each column is the mean value for relevant studies; values in parentheses are minimum and maximum observed literature values. Ranges represent differences in tree species composition and site quality or environmental condition, including variation in disturbance history, elevation, topography, slope, aspect, and soil. Additionally, this variation may also represent sampling bias, because this is a summation of a variety of sources (e.g., more dramatic stands with large trees may have been more likely to be sampled). This may be more pronounced in old-growth community types that contain more stunted examples with smaller trees. Additionally, in fire-adapted systems, recent fire suppression may also bias values.

Basal area and tree density estimates for all trees >2 inches and >4 inches in d.b.h. illustrates variation in stand conditions and available data. Additional diameter cutoffs are included, represented by x, when commonly available in the literature. When x = 0, basal area refers to the basal area of any tree taller than 4.5 feet (1.37 m).

Table 5.3.f—Downed woody debris (DWD) and snag attributes by common forest types (old-growth code) in the Southeastern United States

Category	Old-growth code	DWD			Tree richness (# species)	Snags		
		Number/ha	Mg/ha	m^3/ha		Number/ha	m^2/ha	Mg/ha
Hydric	**10**	–	–	–	32 (19–46)	–	–	–
	14	–	–	202.00 (72.00–336.00)	6 (3–9)	145 (63–270)	8.60 (8.60–8.60)	–
	27	–	–	–	13 (11–15)	69 (0–185)	–	–
	29	–	–	–	–	9 (4–14)	–	–
Mesic	**1**	–	–	–	9 (5–19)	49 (3–181)	–	–
	2a	–	40.50 (37.00–44.00)	48.00 (0–208.00)	12 (5–23)	18 (4–30)	4.00 (3.00–5.30)	11.00 (6.00–16.00)
	2b	–	41.00 (41.00–41.00)	172.00 (172.00–172.00)	4 (2–5)	25 (25–25)	7.70 (3.50–15.70)	13.00 (13.00–13.00)
	2c	–	–	–	6 (4–6)	–	–	–
	31	692 (692–692)	59.30 (33.80–88.00)	172.90 (140.00–220.00)	6 (3–20)	806 (207–1,650)	22.40 (6.50–50.30)	39.40 (39.40–39.40)
	5a	–	17.00 (17.00–17.00)	54.80 (54.80–54.80)	18 (13–27)	–	–	–
	5b	155 (155–155)	30.70 (11.00–47.00)	70.70 (3.10–191.00)	11 (4–27)	34 (3–294)	6.2 (0–23.00)	9.30 (5.00–16.00)
	5	74 (0–151)	72.00 (2.30–14.50)	85.00 (8.00–410.00)	41 (39–43)	50 (2–312)	–	5.40 (5.20–5.50)
	6	–	–	72.00 (72.00–72.00)	15 (2–35)	11 (11–11)	–	–
	13	–	16.40 (9.00–24.00)	–	11 (4–33)	57 (57–57)	71.50 (71.50–71.50)	–
	28	–	–	–	–	–	–	–
Xeric	**21a**	–	27.10 (27.10–27.10)	45.20 (0.20–182.50)	14 (5–43)	98 (0–473)	–	16.40 (4.50–24.00)
	21b	–	–	–	11 (7–19)	–	–	–
	22a	–	–	1.00 (0–2.50)	15 (6–26)	0 (0–0)	–	–
	22b	–	–	–	5 (5–5)	–	–	–
	24a	–	–	–	12 (7–19)	149 (149–149)	4.20 (4.19–4.19)	–
	24b	–	–	4.40 (0.27–8.53)	22 (22–22)	–	–	16.90 (7.08–26.76)
	25	125 (125–125)	27.60 (9.40–56.90)	78.60 (19.80–177.00)	18 (7–46)	42 (5–170)	–	29.30 (29.30–29.30)
	26ab	–	–	15.00 (2.00–28.00)	–	6 (1–10)	0.80 (0.25–1.25)	–
	26c	–	–	10.00 (10.00–10.00)	–	48 (48–48)	1.80 (1.75–1.75)	–
	26d	–	–	34.00 (34.00–34.00)	20 (20–20)	28 (9–63)	3.10 (0.90–5.30)	–
	26	–	–	7.60 (1.00–12.80)	7 (7–7)	4 (0–17)	–	–

– = no data.

First number in each column is the mean value for all studies; values in parentheses are minimum and maximum observed values. Ranges represent differences in tree species composition and site quality or environmental condition, including variation in disturbance history, elevation, topography, slope, aspect, and soil. Additionally, this variation may also represent sampling bias, because this is a summation of a variety of sources (e.g., more dramatic stands with large trees may have been more likely to be sampled). This may be more pronounced in old-growth community types that contain more stunted examples with smaller trees. Additionally, in fire-adapted systems, recent fire suppression may also bias values.

DWD and snags are the mean from the reviewed references of the amount of coarse woody debris in each stand per area.

6. THE OLD-GROWTH FOREST COMMUNITY TYPES OF THE SOUTHERN REGION

6.1 OGCT 1: Northern Hardwood Forest

Community Description

Northern hardwood forests occur exclusively in the northern tier of States in the eastern part of the United States, except for a southern extension along the Appalachian Mountains (table 6.1.a). In the mid and southern Appalachian Mountains, this forest type is restricted to higher elevations that possess cool, mesic conditions. These conditions are most prevalent on northern- and eastern-facing slopes where direct insolation and evapotranspiration rates are lower. These forests are poorly developed in some parts of the Northern Ridge and Valley section, where the elevation is relatively low (Tyrrell et al. 1998). They can be found on both convex and concave slopes. On the steeper convex slopes, there is a greater dominance of yellow birch (*Betula alleghaniensis*) and American beech (*Fagus grandifolia*) compared to sugar maple (*Acer saccharum*) and yellow buckeye (*Aesculus flava*) in concavities. On steeper convex slopes, the plant community grades to high elevation red oak (*Quercus rubra*) forest.

Sugar maple, American beech, and yellow birch are the dominant northern hardwood species (table 6.1.b). Other deciduous associates include American basswood (*Tilia americana*), white ash (*Fraxinus americana*), red maple (*Acer rubrum*), black cherry (*Prunus serotina*), northern red oak (*Quercus rubra*), and tuliptree (*Liriodendron tulipifera*). Evergreen associates include eastern hemlock (*Tsuga canadensis*), eastern white pine (*Pinus strobus*), and red spruce (*Picea rubens*). This old-growth forest community type has <25 percent combined overstory coverage of these evergreen species (Nowacki 1993, Tyrrell et al. 1998). It also includes sweet birch (*Betula lenta*) in boulder fields and very rocky (possibly wet) slopes; yellow birch occurs in high elevation, boulder fields and rocky habitats. Shrub diversity can be variable but often includes Catawba rosebay (*Rhododendron catawbiense*), hobblebush (*Viburnum lantanoides*), red elderberry (*Sambucus racemosa* var. *racemosa*), and southern mountain cranberry (*Vaccinium erythrocarpum*). The herbaceous layer in this type is rich and often features ramps (*Allium tricoccum*), especially on concave slopes.

This old-growth forest community type can be distinguished from mixed mesophytic forests (type 5) in that 1) northern hardwoods occur only at high elevations, typically above 4,000 feet; 2) northern hardwoods have a lower level of tree species richness and diversity; and 3) there is a presence of northern plant species, such as yellow birch, red spruce, red elderberry, hobblebush, and southern mountain cranberry (Nowacki 1993, Schafale 2024, Tyrrell et al. 1998).

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.1.c. Additional classifications related to this community type are found in table 6.1.d.

Rare Communities That May be Embedded in This OGCT:

Northern hardwood forest/beech gap

Southern Appalachian boulderfield forest

Central Appalachian high elevation boulderfield woodland

Disturbances

Fires occur infrequently and are usually limited to small surface burns because of the moist conditions associated with this type. At higher elevations ice, wind, and snowstorms occur periodically and vary in intensity, creating a range of canopy gaps from very large (tree fall over acres) to small (large broken branches to a tree fall). Species composition is usually similar to the surrounding forest. This OGCT is especially vulnerable to damage from the nonnative wild boar (*Sus scrofa*).

Pests and Diseases

The hemlock woolly adelgid (*Adelges tsugae*), a nonnative insect, is currently causing widespread mortality among eastern hemlocks and will affect efforts to maintain or restore this OGCT. Several associated hardwood species have insects and diseases that impact survival including the nonnative emerald ash borer (*Agrilus planipennis*) which affects white ash, especially its ability to reach the overstory, resulting in changes to the midstory structure of the communities where present. American beech is similarly affected by beech bark disease (*Neonectria faginata, N. ditissima* in association with the nonnative beech scale insects *Cryptococcus fagisuga* and possibly *Xylococculus betulae*).

Management Considerations

Restoration:

a. Treat pockets of high-density American beech sprouts when they reduce the desired conditions in the understory and when the sprouts are determined of disease origin or prior land-use history. Thickets of American beech may naturally occur as the result of storm damage or in beech gaps.

b. Plant red spruce (or hemlock when and if available) in appropriate riparian locations where hemlock has been lost.

c. Treat nonnative invasive species populations, including wild boar.

Maintenance:

a. Treat important individuals or groups of threatened ash, eastern hemlock, or American beech where appropriate.

b. Monitor and treat new nonnative invasive species populations.

Representative Northern Hardwood Old-Growth Stands:

Black Mountain Research Natural Area, Pisgah National Forest, Yancey County, NC

Cherry Cove, Blue Ridge Parkway, Haywood County, NC

Walker Cove Research Natural Area, Big Ivy Area, Pisgah National Forest, Buncombe County, NC

Wayah Bald Area, Nantahala National Forest, Macon County, NC

Upper Indian Creek, Nantahala National Forest, Graham County, NC

Table 6.1.a—The potential distribution of OGCT 1: northern hardwood forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD—in part)
		Cherokee NF (Tellico RD, Unaka RD, Watauga RD—all in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part, Mount Rogers NRA)
		NFs of North Carolina (Cheoah RD, Tusquitee RD, Nantahala RD, Pisgah RD, Appalachian RD, Grandfather RD—in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, North River RD)

NF = national forest; RD = ranger district; NRA = national recreation area.

Table 6.1.b—The relationship of OGCT 1: northern hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**70**	Black cherry
	81	Sugar maple-beech-yellow birch
	83	Black birch
SAF forest types	**25**	Sugar maple-beech-yellow birch
	27	Sugar maple
	28	Black cherry-maple
	31	Red spruce-sugar maple-beech
	60	Beech-sugar maple
FIA forest types	**801**	Sugar maple-beech-yellow birch
	802	Black cherry
	805	Hard maple-basswood
	962	Other hardwoods [1]

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.1.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 1: northern hardwood forest

USNVC group codes	USNVC groups	USNVC alliances codes	USNVC alliances
G742	Central Appalachian northeast mesic forest	A0266	Southern Appalachian high montane buckeye-northern hardwood forest

Table 6.1.d—Natural Vegetation Communities for OGCT 1: northern hardwood forest

Natural vegetation community	Code	Community types
Ecological zone	–	Northern hardwood slope forest (Georgia, Kentucky, North Carolina, Tennessee, Virgina, and West Virginia)
	–	Northern hardwood cove forest (Georgia, North Carolina, Tennessee, Virginia, and West Virginia)
NatureServe Terrestrial Ecological System	CES202.593	Appalachian hemlock northern hardwood forest (in part)
	CES202.373	Southern and central Appalachian northern hardwood forest (in part)
	CES202.029	Southern Appalachian northern hardwood forest
LANDFIRE biophysical settings	13090	Southern Appalachian northern hardwood forest

– = Missing codes have not been assigned.

6.2 OGCT 2: Mesic Conifer-Hardwood Forest

Community Description

This old-growth type was presented as conifer-northern hardwood forest in Gaines et al. (1997). Conifer-northern hardwood forest is much more prevalent in the upper northeastern and Great Lakes areas of the United States from Minnesota to Maine, and adjacent Canada. The old-growth type described here, mesic conifer-hardwood forest, reflects a more distinctive southern Appalachian and Cumberland Mountains community type. The distribution of mesic conifer-hardwood forest can overlap with northern hardwood forest (OGCT 1), but can also occur at much lower elevations, below 1,000 feet. Mesic conifer-hardwood forests are found in the northern tier of States from Minnesota to Maine and southward along the Appalachian Mountains to north Georgia (table 6.2.a).

This OGCT is found in the southern Appalachian Mountains on cooler sites primarily on north- and east-facing slopes. At least 25 percent of the overstory canopy contains either coniferous or deciduous trees (table 6.2.b). There are three subtypes within this broad community type. Tables in section 5 contain old-growth attributes for the mesic conifer-hardwood forest community type.

Hemlock-hardwood forest (subtype 2a)

The hemlock-hardwood forests occur in deep coves, moist flats, and ravines but are occasionally found along larger stream bottoms, typically at elevations below 3,500 feet. This subtype can occur across a broad elevational gradient, from 1,000 to 5,000 feet, from North Carolina to Kentucky (NatureServe 2024). Eastern hemlock (*Tsuga canadensis*) is a wet-mesic species that grows best on cool, moderately wet to somewhat poorly drained sites. It is the dominant canopy species with >60 percent cover (Schafale 2024). The main associates are sweet birch (*Betula lenta*), tuliptree (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and northern red oak

(*Quercus rubra*). A common midstory (sometimes canopy) species is Fraser magnolia (*Magnolia fraseri*), although in the Cumberland Mountains and Plateau this is usually replaced by bigleaf magnolia (*Magnolia macrophylla*). At higher elevations and in Kentucky yellow birch (*B. alleghaniensis*), American beech (*Fagus grandifolia*), and eastern white pine (*Pinus strobus*) are usually present (NatureServe 2024). Eastern hemlocks limit the amount of light reaching the forest floor, resulting in sparse understory vegetation. The shrub layer is typically dominated by great laurel (*Rhododendron maximum*). In general, herbaceous diversity is sparse, although in canopy gaps a greater diversity of understory vegetation is common. The organic soil surface and humus consist mostly of needles and twigs.

Acidic cove forest (subtype 2b)

This subtype occurs in similar landscape positions to the hemlock-hardwood forests, although is more abundant at mid to lower elevations, to 600 feet, across the Blue Ridge, the Cumberland Mountains and Plateau, the upper piedmont, and the central Appalachian Mountains (NatureServe 2024). Eastern hemlock can be present or absent within this subtype. Where present, it does not dominate the canopy. A variety of canopy species can occur including tuliptree, sweet birch, red oak, chestnut oak (*Quercus montana*), red maple, pignut hickory (*Carya glabra*), American beech, eastern white pine, and cucumber magnolia (*Magnolia acuminata*) (Fleming et al. 2021, Schafale 2024). Similar to hemlock-hardwood forest, acidic cove forest is typically dominated by great laurel in the shrub layer. In the northern part of its range Catawba rosebay (*Rhododendron catawbiense*) is more abundant than great laurel (Fleming et al. 2021). Because of this dense evergreen shade and low nutrient soils, herbaceous diversity is sparse. Bryophytes, in contrast, are abundant.

Red spruce-northern hardwood forest (subtype 2c)

This transitional red spruce (*Picea rubens*)-northern hardwood forest is found in the central and southern Appalachian Mountains on cool, moist midslopes and ridges on well-drained to somewhat poorly drained acidic soil. It is found at elevations above 2,800 feet (northern) and 4,000 feet (southern), and at progressively higher elevations southward (NatureServe 2024). In the southern Appalachian Mountains (Northern Ridge and Valley and Blue Ridge sections), this forest only occurs on mountaintops. This OGCT blends with northern hardwood forests at mid elevations. The sites where this forest type grows are normally steep, and the soil is shallow and rocky. Some common species associates include yellow birch, sugar maple, American beech, and red maple.

In areas of significant canopy disturbance and brush, especially if it has been followed by a heavy seed set, eastern white pine may become the dominant conifer species (NatureServe 2024, Wendel and Smith 1990). This disturbance variant is not considered an OGCT to maintain, but it may be embedded in subtype 2a and 2b. Eastern white pine is typically not present in subtype 2c, and should not be confused with the New England and Canadian types (NatureServe 2024). In some cases, after a large-scale disturbance, it may be desirable to reduce the growth of eastern white pine.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.2.c. Additional classifications related to this community type are found in table 6.2.d.

Rare Communities That May be Embedded in This OGCT

Carolina hemlock (*Tsuga caroliniana*) forest—mesic subtype (Blue Ridge)

Swamp forest bog complex—spruce subtype (Blue Ridge)

Southern Appalachian acidic cove (silverbell [*Halesia tetraptera*] subtype)

Disturbances

Insect outbreaks, and wind and ice storms, are common disturbances in this OGCT. For subtypes 2a and 2b, windthrow is particularly common on many sites due to high water tables and shallow soils, which limit the downward expansion of roots. This type of disturbance results in frequent gap-phase regeneration and pit-and-mound microtopography. Fire has historically had little influence in the three subtypes.

Pests and Diseases

The hemlock woolly adelgid (*Adelges tsugae*), a nonnative insect, is currently causing widespread mortality among eastern hemlocks and will affect efforts to maintain or restore this OGCT. Several associated hardwood species across the subtypes have insects and diseases that impact survival. This includes the nonnative emerald ash borer (*Agrilus planipennis*), which affects white ash (*Fraxinus americana*), especially its ability to reach the overstory, resulting in changes to the midstory structure of the communities where present. American beech is similarly affected by the nonnative beech bark disease (*Neonectria faginata, N. ditissima* in association with the nonnative scale insects *Cryptococcus fagisuga* and possibly *Xylococculus betulae*).

Management Considerations

Restoration:

a. Plant and release species lost during historical disturbance (subtype 2c).

b. Identify and promote resistant American beech trees and control root suckers of susceptible trees.

c. Control nonnative invasive plant species infestations and wild boar (*Sus scrofa*) populations.

d. Reduce eastern white pine in areas of high density.

Maintenance:

a. Control hemlock woolly adelgid and emerald ash borer with biological and chemical options.

b. Control nonnative invasive plant species infestations and wild boar populations.

c. Reduce eastern white pine in areas of high density.

Representative Conifer-Hardwood Old-Growth Stands:

Flagpole Knob, George Washington National Forest, Virginia Hunting Creek, Bedford County, VA

The Skidmore Special Management Area, George Washington National Forest, Virginia Bottom Creek Gorge, VA

Roaring Branch, north of Big Stone Gap, VA

Big Bald Cove, Union County near Brasstown Bald, Sosebee Cove Scenic Area, GA

Conasauga River Trail, Sosebee Cove Scenic Area, Fannin County, GA

Holcomb Creek Trail, Sosebee Cove Scenic Area, Rabun County, GA

Albright Grove, Great Smoky Mountains National Park, Cocke County, TN

Tight Hollow, Daniel Boone National Forest, Wolfe County, KY (in part)

Rock Creek Research Natural Area, Daniel Boone National Forest, Laurel County, KY (in part)

Table 6.2.a—The potential distribution of OGCT 2: mesic conifer-hardwood forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)
	Allegheny Mountains (335C)	George Wahington-Jefferson NF (James River and Warm Springs RD—in part)
Allegheny Piedmont (334)	**Cumberland Plateau (334A)**	Daniel Boone NF (Cumberland RD—in part, London RD—in part, Redbird RD, Stearns RD—in part)
	Southern Unglaciated Allegheny (334B)	Daniel Boone NF (Cumberland RD—in part)
Mid-Atlantic Province (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF(Glenwood and Pedlar RD—in part)
Central Interior (333)	**Bluegrass (333E)**	Daniel Boone NF (Cumberland RD, London RD—both in part)
Appalachian Piedmont Province (344)	**Central Appalachian Piedmont (344D)**	NFs of North Carolina (Grandfather RD—in part)
	Southern Appalachian Piedmont (344C)	Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part)
	Southern Ridge and Valley (344B)	Chattahoochee-Oconee NF (Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)

NF = national forest; RD = ranger district; NRA = national recreation area.

Table 6.2.b—The relationship of OGCT 2: mesic conifer-hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**3**	White pine
	4	White pine-hemlock
	5	Hemlock
	8	Hemlock-hardwood [1]
	9	White pine-cove hardwood [1]
	10	White pine-upland hardwood [1]
	17	Red spruce-northern hardwood [1]
	41	Cove hardwood-white pine-hemlock (in part)
	56	Yellow poplar-white oak-northern red oak (in part)
SAF forest types	**20**	White pine-northern red oak-red maple
	21	Eastern white pine
	22	Eastern pine-hemlock
	23	Eastern hemlock
	24	Hemlock-yellow birch (in part)
	30	Red spruce-yellow birch
	31	Red spruce-sugar maple-beech
FIA forest types	**103**	Eastern white pine
	104	Eastern white pine-eastern hemlock
	105	Eastern hemlock
	123	Red spruce

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.2.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 2: mesic conifer-hardwood forest

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G020	Southern Appalachian-interior-mesic forest	A3304	Southern hemlock-tuliptree forest
G632	Central and southern Appalachian red spruce-fir-hardwood forest	A0138	Central Appalachian red spruce forest
G742	Central Appalachian-northeast mesic forest	A3302	Central Appalachian-northeast hemlock-northern hardwood forest

Table 6.2.d—Natural vegetation communities for OGCT 2: mesic conifer-hardwood forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Acidic cove forest (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
		Mixed mesophytic acidic cove forest (Kentucky)
		Mixed oak-rhododendron forest (Georgia, Kentucky, North Carolina, Tennessee, and Virginia)
NatureServe Terrestrial Ecological System	CES202.029	Southern Appalachian northern hardwood (in part)
	CES202.593	Appalachian (hemlock-) northern hardwood forest (in part)
LANDFIRE biophysical settings	13090	Southern Appalachian northern hardwood forest (in part)
	13180	Southern and central Appalachian cove
	13700	Appalachian (hemlock-) northern hardwood forest (in part)

– = Missing codes have not been assigned.

6.3 OGCT 5: Mixed Mesophytic and Western Mesophytic Forest

Community Description

Western mesophytic forests are found in provinces in western portions of the Southeast and mixed mesophytic forests can be found primarily in the southern Appalachian Mountains (table 6.3.a). Western mesophytic forests occur on a wide range of topographic positions compared to mixed mesophytic forests, including on drier sites. Mixed mesophytic forests occur on lower north- and east-facing slopes and mesic coves up to an elevation of about 4,500 feet, occasionally to 5,000 feet. In less mountainous terrain, they may cover extensive areas where conditions are suitable. In areas of large boulderfields, primarily in the mountains, another subtype occurs. The boulderfield type is often dominated by yellow birch (*Betula alleghaniensis*). All subtypes tend to have rich herbaceous and shrub floras, with the mixed and boulderfield types usually having the richest diversity, especially if they have high base cation saturation.

Western mesophytic forest (subtype 5a)

Greenberg et al. (1997) found western mesophytic forests are typically dominated by oaks (*Quercus* spp.), but also include many of the mixed mesophytic species, with the exception of yellow buckeye (*Aesculus flava*) and basswood (*Tilia* spp.). Dominant species vary with geographic location, site condition, topographic features, moisture and fertility. These forests are found in the Interior Low Plateau, southern Central Lowland, Ozark Plateau, and Ouachita provinces (primarily on east- and north-facing slopes, aspects, and drainages), the northern Coastal Plain along the Mississippi River and the western portion of Kentucky, including Land Between the Lakes, Mammoth Cave National Park area, as well as a few areas at the western edge of the Cumberland Plateau.

Mixed mesophytic forest (subtype 5b)

Yellow buckeye and basswood are indicator species of this forest type. Mixed mesophytic forests are among the most biologically diverse ecosystems in the United States. The presence of higher pH, cation exchange capacity, percentage of base saturation, and some nutrient components are some of the characteristic features. However, loss of the American chestnut (*Castanea dentata*), and the presence of the nonnative organisms Dutch elm disease (*Ophiostoma ulmi*, *O. himal-ulmi*, *O. novo-ulmi*), emerald ash borer (*Agrilus planipennis*), wild boar (*Sus scrofa*), dogwood anthracnose (*Discula destructiva*), and spongy moth (*Lymantria dispar*) have had a significant impact on composition of these forests and secondary forest. These forests can be found in the Appalachian Plateau, Ridge and Valley, and Blue Ridge provinces.

Boulderfield (subtype 5c)

The boulderfield subtype occurs on well-developed boulderfields, with large rocks providing near complete cover, substantial open space beneath the rocks, soil limited to accumulations on top of and between rocks, and lower strata substantially influenced by the rock cover. Besides yellow birch, other mesophytic tree species are present, most often American basswood (*Tilia americana*) or yellow buckeye (Schafale 2024). Small areas of this subtype can be found below cliffs in east central and eastern Kentucky, and along the northeast face of Pine Mountain, KY. This subtype is distinguished from the high elevation birch (*Betula* spp.) boulders, which is more typically surrounded by northern hardwood forests.

The following are the most common among 25 to 30 characteristic tree species of the mixed mesophytic forest: sugar maple (Acer saccharum), American beech (Fagus grandifolia), eastern hemlock (Tsuga canadensis), mountain silverbell (Halesia tetraptera), tuliptree (Liriodendron tulipifera), red maple (A. rubrum), white oak (Quercus alba), northern red oak (Q. rubra), sweet birch (Betula lenta), yellow buckeye, and American basswood (table 6.3.b). Yellow buckeye and basswood are indicator species for mixed mesophytic forests but are absent from western mesophytic forests. The old-growth age structure is broadly uneven aged or all aged. Irregular distributions are common and reflect severe natural disturbances or irregularities in seed production (Greenberg et al. 1997). Species composition depends on the stand's origin. If the stand originated following a catastrophic disturbance, an old-growth forest may be dominated by pioneer species such as tuliptree. Alternatively, if gap dynamics has been the dominant process driving regeneration of several tree generations, an old-growth forest may be dominated by shade-tolerant species (Greenberg et al. 1997). An old-growth forest may also be a mix of the two. Tables 5.x–5.y contain old-growth attributes for the mixed mesophytic and western mesophytic forest types.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.3.c. Additional classifications related to this community type are found in table 6.3.d.

Rare Communities That May be Embedded in This OGCT:

Cliff/boulderfield assemblages

Seeps of all sizes and across all elevations

Disturbance

The driving background disturbance is the creation of relatively small canopy gaps (0.25–2.00 acres [0.1–0.8 ha]) from the death of a group of trees, and accounts for a relatively constant turnover of trees and species in old-growth mixed mesophytic forests.

Estimates of canopy turnover rates vary from <0.4 to 1.0 percent annually (Romme and Martin 1982). Less frequent, large-scale disturbances such as severe wind storms, ice storms, floods, landslides, fire, damage by native or nonnative insects, or fungal infections may also create openings (<1 to >100 acres). The shade tolerance of different species (as well as the initial composition of species and their regeneration strategies) influences tree regeneration in relation to the size and age of the gap.

Historical disturbances including clearing for increasing game populations, farmlands, dwellings, and extensive logging, as well as current ongoing land conversions have resulted in a scarcity of old-growth mixed mesophytic forests.

Pests and Diseases

Additionally, nonnative invasive plant infestations and nonnative pests and diseases have impacted overstory and understory composition of these mesophytic forests. Impacts from such insects and diseases are known to affect eastern hemlock (hemlock woolly adelgid, *Adelges tsugae*), American chestnut (chestnut blight, *Cryphonectria parasitica*), ash (emerald ash borer, *Agrilus planipennis*), and American beech (beech bark disease: *Neonectria faginata* and *Neonectria ditissima* in association with scale insects *Cryptococcus fagisuga* and possibly *Xylococculus betulae*). This OGCT is especially vulnerable to damage from the nonnative wild boar (*Sus scrofa*).

Management Considerations

Restoration:

a. Protect high value (ecological or social) eastern hemlock or ash (*Fraxinus* spp.) trees with chemical injection or soil drench.

b. Identify hemlock woolly adelgid-resistant eastern hemlock or beech bark disease-resistant American beech individuals.

c. Restore desired structural and composition conditions within the midstory or overstory with mechanical or chemical treatments.

d. Control nonnative invasive plants and wild boar populations.

e. Plant community appropriate tree species strategically to restore woody diversity (where appropriate).

f. Plant herbs, such as American ginseng (*Panax quinquefolius*), that have been impacted by unsustainable harvest or heavy nonnative invasive plant infestations.

Maintenance:

a. Limit vehicular access during restoration and recreation activities to reduce damage to diverse herb layer and reduce introduction of nonnative invasive plants.

b. Control nonnative invasive plant infestations and wild boar populations.

c. Protect and maintain embedded rare plant communities.

d. Plant herbs, such as American ginseng, or trees, such as American chestnut, that have been impacted by unsustainable harvest or insects.

e. Maintain the composition of the community with mechanical or chemical treatments, especially when species are planted during restoration.

Representative Old-Growth Stands:

Joyce Kilmer Memorial Forest Poplar Trail, Nantahala National Forest, Graham County, NC

Bolens Creek, Pisgah National Forest, Yancey County, NC

Straight Creek, Pisgah National Forest, Buncombe County, NC

Mount Sterling Creek Yellowwood Slopes, Pisgah National Forest, Haywood County, NC

Lilley Cornett Woods, Eastern Kentucky University, Letcher County, KY

Rock Creek Research Natural Area, Daniel Boone National Forest, Laurel County, KY (in part)

Tight Hollow, Daniel Boone National Forest, Wolfe County, KY (in part)

Angel Hollow, near Rockcastle River, Daniel Boone National Forest (in part), Laurel County, KY

Claw Unit, east of Stanton near Red River, Daniel Boone National Forest, Powell County, KY

Blanton Forest State Nature Preserve, Pine Mountain, KY (in part)

Beaver Creek Wilderness, Daniel Boone National Forest, KY (a section near stream bottom)

Dick Cove Natural Area, TN

Great Smoky Mountains, TN

Shirley Miller Wildflower Trail, Crockford-Pigeon Mountain Wildlife Management Area, GA

Sitton Gulch in Cloudland Canyon State Park, GA

Near Carter's Lake reregulation dam, Murray County, GA

Black's Bluff Preserve, Floyd County, GA

Till Ridge Cove, Rabun County, GA

Hollifield Ridge on Eagle Mountain, Towns County, GA

Brasstown Bald, Union and Towns County, GA

Ramp Cove, Towns County, GA

Sosebee Cove, Union County, GA

Grassy Mountain Cove, Murray County, GA

Ramp Gap, Rich Mountain Wilderness, Gilmer County, GA

Wolf Pen Gap, Rich Mountain Wilderness, Gilmer County, GA

Chicopee Woods, Elachee Nature Preserve, GA

Big Woods, Mammoth Cave National Park, KY

Table 6.3.a—The potential distribution of OGCT 5: mixed mesophytic and western mesophytic forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part), Lee RD, Mount Rogers NRA—in part, North River RD)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)

Table 6.3.a—The potential distribution of OGCT 5: mixed mesophytic and western mesophytic forest (continued)

Ecological province	Ecological section	National forest unit
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Grandfather RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Tiak RD—in part, Winona RD, Womble RD)
		Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	NFs of Alabama (Bankhead RD—in part)
Mississippi Embayment (342)	**Western Mississippi Alluvial White and Black River Alluvial Plains (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	Ozark-St. Francis NF (St. Francis RD—in part)

NF = national forest; RD = ranger district; NRA = national recreation area.

Table 6.3.b—The relationship of OGCT 5: mixed mesophytic and western mesophytic forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**41**	Cove hardwood-white pine-hemlock (in part)
	50	Yellow poplar
	56	Yellow poplar-white oak-northern red oak (in part)
	69	Beech-magnolia
	81	Sugar maple-beech-yellow birch (in part)
	83	Black birch
	85	White oak-black oak-hickory
SAF forest types	**25**	Sugar maple-beech-yellow birch (in part)
	27	Sugar maple
	52	White oak-black oak-northern red oak
	57	Yellow poplar
	58	Yellow poplar-eastern hemlock
	59	Yellow poplar-white oak-northern red oak
	60	Beech-sugar maple
FIA forest types	**402**	Eastern redcedar-hardwood
	506	Yellow poplar-white oak-northern red oak
	511	Yellow poplar
	516	Cherry-white ash-yellow poplar
	517	Elm-ash-black locust
	801	Sugar maple-beech-yellow birch
	805	Hard maple-basswood
	905	Pin cherry
	962	Other hardwoods [1]

[1] When these types are encountered, further field work may be necessary to fully identify the OGCT present.

Table 6.3.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 5: mixed mesophytic and western mesophytic forest

USNVC group codes	USNVC groups	USNVC alliances codes	USNVC alliances
G020	Appalachian-central interior mesic forest	A0233	Interior low plateau basic mesic forest
		A0235	South-central Appalachian mixed mesophytic forest
		A3265	Piedmont-ridge and valley beech-red oak forest
G742	Central Appalachian-northeast mesic forest	A0266	Southern Appalachian high montane buckeye-northern hardwood forest
		A3301	Central Appalachian-northeast hardwood forest
		A3302	Central Appalachian-northeast hemlock-northern hardwood forest
		A3303	Central Appalachian-northeast red oak-mesic hardwood forest
G791	Ozark-Ouachita mesic forest	A3260	Ozark-Ouachita mesic forest

Table 6.3.d—Natural vegetation communities for OGCT 5: mixed mesophytic and western mesophytic forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Rich cove forest (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Mixed mesophytic rich cove forest (Kentucky and Tennessee)
	–	Rich slope forest (Georgia, Kentucky, Tennessee, and Virginia)
	–	Mixed mesophytic slope forest (Kentucky and Tennessee)
	–	Spicebush cove forest (Virginia)
NatureServe Terrestrial Ecological System	CES202.373	Southern and central Appalachian rich cove forest (in part)
	CES202.887	South-central interior mesophytic forest
	CES202.043	Ozark-Ouachita mesic hardwood forest
LANDFIRE biophysical settings	13180	Southern and central Appalachian cove
	13220	Southern Crowley's Ridge mesic loess slope forest
	15090	Mississippi River Alluvial Plain dry-mesic loess slope forest

– = Missing codes have not been assigned.

6.4 OGCT 6: Coastal Plain Upland Mesic Hardwood Forest

Community Description

These mixed evergreen-deciduous hardwood and coniferous forests occur on the Southeastern Coastal Plain from the Carolinas to Texas at latitudes where evergreen species are not killed by cold winter temperatures. This forest community is often found along mid-to-lower slopes and terraces on well-drained, but moist, fine-textured soils that are protected from frequent fires (table 6.4.a). Several plant associations may be present successionally on highly eroded, nutrient-poor sites where prior to European settlement they existed as narrow bands of vegetation between floodplain forests and upland longleaf pine (*Pinus palustris*)-dominated savannas (Batista and Platt 1997). Although some natural associations still occur based on topographic position, they may have expanded due to changes in the fire regimes.

These forests are multilayered, containing overstory tree species that reach 60 to 100 feet in height and midstory species that usually are <50 feet in height. Tables in section 5 contain old-growth attributes for the Coastal Plain upland hardwood forest community type.

Major overstory hardwood species commonly include American beech (*Fagus grandifolia*); southern magnolia (*Magnolia grandiflora*); sweetgum (*Liquidambar styraciflua*); several oak species including swamp chestnut oak (*Quercus michauxii*), water oak (*Q. nigra*), white oak (*Q. alba*), and Shumard oak (*Q. shumardii*); pignut hickory (*Carya glabra*) and bitternut hickory (*C. cordiformis*); and tuliptree (*Liriodendron tulipifera*). The overstory species composition shifts towards more evergreen species along the southern edge of the Coastal Plain where pines may be among the most abundant overstory species, particularly spruce pine (*Pinus glabra*) and loblolly pine (*P. taeda*). In Florida and Louisiana, these forests may consist primarily of live oak (*Q. virginiana*), cabbage palmetto (*Sabal palmetto*), and dwarf palmetto (*S. minor*) (Batista and Platt 1997) (table 6.4.b).

Dominant midstory species commonly include hophornbeam (*Ostrya virginiana*), American hornbeam (*Carpinus caroliniana*), American holly (*Ilex opaca*), yaupon (*I. vomitoria*), flowering dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), red maple (*Acer rubrum*), and common sweetleaf (*Symplocos tinctoria*). Many rarer species also are likely to be present in the understory, resulting in 40 or more woody species in these forests. Lianas are commonly present, such as muscadine (*Vitis rotundifolia*), eastern poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and crossvine (*Bignonia capreolata*). Few herbaceous species occur beneath the multilayered deciduous and evergreen tree canopies (Batista and Platt 1997). A calcareous variant, more limited in extent including portions of the East Gulf Coastal Plain, the Red Hills (Alabama), and probably the Georgia Piedmont, is dominated by calciphiles such as southern sugar maple (*Acer floridanum*), white ash (*Fraxinus americana*), Shumard oak, chinquapin oak (*Q. muehlenbergii*), and Carolina basswood (*Tilia americana* var. *caroliniana*) (Batista and Platt 1997).

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.4.c. Additional classifications related to this community type are found in table 6.4.d.

Rare Communities That May be Embedded in This OGCT:

West Gulf Coastal Plain beech-white oak forest

Disturbance

Disturbances in this forest community type are characterized by frequent, small-scale gaps of one to a few overstory trees (e.g., drought, insects) which can provide opportunities for regeneration. Larger scale disturbances in the form of hurricanes or wildfires also occur periodically every few decades. During droughts, wildfires can occur when soil moisture is low. Even moderate intensity hurricanes may cause major damage of over 25 percent of the overstory, and the mortality of these overstory trees may be as much as 10 percent several years after the hurricane. The proportion of shade-tolerant species, such as American beech and southern magnolia, relative to the proportion of more light-demanding species, such as oaks, hickories, and pines, appears to reflect the frequency of large-scale disturbances. After hurricanes and wildfires, the gaps are often occupied by aggressive midstory species such as invasives. Large portions of the canopy, as much as 60 percent immediately after hurricanes and as much as 30 percent after several decades, can contain few, if any, overstory tree species. A significant amount of coarse woody debris may be present after hurricanes, but it decays rapidly and does not last much beyond 10 years. The role of fire in this forest type is not well understood, but observations of sites burned and not burned suggest reductions in the frequency with which fires burn down slope from longleaf pine stands, especially under drought conditions, have allowed mesic hardwood forests to spread up slopes into those stands (Batista and Platt 1997).

Historically, fire in Coastal Plain upland mesic forests was likely infrequent and of low intensity (Batista and Platt 1997).

Pests and Diseases

With American beech in the overstory, nonnative beech bark disease (*Neonectria faginata*, *N. ditissima* in association with scale insects *Cryptococcus fagisuga* and possibly *Xylococculus betulae*) has the potential to be a significant future overstory disturbance factor adding to the areas without overstory trees. Additionally, with flowering dogwood in the understory, the understory species composition may become impacted by the nonnative dogwood anthracnose (*Discula destructiva*). The nonnative laurel wilt (*Harringtonia lauricola*) may impact species in the laurel family (Lauraceae) where these species are present (usually in minor occurrence). The nonnative wild boar (*Sus scrofa*) is also a major threat to this OGCT.

Management Considerations

Restoration:

a. Examine potential natural vegetation models to assist with the identification of undesirable community expansion into drier upland communities.

b. Allow prescribed burns in adjacent upland community types to slowly back down slopes with low-intensity fire. Igniting fires in this type is not consistent with its ecology.

c. Review community status after major disturbances like hurricanes.

d. Treat nonnative invasive plant species infestations and control wild boar if present.

e. Control aggressive midstory conditions and reintroduce overstory species through planting, especially for rare species.

Maintenance:

a. Avoid prescribed fire and check that microsite hydrology is not disturbed during fire suppression or other development activities.

b. Minimize activities that increase the risk of soil erosion.

c. Control wild boar populations and invasive plant infestations.

Representative Coastal Plain Upland Mesic Hardwood Old-Growth Stands:

Woodyard Hammock, Tall Timbers Research Station, Leon County, FL

Titi Hammock, Thomas County, GA

San Felasco Hammock, Alachua County, FL

Highlands Hammock, Highlands County, FL

Raglan Hills, Forrest County, MI

Weir Forest, Hardin County, TX

Zemurray Forest, Tangipahoa Parish, LA

Tunica Hills, West Feliciana Parish, LA

Table 6.4.a—The potential distribution of OGCT 6: Coastal Plain upland mesic hardwood forest

Ecological province	Ecological section	National forest unit
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part) Kisatchie NF (Calcasieu RD, Kisatchie RD—both in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD) Ouachita NF (Tiak RD—in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Homochitto RD, Tombigbee RD—in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Tombigbee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part) NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part) NFs of Florida (Apalachicola RD—in part) NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD) NFs of North Carolina (Croatan RD)

NFGT = National Forests and Grasslands in Texas; NF = national forest; RD = ranger district.

Table 6.4.b—The relationship of OGCT 6: Coastal Plain upland mesic hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**13**	Loblolly pine-hardwood [1]
	53	White oak-northern red oak-hickory [2]
	69	Beech-magnolia
	77	Oak hammock
	97	Live oak
SAF forest types	**82**	Loblolly pine-hardwood [1]
	89	Live oak (in part, mesic salt domes)
FIA forest types	**962**	Other hardwoods [1]

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.
[2] Replace red oak with southern red oak (*Quercus falcata*) in parts of the OGCT's range (North Carolina, Louisiana).

Table 6.4.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 6: Coastal Plain upland mesic hardwood forest

USNVC group codes	USNVC groups	USNVC alliances codes	USNVC alliances
G007	**Southern mesic beech-magnolia-oak forest**	A2319	Southern Coastal Plain beech-magnolia forest
		A2320	West Gulf Coastal Plain beech-magnolia forest
G166	**Southern mesic beech-oak-mixed deciduous forest**	A2095	West Gulf Coastal Plain beech-oak forest
		A2096	Southeastern Coastal Plain beech-oak forest
		A3236	Southeast Coastal Plain calcareous mesic hardwood forest
G790	**Southern evergreen oak forest**	A0052	Sand live oak dry sclerophyll forest
		A0053	Coastal Plain sand laurel oak-live oak forest
G798	**Coastal live oak- hickory-palmetto forest**	A0372	Southeast Coastal Plain sand laurel oak-hickory forest
		A0374	West Gulf coast maritime live oak forest
		A3192	Southeastern maritime live oak forest

Table 6.4.d—Natural Vegetation Communities for OGCT 6: Coastal Plain upland mesic hardwood forest

Natural vegetation community	Code	Community types
Ecological zone	–	Mesic hardwood forest (North Carolina and South Carolina)
NatureServe Terrestrial Ecological System	CES203.481	East Gulf Coastal Plain northern loess bluff forest
	CES203.556	East Gulf Coastal Plain southern loess bluff forest
	CES203.477	East Gulf Coastal Plain northern mesic hardwood slope forest
	CES203.476	Southern Coastal Plain mesic slope forest
	CES203.280	West Gulf Coastal Plain mesic hardwood forest
LANDFIRE biophysical settings	13230	West Gulf Coastal Plain mesic hardwood forest
Terrestrial ecological unit inventory (Texas)	–	American beech-white oak steep slopes and ravines forest
		American beech-southern magnolia lower slope and shallow creek bottom forest
		Mesic pine-hardwood lower slopes and terraces forests

– = Missing codes have not yet been assigned.

6.5 OGCT 10: Hardwood Wetland Forest

Community Description

Hardwood wetland forests occur mainly in nonriverine, topographically defined basins on uplands, small drainages (first- through fourth-order streams), inland as far as the Cumberland Plateau and Interior Low Plateaus, and along the margins of Coastal Plain ponds and bays (Tyrrell et al. 1998). They often are referred to as swamp or seepage forests (NatureServe 2024, Schafale 2024). High water tables are usually present, and most sites are moist to wet throughout most of the year (table 6.5.a). Hardwood wetland forests are also found at stream head wetlands. These wetlands are permanently wet to damp (very rarely drying), can be adjacent to sphagnum bogs, and occur in and along small, usually second- or third-order headwater streams in the streams themselves or on adjacent flats. Water depth is generally 0 to 2 feet (0 to 0.6 m). These wetlands are typically oligotrophic (nutrient poor), although they may be fertile where they receive nutrients from adjacent uplands or occur in slightly more calcareous soils in the Mid-Atlantic or Gulf Coastal Plain forests (NatureServe 2024). Soils can be either mineral or organic and neutral to slightly acidic. The similar cypress-tupelo swamp forest (OGCT 14) is more or less restricted to the Coastal Plain and tends to be dominated by cypress (*Taxodium distichum*, *T. ascendens*), or tupelos (*Nyssa aquatica*, *N. biflora*), or both. Other hardwoods, for example, ashes (*Fraxinus* spp.), sweetgum (*Liquidambar styraciflua*), southern magnolia (*Magnolia grandiflora*), and sweetbay (*M. virginiana*) may be present, but are not usually in the overstory. Standing or flowing water to several feet (≥1 m) deep is not uncommon in OGCT 14 communities. Oaks (*Quercus* spp.) are often present in OGCT 10 and seldom so in OGCT 14.

Small stands of OGCT 10 may occur within wetter sections of seasonally wet oak-hardwood woodlands, OGCT 27, on the Cumberland Plateau. This habitat includes small shallow basins that are wet most of the year and contain swamp red maple (*Acer rubrum* var. *trilobum*) and sweetgum (*Liquidambar styraciflua*). White oak (*Quercus alba*) and pitch pine (*Pinus rigida*) may be present on slightly higher ground. Hardwood wetland forests are different from seasonally wet oak-hardwood woodlands due to a lack of seasonal dryness, fewer oaks, and little to no disturbance from fire (Nowacki 1993). In Texas, the sweetbay-swamp tupelo (*Nyssa biflora*) community is represented in this OGCT but there is a lot of overlap with OGCT 14. This gradation also occurs with vegetation surrounding ponds in North Carolina, where they are often dominated by a single tree species such as the hardwoods sweetgum or swamp tupelo, or the conifer pond cypress (*Taxodium ascendens*) (Schafale 2024).

Species composition varies greatly among hardwood wetland forests by physiographic region and soil wetness. Elms (*Ulmus* spp.) may have had more representation within this type prior to the introduction of Dutch elm disease (*Ophiostoma ulmi*, *O. himal-ulmi*, *O. novo-ulmi*) and elm yellows (*Candidatus Phytoplasma ulmi*). Within the Appalachian Mountains and southern Piedmont, swamp red maple, blackgum (*Nyssa sylvatica*), and tuliptree (*Liriodendron tulipifera*), can be dominant (Fleming et al. 2021, NatureServe 2024, Schafale 2024). Further south and within the Coastal Plain species composition still includes swamp red maple and blackgum but can also include black ash (*Fraxinus nigra*), green ash (*F. pennsylvanica*), American elm (*Ulmus americana*), slippery elm (*U. rubra*), sweetgum (*Liquidambar styraciflua*), laurel oak (*Quercus laurifolia*), swamp chestnut oak (*Q. michauxii*), and cherrybark oak (*Q. pagoda*). Other associates may include silver maple (A. saccharinum), swamp white oak (Q. bicolor), bur oak (Q. macrocarpa), American sycamore (Platanus occidentalis), and eastern cottonwood (Populus deltoides) (table 6.5.b). Hardwoods are more common, although conifers, such as pond cypress or loblolly pine (*Pinus taeda*) can be located on the Atlantic coast (Schafale 2024).

Shrub cover is low to moderate with variable species across its southern range including southern highbush blueberry (*Vaccinium formosum*), Elliot's blueberry (*Vaccinium elliottii*), southern wild raisin (*Viburnum nudum*), red and black chokeberries (*Aronia arbutifolia* and *A. melanocarpa*), piedmont azalea (*Rhododendron canescens*), coastal fetterbush (*Eubotrys racemosus*), shining fetterbush (*Lyonia lucida*), and hollies most typically possumhaw (*Ilex decidua*) and American holly (*I. opaca*). Highbush blueberry (*V. corymbosum*), mountain laurel (*Kalmia latifolia*), and steeplebush (*Spiraea tomentosa*) occur in these sites on the Cumberland Plateau. Mosses, including some sphagnum species, and ferns dominate the ground layers if the shrub layer is absent (NatureServe 2024, Tyrrell et al. 1998). Species tolerant of very wet soils, such as lizard's tail (*Saururus cernuus*), can be diagnostic of various examples of this type. Tables in section 5 contain old-growth attributes for the hardwood wetland OGCT.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.5.c. Additional classifications related to this community type are found in table 6.5.d.

Rare Communities That May be Embedded in This OGCT:

Stream head wetlands (second- to fourth-order streams)

Sphagnum bogs

Swamp forest bog complexes

Montane floodplain slough forest

Hillside seepage bog

Atlantic white cedar forest

Disturbances

Their general topographic position and year-round soil moisture typically protect these forests from fire. Because high water tables restrict rooting and limit tree anchorage, trees may be prone to windthrow in some parts of this OGCT, causing a prevalence of tip-up mounds, downed trees, and canopy gaps (Tyrrell et al. 1998). Tree mortality is also caused by fluctuating water levels or flooding from beaver (Castor canadensis) activity (Nowacki 1993). Droughts can increase the risk of wildfire in this OGCT as well as sedimentation from adjacent land use, road construction, oil and gas development, and fire line creation.

Pests and Diseases

In addition to the historical impacts on elms, emerald ash borer (*Agrilus planipennis*), a nonnative insect, is affecting the ash species present in this OGCT throughout its geographic distribution. The nonnative laurel wilt (*Harringtonia lauricola*) is impacting woody plants in the laurel family (*Lauraceae*) in this OGCT. Nonnative wild boar (*Sus scrofa*) is also a pest within this community. In some areas an influx of nonnative invasive species such as multiflora rose (*Rosa multiflora*), tree of heaven (*Ailanthus altissima*), and other invasive plants may occur following overstory mortality associated, for example, with the loss of ash trees from emerald ash borer.

Management Considerations

Restoration:

a. Control nonnative invasive plant infestations and wild boar populations.

b. Restore hydrological functions in the surrounding area.

c. Promote desired conditions (e.g., adequate understory light levels) for embedded rare communities with silvicultural activities such as thinning and group selection.

Maintenance:

a. Maintain soil integrity through limited vehicular access during restoration, recreation, and fire management activities.

b. Protect high value (ecological or social) ash individuals with chemical injections.

c. Control nonnative invasive plant infestations and wild boar populations.

d. Maintain embedded rare communities.

Representative Hardwood Wetland Forest Old-Growth Stands

Currently, no known examples of this community type occur in old-growth conditions in the Southern Region. Forest types contributing to this OGCT, however, are well represented in the Southern Region, and with time, old-growth examples are expected. Representative sites outside the Region include:

Orange Black Gum Swamp, Franklin County, MA
Brandon Swamp, Rutland County, VT
Cornwall Swamp, Addison County, VT
Stony Point Research Natural Area, Chippewa National Forest, MN

Table 6.5.a—The potential distribution of OGCT 10: hardwood wetland forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Southern Cumberland Mountains (335A)**	George Washington-Jefferson NF (Clinch RD)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, James River and Warm Springs RD—in part, Lee RD, North River RD)
Appalachian Piedmont (344)	**Southern Appalachian Piedmont (344C)**	Chattahoochee-Oconee NF (Oconee RD)
		Francis Marion and Sumter NFs (Enoree RD, Long Cane RD—both in part)
	Cumberland Piedmont (344A)	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland District RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Uwharrie RD)
		Francis Marion and Sumter NFs (Enoree RD—in part)
Central Interior (333)	**Highland Rim (333F)**	NFs of Alabama (Bankhead RD—in part)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
Mississippi Embayment (342)	**Western Mississippi Alluvial Plain (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	NFs of Mississippi (Delta RD)
		Ozark-St. Francis NF (St. Francis RD—in part)
	Southern Mississippi Alluvial Plain (342C)	Kisatchie NF (Calcasieu RD—in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Homochitto RD)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD—in part)
	Black Belt Prairie (343B)	NFs of Alabama (Oakmulgee RD—in part)
Red River Uplands (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
		Kisatchie NF (Calcasieu RD, Kisatchie RD—both in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Catahoula RD, Kisatchie RD—in part, Winn RD)

Table 6.5.a—The potential distribution of OGCT 10: hardwood wetland forest (continued)

Ecological province	Ecological section	National forest unit
Coastal Plain (345)	**Okefenokee Lowlands (345H)**	NFs of Florida (Osceola RD—in part)
	Western Gulf Coastal Plains and Flatwoods (345A)	NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part) Kisatchie NF (Calcasieu RD—in part)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Gulf Coastal Lowlands (345D)	NFs of Florida (Apalachicola RD—in part) NFs of Alabama (Conecuh RD—in part) NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part) Francis Marion and Sumter NFs (Long Cane RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Northern Atlantic Coastal Flatwoods (345L)	NFs of North Carolina (Croatan RD) Francis Marion and Sumter NFs (Francis Marion RD)

NF = national forest; RD = ranger district; NFGT = National Forests and Grasslands in Texas.

Table 6.5.b—The relationship of OGCT 10: hardwood wetland forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**58**	Sweetgum-yellow poplar
	68	Sweetbay-swamp tupelo (in part)
	71	Black ash-American elm-red maple [1]
	87	Red maple
SAF forest types	**39**	Black ash-American elm-red maple
	61	River birch-sycamore
	65	Pin oak-sweetgum (in part)
	87	Sweetgum-yellow poplar
	108	Red maple
FIA forest types	**503**	White oak-red oak-hickory
	519	Red maple-oak
	701	Black ash-American elm-red maple
	708	Red maple-lowland
	809	Red maple-upland
	962	Other hardwoods [2]

[1] In parts of the Southern Region, elm may be replaced by sweetgum.
[2] When these types are encountered, further field work may be necessary to fully identify the OGCT present.

Table 6.5.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 10: hardwood wetland forest

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
GO34	**Oak-sweetgum floodplain forest**	A3625	Southeastern sweetgum-green ash flooded and swamp forest
		A3634	Southeast Coastal Plain live oak swamp forest
		A4439	Mid-Atlantic coastal floodplain forest
G037	**Southern Coastal Plain mixed Evergreen swamp**	A3634	Southeast Coastal Plain live oak swamp forest
		A4685	West Gulf Coastal Plain sweetbay mixed hardwood swamp forest
		A0378	Southeastern Coastal Plain sweetbay mixed hardwood swamp forest
		A0196	Southeastern Coastal Plain Atlantic white cedar seepage swamp forest
G637	**Appalachian-interior-northeast floodplain forest group**	A4439	Mid-Atlantic coastal floodplain forest
		A3702	Southern Appalachian sycamore-sweetgum floodplain forest
G902	**Central Appalachian-northeast acidic swamp**	A4460	Central Appalachian northeast red maple-blackgum acidic swamp
G918	**Central Appalachian-northeast alkaline swamp**	A4461	Central Appalachian northeast red maple-green ash alkaline swamp
G1176	**Central interior-Great Lakes flatwoods**	A4474	Central interior pin oak swamp and flatwoods

Table 6.5.d—Natural vegetation communities for OGCT 10: hardwood wetland forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Narrow nonriverine swamp and wet hardwoods forest (South Carolina)
	–	Small stream floodplain forest—in part (North Carolina and South Carolina)
NatureServe Terrestrial Ecological Systems	CES202.324	Southern Piedmont large floodplain forest
	CES202.705	South central interior large f floodplain forest
	CES203.249	Atlantic Coastal Plain small blackwater river floodplain forest
	CES203.250	Atlantic Coastal Plain small brownwater river floodplain forest
	CES203.247	Atlantic Coastal Plain blackwater stream floodplain forest
	CES203.490	Mississippi River bottomland depressions
	CES203.044	Southeastern Coastal Plain natural lakeshore
	CES203.493	Southern Coastal Plain blackwater river floodplain forest
	CES203.487	West Gulf Coastal Plain small stream and river forest
	CES203.304	Southern Atlantic Coastal Plain nonriverine swamp and wet hardwood forest
	CES203.384	Southern Coastal Plain nonriverine basin swamp
LANDFIRE biophysical settings	15060	West Gulf Coastal Plain nonriverine wet hardwood flatwoods

– = Missing codes have not yet been assigned.

6.6 OGCT 13: River Floodplain Hardwood Forest

Community Description

River floodplain hardwood forests range from the mountains and Piedmont, into the Coastal Plain, including the West Gulf Coastal Plain, in the Southeastern United States (table 6.6.a). Species composition and physiognomic characteristics can vary within a broad floodplain with distinctions based on the frequency and duration of flooding, abiotic factors such as soils and geology, and canopy structure (Fleming et. Al. 2021, NatureServe 2024). OGCT 13 and OGCT 28, large floodplain forest, can have similar species composition and be difficult to distinguish. However, OGCT 13 typically occurs in flat areas away from natural levees or on higher point bars or high terraces. In contrast OGCT 28 occurs on riverbanks and first bottoms of major rivers. For OGCT 13, the associated rivers generally originate in the mountains or Piedmont, but the floodplain forests are poorly developed outside the Piedmont or Coastal Plain. Associated river waters typically are turbid, are often reddish in color from suspended clay and silt sediments, and often referred to as brownwater floodplains (NatureServe 2024, Schafale 2024, Shear et al. 1997). The deposit of sediments from periodic flooding can make this OGCT one of the most productive forests in the South. In contrast, other examples with streams originating in Coastal Plain low areas do not have suspended sediments, are typically dark in color with tannins, referred to as blackwater streams, and are acidic with fewer nutrients (NatureServe 2024).

A diversity of tree species can occur within the variants including red maple (*Acer rubrum*), river birch (*Betula nigra*), water hickory (*Carya aquatica*), water oak (*Quercus nigra*), green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), willow oak (*Q. phellos*), laurel oak (*Q. laurifolia*), overcup oak (*Q. lyrata*), American elm (*Ulmus americana*), winged elm (*U. alata*), and cedar elm (*U. crassifolia*) (table 6.6.b). In contrast to OGCT 28, oak species are often more dominant. However, tree species vary across sites based on soil moisture. Typical tree species on adjacent higher elevations (second bottoms) include cherrybark oak (*Q. pagoda*), swamp chestnut oak (*Q. michauxii*), water oak (*Q. nigra*), and willow oak, but may include shagbark hickory (*Carya ovata*), white oak (*Q. alba*), American beech (*Fagus grandifolia*), and tuliptree (*Liriodendron tulipifera*) (NatureServe 2024, Nowacki 1993, Schafale 2024, Shear et al. 1997). The understory is usually open and dominated by grasses and sedges (Fleming et al. 2021). In contrast, lower elevation variants of this type typically have more abundant overcup oak and water hickory and may have scattered pond cypress (*Taxodium ascendens*) and water tupelo (*Nyssa aquatica*).

In the Ridge and Valley, Northern Cumberland Plateau, and Southern Unglaciated Allegheny Plateau, this type is uncommon but occurs on larger riverfront sites and in pockets of well-drained soils behind riverfronts, sometimes on the first terrace. In the mountains, river floodplain hardwood forest can be found on small stream riparian and flatter portions in the small stream floodplain but is typically not found on fourth-order or smaller streams. In the Northern Cumberland and Southern Unglaciated Allegheny Plateaus (Daniel Boone National Forest), the species more tolerant of less well-drained soils are found in backwater areas where denser clay soils have been deposited.

As indicated, OGCT 28 can be difficult to separate from OGCT 13, especially where the riverfront levee is not well formed. However, OGCT 13 forests generally occur on the Piedmont and Coastal Plain, and are probably more abundant east of the Mississippi River. OGCT 28 forests are widespread, but like OGCT 13 forests, are uncommon in the mountains and Appalachian plateaus. Giant (river) cane (*Arundinaria gigantea*) is often present in both types. Giant cane was used and promoted by native tribes and may currently not be as dense as in historic times (Platt and Brantley 1997). It may dominate the shrub layer of forested stands, and can also can be monotypic within a community completely open or with only widely scattered trees—a canebrake. Tables in section 5 contain old-growth attributes for the river floodplain hardwood forest community type.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.6.c. Additional classifications related to this community type are found in table 6.6.d.

Rare Communities That May be Embedded in This OGCT:

River scour bars and prairies

Canebrakes (occur on well-drained, moist soils; A0795 canebrake)

Stream head seeps, sphagnum bog

Disturbances

The primary disturbances are flooding and natural tree mortality resulting in small gaps in the forest canopy. Fire history is poorly understood within this type, but recurrent wildfires could play a role during dry years within those higher terrace examples (NatureServe 2024). American beech and red maple may become more prominent in this community type because annual flooding cycles have been altered and fires have been suppressed (Shear et al. 1997).

Meandering channels often isolate and then destroy significant areas of river floodplain hardwood forests along major rivers. Beaver (*Castor canadensis*) activity can influence local hydrology, however the effects are poorly understood across a large floodplain landscape (NatureServe 2024). Furthermore, tornado and straight-line winds frequently occur in areas where this forest community predominates.

Pests and Diseases

Nonnative pests and diseases affect species found in this OGCT. For example, beech bark disease (*Neonectria faginata*, *N. ditissima* in association with scale insects *Cryptococcus fagisuga* and possibly *Xylococculus betulae*) can significantly alter the composition and structure of the forest by producing numerous root suckers from infected parent trees. Where ash (*Fraxinus* spp.) species are present, high mortality may occur due to emerald ash borer (*Agrilus planipennis*) altering the composition of this OGCT. Additionally, typical elm associates within this OGCT may suffer from Dutch elm disease (*Ophiostoma* spp., including *O. ulmi*, *O. himal-ulmi*, and *O.*

novo-ulmi). This OGCT is especially vulnerable to wild boar (*Sus scrofa*) damage. Given the greater mesic site conditions, and periodic flooding, nonnative invasive plant infestations are often present. This community is at risk to new infestations as well as spread of existing ones.

Management Considerations

Restoration:

a. Protect high value (ecological or social) ash or elm individuals with chemical injections.

b. Identify any beech bark disease-resistant American beech individuals and use chemical controls for root suckers from unhealthy individuals.

c. Control nonnative invasive plant infestations and wild boar populations.

d. Plant giant cane on appropriate sites to help stabilize banks and improve water quality (sediment deposition).

Maintenance:

a. Limit vehicular access during restoration and recreation activities to maintain soil integrity and hydrologic function.

b. Monitor and treat nonnative and invasive species.

c. Control nonnative invasive plant infestations and wild boar populations.

Representative River Floodplain Hardwood Forest Old-Growth Stands:

Boiling Springs Natural Area, Sumter National Forest, SC

Green Ash Research Natural Area, Delta National Forest, MS

Red Gum Research Natural Area, Delta National Forest, MS

Overcup Oak Research Natural Area, Delta National Forest, MS

Mormon Branch Botanical Area, Ocala National Forest, FL

Congaree National Park, Richland County, SC

Savannah River Site, near New Ellenton, SC

Moro Creek Bottoms Preserve, south-central AR

Table 6.6.a—The potential distribution of OGCT 13: river floodplain hardwood forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Southern Cumberland Mountains (335A)**	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, James River and Warm Springs RD—in part, Lee RD, North River RD)
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Oconee RD)
		Francis Marion and Sumter NFs (Enoree RD, Long Cane RD—both in part)
	Central Appalachian Piedmont (334D)	NFs of North Carolina (Uwharrie RD—in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)
Central Interior (333)	**Bluegrass (333E)**	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	Land Between the Lakes (NRA)
		NFs of Alabama (Bankhead RD—in part)
Mississippi Embayment (342)	**Eastern Mississippi Alluvial Plain (342B)**	NFs of Mississippi (Delta RD)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD—in part, Homochitto RD, Tombigbee RD—in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD—in part, Tombigbee RD—in part)
		NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)

Table 6.6.a—The potential distribution of OGCT 13: river floodplain hardwood forest (continued)

Ecological province	Ecological section	National forest unit
Coastal Plain (345)	**West Central Gulf Coastal Plains and Flatwoods (345C)**	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part)
		NFs of Florida (Apalachicola RD—in part)
		NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (344F)	NFs of North Carolina (Uwharrie RD—in part)
		Francis Marion and Sumter NFs (Long Cane RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)

NF = national forest; RD = ranger district; NRA = national recreation area.

Table 6.6.b—The relationship of OGCT 13: river floodplain hardwood forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**13**	Loblolly pine-hardwood [1]
	46	Bottomland hardwood-yellow pine [1]
	58	Sweetgum-yellow poplar
	61	Swamp chestnut oak-cherrybark oak
	62	Sweetgum-oak
	63	Sugarberry-American elm-green ash
	64	Laurel oak-willow oak
	65	Overcup oak-water hickory
	68	Sweetbay-swamp tupelo-red maple
	69	Beech-magnolia
	72	River birch-sycamore
	75	Sycamore-pecan-American elm
	76	Silver maple-American elm
	97	Live oak
SAF forest types	**61**	River birch-sycamore
	62	Silver maple-American elm
	65	Pin oak-sweetgum (in part)
	68	Willow oak-water oak-laurel oak
	82	Loblolly pine-hardwood [1]
	87	Sweetgum-yellow poplar
	88	Willow oak-water oak-diamondleaf oak
	89	Live oak
	91	Swamp chestnut oak-cherrybark oak
	92	Sweetgum-willow oak
	93	Sugarberry-American elm-green ash
	94	Sycamore-sweetgum-American elm
	96	Overcup oak-water hickory
FIA forest types	**508**	Sweetgum-yellow poplar
	601	Swamp chestnut oak-cherrybark oak
	602	Sweetgum-Nuttall oak-willow oak
	605	Overcup oak-water hickory
	606	Atlantic white-cedar
	705	Sycamore-pecan-American elm
	706	Sugarberry-hackberry-elm-green ash
	962	Other hardwoods [1]

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.6.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 13: river floodplain hardwood forest

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G033	**Bald cypress-tupelo floodplain forest**	A3629	Overcup oak floodplain swamp
G034	**Oak-sweetgum floodplain forest**	A3625	Southeastern sweetgum-green ash flooded and swamp forest
		A3626	Piedmont tuliptree-oak-sweetgum floodplain forest
		A3627	West Gulf Coastal Plain oak-sweetgum-tupelo floodplain forest
		A3628	Southeast Coastal Plain oak-pine blackwater floodplain forest
		A3631	West Gulf Coastal Plain oak mesic floodplain forest
		A3633	Piedmont floodplain forest
		A3634	Southeast Coastal Plain live oak swamp forest
		A4683	Southeast Coastal Plain willow oak-water oak floodplain forest
		A4684	West Gulf Coastal Plain oak floodplain forest
		A0795	Giant cane canebrake
G037	**Coastal Plain mixed evergreen swamp**	A4685	West Gulf Coastal Plain forested seep
G979	**Lower Mississippi River Alluvial Plain floodplain forest**	A3592	Mississippi River Alluvial Plain maple-ash swamp forest
G759	**Southern ash-elm-willow floodplain forest**	A3707	Southeast Coastal Plain sycamore-ash-elm floodplain forest
G673	**Central interior northeast floodplain forest**	A3699	Southern interior oak bottomland forest
–	–	–	Swamp chestnut oak-sweetgum floodplain forest
G979	**Lower Mississippi River Alluvial Plain floodplain forest**	A3592	Mississippi River Alluvial Plain maple-ash swamp forest

– = Missing codes have not yet been assigned.

Table 6.6.d—Natural Vegetation Communities for OGCT 13: river floodplain hardwood forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Small river floodplain forest (North Carolina and South Carolina)
	–	Small stream floodplain forest (North Carolina and South Carolina)
	–	Stream floodplain forest (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Streamhead forest and meadow (Georgia, Kentucky, and Tennessee)
NatureServe Terrestrial Ecological System	CES203.066	Atlantic Coastal Plain large river floodplain forest
	CES203.249	Atlantic Coastal Plain small blackwater river floodplain forest
	CES203.250	Atlantic Coastal Plain small brownwater river floodplain forest
	CES203.489	East Gulf Coastal Plain large river floodplain forest
	CES203.247	Atlantic Coastal Plain blackwater stream floodplain forest
	CES203.065	Red River large floodplain forest
	CES203.493	Southern Coastal Plain blackwater river floodplain forest
	CES203.488	West Gulf Coastal Plain large river floodplain forest
	CES202.705	South-central interior large floodplain
	CES202.706	South-central interior small stream and riparian
	CES202.703	Ozark-Ouachita riparian
	CES203.196	Mississippi River high floodplain (bottomland) forest
	CES203.195	Mississippi River low floodplain (bottomland) forest
	CES203.190	Mississippi River riparian forest
	CES203.559	East Gulf Coastal Plain small stream and river floodplain forest
	CES203.487	West Gulf Coastal Plain small stream and river forest
LANDFIRE biophysical settings	14740	Gulf and Atlantic Coastal Plain small stream riparian systems
Florida Natural Areas Inventory	–	Floodplain forest, overcup-water hickory flat subtype
	–	Floodplain forest, diamondleaf oak-spruce pine flat subtype
Terrestrial Ecological Unit Inventory (TEUI) (Texas)	–	Frequently flooded hardwood river floodplain and swamp forest (7 LTPs, 17 associations)

– = Missing codes have not yet been assigned.

LTP = landtype phase, a small unit of similar topography, geology, soils, and vegetation ranging from a few acres (~1 hectare) to a few hundred acres (120 hectares) in size.

6.7 OGCT 14: Cypress-Tupelo Swamp Forest

Community Description

Cypress (*Taxodium* spp.)-tupelo (*Nyssa* spp.) forests primarily occur on the Coastal Plain from southern Delaware through south Florida to southeastern Texas and extend northward along the Mississippi River and its major tributaries to southern Illinois (table 6.7.a). Most of the cypress trees grow within 100 feet of sea level. This forest community type is found almost exclusively in depressions that are prone to frequent flooding, such as swamps, deep sloughs, alluvial flats of major river floodplains, tidal estuaries, margins of coastal marshes, and isolated depressions of the Coastal Plain. Soil types vary but most have poor aeration from high water levels (Devall 1998).

Principal tree species include bald cypress (*Taxodium distichum*), pond cypress (*T. ascendens*), water tupelo (*Nyssa aquatica*), and swamp tupelo (*N. biflora*). These species occur either singly or in mixtures (table 6.7.b). These communities are varied in midstory and understory conditions (Devall 1998). Both Carolina ash (*Fraxinus caroliniana*) and planertree (*Planera aquatica*) are often present in the subcanopy with a shrub layer of buttonbush (*Cephalanthus occidentalis*) and vines like poison ivy (*Toxicodendron radicans*). Slash pine (*Pinus elliottii*), red maple (*Acer rubrum*), sweetbay (*Magnolia virginiana*), sweetgum (*Liquidambar styraciflua*), redbay (*Persea borbonia*), and various oaks (*Quercus* spp.) are also associated tree species.

Bald cypress grows larger and more rapidly than pond cypress and is usually associated with flowing water. Pond cypress ordinarily dominates shallow ponds, edges of stands, and other locations where water collects and stands for part of the year. Though these tree species are not considered shade tolerant, this forest community type as a whole is considered stable (climax) on most sites because prolonged periods of deep flooding curtail invasion by more shade-tolerant species. However, where sediment accumulates or the frequency of flooding diminishes, this forest type may be replaced by others (e.g., river floodplain hardwood forests) (Devall 1998). Tables in section 5 contain attributes for the cypress-tupelo swamp OGCT.

Bald cypress is an important component of bottomland hardwood communities, but those forest types are not considered here. Pond cypress and slash pine may be major components of pine flatwoods.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.7.c. Additional classifications related to this community type are found in table 6.7.d.

Disturbance

Historically, low intensity, small-scale disturbances were probably common in these forests, although they were also occasionally hit by large-scale disturbances such as hurricanes because of their proximity to the coast. Due to hydric conditions, fire is unusual in these forests except during periods of drought and has an impact on stand dynamics and community composition when it occurs (Devall 1998). The principal tree species typically have long life spans; bald cypress, for instance, can live 1,600 years or longer.

Pests and Diseases

Nonnative plants, pests, and diseases affect species found in this OGCT. For example, emerald ash borer (*Agrilus planipennis*) is a threat to ash species and laurel wilt (*Harringtonia lauricola*) is impacting woody plants in the laurel family (Lauraceae) within this community. Where these tree species are present, there may be high levels of mortality and an overall reduction in species diversity. Invasive animals like nutria (*Myocastor coypus*) and plants like Chinese tallow (*Triadica sebifera*) are also impacting the composition and structure of these communities. Nutria have the potential to be very damaging to young cypress growth (Wilhite and Toliver 1990).

Management Considerations

Maintenance:

a. Identify and protect individual trees of significance from emerald ash borer through chemical treatment.

b. Control nonnative invasive plant infestations and nonnative animal populations.

Restoration:

a. Restore historic hydrological regimes when possible.

b. Monitor after large-scale disturbance for changes to the community.

c. Control nonnative invasive species infestations and nonnative animal populations.

d. Encourage regeneration of principle overstory species like cypress, whose seeds do not germinate under water.

e. Plant Lauraceae species.

Representative Cypress-Tupelo Swamp Forest Old-Growth Stands:

Big Cypress, Bienville Parish, LA

Congaree National Park, Richland County, SC

Guilliard Lake Scenic and Research Natural Area, SC

Gum Swamp Research Natural Area, Osceola National Forest, FL

Pond Cypress Swamps, Apalachicola National Forest, FL

Tate’s Hell Swamp, Franklin County, FL

Table 6.7.a—The potential distribution of OGCT 14: cypress-tupelo swamp forest

Ecological province	Ecological section	National forest unit
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Oakmulgee RDâ€”in part, Tuskegee RD)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part) Kisatchie NF (Calcasieu RD, Kisatchie RD—both in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD)
Mississippi Embayment (342)	**Western Mississippi Alluvial White and Black River Alluvial Plains (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	Ozark-St. Francis NF (St. Francis RD—in part) NFs of Mississippi (Delta RD)
	Southern Mississippi Alluvial Plain (342C)	Kisatchie NF (Calcasieu RD—in part, Catahoula RD)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD—in part, Homochitto RD, Tombigbee RDâ€”in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD, Tombigbee RD—both in part) NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part) NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part) NFs of Florida (Apalachicola RD—in part) NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD) NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NFGT = National Forests and Grasslands in Texas.

Table 6.7.b—The relationship of OGCT 14: cypress-tupelo swamp forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region Forest Types	Code	Description
FSVeg EV codes	**23**	Pond cypress
	24	Bald cypress
	67	Bald cypress-water tupelo
SAF forest types	**100**	Pond cypress
	101	Bald cypress
	102	Bald cypress-tupelo
	103	Water tupelo-swamp tupelo
FIA forest types	**607**	Bald cypress-water tupelo
	609	Bald cypress-pond cypress

Table 6.7.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 14: cypress-tupelo swamp forest

USNVC groupcode	USNVC groups	USNVC alliances code	USNVC alliances
G036	**Pond cypress basin swamp**	A3340	Pond cypress mixed shrub basin swamp
		A2321	Pond cypress-graminoid basin swamp
G033	**Bald cypress-tupelo floodplain forest**	A0323	Coastal Plain cypress-tupelo floodplain forest
		2322	Southern bald cypress-tupelo floodplain forest
		A0652	Cypress lakeshore swamp forest
		A3595	Southern bald cypress-swamp blackgum tidal swamp forest

Table 6.7.d—Natural vegetation communities for OGCT 14: cypress-tupelo swamp forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Carolina bay cypress wetland (South Carolina)
NatureServe Terrestrial Ecological System (all are small portion of many systems)	CES203.066	Atlantic Coastal Plain large river floodplain forest
	CES203.249	Atlantic Coastal Plain small blackwater river floodplain forest
	CES203.250	Atlantic Coastal Plain small brownwater river floodplain forest
	CES203.251	Southern Coastal Plain nonriverine cypress dome
	CES203.489	East Gulf Coastal Plain large river floodplain forest
	CES203.247	Atlantic Coastal Plain blackwater stream floodplain forest
	CES203.245	Atlantic Coastal Plain clay-based Carolina bay forest
	CES203.490	Mississippi River bottomland depressions
	CES203.044	Southeastern Coastal Plain natural lakeshore
	CES203.065	Red River large floodplain forest
	CES203.493	Southern Coastal Plain blackwater river floodplain forest
	CES203.488	West Gulf Coastal Plain large river floodplain forest
	CES203.487	West Gulf Coastal Plain small stream and river forest
	CES203.459	West Gulf Coastal Plain near-coast large river swamp
	CES203.262	Southern Atlantic Coastal Plain depression pond
LANDFIRE biophysical settings	13780	Gulf and Atlantic Coastal Plain swamp systems
Florida Natural Areas Inventory (FNAI) Natural Communities	–	Dome swamp, cypress dome subtype
	–	Stand swamp, cypress stand subtype
	–	Basin swamp, blackgum swamp subtype

– = Missing codes have not yet been assigned.

6.8 OGCT 21: Mesic and Dry Mesic Oak Forest

Community Description

Mesic and dry mesic oak forests occur throughout the South in all ecological provinces (table 6.8.a), most commonly in the mountains. They are typically found on ridges and west-facing, south-facing, and, to a lesser extent, east-facing upper slopes (Spetich et al. 2022). There are two OGCT 21 subtypes.

The species composition of this community type varies significantly because of its wide distribution and topographic position. The major species include white oak (*Quercus alba*), scarlet oak (*Q. coccinea*), chestnut oak (*Q. montana*), northern red oak (*Q. rubra*), and black oak (*Q. velutina*). Additional associates include southern red oak (*Q. falcata*), post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), pignut hickory (*Carya glabra*), mockernut hickory (*C. tomentosa*), and red maple (*Acer rubrum*) (table 6.8.b). Red hickory (*C. ovalis*) may be a component (Spetich et al. 2022), as is the case in the Redbird Ranger District of the Daniel Boone National Forest, where it is an important canopy species. Spetich et al. (2022) found that the number of species of shrubs and vines varied from 1 to 10 across the sites examined with blueberries (*Vaccinium* spp.), Virginia creeper (*Parthenocissus quinquefolia*), eastern poison ivy (*Toxicodendron radicans*), and grapes (*Vitis* spp.), the most common. Dry mesic examples in the mountains are dominated by members of the heath family, which are less frequent within mesic examples. With frequent burning, sedges and grasses may become dominant in patches.

Coniferous species such as shortleaf pine (*Pinus echinata*), pitch pine (*P. rigida*), eastern white pine (*P. strobus*), and Table Mountain pine (*P. pungens*) may occur as a mixture, with an overstory coverage of <25 percent. American chestnut (*Castanea dentata*) was a major species in this OGCT until the 1930s (Nowacki 1993). In areas where fire has been excluded, eastern white pine has likely become more abundant. Conversely, on some sites within the region, too much fire in this OGCT could remove the more mesic herbaceous layer species, shifting the community towards a xeric oak or pine type.

Calcareous variants of this type tend to be dry rather than mesic, but still include some typically mesic species. The overstory is dominated by species such as chinquapin oak (*Quercus muhlenbergii*), sugar maple (*Acer saccharum*), blue ash (*Fraxinus quadrangulata*), and white ash (*F. americana*), and may include shagbark hickory (*Carya ovata*), white oak (*Q. alba*), Shumard oak (*Q. shumardii*), basswood (*Tilia americana*), black walnut (*Juglans nigra*), and slippery elm (*Ulmus rubra*). Understory trees may include eastern redcedar (*Juniperus virginiana*), hophornbeam (*Ostrya virginiana*), Carolina buckthorn (*Frangula caroliniana*), upland swampprivet (*Forestiera ligustrina*), and blackhaws (*Viburnum* spp.).

Mesic and dry-mesic oak forest (subtype 21a)

This subtype consists of oak forests typically found on upland sites on southern and western aspects and ridgetops but not on extremely steep slopes. In the Southern Appalachian Mountains, this subtype is found on the upper portions of east-facing slopes. Soil moisture may allow mesophytic species development in the understory with variable oak-dominated types. Soil variability, especially with underlying calcareous or mafic rock, allows development of other variants with greater species richness (Fleming et al. 2021, Schafale 2024). It is often found in a landscape position adjacent to rich and acidic coves with more herbaceous species richness. This subtype constitutes a large part of the landscape in the mountains and Appalachian Plateaus and can also be found across the Piedmont but is scarce in the Coastal Plain.

High elevation northern red oak forest (subtype 21b)

This high elevation subtype occurs from 3,500 to 5,500 feet on broad primary, secondary, and tertiary ridges and mid to upper slopes, commonly on southern and southeastern exposures (Delapp 1978). It occurs on the Chattahoochee, Cherokee, Nantahala, Pisgah, and George Washington and Jefferson National Forests with its greatest concentration in the Nantahala and Pisgah National Forests.

Northern red oak occupies more than 60 percent of the overstory canopy. Associated species composition and structure varies with aspect and soils. Species richness, primarily as result of herbaceous diversity, varies greatly across the subtype. Because of variability in conditions, old-growth examples can vary widely. This subtype may include several different variations including an evergreen shrub-dominated midstory, a rich herbaceous understory, a stunted overstory, an orchard structure, and can occur in a well-developed boulderfield (Schafale 2024). Tree height can be as short as 16 feet (4.9 m) within the stunted and orchard types and exceeding 82 feet (25 m) in the more common types.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.8.c. Additional classifications related to this community type are found in table 6.8.d.

Rare Communities That May be Embedded in This OGCT:

White pine forest (Blue Ridge Mountains)

Calcareous oak-walnut forest (Blue Ridge Mountains)

High elevation red oak rich (on southern and southeastern exposures), stunted, and orchard subtypes (Blue Ridge Mountains)

High elevation white oak forest (Blue Ridge Mountains)

High elevation red oak boulderfields (on southern and southeastern exposures)

Disturbance

The frequency of fire is important in the disturbance regime for this community type. The drier sites where this community type occurs are conducive to recurring, low-intensity surface fires, which are thought to have been quite common prior to European settlement. These fires helped maintain the oak component by eliminating fire-sensitive competitors and stimulating oak regeneration (Nowacki 1993). Furthermore, blowdowns of single or multiple trees result in some gap phase regeneration of more shade-tolerant species where present. Infrequent tornadoes, ice and wind storms may create large (10–100+ acre) canopy gaps resetting successional pathways. In the high elevation red oak subtype, natural disturbances include low temperatures, high winds, ice storms, and occasional wildfires. Ice storms may also affect this community at lower elevations. As this old-growth community ages under more extreme weather events, oak decline (the result of a complex interaction of biotic and abiotic factors) is likely to have a greater influence (Crocker et al. 2023).

Pests and Diseases

Within northern portions of the region, the nonnative spongy moth (*Lymantria dispar*) poses a recurring threat to this OGCT. During years of high site stress, such as drought, the native southern pine beetle (*Dendroctonus frontalis*) may impact the existing pine species. Historic southern pine beetle activity has likely led to a decrease in the pine composition in this community. Oak wilt (*Ceratocystis fagacearum*) (origin uncertain) infection centers may also develop, especially within concentrations of red oaks. This disease is present throughout the Southeastern United States but is particularly prevalent in Texas, Arkansas, Tennessee, Kentucky, Virginia, and the Carolinas (Bragard et al. 2020, Wilson 2001). As existing communities of this OGCT age, they may experience oak decline from multiple stress factors. This type, where fire has been excluded during historic times, may have developed dense levels of mesic species throughout all layers of the community, some being nonnative and invasive.

Management Considerations

Restoration:

a. Return fire by using restoration intervals to sites that have had fire absent from the community.
b. Harvest, remove, or mulch mesic species that encroached during the fire-free period.
c. Reintroduce or supplementally plant appropriate hardwood species where appropriate.
d. Create historic overstory densities and structures by using harvest, removal, mulching, or herbicide and fire to achieve sustainable, climate change-resilient plant communities.
e. Control woody understory species by using herbicides in advance of or in concert with reintroducing prescribed fire.
f. Reintroduce site-appropriate herbaceous species.
g. Reintroduce pine species where appropriate.
h. Control nonnative invasive plants and insects.

Maintenance:

a. Use an appropriate fire return interval.
b. Control undesirable woody encroachment that is too aggressive for fire alone with occasional herbicide use.
c. Allow pockets of compositionally appropriate tree regeneration to advance into the overstory.
d. Control nonnative invasive species and insects such as spongy moth.

Representative mesic and dry mesic oak forest old-growth stands:

Joyce Kilmer Memorial Forest, Graham County, NC

Crabtree Creek, George Washington National Forest, VA

Dolly Anne Special Management Area, George Washington National Forest, VA

Little Walker Mountain, Jefferson National Forest, VA

The Skidmore Special Management Area, George Washington National Forest, VA

Linville Gorge (subtype 21a), Pisgah National Forest, NC

Mount Pisgah (subtype 21b), Pisgah National Forest, NC

Mackey Mountain (subtype 21a), Pisgah National Forest, NC

London Bald Ares (subtype 21a), Nantahala National Forest, NC

Stratton Bald Area (subtype 21b), Joyce Kilmer Wilderness, Nantahala National Forest, NC

Duncan Cove, Pisgah National Forest, NC

Roaring Branch Research Natural Area, Ouachita National Forest, AR

Duke Forest, NC

Big Woods, Mammoth Cave National Park, KY

Lilley Cornett Woods (subtype 21a), Letcher County, KY (in part)

Right Fork Elisha Creek (subtype 21a), Redbird District, Daniel Boone National Forest, KY

Table 6.8.a—The potential distribution of OGCT 21: mesic and dry mesic oak forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)

Table 6.8.a—The potential distribution of OGCT 21: mesic and dry mesic oak forest (continued)

Ecological province	Ecological section	National forest unit
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part, Oconee RD)
		Francis Marion and Sumter NFs (Andrew Pickens RD, Enoree RD, Long Cane RD—all in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Grandfather RD, Uwharrie RD—both in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Poteau RD, Tiak RD—in part, Winona RD, Womble RD)
		Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	Land Between the Lakes (NRA)
		NFs of Alabama (Bankhead RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
		Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD)
		Ouachita NF (Tiak RD—in part)

Table 6.8.a—The potential distribution of OGCT 21: mesic and dry mesic oak forest (continued)

Ecological province	Ecological section	National forest unit
Mississippi Embayment (342)	**Western Mississippi Alluvial White and Black River Alluvial Plains (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	Ozark-St. Francis NF (St. Francis RD—in part)
	Southern Mississippi Alluvial Plain (342C)	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD—in part, Homochitto RD, Tombigbee RD—in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD, Tombigbee RD—both in part) NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part) NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part) NFs of Florida (Apalachicola RD—in part) NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part) Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD) NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NRA = national recreation area; NFGT = National Forests and Grasslands in Texas.

Table 6.8.b—The relationship of OGCT 21: mesic and dry mesic oak forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**51**	Post oak-black oak
	52	Chestnut oak
	53	White oak-northern red oak-hickory
	54	White oak
	55	Northern red oak
	56	Yellow poplar-white oak-northern red oak (in part)
	59	Scarlet oak
	60	Chestnut oak-scarlet oak
	84	Chestnut oak-white oak-scarlet oak
	85	White oak-black oak-hickory
SAF forest types	**44**	Chestnut oak
	52	White oak-black oak-northern red oak
	53	White oak (in part)
	55	Northern red oak
	110	Black oak
FIA forest types	**502**	Chestnut oak
	504	White oak
	505	Northern red oak
	510	Scarlet oak
	515	Chestnut oak-black oak-scarlet oak
	519	Red maple-oak
	962	Other hardwoods [1]

[1] When these types are encountered, further field work may be necessary to fully identify the OGCT present.

Scarlet oak and chestnut oak stands (FSVeg EV codes 52, 59, and 60) associated with dry xeric conditions are also included in OGCT 22.

Table 6.8.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 21: mesic and dry mesic oak forest

Code	USNVC groups	Code	USNVC alliances
G166	**Southern mesic beech-oak-mixed deciduous forest**	A2099	Mississippi Loess plains mesic forest
–	–	A2092	West Gulf Coastal Plain calcareous mesic forest
–	–	A2093	West Gulf Coastal Plain mesic oak forest
–	–	A2094	Southeastern Coastal Plain acidic dry mesic forest
–	–	A3235	Southeast Gulf Coastal Plain mesic oak hardwood forest
G165	**Piedmont Coastal Plain oak forest and woodland**	A3274	Piedmont ash-hickory basic woodland
		A3293	Piedmont dry mesic oak-hickory Forest
		A3294	Piedmont post oak-hickory-pine woodland
		A4434	Piedmont oak-hickory hardpan woodland
		A4438	Piedmont dry chestnut oak forest
G987	**Interior low plateau oak forest**	A2060	Interior low plateau calcareous oak forest
		A2086	Interior low plateau acidic oak forest
G988	**Ozark-Ouachita oak forest**	A2085	Ozark-Ouachita acidic oak forest
		A2098	Ozark-Ouachita calcareous forest
G015	**Southern Appalachian oak-chestnut forest**	A0250	Dry mesic acidic chestnut oak-northern red oak forest
		A3116	Appalachian montane oak forest
		A4390	Southern Appalachian dry mesic oak forest
		A4392	Southern Appalachian dry oak-white pine forest
G016	**Appalachian northeast alkaline forest and woodland**	A2047	Chinquapin oak-maple dry mesic calcareous forest
		A3106	Appalachian Limestone Chinquapin Oak Woodland
G650	**Central Appalachian northeast oak-hickory forest and woodland**	A4436	Central Appalachian dry mesic oak-hickory forest

– = Missing codes have not yet been assigned.

Table 6.8.d—Natural vegetation communities for OGCT 21: mesic and dry mesic oak forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Dry mesic oak forest (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Montane oak-hickory slope forest (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Montane oak-hickory cove (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Montane oak-hickory rich ridge (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Mesic hardwood slope forest (North Carolina and South Carolina)
	–	Dry mesic calcareous forest and woodland (Georgia, Kentucky, Tennessee, and Virginia)
	–	High elevation red oak forest and woodland (Georgia, Kentucky, North Carolina, Tennessee, and Virginia)
	–	Dry and dry mesic oak forest—in part (North Carolina and South Carolina)
NatureServe Terrestrial Ecological System	CES202.886	Southern Appalachian oak forest
	CES202.596	Central and southern Appalachian oak forest
	CES203.241	Southern Atlantic Coastal Plain dry and dry mesic oak forest
	CES203.502	Southern Coastal Plain limestone forest
	CES202.339	Southern Piedmont dry oak-pine forest (in part)
	CES203.241	Southern Atlantic Coastal Plain dry and dry mesic oak forest (in part)
	CES203.071	Mississippi River Alluvial Plain dry mesic loess slope forest
	CES203.079	Crowley's Ridge mesic loess slope forest
	CES202.708	Ozark-Ouachita dry mesic oak woodland
LANDFIRE biophysical settings	13150	Southern Appalachian oak forest

– = Missing codes have not yet been assigned.

6.9 OGCT 22: Dry and Xeric Oak Forest, Woodland, and Savanna

Community Description

Dry and xeric oak forests, woodlands, and savannas are found throughout the southeast in all ecological provinces. They usually occur on very dry and infertile uplands, on steep, south- and west-facing slopes, ridges, or rock outcrops (table 6.9.a). Soils are usually coarse textured, and dry soil conditions may prevail most of the year because bedrock is close to the surface (Tyrrell et al. 1998). Typically, they are forests of acidic soils, but basic or calcareous variants also occur (Fleming et al. 2021, Schafale 2024). Two recognized subtypes occur in the South: the widespread subtype 22a and the southern subtype 22b.

The widespread subtype (subtype 22a)

The widespread subtype includes black oak (*Quercus velutina*), post oak (*Q. stellata*), southern red oak (*Q. falcata*), blackjack oak (*Q. marilandica*), chestnut oak (*Q. montana*), scarlet oak (*Q. coccinea*), and white oak (*Q. alba*) as the major species (Nowacki 1993). It likely contained American chestnut (*Castanea dentata*) historically. Within the southern Appalachian Mountains, coniferous species such as pitch pine (*Pinus rigida*), Table Mountain pine (*P. pungens*), and shortleaf pine (*P. echinata*) may occur as a mixture, typically with an overstory coverage of <25 percent. On the Cumberland Plateau, pitch pine, Virginia pine (*P. virginiana*), and shortleaf pine occur in low numbers within this subtype. In the northern portion of the East Gulf Coastal Plain and piedmont, canopy dominants include southern red oak, post oak, white oak, black oak, scarlet oak, and hickories (*Carya* spp.). Shortleaf pine, loblolly pine (*P. taeda*), and longleaf pine (*P. palustris*) may occur in low numbers. Calcareous to circumneutral variants that we treat as rare communities tend to be more open with scattered trees in some combination of eastern redcedar (*Juniperus virginiana*), chinquapin oak (*Quercus muehlenbergii*), chestnut oak, post oak, and scarlet oak. Pennsylvania sedge (*Carex pensylvanica*) and various grasses including poverty oatgrass (*Danthonia spicata*), little bluestem (*Schizachyrium scoparium*), blackseed speargrass (*Piptochaetium avenaceum*), and eastern bottlebrush grass (*Elymus hystrix*) are the typical herbaceous species.

The southern subtype (subtype 22b)

The southern subtype community is made up of small-statured trees that include turkey oak (*Quercus laevis*), bluejack oak (*Q. incana*), sand post oak (*Q. margarettae*), Mohr oak (*Q. mohriana*), and sand live oak (*Q. geminata*). Larger trees such as live oak (*Q. virginiana*) may also be present (table 6.9.b). Subtype 22b can be associated with longleaf or slash pine (*P. elliottii*) communities in the Coastal Plain and oak barrens in the western portion of region extending to the Carolinas and into Florida. In Texas, this type is best represented by the post oak-longleaf pine sandcap woodland community, an unmapped forest type that occurs as a small inclusion in deep sandy pine uplands. Typically, there is a small pine component, but oaks and hickories usually dominate.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC) see table 6.9.c. Additional classifications related to this community type are found in table 6.9.d.

Tables in section 5 contain attributes for the dry and xeric oak forest, woodland, and savanna old-growth forest community type.

Rare Communities That May be Embedded in This OGCT:

Montane eastern redcedar (*Juniperus virginiana*)-hardwood woodland

Xeric hardpan forests—basic and rocky subtypes (piedmont)

Upland depression swamp forest (piedmont)

Calcareous shale slope woodland (Blue Ridge and Cumberland Plateau)

Acidic shale slope woodland

Ultramafic outcrop barren—pitch pine and white oak subtypes (Blue Ridge)

Redcedar-hardwood glades, woodlands, forests (low elevations)

Disturbance

Periodic surface fires along with droughts, and poor site conditions are important for maintaining the open condition of this old-growth forest community type. Fires are thought to have burned frequently enough to restrict tree density and promote the growth of shade intolerant grasses, forbs, and shrubs (Tyrrell et al. 1998). On sites where frequent fire limited tree density, the era of fire suppression may have resulted in encroachment of mesic tree species; these sites now exist as closed canopy forests (Tyrrell et al. 1998). Short lived oak species may have died out from the community without like replacement in the canopy because of understory shade levels. Tornadoes, ice and wind storms may create large (10–100+ acre) canopy gaps, resetting successional pathways. Other threats include overstocking in surrounding uplands, invasive species, offroad vehicle use, unmanaged right-of-way (ROW) maintenance, soil disturbance, oil and gas development, and in some cases, illegal harvesting of plants.

When pines are present, OGCT 22 is similar to OGCTs 24 and 25 and may represent past management influences.

Pests and Diseases

Within northern portions of the region, the nonnative spongy moth (*Lymantria dispar*) is a recurring threat to this OGCT. During years of high site stress such as drought, oak decline may occur, and the native southern pine beetle (*Dendroctonus frontalis*) may impact the existing pine species. Historic southern pine beetle activity has likely led to decreases in the pine composition within this community. Oak wilt (*Ceratocystis fagacearum*) (origin uncertain) infection centers may also develop, especially within concentrations of red oaks. This disease is present throughout the Southeastern United States, but is particularly prevalent in Texas, Arkansas Tennessee, Kentucky, Virginia, and the Carolinas (Bragard et al. 2020, Wilson 2001). As existing communities of this OGCT age, they may experience greater oak decline from multiple stress factors, including extreme weather events (Crocker et al. 2023). Mesic species encroachment, though not as prevalent as in more mesic OGCTs, may have occurred to some degree in this type, especially in the northern type where eastern white pine is present. Historic disturbances like the nonnative chestnut blight (*Cryphonectria parasitica*) in the northern type, grazing, and targeted timber extraction may have influenced the composition and structure of this community.

Management Considerations

Restoration:

a. Return fire by using restoration intervals to sites that have had fire absent from the community.

b. Harvest, remove, mulch, and apply herbicide to mesic species that encroached during an extended fire-free period.

c. Apply herbicide and slash (fell without removal) in remote areas inaccessible to machinery or where the local community is less represented.

d. Create historic overstory densities and structures by using harvest, removal, mulching and fire, thereby enhancing sustainable, climate change-resilient plant communities.

e. Control woody understories and midstories by using herbicide in advance of or in concert with the reintroduction of prescribed fire to develop advance competitive oak regeneration.

f. Reintroduce site-appropriate herbaceous species.

g. Reintroduce pine species or short lived oak species where appropriate.

h. Reintroduce American chestnut when a disease-resistant (blight and root disease) option becomes available.

Maintenance:

a. Use an appropriate fire return interval.

b. Occasionally use herbicide to control undesirable woody encroachment that is too aggressive for fire alone and in remote areas inaccessible by machinery.

c. Allow pockets of compositionally appropriate tree regeneration to advance into the overstory.

d. Control wild boar (*Sus scrofa*) and nonnative invasive plants.

Example Dry and Xeric Oak Forest, Woodland, and Savanna Old-Growth Stands:

Linville Gorge, Pisgah National Forest, NC

Great Smoky Mountains National Park, NC and TN (Pyle 1988)

Nantahala Gorge (southwest-facing slopes), Nantahala National Forest, NC

Post Oak Stand, Long Cane Ranger District, SC

Right Fork Elisha Creek, Redbird Ranger District, Daniel Boone National Forest, KY—in part

Hot Springs National Park, Hot Springs, AR

Hickory Creek Savanna Unit, Big Thicket National Preserve, Tyler County, TX

Table 6.9.a—The potential distribution of OGCT 22: dry and xeric oak forest, woodland, and savanna

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part, Oconee RD)
		Francis Marion and Sumter NFs (Andrew Pickens RD, Enoree RD, Long Cane RD—all in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Grandfather RD, Uwharrie RD—both in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)

Table 6.9.a—The potential distribution of OGCT 22: dry and xeric oak forest, woodland, and savanna (continued)

Ecological province	Ecological section	National forest unit
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Poteau RD, Tiak RD—in part, Winona RD, Womble RD) Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	LBL (Land Between the Lakes NRA) NFs of Alabama (Bankhead RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part) Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD) Ouachita (Tiak RD—in part)
Mississippi Embayment (342)	**Southern Mississippi Alluvial Plain (342C)**	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD, Tombigbee RD—both in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD, Tombigbee RD—both in part) NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)

Table 6.9.a—The potential distribution of OGCT 22: dry and xeric oak forest, woodland, and savanna (continued)

Ecological province	Ecological section	National forest unit
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part)
		NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part)
		NFs of Florida (Apalachicola RD—in part)
		NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part)
		Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD)
		NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NRA = national recreation area; NFGT = National Forests and Grasslands in Texas.

Table 6.9.b—The relationship of OGCT 22: dry and xeric oak forest, woodland, and savanna, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**45**	Chestnut oak-scarlet oak-yellow pine [1]
	51	Post oak-black oak
	52	Chestnut oak
	53	White oak-northern red oak-hickory
	54	White oak
	57	Scrub oak
	59	Scarlet oak
	60	Chestnut oak-scarlet oak
	84	Chestnut oak-white oak-scarlet oak
SAF forest types	**40**	Post oak-blackjack oak
	43	Bear oak
	44	Chestnut oak
	72	Southern scrub oak
	89	Live oak
	110	Black oak
FIA forest types	**501**	Post oak-blackjack oak
	502	Chestnut oak
	510	Scarlet oak
	514	Southern scrub oak
	515	Chestnut oak-black oak-scarlet oak
	519	Red maple-oak
	962	Other hardwoods [1]

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.9.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 22: dry and xeric oak forest, woodland, and savanna

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G989	**Ozark-Ouachita oak-shortleaf pine woodland and savanna**	A2084	Ozark acidic savanna
		A2165	Ozark alkaline savanna
		A3290	Ozark-Ouachita dry and dry mesic acidic oak woodland
G015	**Southern Appalachian oak forest and woodland**	A4392	Southern Appalachian dry oak-white pine forest
G650	**Central Appalachian northeastern oak forest and woodland**	A4391	Western Allegheny white oak-scarlet oak forest
–	–	A4393	Northeast black oak-white oak-pine forest
–	–	A4435	Central Appalachian dry oak-heath forest
–	–	A4466	Northeast acidic talus woodland
–	–	A4467	Northeast oak rocky woodland

– = Missing codes have not yet been assigned.

Table 6.9.d—Natural vegetation communities for OGCT 22: dry and xeric oak forest, woodland, and savanna

Natural vegetation community category	Code	Community types
Ecological zones	–	Dry oak evergreen heath forest and woodland (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Dry oak deciduous heath forest and woodland (Georgia, Kentucky, North Carolina, South Carolina, Tennessee, and Virginia)
	–	Dry oak-hickory forest (North Carolina)
	–	Dry mixed oak woodland (Coastal Plain)
NatureServe Terrestrial Ecological System	CES202.359	Allegheny-Cumberland dry oak forest and woodland
	CES202.457	Southern ridge and valley Cumberland dry calcareous forest
	CES202.591	Central Appalachian dry oak-pine forest
	CES202.306	Ouachita montane oak forest
	CES202.707	Ozark-Ouachita dry oak woodland
	CES202.339	Southern piedmont dry oak (pine) forest
	CES203.241	Southern Atlantic Coastal Plain dry and dry mesic oak forest (in part)
	CES203.560	Southern Coastal Plain dry upland hardwood forest
	CES202.886	Southern Appalachian oak forest
	CES202.596	Central and southern Appalachian oak forest
	CES202.268	Piedmont hardpan woodland and forest
LANDFIRE biophysical settings	13780	West Gulf Coastal Plain sandhill oak and shortleaf pine forest and woodland

– = Missing codes have not yet been assigned.

6.10 OGCT 24: Xeric Pine and Pine-Oak Forest and Woodland

Community Description

Xeric pine and pine-oak forests and woodlands are found throughout most of the Eastern United States, from southern Missouri and northeast Texas east to the Atlantic coastline and from southern Maine to northern Florida (table 6.10.a). Because this OGCT covers a broad geographic range, there are distinct differences between the communities separated by the Mississippi River. Additionally, portions of this OGCT may occur as small inclusions of savanna in more highly disturbed areas.

This OGCT normally exists on strongly acidic soils with extreme moisture and nutrient deficiencies. Xeric site conditions may exist due to 1) low precipitation; 2) limited moisture absorption or retention because of exposed bedrock, steep slopes, coarse-textured soils, rocky soils, or shallow soils; or 3) elevated evapotranspiration rates on southern-facing slopes (Murphy and Nowacki 1997). This type often occurs as relatively small, isolated fragments because it is usually restricted to minor topographic features.

Xeric pine and pine-oak forests and woodlands typically occur on ridgetops and south-facing upper slopes in the mountains or on excessively drained, sandy uplands in gentler terrain, such as in the Piedmont and Cumberland Plateau (Murphy and Nowacki 1997). Principal species found in the communities east of the Mississippi River include pitch pine (*Pinus rigida*), Virginia pine *(P. virginiana*), Table Mountain pine (*P. pungens*), and chestnut oak (*Quercus montana*) (table 6.10.b). Associated species include shortleaf pine (*P. echinata*), scarlet oak (*Q. coccinea*), black oak (*Q. velutina*), blackjack oak (*Q. marilandica*), post oak (*Q. stellata*), northern red oak (*Q. rubra*), southern red oak (*Q. falcata*), white oak (*Q. alba*), and pignut hickory (*Carya glabra*) (Murphy and Nowacki 1997). Tree canopies dominated by shortleaf pine in the Piedmont and Cumberland Plateau would be considered OGCT 25.

Eastern white pine (*Pinus strobus*) forests can be represented in this OGCT, but many units also consider them a rare community. Eastern white pine forest sites are found on slopes of gorges or ridges in Georgia, North Carolina, South Carolina, and Tennessee (Schafale 2024, USNVC 2022). However, eastern white pine dominated forests on valley flats or gentle lower slopes resulting from planting, past land clearing, logging, or fire suppression are not included.

Sites west of the Mississippi River (West Gulf Coastal Plain) are dominated (>70 percent) by shortleaf pine, the only pine species listed above that occurs west of the river. Chestnut oak is confined to the region east of the river. Principal overstory species are shortleaf pine with associated species including scarlet oak, black oak, blackjack oak, post oak, northern red oak, southern red oak, white oak, and pignut hickory (Murphy and Nowacki 1997).

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC) see table 6.10.c. Additional classifications related to this community type are found in table 6.10.d.

Tables in section 5 contain old-growth attributes for the xeric pine and pine-oak forest and woodland community type.

Rare Communities That May be Embedded in This OGCT:

Carolina hemlock (*Tsuga caroliniana*) forest (typic and pine subtype) (Blue Ridge)

Pine-oak heath (high elevation subtype)

Southern Appalachian white pine forest association (CEGL007100)

Sandstone glades (G178 central interior acidic glade and barrens, A3474 Cumberland sandstone glade and barrens)

Disturbance

These forests and woodlands have historically experienced and are maintained by frequent fires because of prevailing xeric conditions and chemical content (volatile resins and pitch) of most plant species occurring in this community type. Most fires were probably low intensity, surface burns that happened every 3 to 7 years (Lafon et al. 2007, Stambaugh et al. 2020), preventing significant amounts of fuel from building up. Occasionally, fires occurred in some areas that completely consumed the leaf litter, opening the canopy and increasing pine seedling recruitment. On most site types, especially where moisture and nutrients are not as limiting, periodic fires maintain a dominance of yellow pines (native *Pinus* spp. not including *P. strobus*) and the desired grass-forb layer. Pine seedlings rarely become established in oak litter. Over many decades, an increase in the amount of dead biomass can predispose these forests and woodlands to catastrophic fires, especially in older stands that have experienced mortality caused by native southern pine beetle (*Dendroctonus frontalis*). In the absence of fire, successional changes on xeric sites are normally restricted. On other sites, succession in the absence of fire leads to dominance by oaks or eastern white pine along with other shade-tolerant and fire-intolerant species (Murphy and Nowacki 1997).

Ice storms accompanied by strong winds often cause extensive uprooting or blowdown of trees in these stands. Lightning may also damage individual trees. These disturbances can form large gaps, and the downed biomass increases fuel loads, which may lead to high-intensity fires.

Pests and Diseases

The southern pine beetle (*Dendroctonus frontalis*) is an important disturbance factor; it can also be a threat to pine species in xeric pine and pine-oak forests and woodlands. Other insects can destroy seed crops; for example, the native mountain pine coneworm (*Dioryctria yatesi*) in Table Mountain pine. Several native diseases can impact pine trees and cause root rot and heart rot including littleleaf disease (*Phytophthora cinnamomi*), heterobasidion root disease (*Heterobasidion irregulare*), and red heart rot (*Porodaedalea pini*). The oak component of these communities is also sensitive to pests and diseases (see 6.9: OGCT 22).

Management Considerations

Restoration:

a. Return fire by using restoration intervals to sites that have had fire absent from the community.

b. Harvest, remove, and mulch mesic species that encroached during an extended fire-free period.

c. Apply herbicide and slash (fell without removal) in remote areas inaccessible to machinery.

d. Thin or apply mechanical treatments, or both to promote desirable advance regeneration and sustainable (climate change-resilient) stocking levels in areas with an increased midstory, hardwood, or shrub component.

e. Control woody understories and midstories by using herbicides in advance or in concert with the reintroduction of prescribed fire to develop advance competitive pine regeneration.

f. Reintroduce site-appropriate herbaceous species.

g. Reintroduce pine species or short-lived or important oak species not represented (where appropriate), possibly with mechanical or herbicide release.

Maintenance:

a. Use an appropriate fire return interval.

b. Occasionally apply herbicide to control undesirable woody encroachment that is too aggressive for fire alone and in remote areas inaccessible by machinery.

c. Allow pockets of compositionally appropriate tree regeneration to advance into the overstory.

Representative Xeric Pine and Pine-Oak Forest and Woodland Old-Growth Stands:

Lake Winona Research Natural Area, Ouachita National Forest, AR

Roaring Branch Research Natural Area, Polk County, AR

Marshall Forest Preserve, near Rome, GA

Appalachia Lake Long Ridge, Nantahala National Forest, NC

Torreya State Park, Liberty County, FL

Great Smoky Mountains National Park, NC and TN (Pyle 1988)

Magazine Mountain, Ozark National Forest, AR

Hot Springs National Park, AR

Table 6.10.a—The potential distribution of OGCT 24: xeric pine and pine-oak forest and woodland

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD – in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part, Oconee RD)
		Francis Marion and Sumter NFs (Andrew Pickens RD, Enoree RD, Long Cane RD—all in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Grandfather RD, Uwharrie RD—both in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)

Table 6.10.a—The potential distribution of OGCT 24: xeric pine and pine-oak forest and woodland (continued)

Ecological province	Ecological section	National forest unit
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Poteau RD, Tiak RD—in part, Winona RD, Womble RD) Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	NFs of Alabama (Bankhead RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD) Ouachita NF (Tiak RD—in part)
Central Loess Plains (343)	**Black Belt Prairie (343B)**	NFs of Alabama (Oakmulgee RD—in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part) NFs of Florida (Apalachicola RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part) Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Osceola RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD) NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NRA = national recreation area; NFGT = National Forests and Grasslands in Texas.

Table 6.10.b—The relationship of OGCT 24: xeric pine and pine-oak forest and woodland, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**12**	Shortleaf pine-oak [1]
	15	Pitch pine-oak
	16	Virginia pine-oak [1]
	20	Table Mountain pine-hardwood [1]
	32	Shortleaf pine
	33	Virginia pine
	38	Pitch pine
	39	Table Mountain pine
	44	Southern red oak-yellow pine [1]
	49	Bear oak-southern scrub oak-yellow pine [1]
SAF forest types	**43**	Bear oak
	45	Pitch pine
	51	White pine-chestnut oak
	75	Shortleaf pine
	76	Shortleaf pine-oak [1]
	78	Virginia pine-oak [1]
	79	Virginia pine
FIA forest types	**162**	Shortleaf pine
	163	Virginia pine
	165	Table Mountain pine
	167	Pitch pine
	404	Shortleaf pine-oak [1]
	405	Virginia pine-southern red oak
	409	Other pine-hardwood [1]
	510	Scarlet oak
	514	Southern scrub oak

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.10.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 24: xeric pine and pine-oak forest and woodland

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G989	**Ozark-Ouachita oak-shortleaf pine woodland and savanna**	A2082	Ozark-Ouachita shortleaf pine-oak open grassy woodland
G013	**Western Gulf Coastal Plain pine-oak forest and woodland**	A0386	West Gulf Coastal Plain scrub oak-shortleaf pine sandhill woodland alliance
G986	**Interior low plateau woodland, savanna, and barrens**	A2088	Interior low plateau post oak barrens
G015	**Southern Appalachian oak forest and woodland**	A4392	Southern Appalachian dry oak-white pine forest
G905	**Southern Appalachian Virginia pine-Table Mountain pine woodland**	A0144	Carolina hemlock woodland
		A0677	Appalachian Table Mountain pine-pitch pine-chestnut oak woodland
Missing G906	**Central Appalachian northeast pine-oak rocky woodland group**	A3312	Central Appalachian pine-oak acidic shale barrens

Table 6.10.d—Natural vegetation communities for OGCT 24: xeric pine and pine-oak forest and woodland

Natural vegetation community category	Code	Community types
Ecological zone	–	Pine-oak heath woodland (pitch pine) (Georgia, Kentucky, Tennessee, North Carolina, Virginia)
		Pine-oak heath woodland (Table Mountain pine) (Georgia, Tennessee, North Carolina, Virginia)
		Pine-oak heath woodland (Virginia pine) (Kentucky, Tennessee, Virginia)
		Virginia pine-oak heath (ridge) (Kentucky, Virginia)
		Shortleaf pine-oak woodlands (slope) (Georgia, Tennessee)
		Shortleaf pine-oak forest and woodlands (ridges) (Georgia, Kentucky, Tennessee, North Carolina, Virginia)
		Xeric shortleaf pine-oak woodland (Tennessee, North Carolina)
NatureServe Terrestrial Ecological System	CES202.331	Southern Appalachian montane pine forest
	CES202.332	Southern Appalachian low elevation pine forest
	CES203.056	West Gulf Coastal Plain sandhill oak and shortleaf pine forest and woodland
	CES203.506	East Gulf Coastal Plain interior shortleaf pine-oak forest
	CES203.378	West Gulf Coastal Plain pine hardwood forest
	CES202.325	Ozark-Ouachita shortleaf pine-bluestem woodland
	CES202.313	Ozark-Ouachita shortleaf pine-oak forest and woodland
	CES202.600	Central Appalachian pine-oak rocky woodland
LANDFIRE biophysical settings	13520	Southern Appalachian montane pine forest
	13780	West Gulf Coastal Plain sandhill oak and shortleaf pine forest and woodland

– = Missing codes have not yet been assigned.

6.11 OGCT 25: Dry and Dry Mesic Oak-Pine and Pine-Oak Forest and Woodland

Community Description

Dry and dry mesic oak-pine and pine-oak forests and woodlands constitute a large part of the eastern deciduous forest, extending from southern Missouri, southeastern Oklahoma, and east Texas in the west to the Atlantic coast from New Jersey to north Florida (table 6.11.a). Most of these forests occur on coarse textured soils and silty loams on ridges and south-facing slopes in the mountains and plateaus and droughty uplands in the Piedmont and Coastal Plain (White and Lloyd 1998). The oak-pine OGCT consists of at least 20 percent of the basal area in pine and at least 20 percent in oak.

The dry and dry mesic oak-pine and pine-oak (OGCT 25) and dry mesic oak (OGCT 21) types may develop on the same range of sites depending on the type and intensity of disturbances. OGCTs 24 and 25 may occur adjacent to each other along a moisture gradient, with OGCT 24 usually occupying more xeric sites along ridges.

Across eastern old-growth sites, shortleaf pine (*Pinus echinata*) and white oak (*Quercus alba*) are the most common canopy species, whereas pitch pine (*P. rigida*), scarlet oak (*Q. coccinea*) and chestnut oak (*Q. montana*) are more common in mountainous areas. Other common canopy species include Virginia pine (*P. virginiana*), Table Mountain pine (*P. pungens*), post oak (*Q. stellata*), blackjack oak (*Q. marilandica*), and pignut hickory (*Carya glabra*) on dry sites and loblolly pine (*P. taeda*), shortleaf pine (*P. echinata*), southern red oak (*Q. falcata*), black oak (*Q. velutina*), mockernut hickory (*Carya tomentosa*), pignut hickory (*C. glabra*), and red maple (*Acer rubrum*) on dry mesic sites (table 6.11.b). Ericaceous species, such as blueberry (*Vaccinium* spp.), huckleberry (*Gaylussacia* spp.), and mountain laurel (*Kalmia latifolia*), typically dominate the shrub layer, and flowering dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), sassafras (*Sassafras albidum*), and blackgum (*Nyssa sylvatica*) are common in the midstory. Common understory and vine species include sedges (*Carex* spp.), panicgrasses (mostly *Dichanthelium* spp., some *Panicum* spp.), broomsedge (*Andropogon virginicus*) and bluestems (*Andropogon* spp., *Schizachyrium* spp.) and other grasses, striped prince's pine (also called pipsissewa) (*Chimaphila maculata*), tick-trefoils (*Desmodium* spp.), bracken fern (*Pteridium* spp.), greenbriers (*Smilax* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and grapes (*Vitis* spp.). On the Redbird Ranger District of the Daniel Boone National Forest, red hickory (*C. ovalis*) is an important canopy species. Tables in section 5 contain attributes for the dry and dry mesic oak-pine OGCT. Because this OGCT covers a broad geographic range, the species composition can vary.

The Appalachian pine-oak forests and woodlands occur in the southern Appalachian Mountains, including the Cumberland Mountains and Plateaus (NatureServe 2024) in the Southern Region. These forests typically occur on exposed, rocky ridges and upper, convex slopes, as well as on more protected sites (USNVC 2022). Species composition varies with bedrock, geology, soil depth and texture, aspect, and degree of exposure with pitch pine and shortleaf pine mixing with oak at lower elevations. Near the western edge of the Cumberland Plateau in Kentucky (more or less the main portion of the Daniel Boone National Forest) and Tennessee, this type occupies broad, relatively mesic ridges with moderately deep soils. Prior to the 1999–2001 southern pine beetle (*Dendroctonus frontalis*) outbreak, large (≥20 inches [0.5 m] d.b.h.) shortleaf pines were commonplace, sometimes occupying more than one-third of the canopy. Shortleaf and pitch pines together occasionally exceeded 50 percent of the canopy. Where the canopy was open, especially if burned, a diverse forb/grass/low shrub layer was present. Virginia and pitch pines are the usual pine species in the Southern Unglaciated Allegheny Plateau on the Cumberland Ranger District of the Daniel Boone National Forest.

In the mountains at middle elevations and on slopes and steep ridges, pitch pine and Table Mountain pine mix with oak, transitioning into OGCT 24. The vegetation on these latter sites tends to be shorter statured than in other shortleaf pine-oak forests and woodlands, and have sparser herbaceous cover, dense short shrubs, and more open tall shrubs and midstory. Eastern white pine (*P. strobus*) is not considered a principal pine species of the dry and dry mesic oak-pine type in this region, even though it is a common associate of the oak-pine types (White and Lloyd 1998).

Atlantic Coastal Plain and Piedmont forests and woodlands occur east of the Mississippi River. They are dominated by a mix of shortleaf pine and hardwoods, primarily white oak, southern red oak, post oak, scarlet oak, and scrub oaks such as bluejack oak (*Quercus incana*) and sand post oak (*Q. margarettae*). Other trees include black oak, mockernut hickory, hawthorns (*Crataegus* spp.), red maple, sourwood, and hop hornbeam (*Ostrya virginiana*). The midstory and shrub layers are open. The graminoid layer can be open to very dense and may include blackseed speargrass (*Piptochaetium avenaceum*), poverty oatgrass (*Danthonia spicata*), woodoats (*Chasmanthium sessiliflorum*, and possibly *C. laxum*), roundseed panicgrass (*Dichanthelium sphaerocarpon*), and little bluestem (*Schizachyrium scoparium*). In the northern Piedmont, Virginia pine is predominant, sharing dominance with shortleaf pine in Virginia. Loblolly pine increases in importance within this type in the piedmont of Alabama. Shortleaf pine's abundance is historically uncertain because past land use likely influenced its presence (White and Lloyd 1998).

In the West Gulf Coastal Plain, the shortleaf pine-oak forests and woodlands are dominated by a mix of shortleaf pine and loblolly pine with hardwoods, primarily white oak, southern red oak, post oak, as well as scrub oaks such as bluejack oak, sand post oak, and Arkansas oak (*Q. arkansana*) (Nordman et al. 2021). Other trees include black oak, mockernut hickory, black hickory (*Carya texana*), hawthorns, and hophornbeam. The midstory is open. The herbaceous layer can be open to very dense and may include woodoats, roundseed panicgrass, and little bluestem. The shortleaf pine-oak understory was not as species-rich as the adjacent longleaf pine community (White and Lloyd 1998). Loblolly pine (native) can be the dominant pine in stands of southeastern Oklahoma and eastern Texas, but it was also widely planted outside its natural range (Diggs 1999: 207, Weakley et al. 2024: 154). Discerning native from planted stands may be difficult.

In the Interior Highlands, shortleaf pine-oak forest and woodlands occur on dry, dry mesic, and mesic sites most extensively in the Ozark-Ouachita Highlands (NatureServe 2024). Shortleaf pine and oaks dominate the canopy, generally mixed with hickories and other hardwoods. On dry and dry mesic sites on the long ridges and south-facing slopes in the Ouachita Highlands, shortleaf pine is dominant (≥70 percent) in the canopy with an open subcanopy and sparse midstory containing scattered oaks, hickories, and other hardwoods. On north-facing slopes, toe slopes or valley bottoms, this OGCT is often adjacent to OGCT 5a, western mixed mesophytic forests, with codominance by mesic canopy trees and a diverse forb layer. In comparison, the OGCT 25 herbaceous understory is dominated by graminoids including little bluestem, oatgrasses (*Danthonia* spp.), woodoats, and Pennsylvania sedge (*Carex pensylvancia*). Ridgetop grasses include Elliott's bluestem (*Andropogon gyrans*), slender little bluestem (*Schizachyrium tenerum*), and Indiangrass (*Sorghastrum* spp.). Associated trees include post, blackjack, white, black, and southern red oaks, and hickory species (White and Lloyd 1998). The open conditions and graminoid dominance of the herbaceous layer result from a combination of repeated application fire and thinning, management in which the Ouachita National Forest and other national forests in the western part of the region have excelled.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.11.c. Additional classifications related to this community type are found in table 6.11.d.

Rare Communities That May be Embedded in This OGCT:

Sandstone glades

Streamhead seeps and wetlands

Disturbance

The dry and dry-mesic oak-pine and pine-oak forest and woodlands OGCT is transitory on a given site. Historically, fire, aboriginal activities, windfall, natural mortality, and other disturbances maintained this forest community type. Tornadoes, ice and wind storms may create large (10–100+ acre) canopy gaps, resetting successional pathways. Disturbances vary across the range of this OGCT, with lightning fires prevalent in the Coastal Plain and Ozark Mountains, hurricanes in the Coastal Plain, and tornadoes in the Ouachita and Ozark Mountains. As this old-growth community ages under more extreme weather events, oak decline is likely to have a greater influence (Crocker et al. 2023). Fire is less frequent in the Appalachian Piedmont and Mountains. The frequency of natural fires is estimated at between 5 and 32 years throughout the Southeast (White and Lloyd 1998). Beyond a certain gap size (0.1 acre [0.01 ha] in the Piedmont), fire (or other forest floor disturbance) is the limiting factor for maintaining this OGCT. Currently, a lower frequency of fires is resulting in species composition changes. By using fire-scarred shortleaf pines, Stambaugh et al. (2020) determined a low-intensity fire frequency of 4.4 to 5.3 years on the Cumberland Plateau prior to widespread European settlement.

Pests and Diseases

As existing communities of this type age, they may experience oak decline due to multiple stress factors. As this old-growth community ages under more extreme weather events, oak decline is likely to have a greater influence (Crocker et al. 2023). Mesic species encroachment may be occurring to some degree in this type. Historic disturbances like chestnut blight, grazing, and targeted timber extraction may have influenced the composition and structure of this community.

The native southern pine beetle is an important disturbance but also can be a threat to pine species in dry and dry mesic oak-pine and pine-oak forests and woodlands. During years of high site stress such as from drought, oak decline may occur, and southern pine beetle may impact pine species present. Historic southern pine beetle activity has likely led to decreases in the pine composition within this community. Within northern portions of the region, the nonnative spongy moth (*Lymantria dispar*) is a recurring threat to this OGCT. Oak wilt (*Ceratocystis fagacearum*) (origin uncertain) infection centers may also develop, especially within concentrations of red oaks. This disease is present throughout the Southeastern United States, but is particularly prevalent in Texas, Arkansas, Tennessee, Kentucky, Virginia, and the Carolinas (Bragard et al. 2020, Wilson 2001). The native two-lined chestnut borer (*Agrilus bilineatus*) may hasten mortality in stressed oaks.

Other pests including native pine engraver beetles (*Ips calligraphus*, *I. grandicollis*, and *I. avulsus*) may also infest shortleaf pines. The nonnative blackheaded pine sawfly (*Neodiprion excitans*) is known to attack mature trees and cause complete defoliation (Rebek 2010). Stands stressed by storm damage, drought, or poor management are more susceptible to outbreaks. The native littleleaf (*Phytophthora cinnamomi*) and heterobasidon root diseases (*Heterobasidion irregulare*) may cause mortality in mature pines.

Management Considerations

Restoration:

a. Return fire by using restoration intervals to sites that have had fire absent from the community.

b. Thin or use mechanical treatments, or both, to promote desirable advance regeneration and sustainable (climate change resilient) stocking levels in areas with an increased midstory, hardwood, or shrub component.

c. Reintroduce site appropriate herbaceous species.

d. Reintroduce pine species or short-lived oak species where appropriate.

e. Reintroduce American chestnut when a disease-resistant (blight and root disease) option becomes available.

f. Treat nonnative invasive plants.

Maintenance:

a. Use appropriate fire return interval. Due to fire suppression, changes in the structure and composition of the stand can impact the effectiveness of prescribed fire or wildfire outcomes.

b. Maintain canopy structure through vegetation management such as thinning, especially in portions of the community dominated by pine species to reduce southern pine beetle hazard and maintain open conditions.

c. Control nonnative invasive plant infestations.

d. Allow for pockets of compositionally appropriate tree regeneration to advance into the overstory.

Representative Dry and Dry Mesic Oak-Pine and Pine-Oak Forest Old-Growth Stands:

John de la Howe Tract, near McCormick, SC

Duke Forest, NC

Roaring Branch Research Natural Area, AR

Lake Winona Research Natural Area, Ouachita National Forest, AR

Bob's Creek Shortleaf Stand, Kisatchie National Forest, LA

Old Shortleaf Slope Stand, Kisatchie National Forest, LA

Great Smoky Mountains National Park, NC and TN (Pyle 1988)

Hot Spring National Park, AR

Linville Gorge, Pisgah National Forest, NC

Dobson Knob Area, Pisgah National Forest, NC

Little Pisgah Mountain, Pisgah National Forest, NC

Nantahala Gorge (southwest-facing slopes), Nantahala National Forest, NC

Angel Hollow, Daniel Boone National Forest, Laurel County, KY (in part)

Table 6.11.a—The potential distribution of OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)

Table 6.11.a—The potential distribution of OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland (continued)

Ecological province	Ecological section	National forest unit
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part, Oconee RD)
		Francis Marion and Sumter NFs (Andrew Pickens RD, Enoree RD, Long Cane RD—all in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Grandfather RD, Uwharrie RD—both in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Poteau RD, Tiak RD—in part, Winona RD, Womble RD)
		Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	Land Between the Lakes (NRA)
		NFs of Alabama (Bankhead RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
		Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD)
		Ouachita NF (Tiak RD—in part)

Table 6.11.a—The potential distribution of OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland (continued)

Ecological province	Ecological section	National forest unit
Mississippi Embayment (342)	**Western Mississippi Alluvial White and Black River Alluvial Plains (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	Ozark-St. Francis NF (St. Francis RD—in part)
	Southern Mississippi Alluvial Plain (342C)	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD—in part, Homochitto RD, Tombigbee RD—in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD, Tombigbee RD—both in part) NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part) NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part) NFs of Florida (Apalachicola RD—in part) NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part) Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD) NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NRA = national recreation area; NFGT = National Forests and Grasslands in Texas.

Table 6.11.b—The relationship of OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**12**	Shortleaf pine-oak [1]
	13	Loblolly pine-hardwood [1]
	16	Virginia pine-oak [1]
	31	Loblolly pine
	32	Shortleaf pine
	33	Virginia pine
	44	Southern red oak-yellow pine [1]
	47	White oak-black oak-yellow pine [1]
	48	Northern red oak-hickory-yellow pine [1]
	56	Yellow poplar-white oak-northern red oak (in part)
SAF forest types	**75**	Shortleaf pine
	76	Shortleaf pine-oak [1]
	78	Virginia pine-oak [1]
	79	Virginia pine
	80	Loblolly pine-shortleaf pine [1]
	81	Loblolly pine
	82	Loblolly pine-hardwood [1]
FIA forest types	**161**	Loblolly pine
	162	Shortleaf pine
	163	Virginia pine
	404	Shortleaf pine-oak [1]
	405	Virginia pine-southern red oak
	406	Loblolly pine-hardwood [1]
	409	Other pine-hardwood [1]

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.11.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G012	**South-central interior shortleaf pine-oak forest and woodland**	A3271	Ozark-Ouachita shortleaf pine-oak woodland
G013	**Western Gulf Coastal Plain pine-oak forest and woodland**	A3129	West Gulf Coastal Plain shortleaf pine-post oak forest
		A3130	West Gulf Coastal Plain loblolly pine-white oak forest
G165	**Piedmont Coastal Plain oak forest and woodland**	A3270	Upper Coastal Plain shortleaf pine-oak woodland
		A3294	Piedmont post oak-hickory-pine woodland
G905	**Southern Appalachian Virginia pine-Table Mountain pine woodland**	A3269	Appalachian shortleaf pine-oak woodland
G989	**Ozark-Ouachita oak-shortleaf pine woodland and savanna**	A2082	Ozark-Ouachita shortleaf pine-oak open grassy woodland
		A2083	Ozark-Ouachita shortleaf pine-oak woodland

Table 6.11.d—Natural vegetation communities for OGCT 25: dry and dry mesic oak-pine and pine-oak forest and woodland

Natural vegetation community category	Code	Community types
Ecological zone	–	Dry-mesic shortleaf pine-oak forest and woodland (Tennessee)
	–	Dry and dry-mesic oak forest—in part (North Carolina and South Carolina)
	–	Pine-oak heath woodland (pitch pine) (Georgia, Kentucky, Tennessee, North Carolina, and Virginia)
	–	Pine-oak heath woodland (Table Mountain pine) (Georgia, Tennessee, North Carolina, and Virginia)
	–	Pine-oak heath woodland (Virginia pine) (Kentucky, Tennessee, and Virginia)
	–	Virginia pine-oak heath (ridge) (Kentucky and Virginia)
	–	Shortleaf pine-oak woodland (slope) (Georgia and Tennessee)
	–	Shortleaf pine-oak forest and woodland (ridge) (Georgia, Kentucky, Tennessee, North Carolina, and Virginia)
	–	Xeric shortleaf pine-oak woodland (Tennessee and North Carolina)
	–	Pine-oak heath woodland (shortleaf pine) (Georgia, Kentucky, Tennessee, North Carolina, and Virginia)
	–	Shortleaf pine-oak forest and woodland (South Carolina)
	–	Shortleaf pine-oak forest and woodland (eroded) (South Carolina)
NatureServe Terrestrial Ecological System	CES202.591	Central Appalachian dry oak-pine forest
	CES202.306	Ouachita montane oak forest
	CES202.707	Ozark-Ouachita dry oak woodland
	CES202.339	Southern piedmont dry oak (pine) forest
	CES202.359	Allegheny-Cumberland dry oak forest and woodland
	CES202.886	Southern Appalachian oak forest
	CES202.596	Central and southern Appalachian oak forest
	CES202.339	Southern piedmont dry oak (pine) forest
	CES202.457	Southern ridge and valley/Cumberland dry calcareous forest
	CES203.560	Southern Coastal Plain dry upland hardwood forest
	CES203.056	West Gulf Coastal Plain sandhill oak and shortleaf pine forest and woodland
	CES203.072	Crowley's Ridge sand forest
	CES203.378	West Gulf Coastal Plain pine hardwood forest
LANDFIRE biophysical settings	13720	East Gulf Coastal Plain interior shortleaf pine-oak forest
	15070	Ozark-Ouachita shortleaf pine-bluestem woodland
	13670	Ozark-Ouachita shortleaf pine-oak forest and woodland
	13530	Southern Appalachian low elevation pine
	13710	West Gulf Coastal Plain pine-hardwood forest
	13780	West Gulf Coastal Plain sandhill oak and shortleaf pine forest

– = Missing codes have not yet been assigned.

6.12 OGCT 26: Upland Longleaf Pine Forest, Woodland, and Savanna

Community Description

The upland longleaf pine forest, woodland, and savanna community type can be found from Virginia south through central Florida and as far west as east Texas, with extensions into the Appalachian Piedmont and Mountains of north Alabama and northwest Georgia (table 6.12.a). On the Coastal Plain, this forest community is typically found on sandhills. In the mountains, it is usually restricted to sites that are apt to burn, specifically ridgetops and middle and upper slopes with south and southwest exposures (Nowacki 1993).

In this OGCT the dominant canopy tree is longleaf pine (*Pinus palustris*), providing relatively dense to patchy and very open canopies. These old-growth communities have frequent transitions in age, tree sizes, and tree density. Sometimes associated with this forest community type are clusters of deciduous scrub oaks, evergreen scrub oaks, and mesic hardwoods (table 6.12.b). The groundcover consists of hundreds of species of herbs and low shrubs sometimes dominated in the eastern portion of the range by pineland threeawn (*Aristida stricta*) (North Carolina) or Beyrich threeawn (*Aristida beyrichiana*) (farther south), and by slender little bluestem (*Schizachyrium tenerum*) and little bluestem (*Schizachyrium scoparium*) in the western portion of the range (Landers and Boyer 1999). Tables in section 5 contain the attributes for the upland longleaf OGCT. They do not include the wettest flatwoods represented by OGCT 29. There are several subtypes of OGCT 26.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.12.c. Additional classifications related to this community type are found in table 6.12.d.

Mesic longleaf pine flatwoods forest (subtype 26a)

This subtype contains open woodlands naturally dominated by longleaf pine on flat sites with spodosol soils (USNVC 2022) with available soil moisture, at least seasonally. When burned frequently, this community type has a high diversity of forbs. Characteristic species within these mesic sites include switchgrass (*Panicum virgatum*), slender woodoats (*Chasmanthium laxum*), and a diverse mix of herbs within the aster or sunflower (Asteraceae) and pea (Fabaceae) families. This is a coastal plain subtype.

Dry mesic loamy longleaf pine woodland (subtype 26b)

This subtype contains open woodlands found on uplands on sandy to loamy soils ranging from gently rolling, broad ridgetops to steeper side slopes, and in mesic swales and terraces (USNVC 2022). The overstory is dominated by scattered longleaf pine trees, often with clumps of oak midstory and a grassy understory, typically wiregrass (pineland threeawn or Beyrich's threeawn), with a high diversity of forbs when burned frequently. This is a Coastal Plain subtype.

Xeric longleaf pine woodland (subtype 26c)

This subtype contains open woodlands dominated by longleaf pine and oaks with a well-developed layer of native grasses on deep, coarse sands and sandy loams (USNVC 2022). Due to low nutrient availability, longleaf pine trees grow slower and reach smaller stature than in other habitats. On the most xeric sites (barrens), the grass layer and litter accumulation are minimal, even within some sites dominated by lichens (NatureServe 2024). These sites often also have a consistent midstory of small hardwoods, typically oaks (blackjack, bluejack, turkey, or sand post oak). This is a Coastal Plain subtype.

Mountain or piedmont longleaf pine woodland (subtype 26d)

This subtype contains open woodlands dominated or codominated by longleaf pine along with shortleaf pine and oak on dry to xeric sites (USNVC 2022). Within these sites, dominant grass species are often little bluestem or Indian grass. This subtype is found in the noncoastal plain regions (rocky submontane areas of the Piedmont and Ridge and Valley) of Alabama, Georgia, North Carolina, and South Carolina.

Note

Mature and old-aged slash pine planted on upland locations are considered offsite and should not be considered part of this OGCT, even within the natural range of slash pine (Lohrey and Kossuth 1990).

Rare Communities That May be Embedded in This OGCT:

Xeric sandhill scrub (coastal fringe subtype)

Wet piedmont longleaf pine

Disturbance

Fires during the growing season are the major disturbances in the upland longleaf pine old-growth communities. In most instances, the frequency of fires associated with maintaining longleaf pine is estimated to be every 2 to 4 years (Wade et al. 2000: 59). In the Coastal Plain sandhills and transition areas, the frequency is estimated to be 3 to 10 years (Landers and Boyer 1999). In addition to normal fire regimes, other disturbances include lightning, wind events (e.g., tornadoes, tropical storms, and microbursts), and periodic droughts that result in conditions conducive to intense fires (Landers and Boyer 1999). Hurricanes have (Hooper and McAdie 1995) and are likely to continue to (Wade et al. 2000: 56) impact this community type, especially where they exist within 100 miles of the Gulf Coast.

Across their extensive range, longleaf pine ecosystems have been altered through fragmentation, unsustainable harvest, conversion to other land uses and vegetation types such as loblolly pine (*Pinus taeda*), nonnative invasive species (e.g., cogongrass, *Imperata cylindrica*), and exclusion of natural fire regimes. Although rare to infrequent over most of the range of longleaf pine, ice storms may cause minor to extensive damage.

Pests and Diseases

Longleaf pine is susceptible to native southern pine beetle (*Dendroctonus frontalis*) infestations as well as other bark beetles. However, longleaf pine is the least vulnerable to these infestations of the southern pine species. Several other native insects and diseases such as black turpentine beetle (*Dendroctonus terebrans*), brown spot needle blight (*Scirrhia acicola*), fusiform rust (*Cronartium quercuum* f. sp. *fusiforme*), and heterobasidion root rot may affect longleaf pine (Coyle and Lord, n.d.). Stands stressed by storm damage, overcrowding, drought, or poor management are more susceptible to insect and disease outbreaks, especially if the old-growth community is adjacent to overstocked pine plantations.

Management Considerations

Restoration:

a. Reintroduce appropriate restoration fire regimes. Due to fire suppression, change in structure and composition of the stand can impact the effectiveness of prescribed fire or the outcome of wildfire.

b. Use herbicides, if needed, to remove mesic species in the understory and midstory before or concurrently with prescribed fire during restoration efforts.

c. Plant or seed desirable herbaceous species where that component has been lost.

d. Manipulate the overstory through commercial harvest or noncommercial removals, including variable density thinning or gap creation to favor a longleaf pine overstory and its recruitment.

e. Create historic overstory density and structure by using harvest, removal, mulching and fire, thereby enhancing sustainable, climate change-resilient plant communities.

f. Track restoration efforts and outcomes to better inform management activities (USDA Forest Service 2017).

Maintenance:

a. Maintain desired fire return intervals.

b. Maintain canopy structure through vegetation management including variable density thinning and uneven-aged regeneration methods.

c. Maintain longleaf pine as an overstory dominant species. Consider silvicultural prescriptions that favor leaving longleaf pine.

d. Control nonnative invasive plants.

e. Maintain embedded rare communities, including forested wetland systems.

f. Track maintenance efforts and outcomes to better inform management activities (USDA Forest Service 2017).

Representative Upland Longleaf Pine Forest, Woodland, and Savanna Old-Growth Stands:

Boykins Springs Management Area, Angelina National Forest, Texas Wade Tract Preserve, Thomas County, GA

Moody Tract, Appling County, GA

Big Woods, Greenwood Plantation, Thomas County, GA

Big Cypress National Preserve, Collier County, FL

Patterson Natural Area, Eglin Air Force Base, FL

Boyd Tract, Weymouth Woods Sandhills Nature Preserve, Moore County, NC

Havis Park, Flamaton Natural Area, Escambia County, AL

Lostman's Pines, Everglades National Park, FL

Hibbs Road Longleaf Ridge (subtype 26a), Croatan National Forest, NC

Dudley Road (subtype 26a), Croatan National Forest, NC

Goldmine Branch (subtype 26d), Uwharrie National Forest, NC

Table 6.12.a—The potential distribution of OGCT 26: upland longleaf pine forest, woodland, and savanna

Ecological province	Ecological section	National forest unit
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Francis Marion and Sumter NFs (Enoree RD, Long Cane RD—both in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Uwharrie RD—in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
		Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD)
Mississippi Embayment (342)	**Southern Mississippi Alluvial Plain (342C)**	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Homochitto RD)
	Black Belt Prairie (343B)	NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD—in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part)
		NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part)
		NFs of Florida (Apalachicola RD—in part)
		NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part)
		Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD)
		NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NFGT = National Forest and Grasslands in Texas.

Table 6.12.b—The relationship of OGCT 26: upland longleaf pine forest, woodland, and savanna, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**21**	Longleaf pine
	26	Longleaf pine-hardwood [1]
	27	Longleaf pine-slash pine
	30	Longleaf pine-shortleaf pine
SAF forest types	**70**	Longleaf pine
	71	Longleaf pine-scrub oak
	83	Longleaf pine-slash pine
FIA forest types	**141**	Longleaf pine
	403	Longleaf pine-oak

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.12.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 26: upland longleaf pine forest, woodland, and savanna

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G009	**Dry mesic loamy longleaf pine woodland**	A3123	West Gulf Coastal Plain longleaf pine-blackjack oak-bluestem woodland
		A3124	West Gulf Coastal Plain upland longleaf pine-bluestem woodland
		A3125	Southeastern Coastal Plain longleaf pine-sand post oak-wiregrass woodland
		A3126	Southeastern Coastal Plain longleaf pine-blackjack oak clayhill woodland
		A3127	Southeastern Coastal Plain upland longleaf pine-wiregrass woodland
G154	**Xeric longleaf pine woodland**	A3122	Longleaf pine-bluejack oak sandhill woodland
		A4074	Longleaf pine-turkey oak-pineland threeawn woodland
		A4075	Longleaf pine-turkey oak-little bluestem woodland
		A4076	Longleaf pine-turkey oak-sand live oak woodland
		A4077	Longleaf pine-turkey oak-piedmont threeawn woodland
G165	**Shortleaf pine-oak forest and woodland group**	A3272	Montane longleaf pine-shortleaf pine woodland
G596	**Mesic longleaf pine flatwoods-spodosol woodland**	A3160	Southern Coastal Plain mesic longleaf pine flatwoods
		A3161	Atlantic Coastal Plain mesic longleaf pine flatwoods

Table 6.12.d—Natural vegetation communities for OGCT 26: upland longleaf pine forest, woodland, and savanna

Natural vegetation community category	Code	Community types
Ecological zone	–	Atlantic Coastal Plain upland longleaf pine woodland (xeric, dry, mesic phases)
	–	Mesic loamy longleaf woodland
	–	Dry mesic sandy upland longleaf woodland
	–	Xeric longleaf woodland
	–	Longleaf pine forest (piedmont)
NatureServe Terrestrial Ecological System	CES203.281	Atlantic Coastal Plain upland longleaf pine woodland
	CES203.496	East Gulf Coastal Plain interior upland longleaf pine woodland
	CES203.293	West Gulf Coastal Plain upland longleaf pine forest and woodland
	CES202.319	Southeastern interior longleaf pine woodland
LANDFIRE biophysical settings	13510	Southeastern interior longleaf pine woodland
	13470	Atlantic Coastal Plain upland pine woodland
	13460	Atlantic Coastal Plain fall-line sandhills longleaf pine woodland
	13480	West Gulf Coastal Plain upland longleaf pine forest and woodland
	13490	East Gulf Coastal Plain interior upland longleaf pine woodland
	13560	Florida longleaf pine sandhill
	14530	Central Florida pine flatwoods
Florida Natural Area Inventory (FNAI) Natural Communities	–	Mesic flatwoods
	–	Upland pine
	–	Sandhills

– = Missing codes have not yet been assigned.

6.13 OGCT 27: Seasonally Wet Oak-Hardwood Woodland

Community Description

Seasonally wet oak-hardwood woodlands are commonly known as flatwoods and have relatively open understories, although more closed canopy examples are also described. They occur from the Midwest to eastern Oklahoma and Texas and east to Virginia (table 6.13.a). The largest and most developed examples of this OGCT occur within the Ohio, Arkansas, and southern Mississippi River Valleys. They are less common in the East Gulf and Atlantic Coastal Plain. They are principally nonriverine, occurring adjacent to primary and secondary terraces along river bottomlands (Kennedy 1997, NatureServe 2024). These sloughs, isolated depressions, or old riverbeds are hydrologically at the conceptual boundary of upland and wetlands (NatureServe 2024). These wetlands can be seasonally flooded for short periods during the year (Kennedy 1997), although other examples are controlled hydrologically by local rainfall and groundwater (NatureServe 2024).

The principal species are pin oak (*Quercus palustris*), willow oak (*Q. phellos*), white oak (*Q. alba*), water oak (*Q. nigra*), laurel oak (*Q. laurifolia*), swamp chestnut oak (*Q. michauxii*), and Nuttall oak (*Q. texana*). Common associates include overcup oak (*Q. lyrata*), swamp maple (*Acer rubrum* var. *trilobum*), sweetgum (*Liquidambar styraciflua*), water hickory (*Carya aquatica*), swamp tupelo (*Nyssa aquatica*), and water locust (*Gleditsia aquatica*) (Fleming et al. 2021, Kennedy 1997, NatureServe 2024, Schafale 2024). A rarer, slightly drier example in the West Gulf Coastal Plain is dominated by southern red oak (*Q. falcata*). Table 6.13.b contains the relationships between the seasonally wet oak-hardwood woodland OGCT and other forest classification systems, and tables in section 5 contain its old-growth attributes.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.13.c. Additional classifications related to this community type are found in table 6.13.d.

Rare Communities That May be Embedded in This OGCT:

Southern red oak wet flatwoods

Atlanta Coastal Plain wet oak flatwoods

Disturbance

Prior to European settlement, low-intensity fires may have occurred when dry surface conditions developed during seasonal extremes typically lasting from July to October (NatureServe 2024). Although such burns would probably have been confined to the litter layer, they would have helped maintain open conditions in these woodlands. Current fire exclusion has caused most of these communities to shift from woodlands to forests, although the extent of canopy closure is uncertain given the variation of the different communities within this old-growth type (NatureServe 2024). With reduced fire regimes, the seasonally wet oak-hardwood woodland is being replaced by more shade-tolerant species with a general shift to American beech-magnolia (*Magnolia* spp.) over most of its range (Kennedy 1997). Canopy tree deaths and gap-phase regeneration are common in these old-growth stands resulting in multiple-aged stands (Kennedy 1997). This OGCT is especially vulnerable to wild boar (*Sus scrofa*) damage.

Pests and Diseases

Pests and diseases are less common in this community than in other OGCTs across the Southern Region. Elm species are not as common as within other old-growth areas, but winged elm (*Ulmus alata*) can be associated with this OGCT and can be impacted by the nonnative Dutch elm disease (*Ophiostoma* spp., including *O. ulmi*, *O. himal-ulmi*, *O. novo-ulmi*). Where ash species occur, typically at low densities, they can be impacted by nonnative emerald ash borer (*Agrilus planipennis*). Where laurel family (Lauraceae) species, such as federally listed pondberry (*Lindera melissifolia*), are present within the community or in the transition zone to wetter areas, the nonnative laurel wilt (*Harringtonia lauricola*) may impact species within the laurel family (Lauraceae). As with many seasonally wet systems, this old growth is very vulnerable to the nonnative wild boar (*Sus scrofa*).

Management Considerations

Restoration:

a. Mechanically remove thick shrub and midstory layers, possibly with herbicide treatment.

b. Treat nonnative invasive plant species or wild boar, if present.

c. Plant appropriate understory herbaceous layer if not represented due to inappropriate fire regime.

d. Plant appropriate overstory species if natural regeneration is lacking.

e. Apply prescribed fire if natural wildfires do not occur at appropriate frequency and intensity.

Maintenance:

a. Treat nonnative invasive plant species or wild boar, if present.

b. Apply prescribed fire if natural wildfires do not occur at appropriate frequency and intensity.

Representative Seasonally Wet Oak-Hardwood Woodland Old-Growth Stands:

Delta Experimental Forest, Washington County, MS

Mississippi Delta National Forest, Sharkey County, MS

Table 6.13.a—The potential distribution of OGCT 27: seasonally wet oak-hardwood woodland

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part, Oconee RD)
		Francis Marion and Sumter NFs (Andrew Pickens RD, Enoree RD, Long Cane RD—all in part)
	Central Appalachian Piedmont (344D)	Francis Marion and Sumter NFs (Enoree RD—in part)
		George Washington-Jefferson NFs (Glenwood and Pedlar RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)

Table 6.13.a—The potential distribution of OGCT 27: seasonally wet oak-hardwood woodland (continued)

Ecological province	Ecological section	National forest unit
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Poteau RD, Tiak RD—in part, Winona RD, Womble RD) Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	Land Between the Lakes (NRA) NFs of Alabama (Bankhead RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part) Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD) Ouachita NF (Tiak RD—in part)
Cross Timbers (352)	**Texas Cross Timbers and Prairie (352C)**	NFGT (Caddo RD—in part)
	Texas Oak Woods and Prairie (352D)	NFGT (Caddo RD—in part)
Mississippi Embayment (342)	**Western Mississippi Alluvial White and Black River Alluvial Plains (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	Ozark-St. Francis NF (St. Francis RD—in part) NFs of Mississippi (Delta RD)
	Southern Mississippi Alluvial Plain (342C)	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD—in part, Homochitto RD, Tombigbee RD—in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD- in part, Tombigbee RD—in part) NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD—both in part)

Table 6.13.a—The potential distribution of OGCT 27: seasonally wet oak-hardwood woodland (continued)

Ecological province	Ecological section	National forest unit
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part)
		NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part)
		NFs of Florida (Apalachicola RD—in part)
		NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD - in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD)
		NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NRA = national recreation area; NFGT = National Forests and Grasslands in Texas.

Table 6.13.b—The relationship of OGCT 27: seasonally wet oak-hardwood woodland, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**54**	White oak (in part)
	62	Sweetgum-oak
	64	Laurel oak-willow oak
SAF forest types	**53**	White oak (in part)
	65	Pin oak-sweetgum (in part)
	68	Willow oak-water oak-laurel oak
	92	Sweetgum-willow oak
FIA forest types	**504**	White oak
	520	Mixed upland hardwoods [1]
	962	Other hardwoods [1]

[1] When these types are encountered further field work may be necessary to fully identify the old-growth community type present.

Table 6.13.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 27: seasonally wet oak-hardwood woodland

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G130	**Hardwood-loblolly pine nonriverine wet flatwoods**	A4190	West Gulf Coastal Plain pine-oak wet flatwoods
		A3443	Atlantic Coastal Plain oak wet flatwoods
G654	**South-central flatwoods and pond forest**	A1996	White oak wet depression and pond forest
		A3429	Central interior oak pond and flatwoods
		A3430	Piedmont-Cumberland willow oak wet depression forest
		A3431	Interior post oak flatwoods forest
		A4682	Piedmont depression pond
G1179	**Central interior Great Lakes flatwoods**	A4474	Central interior pin oak swamp and flatwoods

Table 6.13.d—Natural vegetation communities for OGCT 27: seasonally wet oak-hardwood woodland

Natural vegetation community category	Code	Community types
Ecological zone	–	None
NatureServe Terrestrial Ecological System	**CES203.548**	West Gulf Coastal Plain nonriverine wet hardwood-pine flatwoods
	CES203.193	Lower Mississippi River flatwoods
	CES203.304	Southern Atlantic Coastal Plain nonriverine swamp and wet hardwood forest (in part)
LANDFIRE biophysical settings	**15130**	Lower Mississippi River flatwoods
	15060	West Gulf Coastal Plain nonriverine wet hardwood flatwoods
	14570	South-central interior/upper coastal plain wet flatwoods

– = Missing codes have not yet been assigned.

6.14 OGCT 28: Eastern Riverfront Forest

Community Description

Eastern riverfront forests occur over a large portion of the Eastern United States, from the forest-prairie margin eastward to the Atlantic coastline. These communities have the potential to occur on all national forests in the South (table 6.14.a). As the name implies, this forest community type is predominant on sites immediately adjacent to major rivers and streams (i.e., riverbanks and first bottoms, natural levees, sandbars, and islands). Riverbanks (natural levees) are often the high ground in the system, but areas of deposition further from the river also provide higher ground as well. As indicated in the description for river floodplain hardwood forest (OGCT 13), that type can be difficult to distinguish a clear boundary with OGCT 28 and many species are shared. Conceptually, OGCT 13 occupies higher ground, secondary terraces, and levees where flooding is less frequent.

The principal species in the eastern riverfront forest community type include river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), eastern cottonwood (*Populus deltoides*), swamp cottonwood (*Populus heterophylla*), sweetgum (*Liquidambar styraciflua*), black willow (*Salix nigra*), and live oak (*Quercus virginiana*) (table 6.14.b). Common associates are red maple (*Acer rubrum* var. *rubrum*), boxelder (*Acer negundo*), hackberry (*Celtis occidentalis*), slippery elm (*Ulmus rubra*), pin oak (*Quercus palustris*), swamp white oak (*Quercus bicolor*), green ash (*Fraxinus pennsylvanica*), sugarberry (*Celtis laevigata*), water oak (*Quercus nigra*), and pecan (*Carya illinoinensis*) (Meadows and Nowacki 1996, NatureServe 2024, Schafale 2024). Black cherry (*Prunus serotina*) and slippery elm (*Ulmus rubra*) are often present in east-central Kentucky. Shingle oak (*Quercus imbricaria*) is present in the riverfront forest across the southern and central Blue Ridge Mountains. Across the mountains and piedmont typical distinguishing shrubs and herbs in these floodplain forests include black alder (*Alnus serrulata*), yellowroot (*Xanthorhiza simplicissima*), winterberry (*Ilex verticillata*), American black elderberry (*Sambucus nigra* ssp. *canadensis*), silky dogwood (*Cornus amomum*), bottlebrush grass (*Elymus hystrix*), river oats (*Chasmanthium latifolium*), swamp nettle (*Boehmeria cylindracea*), and clearweed (*Pilea pumila*) (Fleming et al. 2021, Schafale 2024). White oak (*Quercus alba*), tuliptree (*Liriodendron tulipifera*), and American beech (*Fagus grandifolia*) may be present on slightly higher ground; they are also indicative of more intensive past disturbances (Schafale 2024). Coastal plain riverfront forests typically have more diverse oak species obscuring the transition to OGCT 13. Deciduous holly (*Ilex decidua*), Virginia sweetspire (*Itea virginica*), sweet-pepperbush (*Clethra alnifolia*), shining fetterbush (*Lyonia lucida*), buttonbush (*Cephalanthus occidentalis*), southern swamp dogwood (*Cornus foemina*), and Elliott's blueberry (*Vaccinium elliottii*) are scattered across various types in the open understory, which is often dominated by grasses and sedges (Fleming et al. 2021, NatureServe 2024). Tables in section 5 contain old-growth attributes for the eastern riverfront forest community type.

Eastern riverfront forests are dynamic ecosystems. After a major stand-replacing flood event, sites will be a nearly pure eastern cottonwood stand followed by a nearly pure black willow stand (Meadows and Nowacki 1996). In east-central and eastern Kentucky replacement stands are more likely to be American sycamore or boxelder, but black willow may be present; eastern cottonwood is uncommon. Elsewhere, over time and without disturbance, the vegetation will be replaced by typical riverfront hardwood stands generally dominated by sycamore, pecan, green ash, sugarberry, and American elm. Eastern cottonwood and black willow trees can be a component of the stand but do not dominate in the old-growth condition.

The degree and pattern of disturbances can result in different stand compositions and structures not representing the old-growth conditions. With more flooding, shorter-lived trees like boxelder, willow (*Salix* spp.), and silver maple may dominate. Drier sites tend to develop a midstory. In more montane habitats, these sites are variable, ranging from a denser evergreen ericaceous shrub layer to more scattered deciduous shrubs. Within both of those, annual herbaceous plants and many nonnative invasive species are very abundant because of frequent flash flooding.

As previously indicated, eastern riverfront community type (OGCT 28) is sometimes difficult to separate from the river floodplain hardwood forest community type (OGCT 13), especially where the riverfront levee is not well formed or easily discernible. Forest type and species composition are influenced by soil types, drainage, and flooding patterns, resulting in a patchy ecosystem.

Giant cane (*Arundinaria gigantea*) is often present in both OGCT 13 and OGCT 28. In addition, switch cane (*Arundinaria tecta*) is present in riverfront forests across the piedmont. Both these canes were used and promoted by native tribes and may currently not be as dense as in historic times (Platt and Brantley 1997). Of the two species, only giant cane results in open or essentially treeless canebrakes as a rare community in this old-growth type. In contrast, switch cane may result in canebrakes within peatlands of the Coastal Plain, communities associated with OGCT 29. For associations between this community type and the U.S. National Vegetation Classification System (USNVC) see table 6.14.c. Additional classifications related to this community type are found in table 6.14.d.

Rare Communities That May be Embedded in This OGCT:

Canebrakes

River scour bars and prairies

Stream head seeps, sphagnum bogs

Disturbance

This community type is restricted to riparian zones where intense flooding, such as ice and water scouring routinely occurs. These floods expose mineral soils, reduce competing undergrowth, and increase surface light levels. Floods may occur any time of year with high water levels lasting a few hours to more than a week, depending on location in the watershed and rainfall amounts. The locations of these forests will shift as river courses change. In the absence of floods, these forests are susceptible to encroachment by shade-tolerant species (Meadows and Nowacki 1996).

Pests and Diseases

This OGCT is vulnerable to a number of nonnative pests and diseases. Beech bark disease (*Neonectria faginata*, *N. ditissima* in association with scale insects *Cryptococcus fagisuga* and possibly *Xylococculus betulae*), where present, may significantly alter the composition and structure of the forest through the development of abundant root suckers from infected parent trees. Where ash species are present, high mortality may occur from emerald ash borer (*Agrilus planipennis*), which alters the species composition of this OGCT. Additionally, typical elm associates within this OGCT may suffer from Dutch elm disease (*Ophiostoma* spp., including *O. ulmi*, *O. himal-ulmi*, *O. novo-ulmi*). This OGCT is especially vulnerable to wild boar (*Sus scrofa*) damage.

Management Considerations

Restoration:

a. Protect high value (ecological or social) ash or elm individuals with chemical injections.

b. Identify beech bark disease resistant American beech individuals and use chemical control for root suckers from unhealthy individuals.

c. Control nonnative invasive plant infestations and wild boar populations.

d. Plant giant cane in appropriate locations to maintain or restore canebrakes and bank stability, and improve water quality (sediment trapping).

e. Plant appropriate woody species in appropriate locations to maintain or restore community diversity.

Maintenance:

a. Limit vehicular access during restoration and recreation activities to maintain soil and bank integrity, and hydrologic function.

b. Control nonnative invasive species occurrences and wild boar populations.

c. Thin in areas of heavy shade to promote existing or expanding giant cane.

Representative Eastern Riverfront Forest Old-Growth Stands:

Green Ash Natural Area, Delta National Forest, Sharkey County, MS

Mississippi River Birch Bottom, Kisatchie National Forest, LA

Table 6.14.a—The potential distribution of OGCT 28: eastern riverfront forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Chattahoochee-Oconee NF (Blue Ridge RD, Chattooga RD—in part, Conasauga RD—in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Francis Marion and Sumter NFs (Andrew Pickens RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD, Mount Rogers NRA—both in part)
		NFs of North Carolina (Appalachian RD, Cheoah RD, Grandfather RD—in part, Nantahala RD, Pisgah RD, Tusquitee RD)
	Southern Cumberland Mountains (335A)	George Washington-Jefferson NF (Clinch RD—in part)
		Daniel Boone NF (Redbird RD, Stearns RD—both in part)
	Northern Cumberland Mountains (335B)	George Washington-Jefferson NF (Clinch RD—in part)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, Mount Rogers NRA—in part, North River RD)
Mid-Atlantic (336)	**Northern Appalachian Piedmont (336A)**	George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Bankhead RD—in part, Oakmulgee RD—in part, Tuskegee RD)
	Southern Ridge and Valley (344B)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Cherokee NF (Ocoee RD, Tellico RD, Unaka RD, Watauga RD—all in part)
		Chattahoochee-Oconee NF (Conasauga RD—in part)
		George Washington-Jefferson NF (Clinch RD—in part)
	Southern Appalachian Piedmont (344C)	NFs of Alabama (Shoal Creek RD, Talladega RD—both in part)
		Chattahoochee-Oconee NF (Chattooga RD—in part, Oconee RD)
		Francis Marion and Sumter NFs (Andrew Pickens RD, Enoree RD, Long Cane RD—all in part)
	Central Appalachian Piedmont (344D)	NFs of North Carolina (Grandfather RD, Uwharrie RD—both in part)
		Francis Marion and Sumter NFs (Enoree RD—in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part)
Allegheny Piedmont (334)	**Southern Unglaciated Allegheny Plateau (334B)**	Daniel Boone NF (Cumberland RD—in part)
	Cumberland Plateau (334A)	Daniel Boone NF (Cumberland RD, London RD, Redbird RD, Stearns RD—all in part)

Table 6.14.a—The potential distribution of OGCT 28: eastern riverfront forest (continued)

Ecological province	Ecological section	National forest unit
Central Interior (333)	**Ouachita Mountains (333A)**	Ouachita NF (Caddo RD, Choctaw RD, Cold Springs RD, Fourche RD, Jessieville RD, Kiamichi RD, Mena RD, Oden RD, Poteau RD, Tiak RD—in part, Winona RD, Womble RD) Ozark-St. Francis NF (Magazine Mountain RD, Baylou RD—in part, Pleasant Hill RD—in part)
	Ozark Highlands (333B)	Ozark-St. Francis NF (Baylou RD—in part, Boston Mountain RD, Buffalo RD, Pleasant Hill RD—in part, Sylamore RD)
	Bluegrass (333E)	Daniel Boone NF (Cumberland RD, London RD—both in part)
	Highland Rim (333F)	Land Between the Lakes (NRA) NFs of Alabama (Bankhead RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part) Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD) Ouachita NF (Tiak RD—in part)
Cross Timbers (352)	**Texas Cross Timbers and Prairie (352C)**	NFGT (Caddo RD—in part)
	Texas Oak Woods and Prairie (352D)	NFGT (Caddo RD—in part)
Mississippi Embayment (342)	**Western Mississippi Alluvial White and Black River Alluvial Plains (342A)**	Ozark-St. Francis NF (St. Francis RD—in part)
	Eastern Mississippi Alluvial Plain (342B)	Ozark-St. Francis NF (St. Francis RD—in part) NFs of Mississippi (Delta RD)
	Southern Mississippi Alluvial Plain (342C)	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Holly Springs RD— in part, Homochitto RD, Tombigbee RD—in part)
	Black Belt Prairie (343B)	NFs of Mississippi (Holly Springs RD— in part, Tombigbee RD—in part) NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD, Tombigbee RD – both in part)

Table 6.14.a—The potential distribution of OGCT 28: eastern riverfront forest (continued)

Ecological province	Ecological section	National forest unit
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part)
		NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (Chickasawhay RD, De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part)
		NFs of Florida (Apalachicola RD—in part)
		NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part)
		Francis Marion and Sumter NFs (Long Cane RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD)
		NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NRA = national recreation area; NFGT = National Forest and Grasslands in Texas.

Table 6.14.b—The relationship of OGCT 28: eastern riverfront forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**58**	Sweetgum-yellow poplar
	61	Swamp chestnut oak-cherrybark oak
	62	Sweetgum-oak
	72	River birch-sycamore
	75	Sycamore-pecan-American elm
	76	Silver maple-American elm
	82	Black walnut
SAF forest types	**61**	River birch-sycamore
	62	Silver maple-American elm
	87	Sweetgum-yellow poplar
	88	Willow oak-water oak-diamondleaf oak
	89	Live oak
	91	Swamp chestnut oak-cherrybark oak
	92	Sweetgum-willow oak
	94	Sycamore-sweetgum-American elm
FIA forest types	**702**	River birch-sycamore
	703	Cottonwood
	704	Willow
	705	Sycamore-pecan-American elm
	962	Other hardwoods [1]

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.14.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 28: eastern riverfront forest

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G652	**Midwest floodplain forest**	A3712	Midwest sycamore-river birch floodplain forest
		A3713	Midwest mesic floodplain forest
G673	**Central interior northeast floodplain forest**	A3698	Ozark and west Gulf riverfront forest
		A3699	Appalachian piedmont river birch-sycamore floodplain forest
		A3700	South-central floodplain forest
		A3701	Central Appalachian piedmont sycamore-green ash floodplain forest
		A3702	Southern Appalachian sycamore-sweetgum floodplain forest
		A3711	South-central mesic floodplain forest
G044	**Central interior Appalachian seepage swamp**	A3358	Southern Appalachian piedmont red maple-blackgum seepage forest

Table 6.14.d—Natural vegetation communities for OGCT 28: eastern riverfront forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Large floodplain forest
NatureServe Terrestrial Ecological System	CES203.066	Atlantic Coastal Plain large river floodplain forest
	CES203.249	Atlantic Coastal Plain small blackwater river floodplain forest
	CES203.250	Atlantic Coastal Plain small brownwater river floodplain forest
	CES203.489	East Gulf Coastal Plain large river floodplain forest
	CES203.196	Mississippi River high floodplain (bottomland) forest
	CES203.195	Mississippi River low floodplain (bottomland) forest
	CES203.190	Mississippi River riparian forest
	CES203.065	Red River large floodplain forest
	CES203.493	Southern Coastal Plain blackwater river floodplain forest
	CES203.488	West Gulf Coastal Plain large river floodplain forest
LANDFIRE biophysical setting	14730	Gulf and Atlantic Coastal Plain floodplain systems

– = Missing codes have not yet been assigned.

6.15 OGCT 29: Southern Wet Pine Forest, Woodland, and Savanna

Community Description

Southern wet pine forests, woodlands, and savannas are part of the pine flatwoods forests of the Atlantic and Gulf Coastal Plain (table 6.15.a). Representative sites include boggy nonriverine flatlands, coastal flatlands, swamps, and lowlands adjacent to ponds, streams, and other wet areas. A rare type also extends into the North Carolina and possibly South Carolina Piedmont (Schafale 2024).

Species composition differs widely among stands and is largely dependent on the degree of flooding. On mineral soils where flooding is limited, longleaf pine (*Pinus palustris*) or slash pine (*Pinus elliottii*) predominate (table 6.15.b). Fire usually restricts hardwood species. Longleaf and slash pine are replaced by pond pine (*Pinus serotina*) on organic soils subject to prolonged flooding. Associates of the pond pine community are swamp tupelo (*Nyssa biflora*), blackgum (*N. sylvatica*), water oak (*Quercus nigra*), bald cypress (*Taxodium distichum*), pond cypress (*T. ascendens*), sweetbay (*Magnolia virginiana*), loblolly bay (*Gordonia lasianthus*), and redbay (*Persea borbonia*) (Harms 1996, Nowacki 1993). In wet piedmont forests, a woodland structure can be present with longleaf pine dominant or codominant with loblolly pine (*Pinus taeda*) and possibly shortleaf pine (*Pinus echinata*) (Schafale 2024). Although currently more extensive than was natural, loblolly pine is native in eastern Texas (Diggs et al. 1999: 207) and southeast Oklahoma (Weakley et al. 2024: 154), especially on periodically flooded sites. Some old stands may be native, although discerning them from planted stands may be difficult. Often herb diversity, with more frequent fire, has a dense grassy layer with frequent herbs.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.15.c. Additional classifications related to this community type are found in table 6.15.d.

Tables in section 5 contain old-growth attributes for the southern wet pine forest, woodland, and savanna community type.

An important unique type is the pocosin dominated by pond pine with a dense shrub layer of wetland, evergreen shrubs tolerant of the organic soils, low nutrient conditions, and fire. These vary in species composition and overstory density by the thickness of the underlying peat layer (Schafale 2024). In pre-European settlement fire regimes, canebrakes would have been more common and extensive.

Note—Mature and old-aged slash pine planted on upland locations are considered offsite and should not be considered part of this OGCT even within the natural range of slash pine (Lohrey and Kossuth 1990).

Rare Communities That May be Embedded in This OGCT:

Wet piedmont longleaf pine forest

Pond pine woodland (canebrake subtype, G1)

Wet loamy pine savanna (G1)

High pocosin-evergreen (G3)

Low pocosin-titi (G2G3)

Disturbance

This OGCT is fire-dependent and in the absence of fire, pines are eventually replaced by hardwoods (Harms 1996). Canopy gaps occur from lightning, windthrow, and tree mortality. Hurricanes impact large portions of the range of OGCT 29, especially within 100 miles of the Gulf of Mexico (Hooper and McAdie 1995). Flooding with soil saturation or inundations alternating with periods of drought are natural processes. Occurring rarely, ice storms may cause minor to extensive damage.

Pests and Diseases

Southern pine species are susceptible to disease and pests that impact individual trees including native southern pine beetle (*Dendroctonus frontalis*) and pine engraver beetles (*Ips* spp.), especially in overstocked conditions or when lack of fire allows loblolly pine to invade. Nonnative organisms are also found in this OGCT; redbay (*Persea borbonia*) and other species in the laurel family (Lauraceae) are susceptible to laurel wilt (*Harringtonia lauricola*), which is transmitted by the redbay ambrosia beetle (*Xyleborus glabratus*). Across the range of this OGCT, Chinese tallow tree (*Triadica sebifera*) may aggressively invade, especially after disturbance. This OGCT is especially vulnerable to wild boar (*Sus scrofa*) damage.

Management Considerations

Restoration:

a. Use growing season fires to restore understory conditions and appropriate tree densities to ensure sustainable, climate-resilient plant communities.

b. Plant tree species appropriate to the site where offsite species have been removed.

c. Control nonnative invasive species, such as Chinese tallow (*Triadica sebifera*) tree or wild boar.

d. Thin or burn to restore embedded rare communities, including forested wetlands.

Maintenance:

a. Maintain soil integrity through limited vehicular access during restoration and recreation activities.

b. Maintain a fire regime appropriate for the site (2- to 6-year return interval). Due to fire suppression, a change in the structure and composition of the stand can impact the effectiveness of prescribed fire or the outcome of wildfire. Frequency and seasonality can also impact species composition and tree response to fire (FNAI 2010).

c. Control nonnative invasive plant or animal species.

d. Maintain embedded rare communities, including forested wetlands.

Representative Southern Wet Pine Forest, Woodland, and Savanna Old-Growth Stands:

Beehead Ranch Pine Flatwoods, Tosohatchee State Preserve, FL

Big Cypress National Preserve, Collier County, FL

Slash Pine Tract, Bradwell Bay Wilderness, Apalachicola National Forest, FL

Pocosin Wilderness, Croatan National Forest, Carteret County, NC

Catfish Lake, Carolina Bay Road, Croatan National Forest, Jones County, NC

Table 6.15.a—The potential distribution of OGCT 29: southern wet pine forest, woodland, and savanna

Ecological province	Ecological section	National forest unit
Appalachian Piedmont (344)	**Cumberland Piedmont (344A)**	NFs of Alabama (Oakmulgee RD—in part, Tuskegee RD)
	Central Appalachian Piedmont (334D)	NFs of North Carolina (Uwharrie RD—in part)
Red River Uplands Province (341)	**East Texas Piney Woods (341A)**	NFGT (Angelina RD—in part, Davy Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
		Kisatchie NF (Calcasieu RD—in part, Kisatchie RD—in part)
	Arkansas-Louisiana Piney Woods (341B)	Kisatchie NF (Caney RD, Catahoula RD, Kisatchie RD—in part, Winn RD)
		Ouachita (Tiak RD—in part)
Mississippi Embayment (342)	**Southern Mississippi Alluvial Plain (342C)**	Kisatchie NF (Calcasieu RD, Catahoula RD—both in part)
Central Loess Plains (343)	**Mississippi Loess Plain (343A)**	NFs of Mississippi (Homochitto RD)
	Black Belt Prairie (343B)	NFs of Alabama (Oakmulgee RD—in part)
	Southern Loess Plain (343C)	NFs of Mississippi (Bienville RD—in part)
Coastal Plain (345)	**Western Gulf Coastal Plains and Flatwoods (345A)**	Kisatchie NF (Calcasieu RD—in part)
		NFGT (Angelina RD—in part, Davey Crockett RD, Sabine RD—in part, Sam Houston RD—in part)
	West Central Gulf Coastal Plains and Flatwoods (345C)	NFs of Mississippi (De Soto RD—in part, Bienville RD—in part)
	Gulf Coastal Lowlands (345D)	NFs of Alabama (Conecuh RD—in part)
		NFs of Florida (Apalachicola RD—in part)
		NFs of Mississippi (De Soto RD—in part)
	East Central Gulf Coastal Plains and Flatwoods (345E)	NFs of Alabama (Conecuh RD—in part)
	Fall Line Coastal Plains and Flatwoods (345F)	NFs of North Carolina (Uwharrie RD—in part)
	Okefenokee Lowlands (345H)	NFs of Florida (Osceola RD—in part)
	Florida Gulf Coastal Lowlands (345I)	NFs of Florida (Apalachicola RD—in part, Wakulla RD)
	Florida Coastal Plains Central Highlands (345J)	NFs of Florida (Lake George RD—in part, Osceola RD—in part, Seminole RD)
	Florida Atlantic Coastal Lowlands (345K)	NFs of Florida (Lake George RD—in part)
	Atlantic Coastal Flatwoods (345L)	Francis Marion and Sumter NFs (Francis Marion RD)
		NFs of North Carolina (Croatan RD)

NF = national forest; RD = ranger district; NFGT = National Forests and Grasslands in Texas.

Table 6.15.b—The relationship of OGCT 29: southern wet pine forest, woodland, and savanna, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**14**	Slash pine-hardwood [1]
	18	Pond pine-hardwood [1]
	21	Longleaf pine
	22	Slash pine
	36	Pond pine
	79	Slash pine-cypress
SAF forest types	**70**	Longleaf pine
	83	Longleaf pine-slash pine
	84	Slash pine
	85	Slash pine-hardwood
	98	Pond pine
FIA forest types	**141**	Longleaf pine
	142	Slash pine
	166	Pond pine
	407	Slash pine-hardwood

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.15.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 29: southern wet pine forest, woodland, and savanna

USNVC group code	USNVC groups	USNVC Alliances code	USNVC alliances
G037	**Southern Coastal Plain mixed evergreen swamp**	A0060	Bay swamp forest
		A0581	Pond pine pocosin
G190	**Wet mesic longleaf pine open woodland**	A3305	Atlantic Coastal Plain wet longleaf pine savanna
		A3306	West Gulf Coastal Plain longleaf pine wet savanna
		A4104	East Gulf Coastal Plain wet pine open woodland

Table 6.15.d—Natural vegetation communities for OGCT 29: southern wet pine forest, woodland, and savanna

Natural vegetation community category	Code	Community types
Ecological zone	–	Wet pine savanna and flatwoods (wet and mesic-wet phase) (North Carolina and South Carolina)
	–	Pine woodland wet pine savanna (North Carolina)
	–	Pond pine forest or woodland (North Carolina)
	–	Mixed pine forest (North Carolina)
	–	Wet pine flatwood (North Carolina)
	–	Peatland low pocosin (North Carolina)
	–	Peatland high pocosin and canebrake (North Carolina and South Carolina)
	–	Pocosin in Carolina Bay (South Carolina)
	–	Streamhead seepage, pocosin, and baygall (South Carolina)
	–	Interior longleaf pine woodland piedmont (North Carolina)
NatureServe Terrestrial Ecological System	CES202.319	Southeastern interior longleaf pine woodland
	CES203.265	Central Atlantic Coastal Plain wet longleaf pine savanna and flatwoods
	CES203.267	Atlantic Coastal Plain peatland pocosin and canebrake-pond pine pocosin
	CES203.252	Atlantic Coastal Plain streamhead seepage swamp, pocosin, and baygall
LANDFIRE biophysical settings	14510	West Gulf Coastal Plain wet longleaf pine savanna and flatwoods
	14490	Central Atlantic Coastal Plain wet longleaf pine savanna and flatwoods
	14500	Southern Atlantic Coastal Plain wet pine savanna and flatwoods
	14530	Central Florida pine flatwoods
	14850	East Gulf Coastal Plain savanna and wet prairie
Florida Natural Areas Inventory (FNAI) Natural Communities	–	Wet flatwoods

– = Missing codes have not yet been assigned.

6.16 OGCT 31: Montane and Allied Spruce and Spruce-Fir Forest

Community Description

Montane and allied spruce (*Picea* spp.) and spruce-fir (*Abies* spp.) forests typically occur at middle to high elevations in the Appalachian Mountains from Maine to North Carolina (table 6.16.a). In the Southern Region, this OGCT occurs on the highest mountains of the southern Blue Ridge, where it caps many of the highest peaks, exceeding 6,000 feet. The southern and central spruce-fir system ranges from the Balsam Mountains and Great Smoky Mountains in North Carolina and Tennessee north to western Virginia and eastern West Virginia (NatureServe 2024). Site conditions are usually severe, including short frost-free seasons and shallow, poorly developed, acidic soils, often with rich amounts of organic matter (Fleming et al. 2021). Near steep rock faces soils may be highly erodible. The montane and allied spruce and spruce-fir forest community type typically occurs in fog-shrouded locations where moisture is obtained through direct cloud contact as well as through frequent rainfall (NatureServe 2024).

Overstory dominance within this group includes red spruce (*Picea rubens*) or Fraser fir (*Abies fraseri*) (Fleming et al. 2021, Schafale 2024). In lower elevation examples of this type, yellow birch (*Betula alleghaniensis*), American mountain ash (*Sorbus americana*), mountain maple (*Acer spicatum*), and other hardwoods may be codominant (table 6.16.b). Hobblebush (*Viburnum lantanoides*), Catawba rhododendron (*Rhododendron catawbiense*), and southern cranberry (*Vaccinium erythrocarpum*) are common understory shrubs (Fleming et al. 2021, Schafale 2024). The habitat includes a nonvascular understory dispersed among the sparse herb layer. The most common subtypes are either herb-dominated, transitioning to yellow birch herb or shrub, or at their lowest elevation, around 4,500 feet, with great laurel (*Rhododendron maximum*) (Schafale 2024). Tables in section 5 contain old-growth attributes for the montane and allied spruce and spruce-fir forest community type.

For associations between this community type and the U.S. Natural Vegetation Classification System (USNVC 2022) see table 6.16.c. Additional classifications related to this community type are found in table 6.16.d.

Rare Communities That May be Embedded in This OGCT:

Fraser fir forest (herb and rhododendron subtypes) (Blue Ridge)

Red spruce-Fraser fir forest (boulderfield and rhododendron subtypes) (Blue Ridge)

Disturbance

Historically this OGCT was heavily disturbed by harvest and subsequent wildfires at the turn of the 19th century. Natural disturbances vary from the most common single or multiple treefall gaps resulting in small patches, to less common medium and large patches resulting from ice storms or moderate winds. Larger patches result from occasional extreme wind events (NatureServe 2024). Tree mortality from windthrow or insect infestation can predispose these areas to fire during droughts (Tyrrell et al. 1998) although occurrences since the early 1900s are rare. Concerns have been raised about red spruce decline from pollution, such as acid deposition. Although this decline has been documented for this community type in the northeast portion of its range, the detection of decline is problematic because of disturbances from insects (SAMAB 1996). With climate change and insects and diseases, this system may be trending toward red spruce dominated, possibly codominant with yellow birch, and toward red spruce-northern hardwood types, depending on the site. In old-growth stands, red spruce is the dominant species as opposed to Fraser fir, given its greater longevity (400+ years versus 150 years) (White et al. 1993).

Pests and Diseases

Insect outbreaks, including the nonnative balsam woolly adelgid (*Adelges piceae*), can cause widespread change; however, they do not result in the complete loss of Fraser fir. The nonnative wild boar (*Sus scrofa*) is known to be highly destructive in this OGCT.

Management Considerations

Restoration:

a. Plant and release red spruce and Fraser fir in mature northern hardwood forests on appropriate sites, which may be appropriate to expand the potential for this OGCT to develop in the future.

b. Plant Fraser fir where that component is lost because of balsam woolly adelgid.

c. Control nonnative invasive plant species infestations and wild boar populations.

Maintenance:

a. Monitor structure and composition periodically after disturbance.

Representative Montane and Allied Spruce and Spruce-Fir Forest Old-Growth Stands:

Balsam Cone, Potato Hill, Black Mountain Research Natural Area, Pisgah National Forest, Yancey County, NC

Mount Pisgah, Pisgah National Forest, Haywood County, NC

Indian Gap, Great Smoky Mountains National Park, Sevier County, TN

Table 6.16.a—The potential distribution of OGCT 31: montane and allied spruce and spruce-fir forest

Ecological province	Ecological section	National forest unit
Appalachian Mountains (335)	**Blue Ridge Mountains (335E)**	Cherokee NF (Unaka RD, Watauga RD—both in part)
		George Washington-Jefferson NF (Glenwood and Pedlar RD—in part, Mount Rogers NRA)
		NFs of North Carolina (Appalachian RD, Nantahala RD, Pisgah RD)
	Northern Ridge and Valley (335D)	George Washington-Jefferson NF (Eastern Divide RD, Glenwood and Pedlar RD—in part, James River and Warm Springs RD—in part, Lee RD, North River RD)
	Allegheny Mountains (335C)	George Washington-Jefferson NF (James River and Warm Springs RD—in part)

NF = national forest; RD = ranger district; NRA = national recreation area.

Table 6.16.b—The relationship of OGCT 31: montane and allied spruce and spruce-fir forest, to the forest classification systems of the National Forest System, the Society of American Foresters (SAF), and Forest Inventory and Analysis (FIA)

Southern Region forest types	Code	Description
FSVeg EV codes	**6**	Fraser fir
	7	Red spruce-Fraser fir
	17	Red spruce-northern hardwood [1]
SAF forest types	**30**	Red spruce-yellow birch
	34	Red spruce-Fraser fir
FIA forest types	**123**	Red spruce
	129	Red spruce-Fraser fir

[1] When these types are encountered further field work may be necessary to fully identify the OGCT present.

Table 6.16.c—U.S. Natural Vegetation Classification System (USNVC) for OGCT 31: montane and allied spruce and spruce-fir forest

USNVC group code	USNVC groups	USNVC alliances code	USNVC alliances
G632	**Central and southern Appalachian red spruce-fir hardwood forest**	A0136	Southern Appalachian spruce-fir forest
		A0138	Central Appalachian red spruce forest

Table 6.16.d—Natural Vegetation Communities for OGCT 31: montane and allied spruce and spruce-fir forest

Natural vegetation community category	Code	Community types
Ecological zone	–	Spruce-fir upland forest (North Carolina, Tennessee, and Virginia)
NatureServe Terrestrial Ecological System	CES202.028	Central and southern Appalachian spruce-fir forest
LANDFIRE biophysical settings	13500	Central and southern Appalachian spruce-fir forest

– = Missing codes have not yet been assigned.

REFERENCES

Abell, C.A.; Abell, M.; Barret, L.I. [et al.]. 1935. Forest Improvement Measures for the Southern Appalachians. Tech. Bull. 476. Asheville, NC: U.S. Department of Agriculture, Forest Service, Appalachian Forest Experiment Station.

Abrams, M.D. 2007. Tales from the blackgum, a consummate subordinate tree. BioScience. 57(4): 347–359. https://doi.org/10.1641/B570409.

Abrams, M.D.; Nowacki, G.J. 2020. Native American imprint in palaeoecology. Nature Sustainability. 3: 896–897. https://doi.org/10.1038/s41893-020-0578-6.

Ackers, S.H.; Davis, R.J.; Olsen, K.A.; Dugger, K.M. 2015. The evolution of mapping habitat for northern spotted owls (*Strix occidentalis caurina*): A comparison of photo-interpreted, Landsat-based, and LiDAR-based habitat maps. Remote Sensing of Environment. 156: 361–373. https://doi.org/10.1016/j.rse.2014.09.025.

Alexander, H.D.; Siegert, C.; Brewer, J.S. [et al.]. 2021. Mesophication of oak landscapes: evidence, knowledge gaps, and future research. BioScience. 71(5): 531–542. https://doi.org/10.1093/biosci/biaa169.

Allen, J.L.; Lendemer, J.C. 2016. Climate change impacts on endemic, high-elevation lichens in a biodiversity hotspot. Biodiversity and Conservation. 25: 555–568. https://doi.org/10.1007/s10531-016-1071-4.

Avilla, L.R.; Hines, B.; Elliott, E.L. 2022. A survey of bats at Lilley Cornett Woods Appalachian Ecological Research Station, Letcher County, Kentucky, before the arrival of white-nosed syndrome. Journal of the Kentucky Academy of Science. 83(1-2): 1–9. https://doi.org/10.3101/kyac-83-01-02.

Ayres, H.B.; Ashe, W.W. 1905. The southern Appalachian forests. Professional Pap. 37. Washington, DC: USDOI Geological Survey, Government Printing Office. 291 p. https://doi.org/10.3133/pp37.

Bače, R.; Svoboda, M.; Janda, P. [et al.]. 2015. Legacy of Pre-Disturbance Spatial Pattern Determines Early Structural Diversity following Severe Disturbance in Montane Spruce Forests. PLOS ONE. 10(9): e0139214. https://doi.org/10.1371/journal.pone.0139214.

Barndt, S.; Gray, A.; Hayward, G. [et al.]. 2023. Mature and old-growth forests: definition, identification, and initial inventory on lands managed by the Forest Service and Bureau of Land Management. FS-1215a. Washington, DC: U.S. Department of Agriculture, Forest Service. 63 p.

Barnett, K.; Aplet, G.H.; Belote, R.T. 2023. Classifying, inventorying, and mapping mature and old-growth forests in the United States. Frontiers in Forests and Global Change. 5(100372): 1–25. https://doi.org/10.3389/ffgc.2022.1070372.

Barton, A.M.; Keeton, W.S., eds. 2018. Ecology and Recovery of Eastern Old-Growth Forests. Washington, DC: Island Press. 360 p.

Bataineh, M.M. 2020. Aboveground carbon stock and distribution in managed and unmanaged mature, natural-origin, pine-hardwood forest stands. In: Bragg, D.C.; Koerth, N.E.; Holley, A.G., eds. Proceedings of the 20th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS-253. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 279–286.

Batista, W.B.; Platt, W.J. 1997. An old-growth definition for southern mixed hardwood forests. Gen. Tech. Rep. SRS-9. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 15 p. https://doi.org/10.2737/SRS-GTR-9.

Batista, W.B.; Platt, W.J. 2003. Tree population responses to hurricane disturbance: syndromes in a southeastern USA old-growth forest. Journal of Ecology. 91: 197–212.

Bauhus, J.; Puettmann, L.; Messier, C. 2009. Silviculture for old-growth attributes. Forest Ecology and Management. 258(4): 525–537. https://doi.org/10.1016/j.foreco.2009.01.053.

Bechtold, W.A.; Patterson, P.L. 2005. The enhanced forest inventory and analysis program—a national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p. https://doi.org/10.2737/SRS-GTR-80.

Bell, D.M.; Bradford, J.B.; Lauenroth, W.K. 2014. Mountain landscapes offer few opportunities for high-elevation tree species migration. Global Change Biology. 20(5): 1441–1451. https://doi.org/10.1111/gcb.12504.

Bell, D.M.; Wilson, B.T.; Werstak, C.E., Jr. [et al.]. 2022. Examining *k*-Nearest Neighbor Small Area Estimation Across Scales Using National Forest Inventory Data. Frontiers in Forests and Global Change. 5: 763422. https://doi.org/10.3389/ffgc.2022.763422.

Berry, T.; Beasley, P.; Clements, J., eds. 2006. The Forgotten Expedition, 1804-1805: The Louisiana Purchase Journals of Dunbar and Hunter. Baton Rouge, LA: Louisiana State University Press. 248 p.

Blicharska, M.; Mikusiński, G. 2014. Incorporating social and cultural significance of large old trees in conservation policy. Conservation Biology. 28(6): 1558–1567. https://doi.org/10.1111/cobi.12341.

Bond, B.J. 2000. Age-related changes in photosynthesis of woody plants. Trends in Plant Science. 5(8): 349–353. https://doi.org/10.1016/S1360-1385(00)01691-5.

Bragard, C.; Dehnen-Schmutz, K.; Di Serio, F. [et al.]. 2020. Commodity risk assessment of oak logs with bark from the US for the oak wilt pathogen *Bretziella fagacearum* under an integrated systems approach EFSA Panel on Plant Health (PLH). EFSA Journal. 18(12): 6352. https://doi.org/10.2903/j.efsa.2020.6352.

Bragg, D.C. 2003. Natural presettlement features of the Ashley County, Arkansas area. American Midland Naturalist. 149: 1–20. https://doi.org/10.1674/0003-0031(2003)149[0001:NPFOTA]2.0.CO;2.

Bragg, D.C. 2005. Presettlement *Pinus taeda* in the Mississippi Valley Alluvial Plain of the Monroe County, Arkansas area. Journal of the Arkansas Academy of Science. 59: 187–195.

Bragg, D.C. 2010. Stand conditions immediately following a restoration harvest in an old-growth pine-hardwood remnant. Journal of the Arkansas Academy of Science. 64(1): 57–69.

Bragg, D.C. 2016. Overstory Species Composition, Structure, and Conservation Challenges of a Mature, Natural-Origin Pine Stand After Decades of Management. Southeastern Naturalist. 15(SI9): 16–41. https://doi.org/10.1656/058.015.0sp906.

Bragg, D.C. 2023. “Such wonderful country for hunting, fishing, and gathering, and just as poor for horticulture”: the historical natural environment surrounding the Eagle Lake Mounds Site (3BR4). The Arkansas Archeologist. 60: 25–58.

Bragg, D.C.; Bragg, H.A. 2016. Historical and contemporary environmental context for the Saline-Fifteen site (3BR119). Arkansas Archeologist. 55: 1–30.

Bragg, D.C.; Koerth, N.E.; Holley, A.G., eds. 2020. Proceedings of the 20th Biennial Southern Silvicultural Research Conference. e-Gen. Tech. Rep. SRS-253. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 338 p.

Bragg, D.C.; Mroz, G.D.; Reed, D.D. 1997. Relationship between “birdseye” sugar maple (*Acer saccharum*) occurrence and its environment. Canadian Journal of Forest Research. 27: 1182–1191. https://doi.org/10.1139/x97-032.

Bragg, D.C.; Shelton, M.G. 2014. The Value of Old Forests: Lessons from the Reynolds Research Natural Area. In: Hayes, D.C.; Stout, S.L.; Crawford, R.H. [et al.], eds. USDA Forest Service Experimental Forests and Ranges: Research for the Long Term. New York: Springer: 61–84. https://doi.org/10.1007/978-1-4614-1818-4_3.

Bratton, S.P. 1976. Resource division in an understory herb community: responses to temporal and microtopographic gradients. The American Naturalist. 110(974): 679–693. https://doi.org/10.1086/283097.

Brecheisen, Z.S.; Cook, C.W.; Heine, P.R.; Richter, D.deB. 2019. Micro-topographic roughness analysis (MTRA) highlights minimally eroded terrain in a landscape severely impacted by historic agriculture. Remote Sensing of the Environment. 222: 78–89. https://doi.org/10.1016/j.rse.2018.12.025.

Brudvig, L.A.; Grman, E.; Habeck, C.W. [et al.]. 2013. Strong legacy of agricultural land use on soils and understory plant communities in longleaf pine woodlands. Forest Ecology and Management. 310: 944–955. https://doi.org/10.1016/j.foreco.2013.09.053.

Brunswig, N.; Richardson, S.; Johnson, M.; Heitkamp, B. 2016. Bird-friendly recommendations for bottomland forests in the Carolinas: birds and people on common ground. In: Schweitzer, C.J.; Clatterbuck, W.K.; Oswalt, C.M., eds. Proceedings of the 18th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS-212. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 614 p.

Buchert, G.P.; Rajora, O.P.; Hood, J.V.; Dancik, B.P. 1997. Effects of harvesting on genetic diversity in old-growth eastern white pine in Ontario, Canada. Conservation Biology. 11: 747–758. https://doi.org/10.1046/j.1523-1739.1997.96074.x.

Bunn, W.A.; Jenkins, M.A.; Brown, C.B.; Sanders, N.J. 2010. Change within and among forest communities: the influence of historic disturbance, environmental gradients, and community attributes. Ecography. 33(3): 425–434. https://doi.org/10.1111/j.1600-0587.2009.06016.x.

Burrill, E.A.; DiTommaso, A.M.; Turner, J.A. [et al.]. 2021. The Forest Inventory and Analysis Database: database description and user guide version 9.0.1 for Phase 2. U.S. Department of Agriculture, Forest Service. 1026 p. https://research.fs.usda.gov/understory/forest-inventory-and-analysis-database-user-guide-nfi. [Date accessed: 20 April 2023].

Burton, J.A. 2009. Fire frequency effects on vegetation of an upland old growth forest in eastern Oklahoma. Oklahoma State University. 18 p. M.S. thesis.

Busing, R.T.; White, P.S. 1997. Species diversity and small-scale disturbance in an old-growth temperate forest: a consideration of gap partitioning concepts. Oikos. 78(3): 562–568. https://doi.org/10.2307/3545618.

Butler, R.B.; Crosby, M.K.; Hodges, B.N. 2018. Fifty-five years of change in a northwest Georgia old-growth forest. Castanea. 83(1): 152–159. https://doi.org/10.2179/16-113.

Butler, S.M. 2014. Disturbance history and stand dynamics in secondary and old-growth forests of the Southern Appalachian Mountains, USA. The Journal of the Torrey Botanical Society. 141(3): 189–204. https://doi.org/10.3159/TORREY-D-13-00056.1.

Cannon, C.H.; Piovesan, G.; Munné-Bosch, S. 2022. Old and ancient trees are life history lottery winners and vital evolutionary resources for long-term adaptive capacity. Nature Plants. 8: 136–145. https://doi.org/10.1038/s41477-021-01088-5.

Carey, E.V.; Sala, A.; Keane, R.; Callaway, R.M. 2001. Are old forests underestimated as global carbon sinks? Global Change Biology. 7(4): 339–344. https://doi.org/10.1046/j.1365-2486.2001.00418.x.

Carlson, P.J. 1995. An assessment of the old-growth forest resource on National Forest System lands in the Chattooga River watershed. Report to the United States Department of Agriculture, Forest Service, Region 8. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. [Pages unknown].

Carter, E.E. 1909. Methods of Increasing Forest Productivity. Circ. 172. Washington, DC: U.S. Department of Agriculture, Forest Service.

Casey, P.A.; Wynia, R.L. 2010. Culturally Significant Plants. Manhattan, KS: U.S. Department of Agriculture, Natural Resources Conservation Service, Kansas Plant Materials Center. 54 p.

Catanzaro, P.F.; D'Amato, A.W. 2022. Restoring Old-Growth Characteristics to New England's and New York's Forests. Amherst, MA: University of Massachusetts. 36 p.

Caterino, M.S.; Vásquez-Vélez, L.M.; Myers, S.S. 2017. On the conservation value of second-growth forests for leaf-litter inhabiting beetles. Insect Systematics and Diversity. 1(1): 20–28. https://doi.org/10.1093/isd/ixx001.

Cavender, J.C.; Kawabe, K. 1989. Cellular Slime Molds of Japan. I. Distribution and Biogeographical Considerations. Mycologia. 81(5): 683–691. https://doi.org/10.1080/00275514.1989.12025809.

Chandler, J.L.; McGraw, J.B. 2015. Variable effects of timber harvest on the survival, growth, and reproduction of American ginseng (*Panax quinquefolius* L.). Forest Ecology and Management. 344: 1–9. https://doi.org/10.1016/j.foreco.2015.02.007.

Chapman, H.H. 1909. A Method of Studying Growth and Yield of Longleaf Applied in Tyler Co., Texas. Proceedings of the Society of American Foresters IV. 2: 207–220.

Chapman, J.I.; McEwan, R.W. 2016. Thirty years of compositional change in an old-growth temperate forest: the role of topographic gradients in oak-maple dynamics. PLOS ONE. 11(7): e0160238. https://doi.org/10.1371/journal.pone.0160238.

Cipollini, M.; Felch, P.; Dingley, N.R.; Maddox, C. 2019. Changes in tree canopy, understory vegetation, and fuel composition after 10 years of restoration management in an old-growth mountain longleaf pine forest. Natural Areas Journal. 39(2): 197–211. https://doi.org/10.3375/043.039.0207.

Claiborne, J.F.H. 1906. A trip through the Piney Woods. Publications of the Mississippi Historical Society. 9: 487–538.

Clark, M.K. 2003. Survey and monitoring of rare bats in bottomland hardwood forests. In: O'Shea, T.J.; Bogan, M.A., eds. Monitoring trends in bat populations of the United States and territories: problems and prospects. Inf. and Tech. Rep. USGS/BED/TTR-2003-0003. U.S. Department of the Interior, U.S. Geological Survey, Biological Resources Discipline: 79–90.

Clark, P.; D'Amato, A.W.; Evans, K.S. [et al.]. 2021. Ecological memory and regional context influence performance of adaptation plantings in northeastern US temperate forests. Journal of Applied Ecology. 59: 314–329. https://doi.org/10.1111/1365-2664.14056.

Clark, P.W.; D'Amato, A.W.; Palik, B.J. [et al.]. 2023. A lack of ecological diversity in forest nurseries limits the achievement of tree-planting objectives in response to global change. Bioscience. 73(8): 575-586. https://doi.org/10.1093/biosci/biad049.

Clarke, S.R.; Nowak, J.T. 2009. Southern pine beetle. Forest Insect and Disease Leaflet 49. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, 8 p.

Clarke-McNary Act of 1924; 43 Stat. 653; 68 U.S.C. Ch. 348.

Clebsch, E.E.C.; Busing, R.T. 1989. Secondary succession, gap dynamics, and community structure in a southern Appalachian cove forest. Ecology. 70(3): 728–735. https://doi.org/10.2307/1940223.

Comer, P.J.; Faber-Langendoen, D.; Evans, R. [et al.]. 2003-present. Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems. Arlington, VA: NatureServe.

Conley, L.R. 2011. Bat Species Diversity in Old-Growth vs. Second Growth Forests in Lilley Cornett Woods, Letcher County, Kentucky. Richmond, KY: Eastern Kentucky University. 26 p. M.S. thesis.

Cooper-Ellis, S. 1998. Bryophytes in old-growth forests of western Massachusetts. Journal of the Torrey Botanical Society. 125(2): 117–132. https://doi.org/10.2307/2997299.

Copeyon, C.K.; Walters, J.R.; Carter, J.H., III 1991. Induction of red-cockaded woodpecker group formation by artificial cavity construction. The Journal of Wildlife Management. 55(4): 549–556. https://doi.org/10.2307/3809497.

Cortese, A.M.; Horton, T.R. 2023. Islands in the shade: scattered ectomycorrhizal trees influence soil inoculum and heterospecific seedling response in a northeastern secondary forest. Mycorrhiza. 33: 33–44. https://doi.org/10.1007/s00572-023-01104-w.

Costanza, J.K.; Koch, F.H.; Reeves, M. [et al.]. 2023. Disturbances to Forests and Rangelands. In: Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: U.S. Department of Agriculture, Forest Service. 5-1–5-55. Chapter 5. https://doi.org/10.2737/WO-GTR-102-Chap5.

Coyle, D.; Lord, L. [N.d.]. Longleaf resiliency: insects and disease. Web-based information sheet. America's Longleaf Restoration Institute. 2 p. https://americaslongleaf.org/media/3imdyeo2/longeaf-resiliency-to-insects-and-diseases.pdf. [Date accessed: 23 July 2025].

Crocker, E.; Gurung, K.; Calvert, J. [et al.]. 2023. Integrating GIS, remote sensing, and citizen science to map oak decline risk across the Daniel Boone National Forest. Remote Sensing. 15: 2250. https://doi.org/10.3390/rs15092250.

Crockett, E.T.H.; Atkins, J.W.; Guo, Q. [et al.]. 2023. Structural and species diversity explain aboveground carbon storage in forests across the United States: Evidence from GEDI and forest inventory data. Remote Sensing of Environment. 295(2): 113703. https://doi.org/10.1016/j.rse.2023.113703.

Croker, T.C. 1979. The longleaf pine story. Journal of Forest History. 23: 32–43. https://doi.org/10.2307/4004596.

Crosby, M.K.; Butler, R.B.; Hodges, B.N. 2020. Red maple composition in an old growth forest 50 years following disturbance. In: Bragg, D.C.; Koerth, N.E.; Holley, A.G., eds. Proceedings of the 20th Biennial Southern Silvicultural Research Conference. e-Gen. Tech. Rep. SRS-253. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 287–291.

D'Amato, A.W.; Catanzaro, P.C. 2007. Restoring old-growth characteristics. Cooperative Extension Landowner Outreach. Amherst, MA: University of Massachusetts. 36 p.

D'Amato, T.; Catanzaro, P. 2022. Restoring Old-Growth Characteristics to New England's and New York's Forests. https://portal.ct.gov/-/media/DEEP/forestry/Restoring-Old-Growth-Characteristics.pdf. [Date accessed: 24 February 2025].

Dale, V.H.; Joyce, L.A.; McNulty, S. [et al.]. 2001. Climate Change and Forest Disturbances: Climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. BioScience. 51(9): 723–734. https://doi.org/10.1641/0006-3568(2001)051[0723:CCAFD]2.0.CO;2.

Dash, P.K.; Bhattacharyya, P.; Roy, K.S. [et al.] 2019. Environmental constraints' sensitivity of soil organic carbon decomposition to temperature, management practices and climate change. Ecological Indicators 107: 10564. https://doi.org/10.1016/j.ecolind.2019.105644.

Dassot, M.; Constant, T.; Fournier, M. 2011. The use of terrestrial LiDAR technology in forest science: application fields, benefits and challenges. Annals of Forest Science. 68: 959–974. https://doi.org/10.1007/s13595-011-0102-2.

Davidson, E.A.; Janssens, I.A. 2006. Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. Nature. 440(7081): 165–173. https://doi.org/10.1038/nature04514.

Davis, D.E. 2021. The American chestnut: An environmental history. Vol. 1. Athens, GA: University of Georgia Press. 353 p.

Davis, M.B. 1983. Quaternary history of the deciduous forests of eastern North America and Europe. Annals of the Missouri Botanical Garden. 70(3): 550–563. https://doi.org/10.2307/2992086.

Davis, M.D. 1993. Old growth in the East: a survey. Revised Edition. Mount Vernon, KY: Appalachia-Science in the Public Interest.

Deal, R., ed. 2018. Dictionary of forestry. Washington, DC: Society of American Foresters. 208 p.

Delapp, J.A. 1978. Gradient analysis and classification of the high elevation red oak community of the southern Appalachians. Raleigh, NC: North Carolina State University. Ph.D. dissertation.

Delcourt, H.A. 2002. Forests in Peril. Blacksburg, VA: The MacDonald and Woodward Publishing Company. 234 p.

DellaSala, D.A.; Mackey, B.; Norman, P. [et al.]. 2022. Mature and old-growth forests contribute to large-scale conservation targets in the conterminous United States. Frontiers in Forests and Global Change. 5: 979528. https://doi.org/10.3389/ffgc.2022.979528.

Devall, M.S. 1998. An interim old-growth definition for cypress-tupelo communities in the southeast. Gen. Tech. Rep. SRS-19. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 20 p. https://doi.org/10.2737/SRS-GTR-19.

Diggins, C.A.; Ford, W.M. 2021. Effects of surveying for the federally endangered spruce-fir moss spider (*Micorhexura montivaga* Crosby & Bishop) on its bryophyte habitat. Southeastern Naturalist. 20(1): 77–91. https://doi.org/10.1656/058.020.0106.

Diggs, G.M., Jr.; Lipscomb, B.L.; O'Kennon, R.J. 1999. Shinners and Mahler's flora of North Central Texas. Fort Worth, TX: Botanical Research Institute of Texas. 1626 p.

Dinkins, H. [N.d.]. Plants of the Cherokee and their uses. Highlands, NC: Highlands Biological Station. https://highlandsbiological.org/wp-content/uploads/2019/07/Plant-webpagee3.pdf. [Date accessed: 12 March 2025].

Dobrowski, S.Z. 2011. A climatic basis for microrefugia: the influence of terrain on climate. Global Change Biology. 17(2): 1022–1035. https://doi.org/10.1111/j.1365-2486.2010.02263.x.

Dobrowski, S.Z.; Littlefield, C.E.; Lyons, D.S. [et al.]. 2021. Protected-area targets could be undermined by climate change-driven shifts in ecoregions and biomes. Communications Earth & Environment. 2: 198. https://doi.org/10.1038/s43247-021-00270-z.

Dongoske, K.E.; Pasqual, T.; King, T.F. 2015. Environmental reviews and case studies: The National Environmental Policy Act (NEPA) and the silencing of Native American worldviews. Environmental Practice. 17(1): 36–45. https://doi.org/10.1017/S1466046614000490.

Douglas, D. 2011. Land snail species diversity and composition between different forest disturbance regimes in central and eastern Kentucky forests. Richmond, KY: Eastern Kentucky University. 24 p. M.S. thesis.

Douglas, D.D.; Brown, D.R.; Pederson, N. 2013. Land snail diversity can reflect degrees of anthropogenic disturbance. Ecosphere. 4(2): 1–14. https://doi.org/10.1890/ES12-00361.1.

Ducey, M.J.; Gunn, J.S.; Whitman, A.A. 2013. Late-successional and old-growth forests in the northeastern United States: Structure, dynamics, and prospects for restoration. Forests. 4(4): 1055–1086. https://doi.org/10.3390/f4041055.

Duffy, D.C.; Meier, A.J. 1992. Do Appalachian understories ever recover from clearcutting? Conservation Biology. 6(2): 196–201. https://doi.org/10.1046/j.1523-1739.1992.620196.x.

Dunbar, W. 1809. Observations on the comet of 1807-8. Transactions of the American Philosophical Society. 6: 368–374. https://doi.org/10.2307/1004812.

Eastern OLDLIST. 2025. Eastern OLDLIST: a database of maximum ages for EasternNorth America. https://dendro.cnre.vt.edu/olds. [Date accessed: January 2025].

Edmondson, A. 2019. Analysis and conservation of native forests at Kessler Mountain Fayetteville, AR: University of Arkansas. 45 p. M.S. thesis.

Elliott, K.J. 2014. Herbaceous species composition and richness of mesophytic cove forests in the southern Appalachians: synthesis and knowledge gaps. The Journal of the Torrey Botanical Society. 141(1): 39–71. https://doi.org/10.3159/TORREY-D-13-00054.1.

Endangered Species Act of 1973. Act of December 28, 1973; 16 U.S.C. 1531-1544.

Engstrom, R.T.; Hiers, J.K.; Robertson, K.M. [et al.]. 2022. Long-Term Recovery of Selected Indicator Species Following Soil Disturbance and Compaction in an Old-Growth Longleaf Pine (*Pinus palustris*) Woodland. Natural Areas Journal. 42(1): 89– 97. https://doi.org/10.3375/21-23.

Esri, Inc. 2024. ArcGIS Pro 3.3. Redlands, CA.

Eyre, F.H., ed. 1980. Forest Cover Types of the United States and Canada. Washington, DC: Society of American Foresters. 148 p.

Falk, D.A.; van Mantgem, P.J.; Keeley, J.E. [et al.]. 2022. Mechanisms of forest resilience. Forest Ecology and Management. 512: 120129. https://doi.org/10.1016/j.foreco.2022.120129.

Fan, Z.; Shifley, S.R.; Spetich, M.A. [et al.]. 2003. Distribution of cavity trees in midwestern old-growth and second-growth forests. Canadian Journal of Forest Research. 33: 1481–1494. https://doi.org/10.1139/x03-068.

Food and Agriculture Organization of the United Nations [FAO]. 2023. Terms and definitions, FRA [Global Forest Resource Assessment] 2025. Forest Resources Assessment Working Paper 194. Rome, Italy: United Nations, Food and Agriculture Organization. 27 p.

Farge, K.W. 2018. Passive restoration of forest structure and composition in bottomland hardwood forests in Texas. Natural Areas Journal. 38(2): 168–182. https://doi.org/10.3375/043.038.0207.

Federal Register. 1982. U.S. Department of Agriculture, Forest Service. National Forest System Land and Resource Management Planning. 47(190): 43026–43052.

Federal Register. 2012. U.S. Department of Agriculture, Forest Service. National Forest System Land Management Planning. 77(68): 21162–21276.

Forest Ecosystem Management Assessment Team [FEMAT]. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Washington, DC: Government Printing Office. 1039 p.

Flatley, W.T.; Lafon, C.W.; Grissino-Mayer, H.D.; LaForest, L.B. 2015. Changing fire regimes and old-growth forest succession along a topographic gradient in the Great Smoky Mountains. Forest Ecology and Management. 350: 96–106. https://doi.org/10.1016/j.foreco.2015.04.024.

Flebbe, P.A.; Dolloff, C.A. 1995. Trout use of woody debris and habitat in Appalachian wilderness streams of North Carolina. North American Journal of Fisheries Management. 15(3): 579–590. https://doi.org/10.1577/1548-8675(1995)015<0579:TUOWDA>2.3.CO;2.

Fleming, G.P.; Patterson, K.D.; Taverna, K. 2021. The Natural Communities of Virginia: a Classification of Ecological Community Groups and Community Types. Third approximation. Version 3.3. Richmond, VA: Virginia Department of Conservation and Recreation, Division of Natural Heritage. 47 p.

Fleming, H.L.; Jones, J.C. 2013. Probability of detection and visual count error for Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) and southeastern myotis (*Myotis austroriparius*) in tree cavities. The American Midland Naturalist. 169(1): 56–65. https://doi.org/10.1674/0003-0031-169.1.56.

Florida Natural Areas Inventory [FNAI]. 2010. Guide to the natural communities of Florida. 2010 Edition. Tallahassee, FL: Florida Natural Areas Inventory, Florida State University. https://www.fnai.org/PDFs/Full_FNAI-Natural-Community-Classification-Guide-2010_20150218.pdf. [Date accessed: 25 February 2025].

Ford, W.M.; Chapman, B.R.; Menzel, M.A.; Odom, R.H. 2002. Stand age and habitat influences on salamanders in Appalachian cove hardwood forests. Forest Ecology and Management. 155(1-3): 131–141. https://doi.org/10.1016/S0378-1127(01)00553-9.

Foster, H.T.; Black, B.; Abrams, M.D. 2004. A witness tree analysis of the effects of Native American Indians on the pre-European settlement forests in east-central Alabama. Human Ecology. 32(1): 27–47. https://doi.org/10.1023/B:HUEC.0000015211.98991.9c.

Fowler, C.; Konopik, E. 2007. The history of fire in the southern United States. Human Ecology Review. 14(2): 165–176.

Fowler, K.J. 2004. Sarah Canary. New York: Penguin Random House, G.P. Putnam's Sons. 304 p.

Franklin, J.F.; Hall, F.; Laudenslayer, W. [et al.]. 1986. Interim definitions for old growth Douglas-fir and mixed-conifer forests in the Pacific Northwest and California. Res. Note PNW-447. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 15 p. https://doi.org/10.2737/PNW-RN-447.

Fraser, J.S.; Pile Knapp, L.S.; Graham, B. [et al.]. 2023. Carbon dynamics in old-growth forests of the Central Hardwoods Region, USA. Forest Ecology and Management. 537: 120958. https://doi.org/10.1016/j.foreco.2023.120958.

Fraterrigo, J.M.; Turner, M.G.; Pearson, S.M.; Dixon, P. 2005. Effects of past land use on spatial heterogeneity of soil nutrients in southern Appalachian forests. Ecological Monographs. 75(2): 215–230. https://doi.org/10.1890/03-0475.

Frelich, L.E.; Reich, P.B. 2003. Perspectives on development of definitions and values related to old-growth forests. Environmental Reviews. 11(S1): 9–22. https://doi.org/10.1139/a03-011.

Fridell, J. 2001. Endangered and threatened wildlife and plants; designation of critical habitat for the Spruce-fir Moss Spider. Federal Register. 66(130): 35547–35566.

Frost, C.C. 2006. History and future of the longleaf pine ecosystem. In: Jose, S.; Jokela, E.J.; Miler, D.L., eds. The longleaf pine ecosystem: ecology, silviculture, and restoration. New York: Springer: 9–48. https://doi.org/10.1007/978-0-387-30687-2_2.

Gaines, G.; Arndt, P.; Croy, S. [et al.]. 1997. Guidance for conserving and restoring old-growth forest communities on national forests in the southern region. For. Rep. R8- 62. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 16 p.

Garver, R.D.; Miller, R.H. 1933. Selective logging in the shortleaf and loblolly pine forests of the Gulf States region. USDA Tech. Bull. 375. Washington, DC: Government Printing Office. 54 p.

Gault, K.E.; Walters, J.R.; Tomcho, J. [et al.]. 2004. Nest Success of Southeastern American Kestrels Associated with Red-Cockaded Woodpeckers in Old-Growth Longleaf Pine Habitat in Northwest Florida. Southeastern Naturalist. 3(2): 191–204. https://doi.org/10.1656/1528-7092(2004)003[0191:NSOSAK]2.0.CO;2.

Gerstaecker, F. 1861. Wild sports in the far West. Boston: Crosby, Nichols and Co. 396 p. https://doi.org/10.5962/bhl.title.17183.

Gilhen-Baker, M.; Roviello, V.; Beresford-Kroeger, D.; Roviello, G.N. 2022. Old growth forests and large old trees as critical organisms connecting ecosystems and human health. A review. Environmental Chemistry Letters. 20(2): 1529–1538. https://doi.org/10.1007/s10311-021-01372-y.

Gilliam, F.S.; Turrill, N.L.; Adams, M.B. 2005. Herbaceous-layer and overstory species in clear-cut and mature central Appalachian hardwood forests. Ecological Applications. 5(4): 947–955. https://doi.org/10.2307/2269345.

Goode, J.D., Hart, J.L., Dey, D.C. [et al.]. 2023. Restoration of low-intensity fire in *Quercus-Pinus* mixedwoods following a prolonged period of fire exclusion. Canadian Journal of Forest Research. 54(1): 97–109. https://doi.org/10.1139/cjfr-2023-0116.

Gooding, G.; Langford, J.R. 2004. Characteristics of tree roosts of Rafinesque's big-eared bat and southeastern bat in northeastern Louisiana. Southwestern Naturalist. 49(1): 61–67. https://doi.org/10.1894/0038-4909(2004)049<0061:COTROR>2.0.CO;2.

Gray, A.N.; Pelz, K.; Hayward, G.D.; Schuler, T. [et al.]. 2023. Perspectives: The wicked problem of defining and inventorying mature and old-growth forests. Forest Ecology and Management. 546(121350): 1–11. https://doi.org/10.1016/j.foreco.2023.121350.

Greenberg, C.H.; McLeod, D.E.; Loftis, D.L. 1997. An Old-Growth Definition for Western and Mixed Mesophytic Forests. Gen. Tech. Rep. SRS-16. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 14 p. https://doi.org/10.2737/SRS-GTR-16.

Gremillion, K.J. 2015. Prehistoric upland farming, fuelwood, and forest composition on the Cumberland Plateau, Kentucky, USA. Journal of Ethnobiology. 35(1): 60–84. https://doi.org/10.2993/0278-0771-35.1.60.

Gustafson, E.J.; Kern, C.C.; Kabrick, J.M. 2023. Can assisted tree migration today sustain forest ecosystem goods and services for the future. Forest Ecology and Management. 529(12): 120723. 18 p. https://doi.org/10.1016/j.foreco.2022.120723.

Hackett, H.M.; Pagels, J.F. 2003. Nest site characteristics of the endangered northern flying squirrel (*Glaucomys sabrinus coloratus*) in southwest Virginia. The American Midland Naturalist. 150(2): 321–331. https://doi.org/10.1674/0003-0031(2003)150[0321:NSCOTE]2.0.CO;2.

Hall, B. 1830. Travels in North America, in the Years 1827 and 1828, Vol. III. Edinburgh, Scotland: Robert Cadell.

Hamel, P.B. 1992. Land manager's guide to the birds of the South. Gen. Tech. Rep. SE-22. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 437 p.

Hamel, P.B. 2000. Status Assessment: cerulean warbler. Ft. Snelling, MN: U.S. Fish and Wildlife Service. 141 p.

Hamel, P.B.; Rosenberg, K.V. 2007. Developing management guidelines for cerulean warbler breeding habitat. In: Buckley, D.S.; Clatterbuck, W.K., eds. Proceedings of the 15th central hardwood forest conference. Gen. Tech. Rep. SRS-101. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 364–374.

Hamilton, R.C., comp. 1993. Characteristics of old-growth forests in the Intermountain Region. Ogden, UT: U.S. Department of Agriculture, Forest Service,Intermountain Region. 86 p.

Hammond, D.H.; Varner, J.M.; Fan, Z.; Kush, J.S. 2016. Long-term stand dynamics of old-growth mountain longleaf pine (*Pinus palustris*) woodlands. Forest Ecology and Management. 364: 154–164. https://doi.org/10.1016/j.foreco.2015.12.029.

Hamrick, J.L.; Godt, M.J.W.; Gonzales, E. 2006. Conservation of genetic diversity in old-growth forest communities of the southeastern United States. Applied Vegetation Science. 9(1): 51–58. https://doi.org/10.1111/j.1654-109X.2006.tb00655.x.

Hanberry, B.B.; Bragg, D.C.; Alexander, H.D. 2020. Open forest ecosystems: An excluded state. Forest Ecology and Management. 472(118256): 1–11. https://doi.org/10.1016/j.foreco.2020.118256.

Hanberry, B.B.; Bragg, D.C.; Hutchinson, T.F. 2018a. A reconceptualization of open oak and pine ecosystems of eastern North America using a forest structure spectrum. Ecosphere. 9(10): 1–22. https://doi.org/10.1002/ecs2.2431.

Hanberry, B.B.; Coursey, K.; Kush, J.S. 2018b. Structure and composition of historical longleaf pine ecosystems in Mississippi, USA. Human Ecology. 46: 241–248. https://doi.org/10.1007/s10745-018-9982-1.

Hanberry, B.B.; Stober, J.M.; Bragg, D.C. 2023. Documenting Two Centuries of Change in Longleaf Pine (*Pinus palustris*) Forests of the Coastal Plain Province, Southeastern USA. Forests. 14(1938): 1–25. https://doi.org/10.3390/f14101938.

Hannah, L.; Flint, L.; Syphard, A.D. [et al.]. 2014. Fine-grain modeling of species' response to climate change: holdouts, stepping-stones, and microrefugia. Trends in Ecology and Evolution. 29(7): 390–397. https://doi.org/10.1016/j.tree.2014.04.006.

Harms, W.R. 1996. An Old-Growth Definition for Wet Pine Forests, Woodlands, and Savannas. Gen. Tech. Rep. SRS-2. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 11 p. https://doi.org/10.2737/SRS-GTR-2.

Harper, F., ed. 1998. The travels of William Bartram. Athens, GA: University of Georgia Press. 727 p.

Harper, R.M. 1913. Economic botany of Alabama. Part 1: Geographical report on forests. Monograph 8. University, AL: Geological Survey of Alabama. 222 p. https://doi.org/10.5962/bhl.title.41458.

Hauck, M.; Csapek, G.; Dulamsuren, C. 2023. The significance of large old trees and tree cavities for forest carbon estimates. Forest Ecology and Management. 415(121319): 1–10. https://doi.org/10.1016/j.foreco.2023.121319.

Hayek, J.C. 2019. Maximum Tree Age and Longevity. Forestry Bull. NRES-502. Urbana, IL: University of Illinois Extension Tech. 6 p.

Healey, S.P.; Cohen, W.B.; Yang, Z. [et al.]. 2018. Mapping forest change using stacked generalization: An ensemble approach. Remote Sensing of Environment. 204: 717–728. https://doi.org/10.1016/j.rse.2017.09.029.

Healthy Forests Restoration Act of 2003; 16 U.S.C. 6501 et seq.

Hicke, J.A.; Allen, C.D.; Desai, A.R. [et al.]. 2012. Effects of biotic disturbances on forest carbon cycling in the United States and Canada. Global Change Biology. 18(1): 7–34. https://doi.org/10.1111/j.1365-2486.2011.02543.x.

Hilbert, J.; Wiensczyk, A. 2007. Old-growth definitions and management: A literature review. Journal of Ecosystems and Management. 8(1): 15–31. https://doi.org/10.22230/jem.2007v8n1a360.

Hilgard, E.W. 1860. Report on the geology and agriculture of the state of Mississippi. Jackson, MS: E. Barksdale, State Printer. 391 p.

Himes, J.M.; Rentch, J.S. 2013. Canopy Gap Dynamics in a Second-Growth Appalachian Hardwood Forest in West Virginia. Castanea. 78(3): 171–184. https://doi.org/10.2179/13-006.

Hinkle, C.R.; McComb, W.C.; Safley, J.M., Jr.; Schmalzer, P.A. 1993. Mixed mesophytic forests. In: Martin, W.H.; Boyce, S.G.; Echternacht, A.C., eds. Biodiversity of the southeastern United States. Upland terrestrial communities. New York: John Wiley and Sons: 203–253.

Hooper, R.G. 1996. Arthropod biomass in winter and the age of longleaf pines. Forest Ecology and Management. 82(1-3): 115–131. https://doi.org/10.1016/0378-1127(95)03675-X.

Hooper, R.G.; Lennartz, M.R.; Muse, H.D. 1991. Heart Rot and Cavity Tree Selection by Red-Cockaded Woodpeckers. The Journal of Wildlife Management. 55(2): 323–327. https://doi.org/10.2307/3809158.

Hooper, R.G.; McAdie, C.J. 1995. Hurricanes and the long-term management of the red-cockaded woodpecker. In: Kulhavy, D.L.; Hooper, R.L.; Costa, R., eds. Red-cockaded woodpecker: recovery, ecology and management. Nacogdoches, TX: Stephen F. Austin University, Center for Applied Studies in Forestry: 148–166.

Hoover, C.M.; Smith, J.E. 2023. Aboveground live tree carbon stock and change in forests of conterminous United States: influence of stand age. Carbon Balance and Management. 18(1): 7. https://doi.org/10.1186/s13021-023-00227-z.

Hough, F.B. 1878. Report upon forestry. From the committee appointed to memorialize Congress and the state legislatures, regarding the cultivation of timber and the preservation of forests. Salem: The Salem Press. 14 p. https://doi.org/10.5962/bhl.title.48935.

Housman, I.W.; Campbell, L.S.; Heyer, J.P. [et al.]. 2022. US Forest Service Landscape Change Monitoring System Methods Version 2021.7. GTAC-10252-RPT3. Salt Lake City, UT: U.S. Department of Agriculture, Forest Service, Geospatial Technology and Applications Center. 27 p.

Ishii, H.; McDowell, N. 2002. Age-related development of crown structure in coastal Douglas-fir trees. Forest Ecology and Management. 169: 257–270. https://doi.org/10.1016/S0378-1127(01)00751-4.

Jackson, M.M.; Pearson, S.M.; Turner, M.G. 2013. Performance and population dynamics of a native understory herb differ between young and old forest stands in the Southern Appalachians. Forest Ecology and Management. 304: 444–454. https://doi.org/10.1016/j.foreco.2013.05.049.

Jacot, A.P. 1935. Molluscan Populations of Old Growth Forests and Rewooded Fields in the Asheville Basin of North Carolina. Ecology. 16(4): 603–605. https://doi.org/10.2307/1932590.

Jarron, L.R.; Coops, N.C.; MacKenzie, W.H.; Dykstra, P. 2021. Detection and Quantification of Coarse Woody Debris in Natural Forest Stands Using Airborne LiDAR. Forest Science. 67(5): 550–563. https://doi.org/10.1093/forsci/fxab023.

Jenkins, C.N.; Van Houtan, K.S.; Pimm, S.L.; Sexton, J.O. 2015. US protected lands mismatch biodiversity priorities. Proceedings of the National Academy of Sciences. 112(16): 5081–5086. https://doi.org/10.1073/pnas.1418034112.

Johnson, A.S.; Hale, P.E. 2002. The historical foundations of prescribed burning for wildlife: a southeastern perspective. In: Ford, W.M.; Russell, K.R.; Moorman, C.E., eds. Proceedings: the role of fire for nongame wildlife management and community restoration: traditional uses and new directions. Gen. Tech. Rep. NE-288. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station: 11–23.

Johnson, A.; Clavijo, A.E.; Hamar, G. [et al.]. 2021. Wood Products for Cultural Uses: Sustaining Native Resilience and Vital Lifeways in Southeast Alaska, USA. Forests. 12(1): 90. https://doi.org/10.3390/f12010090.

Johnston, C.M.T.; Guo, J.; Prestemon, J.P. 2023. Forest Products. In: Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: U.S. Department of Agriculture, Forest Service: 7-1–7-26. Chapter 7. https://doi.org/10.2737/WO-GTR-102-Chap7.

Joint Hearing before the Committee on Agriculture, Nutrition, and Forestry, 101st 420 Congress, October 25, 1989, p. 116.

Joint Oversight Hearing on the National Forest Planning Process as Provided in the National Forest Management Act of 1976. Joint Hearing before the Committee on Agriculture, Nutrition, and Forestry and the Committee on Energy and Natural Resources United States Senate. 101st Congress. First Session on Issues Related to the National Forest Planning Process. October 25, 1989. Washington, DC: U.S. Government Printing Office. 116 p.

Joint Secretarial Order No. 3403, Joint Secretarial Order on Fulfilling the Trust Responsibility to Indian Tribes in the Stewardship of Federal Lands and Waters (Nov. 15, 2021). U.S. Departments of Interior and Agriculture. https://www.usda.gov/sites/default/files/documents/joint-so-3403-stewardship-tribal-nations.pdf. [Date accessed: 03 November 2025].

Jones, E.W. 1945. The structure and reproduction of the virgin forest of the north temperate zone. New Phytologist. 45: 130–148. https://doi.org/10.1111/j.1469-8137.1945.tb05026.x.

Jüriado, I.; Liira, J.; Csencsics, D. [et al.]. 2011. Dispersal ecology of the endangered woodland lichen *Lobaria pulmonaria* in managed hemiboreal forest landscape. Biodiversity Conservation. 20: 1803–1819. https://doi.org/10.1007/s10531-011-0062-8.

Kalisz, P.J.; Dotson, D.B. 1989. Land-use History and the Occurrence of Exotic Earthworms in the Mountains of Eastern Kentucky. American Midland Naturalist. 122(2): 288–297. https://doi.org/10.2307/2425915.

Kalisz, P.J.; Wood, H.B. 1995. Native and exotic earthworms in wildland ecosystems. In: Hendrix, P.F., ed. Earthworm ecology and biogeography. Boca Raton, FL: Lewis Publishers, CRC Press: 117–126.

Karki, L.; Hallgren, S.W. 2015. Tree-Fall Gaps and Regeneration in Old-Growth Cross Timbers Forests. Natural Areas Journal. 35(4): 533–541. https://doi.org/10.3375/043.035.0405.

Keeton, W. 2020. Eastern Old-Growth Forests in an Era of Change. Northern Woodlands. https://northernwoodlands.org/articles/article/eastern-old-growth-forests-in-an-era-of-change. [Date accessed: 23 June 23 2021].

Keeton, W.S. 2006. Managing for late-successional/old-growth characteristics in northern hardwood-conifer forests. Forest Ecology and Management. 235(1-3): 129–142. https://doi.org/10.1016/j.foreco.2006.08.005.

Keeton, W.S. 2018. Source or Sink? Carbon Dynamics in Eastern Old-Growth Forests and Their Role in Climate Change Mitigation. In: Barton, A.M.; Keeton, W.S., eds. Ecology and Recovery of Eastern Old-Growth Forests. Washington, DC: Island Press: 267–288. https://doi.org/10.5822/978-1-61091-891-6_14.

Kellett, M.J.; Malloof, J.E.; Masino, S.A. [et al.]. 2023. Forest-clearing to create early-successional habitats: Questionable benefits, significant costs. Frontiers in Forests and Global Change. 5(1073677): 1–30. https://doi.org/10.3389/ffgc.2022.1073677.

Kennedy, H.E., Jr.; Nowacki, G.J. 1997. An Old-Growth Definition for Seasonally Wet Oak-Hardwood Woodlands. Gen. Tech. Rep. SRS-8. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 10 p. https://doi.org/10.2737/SRS-GTR-008.

Kern, C.C.; Scharszmann, J.; Kabrick, J. [et al.]. 2019. Mounds facilitate regeneration of light-seeded and browse-sensitive tree species after moderate-severity wind disturbance. Forest Ecology and Management. 437: 139–147. https://doi.org/10.1016/j.foreco.2018.12.040.

Kim, S.; McGaughey, R.J.; Andersen, H.E.; Schreuder, G. 2009. Tree species differentiation using intensity data derived from leaf-on and leaf-off airborne laser scanner data. Remote Sensing of Environment. 113: 1575–1586. https://doi.org/10.1016/j.rse.2009.03.017.

Kimmins, J.P. 2003. Old-growth forest: An ancient and stable sylvan equilibrium, or a relatively transitory ecosystem condition that offers people a visual and emotional feast? Answer—it depends. The Forestry Chronicles. 79: 429–440. https://doi.org/10.5558/tfc79429-3.

Kleinman, J.S.; Ford, S.A.; Hart, J.L. 2017. Catastrophic wind and salvage harvesting effects on woodland plants. Forest Ecology and Management. 403: 112–125. https://doi.org/10.1016/j.foreco.2017.08.006.

Koo, K.A.; Patten, B.C.; Madden, M. 2015. Predicting Effects of Climate Change on Habitat Suitability of Red Spruce (*Picea rubens* Sarg.) in the Southern Appalachian Mountains of the USA: Understanding Complex Systems Mechanisms Through Modeling. Forests. 6(4): 1208–1226. https://doi.org/10.3390/f6041208.

Korstian, C.F. 1924. Growth on cut-over and virgin western yellow pine lands in Central Idaho. Journal of Agricultural Research. 28: 1139–1148.

Kush, J.S.; Meldahl, R.S.; Avery, C. 2004. A Restoration Success: Longleaf Pine Seedlings Established in a Fire-Suppressed, Old-Growth Stand. Ecological Restoration. 22(1): 6–10. https://doi.org/10.3368/er.22.1.6.

Lafon, C.W.; Waldron, J.D.; Cairns, D.M. [et al.]. 2007. Modeling the Effects of Fire on the Long-Term Dynamics and Restoration of Yellow Pine and Oak Forests in the Southern Appalachian Mountains. Restoration Ecology. 15(3): 400–411. https://doi.org/10.1111/j.1526-100X.2007.00236.x.

Landers, J.L.; Boyer, W.D. 1999. An old-growth definition for upland longleaf and south Florida slash pine forests, woodlands, and savannas. Gen. Tech. Rep. SRS-29. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 15 p. https://doi.org/10.2737/SRS-GTR-29.

Lanner, R.M. 2002. Why do trees live so long? Ageing Research Reviews. 1: 653–671. https://doi.org/10.1016/S1568-1637(02)00025-9.

Lapin, M. 2005. Old-Growth Forests: a Literature Review of the Characteristics of Eastern North American Forests. Montpelier, VT: Vermont Natural Resources Council. 20 p. https://vnrc.org/wp-content/uploads/2019/08/VNRC-Old-Growth-pub.pdf. [Date accessed: 27 February 2025].

Larson, A.J.; Lutz, J.A.; Gersonde, R.F. [et al.] 2008. Potential site productivity influences the rate of forest structural development. Ecological Applications. 18: 899–910. https://doi.org/10.1890/07-1191.1.

Larson, P.R. 1963. Stem Form Development of Forest Trees. Forest Science Monographs. 5: 1–42. https://doi.org/10.1093/forestscience/9.s2.a0001.

Le Page du Pratz, A.S. 1774. The history of Louisiana, or of the western parts of Virginia and Carolina. London: T. Becket. 376 p. https://doi.org/10.5962/bhl.title.46925.

Leckie, S.; Vellend, M.; Bell, G.; Lechowicz, M.J. 2000. The seed bank in an old-growth, temperate deciduous forest. Canadian Journal of Botany. 78: 181–192. https://doi.org/10.1139/b99-176.

Lindenmayer, D.B.; Laurance, W.F. 2017. The ecology, distribution, conservation and management of large old trees. Biological Reviews. 92: 1434–1458. https://doi.org/10.1111/brv.12290.

Liu, Y.; Stanturf, J.; Goodrick, S. 2010. Trends in global wildfire potential in a changing climate. Forest Ecology and Management. 259(4): 685–697. https://doi.org/10.1016/j.foreco.2009.09.002.

Lockley, T.J., ed. 2021. Maroon Communities in South Carolina: A Documentary Record. Columbia, SC: University of South Carolina. 142 p. https://doi.org/10.2307/j.ctv1ft83wx.

Loeb, S.C.; Lacki, M.J.; Miller, D.A., eds. 2011. Conservation and management of eastern big-eared bats: a symposium. Gen. Tech. Rep. SRS-145. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 157 p. https://doi.org/10.2737/SRS-GTR-145.

Loeb, S.C.; O'Keefe, J.M. 2006. Habitat Use by Forest Bats in South Carolina in Relation to Local, Stand, and Landscape Characteristics. The Journal of Wildlife Management. 70(5): 1210–1218. https://doi.org/10.2193/0022-541X(2006)70[1210:HUBFBI]2.0.CO;2.

Loeffler, D.; Anderson, N.; Stockmann, K. [et al.]. 2014. Estimates of carbon stored in harvested wood products from United States Forest Service Southern Region, 1911-2012. Unpublished report. On file with: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Laboratory, 5775 W. Broadway St., Missoula, MT 59808. 27 p.

Loehle, C. 1988. Tree life history strategies: the role of defenses. Canadian Journal of Forest Research. 18(2): 209–222. https://doi.org/10.1139/x88-032.

Lohrey, R.E.; Kossuth, S.V. 1990. *Pinus elliottii* Englem. slash pine. In: Burns, R.M.; Honkala, B.H., tech. coords., Silvics of North America, Vol. 1. Conifers. USDA Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 338–347.

Long, E.C. 1889. Notes on some of the forest features of Florida, with items of tree growth in that state. In: Proceedings of the 7th American Forestry Congress. Washington, DC: Gibson Bros., Printers and Bookbinders.

Long, J.W.; Anderson, M.K.; Quinn-Davidson, L. [et al.]. 2016. Restoring California black oak ecosystems to promote tribal values and wildlife. Gen. Tech. Rep. PSW-252. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 110 p. https://doi.org/10.2737/PSW-GTR-252.

López-Otín, C.; Blasco, M.A.; Partridge, L. [et al.]. 2013. The Hallmarks of Aging. Cell. 153(6): 1194–1217. https://doi.org/10.1016/j.cell.2013.05.039.

Lorimer, C.G. 1980. Age Structure and Disturbance History of a Southern Appalachian Virgin Forest. Ecology. 61(5): 1169–1184. https://doi.org/10.2307/1936836.

Lorimer, C.G.; Frelich, L.E. 1994. Natural Disturbance Regimes in Old-Growth Northern Hardwoods: Implications for Restoration Efforts. Journal of Forestry. 92: 33–38. https://doi.org/10.1093/jof/92.1.33.

Lutz, H.J. 1930. The vegetation of Heart's Content, A Virgin Forest in Northwestern Pennsylvania. Ecology. 11: 1–29. https://doi.org/10.2307/1930778.

Luyssaert, S.; Schulze, E.D.; Borner, A. [et al.]. 2008. Old-growth forests as global carbon sinks. Nature. 455: 213–215. https://doi.org/10.1038/nature07276.

Magnani, F.; Mencuccini, M.; Borghetti, M. [et al.]. 2007. The human footprint in the carbon cycle of temperate and boreal forests. Nature. 447: 848–850. https://doi.org/10.1038/nature05847.

Maloof, J. 2016. Nature's temples: the complex world of old-growth forests. Portland, OR: Timber Press. 200 p.

Maloof, J. 2019. Eastern Old-Growth Forests: Two Books Twenty-two Years Apart. Bulletin of the Ecological Society of America. 100(4): 1–3. https://doi.org/10.1002/bes2.1609.

Martin, W.H. 1975. The Lilley Cornett Woods: A Stable Mixed Mesophytic Forest in Kentucky. Botanical Gazette. 136(2): 171–183. https://doi.org/10.1086/336799.

Martin, W.H. 1992. Characteristics of old-growth mixed mesophytic forests. Natural Areas Journal. 12(3): 127.

Matlock, G.R. 1994. Plant Species Migration in a Mixed-History Forest Landscape in Eastern North America. Ecology. 75(5): 1491–1502. https://doi.org/10.2307/1937472.

Mattoon, W.R. 1915. The southern Cypress. Agric. Bull. 272. Washington, DC: U.S. Department of Agriculture, Government Printing Office. 74 p. https://doi.org/10.5962/bhl.title.109095.

Maxwell, C.J.; Scheller, R.M. 2020. Identifying Habitat Holdouts for High Elevation Tree Species Under Climate Change. Frontiers in Forests and Global Change. 2: 94. https://doi.org/10.3389/ffgc.2019.00094.

McCarthy, B. 2014. The Herbaceous Layer of Eastern Old-Growth Deciduous Forests. In: Gilliam, F., ed. The herbaceous layer in forests of Eastern North America. New York: Oxford University Press: 202–214. Chapter 7. https://doi.org/10.1093/acprof:osobl/9780199837656.003.0007.

McCarthy, W. 2019. What is an "old-growth" forest? Yale–Food and Agriculture Letter, December 17, 2019. https://yaleclimateconnections.org/2019/12/what-is-an-old-growth-forest/. [Date accessed: 28 February 2025].

McDonald, M.; Van Woudenberg, B.; Dorin, A.M. [et al.]. 2017. The effects of bark quality on corticolous lichen community composition in urban parks of southern Ontario. Botany. 95: 1141–1149. https://doi.org/10.1139/cjb-2017-0113.

McGee, G.G.; Kimmerer, R.W. 2002. Forest age and management effects on epiphytic bryophyte communities in Adirondack northern hardwood forests, New York: Canadian Journal of Forest Research. 32(9): 1562–1576. https://doi.org/10.1139/x02-083.

McGee, G.G.; Birmingham, J.P. 1997. Decaying Logs as Germination Sites in Northern Hardwood Forests. Northern Journal of Applied Forestry. 14(4): 178–182. https://doi.org/10.1093/njaf/14.4.178.

McKenney, D.; Pedlar, J.; O'Neill, G. 2009. Climate change and forest seed zones: Past trends, future prospects and challenges to ponder. Forestry Chronicle. 85: 258–266. https://doi.org/10.5558/tfc85258-2.

McManamay, R.H.; Resler, L.M.; Campbell, J.B.; McManamay, R.A. 2011. Assessing the impacts of balsam woolly adelgid (*Adelges piceae* Ratz.) and anthropogenic disturbance on the stand structure and mortality of Fraser fir [*Abies fraseri* (Pursh) Poir.] in the Black Mountains, North Carolina. Castanea. 76(1): 1–19. https://doi.org/10.2179/09-059.1.

McMinn, J.W.; Crossley, D.A. Jr., eds. 1993. Biodiversity and coarse woody debris in southern forest, proceedings of the workshop on coarse woody debris in southern forest: effects on biodiversity. Gen. Tech. Rep. SE-94. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 156 p.

Meadows, J.S.; Nowacki, G.J. 1996. An Old-Growth Definition for Eastern Riverfront Forests. Gen. Tech. Rep. SRS-4. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 7 p. https://doi.org/10.2737/SRS-GTR-4.

Mehl, M.S. 1992. Old-growth descriptions for the major forest cover types in the Rocky Mountain Region. In: Kaufmann, M.R.; Moir, W.H.; Bassett, R.L., tech. coords. Old-growth forests in the Southwest and Rocky Mountain Regions: Proceedings of a Workshop. Gen. Tech. Rep. RM-213. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 106–120.

Meier, A.J.; Bratton, S.P.; Duffy, D.C. 1995. Possible Ecological Mechanisms for Loss of Vernal-Herb Diversity in Logged Eastern Deciduous Forests. Ecological Applications. 5(4): 935–946. https://doi.org/10.2307/2269344.

Melillo, J.M.; Richmond, T.; Yohe, G.W., eds. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. 841 p. https://doi:10.7930/J0Z31WJ2.

Mesavage, C.; Girard, J.W. 1946. Tables for estimating cubic-foot volume of timber. Washington, DC: U.S. Department of Agriculture, Forest Service. 94 p. https://doi.org/10.5962/bhl.title.127722.

Mitchell, R.J.; Engstrom, T.; Sharitz, R.R. [et al.]. 2009. Old Forests and Endangered Woodpeckers: Old-Growth in the Southern Coastal Plain. Natural Areas Journal. 29(3): 301–310. https://doi.org/10.3375/043.029.0309.

Moore, C.T.; Conroy, M.J. 2006. Optimal Regeneration Planning for Old-Growth Forest: Addressing Scientific Uncertainty in Endangered Species Recovery through Adaptive Management. Forest Science. 52(2): 155–172. https://doi.org/10.1093/forestscience/52.2.155.

Moore, K.D. 2007. In the Shadow of the Cedars: the Spiritual Values of Old-Growth Forests. Conservation Biology. 21(4): 1120–1123. https://doi.org/10.1111/j.1523-1739.2007.00669.x.

Moore, K.D.; Nelson, M.P. 2023. The perilous and important art of definition: the case of the old-growth forest. Frontiers in Ecology and the Environment. 21(6): 264–265. https://doi.org/10.1002/fee.2661.

Mori, A.S.; Dee, L.E.; Gonzalez, A. [et al.]. 2021. Biodiversity–productivity relationships are key to nature-based climate solutions. Nature Climate Change. 11: 543–550. https://doi.org/10.1038/s41558-021-01062-1.

Mosseler, A.; Major, J.E.; Rajora, O.P. 2003. Old-growth red spruce forests as reservoirs of genetic diversity and reproductive fitness. Theoretical and Applied Genetics. 106(5): 931–937. https://doi.org/10.1007/s00122-002-1156-1.

Moyer, J.M.; Owen, R.J.; Duinker, P.N. 2008. Forest Values: A Framework for Old-Growth Forest with Implications for Other Forest Conditions. The Open Forest Science Journal. 1: 27–36. https://doi.org/10.2174/1874398600801010027.

Mueller, N.G.; Spengler, R.N.; Glenn, A.; Lama, K. 2021. Bison, anthropogenic fire, and the origins of agriculture in eastern North America. The Anthropocene Review. 8(2): 141–158. https://doi.org/10.1177/2053019620961119.

Muller, R.N.; Martin; W.H. 1983. Autumn Leaf Fall and Nutrient Return in an Old-Growth and Second Growth Forest in Eastern Kentucky. Botanical Gazette. 144: 552–558. https://doi.org/10.1086/337410.

Munoz, S.E.; Mladenoff, D.J.; Schroeder, S.; Williams, J.W. 2014. Defining the spatial patterns of historical land use associated with the indigenous societies of eastern North America. Journal of Biogeography. 41: 2195–2210. https://doi.org/10.1111/jbi.12386.

Murphy, P.A.; Nowacki. G.J. 1997. An old-growth definition for xeric pine and pine-oak woodlands. Gen. Tech. Rep. SRS-7. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 11 p. https://doi.org/10.2737/SRS-GTR-7.

Nagel, L.M.; Palik, B.J.; Battaglia, M.A. [et al.]. 2017. Adaptive Silviculture for Climate Change: A National Experiment in Manager-Scientist Partnerships to Apply an Adaptation Framework. Journal of Forestry. 115: 167–178. https://doi.org/10.5849/jof.16-039.

National Council on Science and Sustainable Forestry [NCSSF]. 2008. Beyond old growth: older forests in a changing world. A synthesis of findings from five regional workshops. Washington, DC: National Council on Science and Sustainable Forestry. 40 p.

National Forest Management Act of 1976 [NFMA]; Act of October 22, 1976; 16 U.S.C. 1600.

National Forest Reservation Commission [NFRC]. 1933. Review of the work of the National Forest Reservation Commission, 1911–1933. Washington, DC: Government Printing Office. 21 p.

National Forest Reservation Commission [NFRC]. 1976. Final report of the National Forest Reservation Commission for the fiscal year ending September 30, 1976, and subsequent actions to October 22, 1976. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office. 29 p.

NatureServe. 2024. NatureServe Explorer. Arlington, VA: NatureServe. https://explorer.natureserve.org/. [Date accessed: 1 October 2024].

Nelson, M.L.; Brewer, C.K.; Solem, S.J., eds. 2015. Existing vegetation classification, mapping, and inventory technical guide, version 2.0. Gen. Tech. Rep. WO-90. Washington, DC: U.S. Department of Agriculture, Forest Service. 210 p.

Nicholson, C.P. 2004. Ecology of the Cerulean Warbler in the Cumberland Mountains of east Tennessee. Knoxville, TN: The University of Tennessee. 108 p. Ph.D. dissertation.

Nordman, C.; Faber-Langendoen, D.; Baggs, J. 2021. Full Descriptions of all Shortleaf Pine-Oak Woodland Metrics. NatureServe and the USDA Forest Service. https://www.natureserve.org/sites/default/files/projects/files/Shortleaf_Pine_Metrics_Full_Descriptions_Nov2021.pdf. [Date accessed: 15 December 2025].

Nowacki, G.J. 1993. Final project report: the development of old-growth definitions for the Eastern United States, Phase II. Unpublished report. 218 p. On file with: U.S. Department of Agriculture, Forest Service, Southern Region, 1720 Peachtree Rd., Atlanta, GA 30367.

Nowacki, G.J.; Abrams, M.D. 2008. The Demise of Fire and "Mesophication" of Forests in the Eastern United States. BioScience. 58(2): 123–138. https://doi.org/10.1641/B580207.

O'Brien, L.; Schuck, A.; Fraccaroli, C. [et al.]. 2021. Protecting old-growth forests in Europe-a review of scientific evidence to inform policy implementation. Final report. Barcelona: European Forest Institute. 103 p. https://doi.org/10.36333/rs1.

Office of Science and Technology Policy [OSTP]. 2021. Memorandum for the Heads of Departments and Agencies: Indigenous Traditional Ecological Knowledge and Federal Decision Making. Washington, DC: Executive Office of the President, Office of Science and Technology Policy, Council on Environmental Quality. https://www.nrc.gov/docs/ML2428/ML24282B058.pdf. [Date accessed: 7 April 2025].

Ogan, C.V.; Jurek, R.M. 1997. Biology and ecology of feral, free-roaming, and stray cats. In: Harris, J.E.; Ogan, C.V., eds. Mesocarnivores of northern California: Biology, Management, and Survey Techniques, Workshop Manual. Arcata, CA: The Wildlife Society, California North Coast Chapter: 87-91. https://www.fs.usda.gov/psw/publications/4251/ogan1.PDF. [Date accessed: 7 April 2025].

Ohmann, J.L.; Gregory, M.J. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest-neighbor imputation in coastal Oregon, U.S.A. Canadian Journal of Forest Research. 32(4): 725–741. https://doi.org/10.1139/x02-011.

Ohmann, J.L.; Gregory, M.J.; Henderson, E.B.; Roberts, H.M. 2011. Mapping gradients of community composition with nearest-neighbour imputation: extending plot data for landscape analysis. Journal of Vegetation Science. 22(4): 660–676. https://doi.org/10.1111/j.1654-1103.2010.01244.x.

Oishi, A.C.; Denham, S.O.; Brantley, S.T. [et al.]. 2020. Quantifying the effects of stand age on components of forest evapotranspiration. Acta Horticulturae. 1300: 89–96. https://doi.org/10.17660/ActaHortic.2020.1300.12.

Oliver, C.D.; Larson, B.C. 1996. Forest stand dynamics. New York: John Wiley and Sons. 509 p.

Olmsted, F.E. 1902. A working plan for forest lands near Pine Bluff, Arkansas. Bull. 32. Washington, DC: U.S. Department of Agriculture, Bureau of Forestry. 48 p. https://doi.org/10.5962/bhl.title.66123.

Oswald, W.W.; Foster, D.R.; Shuman, B.N. [et al.]. 2020. Conservation implications of limited Native American impacts in pre-contact New England. Nature Sustainability. 3: 241–246. https://doi.org/10.1038/s41893-019-0466-0.

Owen, R.J.; Duinker, P.N.; Beckley, T.M. 2009. Capturing Old-Growth Values for Use in Forest Decision-Making. Environmental Management. 43: 237–248. https://doi.org/10.1007/s00267-008-9133-3.

Palik, B.J.; Clark, P.W.; D'Amato, A.W. [et al.]. 2022. Operationalizing forest assisted migration in the context of climate change adaptation: Examples from the eastern USA. Ecosphere. 13(10): e4260. 19 p. https://doi.org/10.1002/ecs2.4260.

Palik, B.J.; D'Amato, A.W.; Franklin, J.F.; Johnson, K.N. 2020. Ecological silviculture: Foundations and applications. Long Grove, IL: Waveland Press. 339 p.

Pederson, N. 2010. External Characteristics of Old Trees in the Eastern Deciduous Forest. Natural Areas Journal. 30(4): 397–407. https://doi.org/10.3375/043.030.0405.

Pederson, N.; D'Amato, A.W.; Orwig, D.A. 2007. Natural history from dendrochronology: maximum ages and canopy persistence of rarely studied hardwood species. In: Buckley, D.S.; Clatterbuck, W.K., eds. Proceedings of the 15th Central Hardwood Forest Conference. Gen. Tech. Rep. SRS-101. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 695–701.

Pelz, K.A.; Hayward, G.; Gray, A.N. [et al.]. 2023. Quantifying old-growth forest of United States Forest Service public lands. Forest Ecology and Management. 549(121437): 1–9. https://doi.org/10.1016/j.foreco.2023.121437.

Pesklevits, A.; Duinker, P.N.; Bush, P.G. 2011. Old-growth Forests: Anatomy of a Wicked Problem. Forests. 2: 343–356. https://doi.org/10.3390/f2010343.

Petranka, J.W.; Brannon, M.P.; Hopey, M.E.; Smith, C.K. 1994. Effects of timber harvesting on low elevation populations of southern Appalachian salamanders. Forest Ecology and Management. 67(1-3): 135–147. https://doi.org/10.1016/0378-1127(94)90012-4.

Phipps, R.L. 1985. Collecting, Preparing, Crossdating, and Measuring Tree Increment Cores. Water-Resources Investigations Report 85–4148. U.S. Geological Survey. 47 p.

Pinchot, G. 1898. The Adirondack spruce. New York: The Critic Co. 232 p. https://tile.loc.gov/storage-services/public/gdcmassbookdig/adirondackspruc00pinc/adirondackspruc00pinc.pdf. [Date accessed: 11 March 2025].

Platt, S.G.; Brantley, C.G. 1997. Canebrakes: An Ecological and Historical Perspective. Castanea. 62(1): 8–21. https://www.jstor.org/stable/4034098.

Plotkin, A.B.; Schoonmaker, P.; Leon, B.; Foster, D. 2017. Microtopography and ecology of pit-mound structures in second-growth versus old-growth forests. Forest Ecology and Management. 404: 14–23. https://doi.org/10.1016/j.foreco.2017.08.012.

Pregitzer, K.S.; Euskirchen, E.S. 2004. Carbon cycling and storage in world forests: biome patterns related to forest age. Global Change Biology. 10: 2052–2077. https://doi.org/10.1111/j.1365-2486.2004.00866.x.

Pyle, C. 1988. The type and extent of anthropogenic vegetation disturbance in the Great Smoky Mountains before National Park Service acquisition. Castanea. 53: 183–196.

Rajora, O.P.; Rahman, M.H.; Buchert, G.P.; Dancik, B.P. 2000. Microsatellite DNA analysis of genetic effects of harvesting in old-growth eastern white pine (*Pinus strobus*) in Ontario, Canada. Molecular Ecology. 9: 339–348. https://doi.org/10.1046/j.1365-294x.2000.00886.x.

Ramseur, J.L. 2023. U.S. Greenhouse Gas Emissions Trends and Projections from the Inflation Reduction Act. CRS Report No. R47385. https://www.congress.gov/crs-product/R47385. [Date accessed: 11 March 2025].

Ranius, T.P.; Johansson, N.B.; Niklasson, M. 2008. The influence of tree age and microhabitat quality on the occurrence of crustose lichens associated with old oaks. Journal of Vegetation Science. 19: 653–662. https://doi.org/10.3170/2008-8-18433.

Rebek, E.J. 2010. Pine sawfly activity reported across the state. Pest e-alerts. Sillwater, OK: Oklahoma State University. 9(19): 1–4 p.

Reed, F.W. 1905. A working plan for forest lands in central Alabama. Bull. 68. Washington, DC: U.S. Department of Agriculture, Forest Service. 71 p. https://doi.org/10.5962/bhl.title.66742.

Remsen, J.V., Jr. 1986. Was Bachman's warbler a bamboo specialist? The Auk. 103: 216–219.

Riitters, K.; Coulston, J.W.; Mihiar, C. [et al.]. 2023. Land Resources. In: Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: U.S. Department of Agriculture, Forest Service. 4-1–4-37. Chapter 4. https://doi.org/10.2737/WO-GTR-102-Chap4.

Riley, K.L.; Grenfell, I.C.; Finney, M.A.; Wiener, J.M. 2021. TreeMap, a tree-level model of conterminous US forests circa 2014 produced by imputation of FIA plot data. Scientific Data. 8(1): 11. https://doi.org/10.1038/s41597-020-00782-x.

Robbins, Z.J.; Loudermilk, E.L.; Mozelewski, T.G. [et al.]. 2024. Fire regimes of the Southern Appalachians may radically shift under climate change. Fire Ecology. 20(1): 1–17. https://doi.org/10.1186/s42408-023-00231-1.

Robertson, D. F. 1990. Position statement on National Forest old-growth values. Washington, DC: U.S. Department of Agriculture. U.S. Senate: 4.

Rogers, B.M.; Jantz, P.; Goetz, S.J. 2017. Vulnerability of eastern US tree species to climate change. Global Change Biology. 23(8): 3302–3320. https://doi.org/10.1111/gcb.13585.

Romme, W.H.; Martin, W.H. 1982. Natural disturbance by tree falls in old-growth mixed mesophytic forest: Lilley Cornett Woods, Kentucky. In: Muller, R.N., ed. Proceedings of the fourth annual Central Hardwood Forest Conference. Lexington, KY: University of Kentucky: 367–383.

Rosenberg, D.K.; Fraser, J.D.; Stauffer, D.F. 1988. Use and Characteristics of Snags in Young and Old Forest Stands in Southwest Virginia. Forest Science. 34(1): 224–228. https://doi.org/10.1093/forestscience/34.1.224.

Royo, A.A.; Raymond, P.; Kern, C.C. [et al.]. 2023. Desired REgeneration through Assisted Migration (DREAM): Implementing a research framework for climate-adaptive silviculture. Forest Ecology and Management. 546(1): 121298. https://doi.org/10.1016/j.foreco.2023.121298.

Rubino, D.L.; Vis, M.L. 2001. A Survey of the mosses of Dysart Woods, an Ohio old-growth forest. Castanea. 66(4): 327–335.

Ryan, M.G.; Harmon, M.E.; Birdsey, R.A. [et al.]. 2010. A synthesis of the science on forests and carbon for U.S. forests. Ecological Society of America: Issues in Ecology. 13: 1–16.

Schafale, M. 2024. Classification of the Natural Communities of North Carolina - 4th Approximation. North Carolina Natural Heritage Program. Raleigh, NC: North Carolina Department of Natural and Cultural Resources. 1,253 p. https://doi.org/10.5149/9781469683904_Schafale.

Scheff , R.J., Jr. 2012. The development of old-growth structural characteristics in second-growth forests of the Cumberland Plateau, Kentucky, U.S.A. Richmond, KY: Eastern Kentucky University. 100 p. M.S. thesis.

Scheidegger, C.; Bilovitz, P.O.; Werth, S. [et al.]. 2012. Hitchhiking with forests: population genetics of the epiphytic lichen *Lobaria pulmonaria* in primeval and managed forests in southeastern Europe. Ecology and Evolution. 2(9): 2223–2240. https://doi.org/10.1002/ece3.341.

Scherman, S.J.; Risch, T.S.; Rolland, V. 2022. Fall and winter activity of two bat species in response to winter flooding and decreasing temperature. Global Ecology and Conservation. 38: e02276. https://doi.org/10.1016/j.gecco.2022.e02276.

Schuler, T.M.; Ford, W.M.; Collins, R.J. 2002. Successional dynamics and restoration implications of a montane coniferous forest in the central Appalachians, USA. Natural Areas Journal. 22: 88–98.

Schwarz, G.F. 1907. The longleaf pine in virgin forest; a silvical study. New York: John Wiley and Sons. 135 p. https://doi.org/10.5962/bhl.title.36339.

Seidl, R.; Spies, T.A.; Rammer, W. [et al.]. 2012. Multi-scale Drivers of Spatial Variation in Old-Growth Forest Carbon Density Disentangled with Lidar and an Individual-Based Landscape Model. Ecosystems. 15: 1321–1335. https://doi.org/10.1007/s10021-012-9587-2.

Shear, T.; Young, M.; Kellison, R. 1997. An Old-Growth Definition for Red River Bottom Forests in the Eastern United States. Gen. Tech. Rep. SRS-10. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 9 p. https://doi.org/10.2737/SRS-GTR-10.

Sherrard, T.H. 1903. A working plan for forest lands in Hampton and Beaufort counties, South Carolina. Bull. 43. Washington, DC: U.S. Department of Agriculture, Bureau of Forestry. 54 p. https://doi.org/10.5962/bhl.title.66743.

Sierra Club. 2022. Glossary for Forests and Forestry Practices. Sierra Club Forests and Climate Team. 10 p. Unpublished document. https://www.sierraclub.org/grassroots-network/forests-climate/resources. [Date accessed: 12 December 2023].

Sillet, S.C.; McCune, B.; Peck, J.E. [et al.]. 2000. Dispersal limitations of epiphytic lichens result in species dependent on old-growth forests. Ecological Applications. 10(3): 789–799. https://doi.org/10.1890/1051-0761(2000)010[0789:DLOELR]2.0.CO;2.

Simon, S.A. 2011a. Ecological Zones on the George Washington National Forest: First Approximation Mapping. 25 p. Unpublished report. Arlington, VA: The Nature Conservancy, Virginia Field Office. 25 p.

Simon, S.A., 2011b. Ecological Zones in the Southern Blue Ridge: 3rd Approximation. 78 p. Unpublished report. Asheville, NC: Report and maps provided to the National Forests in North Carolina. Ecological Modeling and Fire Ecology.

Simon, S.A. 2013. Ecological Zones on the Jefferson National Forest Study Area: First Approximation. 29 p. Unpublished report. Arlington, VA: The Nature Conservancy, Virginia Field Office.

Simon, S.A. 2014. Ecological Systems on the Francis Marion National Forest: 2nd Approximation. Unpublished report. Asheville, NC: Ecological Modeling and Fire Ecology.

Simon, S.A. 2016. Ecological Zones on the Chattahoochee and Cherokee -(south) National Forests: 1st Approximation. Unpublished report. Asheville, NC: Ecological Modeling and Fire Ecology.

Simon, S.A. 2019. Ecological Zones on the Croatan National Forest: 2nd Approximation. Unpublished report. Asheville, NC: Ecological Modeling and Fire Ecology.

Simon, S.A. 2023. Ecological Zones in the Cumberland Plateau, Cumberland Mountains and Allegheny Plateau in Eastern Kentucky 2nd Approximation: August 2023. Unpublished report. Asheville, NC: Ecological Modeling and Fire Ecology.

Simon, S.A.; Collins, T.K.; Kauffman, G.L. [et al.]. 2005. Ecological zones in the Southern Appalachians: first approximation. Res. Pap. SRS-41, Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 41 p. https://doi.org/10.2737/SRS-RP-41.

Skovsgaard, J.P.; Vanclay, J.K. 2008. Forest site productivity: a review of the evolution of dendrometric concepts for even-aged stands. Forestry. 81(1): 13–31. http://dx.doi.org/10.1093/forestry/cpm041.

Small, C.J.; McCarthy, B.C. 2005. Relationship of understory diversity to soil nitrogen, topographic variation, and stand age in an eastern oak forest, USA. Forest Ecology and Management. 217(2-3): 229–243. https://doi.org/10.1016/j.foreco.2005.06.004.

Smith Mastran, S.; Lowerre, N. 1983. Mountaineers and rangers: a history of federal forest management in the southern Appalachians, 1900-81. FS-380. Washington, DC: U.S. Department of Agriculture, Forest Service. 191 p.

Smith, J.E.; Molina, R.; Huso, M.M.P. 2002. Species richness, abundance, and composition of hypogeous and epigeous ectomycorrhizal fungal sporocarps in young, rotation-age, and old-growth stands of Douglas-fir (*Pseudotsuga menziesii*) in the Cascade Range of Oregon, USA. Canadian Journal of Botany. 80(2): 186–204. https://doi.org/10.1139/b02-003.

Smith, J.E.; Molina, R.; Huso, M.M.P.; Larsen, M.J. 2000. Occurrence of *Piloderma fallax* in young, rotation-age, and old-growth stands of Douglas-fir (*Pseudotsuga menziesii*) in the Cascade Range of Oregon, U.S.A. Canadian Journal of Botany. 78: 995–1001. https://doi.org/10.1139/b00-085.

Smith, W.P.; Zollner, P.A. 2001. Seasonal Habitat Distribution of Swamp Rabbits, White-Tailed Deer, and Small Mammals in Old Growth and Managed Bottomland Hardwood Forests. Gen. Tech. Rep. SRS-42. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 83–98.

Snell, K.L.; Keller, H.W.; Eliasson, U.H. 2003. Tree Canopy Myxomycetes and New Records from Ground Sites in the Great Smoky Mountains National Park. Castanea. 68(2): 97–108.

Southern Appalachain Man and the Biosphere [SAMABB]. 1996. Southern Appalachain Assessment. Summary Report. https://digital.library.unt.edu/ark:/67531/metadc689958/. [Data accessed: 15 December 2025].

Sperduto, D.D.; Nichols, W.F.; Crowley, K.F.; Bechtel, D.A. 2000. Black Gum (*Nyssa sylvatica* Marsh) in New Hampshire. Concord, NH: New Hampshire Natural Heritage Inventory.

Spetich, M.A.; Jenkins, M.A.; Shiftley, S.R. [et al.]. 2022. Characteristics of Dry-Mesic Old-Growth Forests in the Eastern United States. Earth. 3(3): 975–1009. https://doi.org/10.3390/earth3030057.

Spetich, M.A.; Parker, G.R. 1998. Distribution of Biomass in an Indiana Old-Growth Forest from 1926 to 1992. The American Midland Naturalist. 139(1): 90–107. https://doi.org/10.1674/0003-0031(1998)139[0090:DOBIAI]2.0.CO;2.

Spies, T.A. 2004. Ecological Concepts and Diversity of Old-Growth Forests. Journal of Forestry. 102(3): 14–20. https://doi.org/10.1093/jof/102.3.14.

Spies, T.A.; Hemstrom, M.A.; Youngblood, A.; Hummel, S. 2006. Conserving Old-Growth Forest Diversity in Disturbance-Prone Landscapes. Conservation Biology. 20(2): 351–362. https://doi.org/10.1111/j.1523-1739.2006.00389.x.

Stahle, D.W.; Chaney, P.L. 1994. A predictive model for the location of ancient forests. Natural Areas Journal. 14(3): 151–158.

Stahle, D.W.; Edmondson, J.R.; Howard, I.M. [et al.] 2019. Longevity, climate sensitivity, and conservation status of wetland trees at Black River, North Carolina. Environmental Research Communications. 1: 041002. https://doi.org/10.1088/2515-7620/ab0c4a.

Stambaugh, M.C.; Guyette, R.P.; Marschall, J.M. 2011. Longleaf pine (*Pinus palustris* Mill.) fire scars reveal new details of a frequent fire regime. Journal of Vegetation Science. 22(6): 1094–1104. https://doi.org/10.1111/j.1654-1103.2011.01322.x.

Stambaugh, M.C.; Marschall, J.M.; Abadir, E.R. 2020. Revealing historical fire regimes of the Cumberland Plateau, USA, through remnant fire-scarred shortleaf pines (*Pinus echinata* Mill.). Fire Ecology. 16: 24. https://doi.org/10.1186/s42408-020-00084-y.

Stoddard, M.A. 1812. Sketches, historical and descriptive, of Louisiana. Philadelphia, PA: Mathew Carey. 488 p.

Thomas, H. 2013. Senescence, ageing and death of the whole plant. New Phytologist. 197: 696–711. https://doi.org/10.1111/nph.12047.

Traylor, C.R.; Caterino, M.S.; Ulyshen, M.D. [et al.]. 2022. Assessing the Old-Growth Dependency of Two Saproxylic Beetle Species in the Southern Appalachian Mountains. Insect Systematics and Diversity. 6(3): 5. https://doi.org/10.1093/isd/ixac012.

Tripp, E.A.; Lendemer, J.C.; McCain, C.M. 2019. Habitat quality and disturbance drive lichen species richness in a temperate biodiversity hotspot. Oecologia. 190: 445–457. https://doi.org/10.1007/s00442-019-04413-0.

Trousdale, A.W. 2011. Ecology of tree-roosting Rafinesque's bigeared bats in the Eastern United States. In: Loeb, S.C.; Lacki, M.J.; Miller, D.A., eds. Conservation and management of eastern big-eared bats: a symposium. Gen. Tech. Rep. SRS-145. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 27–38.

Turchin, P.; Davidson, J.; Hayes, J.L. 1999. Effects of Thinning on Development of Southern Pine Beetle Infestations in Old Growth Stands. Southern Journal of Applied Forestry. 23(4): 193–196. https://doi.org/10.1093/sjaf/23.4.193.

Turner, N.J.; Ari, Y.; Berkes, F. [et al.]. 2009. Cultural Management of Living Trees: an International Perspective. Journal of Ethnobiology. 29(2): 237–270. https://doi.org/10.2993/0278-0771-29.2.237.

Tuttle, J.P.; White, P.S. 2016. Structural and Compositional Change in Great Smoky Mountains National Park since Protection, 1930s–2000s. In: Greenberg, C.H.; Collins, B.S., eds. Natural Disturbances and Historic Range of Variation: Type, Frequency, Severity, and Post-Disturbance Structure in Central Hardwood Forests USA. Cham, Switzerland: Springer: 263–294. https://doi.org/10.1007/978-3-319-21527-3_10.

Tyrrell, L.E.; Nowacki, G.J.; Crow, T.R. [et al.]. 1998. Information about old growth for selected forest type groups in the eastern United States. Gen. Tech. Rep. NC-197. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 507 p. https://doi.org/10.2737/NC-GTR-197.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1940. National forests in the southern Appalachians. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 46 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1989a. Chief Dale Robertson letter to regional foresters, station directors, and Washington Office staff regarding national forest old-growth values and the generic definition and description of old-growth forests. October 11, 1989. On file with: U.S. Department of Agriculture, Forest Service, Auditors Building 201 14th Street, SW at Independence Ave, SW Washington, DC 20250.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1989b. Position statement on national forests old-growth values. Unnumbered internal memo to regional foresters, station directors, and Washington Office staff, October 11, 1989. On file with: U.S. Department of Agriculture, Forest Service, Auditors Building 201 14th Street, SW at Independence Ave, SW Washington, DC 20250.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2005. Terrestrial Ecological Unit Inventory Technical Guide. Gen. Tech. Rep. WO-68. Washington, DC: U.S. Department of Agriculture, Forest Service. 104 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2009. Forest Service Handbook 2409.17 Silvicultural Practices Handbook: Silvicultural Examinations and Prescriptions and Evaluations. Southern Region Supplement: R8-2409.17-2010. 32 p. Chapter 8.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2012. Federal Register 21162. Code of Federal Regulations, Title 36, 219.3. National Forest System Land and Resource Management Planning. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2017. Southern Region National Forest System longleaf pine restoration strategy. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 18 p. https://www.restorethegulf.gov. [Date accessed: 1 March 2024].

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2019. El Yunque National Forest Revised Land and Resources Management plan. https://www.fs.usda.gov/detail/elyunque/landmanagement/planning/?cid=stelprdb5411382. [Date accessed: 12 March 2025].

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2022. Land areas of the National Forest System as of September 30, 2022. FS-383. Washington, DC: U.S. Department of Agriculture, Forest Service. 259 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2023a. Final environmental impact statement for the Land Management Plan of the Nantahala and Pisgah National Forests. R8 MB-161. Atlanta, GA: U.S. Department of Agriculture, Forest Service, Southern Region. 754 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2023b. Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment. Gen. Tech. Rep. WO-102. Washington, DC: U.S. Department of Agriculture, Forest Service. 348 p. https://doi.org/10.2737/WO-GTR-102.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2023c. Mature and old-growth forests: definition, identification, and initial inventory on lands managed by the Forest Service and Bureau of Land Management: fulfillment of Executive Order 14072, Section 2(b). FS-1215a. Washington, DC: U.S. Department of Agriculture, Forest Service. 63 p.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2015. Field Sampled Vegetation (FSVeg) Common Stand Exam User Guide. Version 2.12.6. https://www.fs.usda.gov/nrm/fsveg/index.shtml. [Date accessed: 7 April 2025].

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2025. Ecological Subregions: Domains, Provinces, Sections, and Subsections for the Conterminous United States. Draft 2025 edition. Washington, DC: U.S. Department of Agriculture, Forest Service.

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management [USDA and USDOI]. 1994. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl. 74 p. https://www.fs.usda.gov/r6/reo/library/downloads/documents/NWFP-ROD-1994.pdf. [Date accessed: 12 March 2025].

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management [USDA and USDOI]. 2024. Introductory Report: Analysis of Threats to Mature and Old-Growth Forests on Lands Managed by the Forest Service and Bureau of Land Management in Fulfillment of Section 2(c) of Executive Order No. 14072. June 2024. FS-1215c. Washington, DC. U.S. Department of Agriculture, Forest Service. 117 p.

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior [USDA and USDOI]. 2022. LANDFIRE. http://www.landfire.gov/index.php. [Date accessed: 6 March 2024].

U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior [USDA and USDOI]. 2022. LANDFIRE: Biophysical Settings - BPS. (CONUS LF 2016 Remap). https://landfire.gov/viewer/. [Date accessed: 13 December 2024].

U.S. Department of the Interior, Geological Survey, and U.S. Department of Agriculture [USDOI and USDA]. 2016. LANDFIRE: Existing Vegetation Type Layer. https://www.landfire/viewer. [Date accessed: 28 October 2021].

U.S. Fish and Wildlife Service. [USFWS]. 2014. 5-Year Review: Spruce-fir moss spider (*Microhexura montivaga*). Asheville, NC: Southeast Region, Asheville Ecological Services Field Office.

U.S. National Park Service. [NPS]. 2024. People of the Floodplain. Congaree National Park. https://www.nps.gov/cong/learn/historyculture/history-culture.htm. [Date accessed: 12 March 2025].

U.S. National Vegetation Classification [USNVC]. 2022. Database 2.04. Washington, DC: Federal Geographic Data Committee, Vegetation Subcommittee. https://usnvc.org/. [Date accessed: 12 March 2025].

Valett, H.M.; Crenshaw, C.L.; Wagner, P.F. 2002. Stream nutrient uptake, forest succession, and biogeochemical theory. Ecology. 83(10): 2888–2901. https://doi.org/10.1890/0012-9658(2002)083[2888:SNUFSA]2.0.CO;2.

Van't Woudt, B.D. 1990. Roaming, stray, and feral domestic cats and dogs as wildlife problems. Proceedings of the Vertebrate Pest Conference. 14(4): 291–295. https://escholarship.org/uc/item/1378w5fk.

Van Tuyl, S.; Law, B.E.; Turner, D.P.; Gitelman, A.I. 2005. Variability in net primary production and carbon storage in biomass across Oregon forests—an assessment integrating data from forest inventories, intensive sites, and remote sensing. Forest Ecology and Management. 209: 273–291. https://doi.org/10.1016/j.foreco.2005.02.002.

Varner, J.M., J.S. Kush, and R.S. Meldah1. 1999. Old-growth montane longleaf pine stand structure: a preliminary assessment. In: Haywood, J.D., ed. Proceedings of the 10th Southern Silvicultural Research Conference. Gen. Tech. Rep. GTR- SRS-30. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 606–608.

Varner, J.M., III; Kush, J.S.; Meldahl, R.S. 2000. Ecological restoration of an old-growth longleaf pine stand utilizing prescribed fire. In: Moser, W.K.; Moser, C.E., eds. Tall Timbers Fire Ecology Conference Proceedings, No. 21: Tallahassee, FL: Tall Timbers Research Station: 216–219. https://research.fs.usda.gov/treesearch/2297. [Date accessed: 12 March 2025].

Vose, J.M.; Bolstad, P.V. 2007. Biotic and abiotic factors regulating forest floor CO2 flux across a range of forest age classes in the southern Appalachians. Pedobiologia. 50(6): 577–587. https://doi.org/10.1016/j.pedobi.2006.10.006.

Vose, J.M.; Peterson, D.L.; Patel-Weynand, T., eds. 2012. Effects of climatic variability and change on forest ecosystems: a comprehensive science synthesis for the U.S. forest sector. Gen. Tech. Rep. PNW-870. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 265 p. https://doi.org/10.2737/PNW-GTR-870.

Vosick, D.; Ostergren, D.M.; Murfitt, L. 2007. Old-growth Policy. Ecology and Society. 12(2). 14 p. https://doi.org/10.5751/ES-02172-120219.

Wade, D.D.; Brock, B.L.; Brose, P.H. 2000. Fire in Eastern Ecosystems. In: Brown, J.K.; Smith, J.K., eds. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-42-vol 2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 53–96. Chapter 4. https://www.fs.usda.gov/rm/pubs/rmrs_gtr042_2.pdf. [Date accessed: 12 March 2025].

Wang, Y.; Fang, H. 2020. Estimation of LAI with the LiDAR Technology: A Review. Remote Sensing. 12(20): 3457. https://doi.org/10.3390/rs12203457.

Weakley, A.S.; Southeastern Flora Team. 2024. Flora of the Southeastern United States. Chapel Hill, NC: University of North Carolina at Chapel Hill Herbarium, North Carolina Botanical Garden. 2203 p. https://ncbg.unc.edu/research/unc-herbarium/flora-request/. [Date accessed: 12 March 2025].

Wear, D.N.; Greis, J.G., eds. 2013. The Southern Forest Futures Project: Technical Report. Gen. Tech. Rep. SRS-178. Ashville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 542 p. https://doi.org/10.2737/SRS-GTR-178.

Webster, C.R.; Jenkins, M.A. 2005. Coarse woody debris dynamics in the southern Appalachians as affected by topographic position and anthropogenic disturbance history. Forest Ecology and Management. 217(2-3): 319–330. https://doi.org/10.1016/j.foreco.2005.06.011.

Webster, J.R.; Golladay, S.W.; Benfield, E.F. [et al.]. 1992. Catchment disturbance and stream response: an overview of stream research at Coweeta Hydrologic Laboratory. River Conservation and Management. 15: 232–253.

Weeks Act of 1911; 36 Stat. 961. 61 U.S.C. 11798.

Wendel, G.W.; Smith, H.C. 1990. *Pinus strobus* L. Eastern white pine. In: Burns, R.M.; Honkala, B.H., tech coords. Silvics of North America. Volume 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 28. https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/silvics_vol1.pdf. [Date accessed: 14 March 2024].

Westfall, J.A.; Coulston, J.W.; Moisen, G.G.; Andersen, H.-E., comps. 2022. Sampling and estimation documentation for the Enhanced Forest Inventory and Analysis Program: 2022. Gen. Tech. Rep. NRS-207. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 129 p. https://doi.org/10.2737/NRS-GTR-207.

White, D.L.; Lloyd, F.T. 1995. Defining Old Growth: Implications for Management. In: Edwards, M.B., comp. Proceedings Eighth Biennial Southern Silvicultural Research Conference. Gen. Tech. Rep. SRS-1. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 51–62.

White, D.L.; Lloyd, F.T. 1998. An Old-Growth Definition for Dry and Dry-Mesic Oak-Pine Forests. Gen. Tech. Rep. SRS-23. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 42 p. https://doi.org/10.2737/SRS-GTR-23.

White, P.S.; Buckner, E.R.; Pittillo, J.D.; Cogbill, C.V. 1993. High-Elevation Forests: Spruce-Fir Forests, Northern Hardwood Forests, and Associated Communities. In: Martin, W.H.; Boyce, S.G.; Echternacht, A.C., eds. Biodiversity of the Southeastern United States: Upland Terrestrial Communities. New York: John Wiley and Sons: 305–337.

Whittaker, R.H. 1956. Vegetation of the Great Smoky Mountains. Ecological Monographs. 26(1): 1–80. https://doi.org/10.2307/1943577.

Wickham, S.; Augustine, S.; Forney, A. [et al.]. 2022. Incorporating place-based values into ecological restoration. Ecology and Society. 27(3): 32. https://doi.org/10.5751/ES-13370-270332.

Wigle, R.D.; Wiersma, Y.F.; Arsenault, A.; McMullin, R.T. 2021. Drivers of arboreal lichen community structure and diversity on *Abies balsamea* and *Betula alleghaniensis* in the Avalon Forest Ecoregion, Newfoundland. Botany. 99(1): 43–54. https://doi.org/10.1139/cjb-2020-0061.

Wilderness Act of 1964; Act of September 3, 1964; 16 U.S.C. 1131-1136.

Wilhite, L.P.; Toliver, J.R. 1990. *Taxodium distichum* (L.) Rich. Baldcypress. In: Burns, R.M.; Honkala, B.H., tech coords. Silvics of North America. Volume 1. Conifers. Agric. Handb. 654. Washington, DC: U.S. Department of Agriculture, Forest Service: 563–569. https://www.srs.fs.usda.gov/pubs/misc/ag_654/volume_1/silvics_vol1.pdf. [Date accessed: 14 March 2024].

Williams, C.; Norman, E.M.; Taylor, W.K., eds. 2020. André Michaux in North America: Journals & Letters, 1785-1797. Tuscaloosa, AL: University of Alabama Press. 608 p.

Williams, D.A.; Wang, Y.; Borchetta, M.; Gaines, M.S. 2007. Genetic diversity and spatial structure of a keystone species in fragmented pine rockland habitat. Biological Conservation. 138(1-2): 256–268. https://doi.org/10.1016/j.biocon.2007.04.024.

Williams, G.W. 2003a. Private property to public property: the beginnings of the national forests in the South. Providence, RI: American Society for Environmental History meeting. 30 p. https://www.npshistory.com/publications/usfs/aseh-so-nf-2003.pdf. [Date accessed: 20 November 2023].

Williams, G.W. 2003b. The beginnings of the national forests in the South: protection of watersheds. Lexington, VA: 14th Annual Environment Virginia Conference. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=194d6994fe2d51cb1df2b6fa078d654eff8fbbf3. [Date accessed: 12 March 2025].

Wilson, A.D. 2001. Oak Wilt: A Potential Threat to Southern and Western Oak Forests. Journal of Forestry. 99(5): 4–11. https://doi.org/10.1093/jof/99.5.4.

Wilson, B.T.; Knight, J.F.; McRoberts, R.E. 2018. Harmonic regression of Landsat time series for modeling attributes from national forest inventory data. ISPRS Journal of Photogrammetry and Remote Sensing. 137: 29–46. https://doi.org/10.1016/j.isprsjprs.2018.01.006.

Wirth, C.; Messier, C.; Bergeron, Y. [et al.]. 2009. Old-Growth Forest Definitions: a pragmatic view. In: Wirth, C.; Gleixner, G.; Heimann, M., eds. Old-Growth Forests: Function, Fate and Value. Berlin: Springer-Verlag: 11–33. https://doi.org/10.1007/978-3-540-92706-8.

Woodall, C.W.; Liknes, G.C. 2008. Relationships between forest fine and coarse woody debris carbon stocks across latitudinal gradients in the United States as an indicator of climate change effects. Ecological Indicators. 8(5): 686–690. https://doi.org/10.1016/j.ecolind.2007.11.002.

Woodbridge, M. 2020. Long-term landscape-scale impact of early 20th century logging on plant communities in the southern Appalachians. Syracuse, NY: State University of New York. 205 p. Ph.D. dissertation.

Woodbridge, M.; Dovciak, M. 2022. Logging legacies in a plant biodiversity hotspot: Altered distribution and abundance patterns of the shrub layer in the southern Appalachians. Forest Ecology and Management. 516: 120245. https://doi.org/10.1016/j.foreco.2022.120245.

Woodbridge et al. [In press]. Old-growth literature database. Asheville, NC: U.S. Department of Agriculture, Forest Service.

Woodbridge, M.; Goode, J.D.; Bragg, D. 2025. An Annotated Bibliography of Old Growth in Forests of the Southeastern United States. Gen. Tech. Rep. SRS-279. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 145 p.

Wyatt, J.L.; Silman, M.R. 2010. Centuries-old logging legacy on spatial and temporal patterns in understory herb communities. Forest Ecology and Management. 260(1): 116–124. https://doi.org/10.1016/j.foreco.2010.04.010.

Yazzie, V. 2007. The Tribal Perspective of Old Growth in Frequent-Fire Forests—Its History. Ecology and Society. 12: 21. https://doi.org/10.5751/ES-02252-120221.

Yost, E.C.; Johnson, K.S.; Blozan, W.F. 1994. Old-Growth Project: Long-Term monitoring Plot Establishment. Technical Report NPS/SERGSM/NRTR-Science Division. Gatlinburg, TN: National Park Service.

Young, G.A.; Hoffman, M.P., eds. 1993. The expedition of Hernando de Soto west of the Mississippi, 1541-1543. Fayetteville, AR: University of Arkansas Press. 311 p.

Young, J.K; Olson, K.A; Reading, R.P. [et al.]. 2011. Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. Bioscience 61(2): 125–132. https://doi.org/ 10.1525/bio.2011.61.2.7.

Zhao, S.; Pederson, N.; D'Orangeville, L. [et al.]. 2018. The International Tree-Ring Data Bank (ITRDB) revisited: Data availability and global ecological representativity. Journal of Biogeography. 46: 355–368. https://doi.org/10.1111/jbi.13488.

Zon, R. 1905. Loblolly pine in eastern Texas, with special reference to the production of cross-ties. Bull. 64. Washington, DC: U.S. Department of Agriculture, Forest Service. 53 p.

GLOSSARY

A

Accessibility—The relative ease or difficulty of getting from or to someplace, especially the ability of a site, facility or opportunity to be used by persons of varying physical and mental abilities.

Acid deposition—Rain, snow, or dry particulate matter containing high concentrations of acid anions (e.g., nitrate and sulfate), usually produced by atmospheric transformation of the byproducts of fossil fuel combustion. Precipitation with a pH lower than 5.0 is generally considered to be acidic.

Acid neutralizing capacity—The total capacity of a water sample to neutralize acids, as determined by titration with a strong acid. Includes alkalinity (e.g., carbonate) plus base cations.

Acidification—To convert into an acid or become acid. In forested systems decreases in PH based on deposition of acid precipitation can reduce soil fertility and alter nutrient cycling.

Adaptive capacity—The ability of ecosystems to respond, cope, or adapt to disturbances and stressors, including environmental change, to maintain options for future generations. As applied to ecological systems, it is determined by:

1. Genetic diversity within species in ecosystems, allowing for selection of individuals with traits adapted to changing environmental conditions.
2. Biodiversity within the ecosystem, both in terms of species richness and relative abundance, which contributes to functional redundancies.
3. The heterogeneity and integrity of ecosystems occurring as mosaics within broader scaled landscapes or biomes, making it more likely that some areas will escape disturbance and serve as source areas for recolonization.

Adaptive management—An approach to natural resource management where actions are designed and executed and effects are monitored for the purpose of learning and adjusting future management actions, which improves the efficiency and responsiveness of management (USDA Forest Service 2012a).

Administrative unit—All NFS lands where one forest supervisor has responsibility. The basic geographic management area within a Forest Service region, station, or area.

Advance regeneration (reproduction)—Seedlings or saplings that develop, or are present, in the understory.

Adverse effect—An action that has an apparent direct or indirect adverse effect on the conservation and recovery of a species listed as threatened or endangered. Such actions include, but are not limited to:

- Any action that directly alters, modifies, or destroys critical or essential habitats or renders occupied habitat unsuitable for use by a listed species, or that otherwise affects its productivity, survival, or mortality.
- Any action that directly results in the taking of a listed species. See Title 50 Code of Federal Regulations, Section 17.3 for an explanation of what constitutes a taking (ESA 1973).
- Any action involving the disposal of land that is essential to achieving recovery objectives.

Age class (cohort)—A distinct aggregation of trees originating from a single natural disturbance or regeneration cutting.

Air quality class—Three broad classifications used to prevent significant deterioration of air quality for all areas of the country.

- Class I: all areas where essentially any degradation of air quality would be considered significant deterioration.
- Class II: all areas where moderate degradation over baseline concentrations are allowed.
- Class III: all others.

All-terrain vehicle (ATV)—A type of off-highway vehicle that travels on three or more low- pressure tires, has handlebar steering, is ≤50 inches in width, and has a seat designed to be straddled by the operator.

Appropriate management response—The response to a wildland fire based on an evaluation of risks to firefighter and public safety. Circumstances under which the fire occurs, including weather and fuel conditions, natural and cultural resource management objectives, protection priorities, and values to be protected. The evaluation includes an analysis of the context of the specific fire within the overall logic, geographic area, or national wildland fire situation.

Area of influence—An area influenced by the management of the plan area that is used during the land management planning process to evaluate social, cultural, and economic conditions. The area is usually a grouping of counties.

Artificial regeneration (reproduction)—Creation of a new age class by renewal of a tree crop by direct seeding, or by planting seedlings or cuttings.

Assessment—An assessment is the identification and evaluation of existing information to support land management planning. Assessments are not decisionmaking documents but provide current information on select topics relevant to the plan area, in the context of the broader landscape (USDA Forest Service 2012a).

At-risk species—The set of at-risk species for planning purposes includes federally recognized threatened, endangered, proposed and candidate species, and species of conservation concern.

Authorized use—Specific activity or occupancy, including a ski area, historical marker, or oil and gas lease, for which a special authorization is issued.

B

Background—The area after the middle ground in a picture or landscape, generally over 4 miles distance from the viewer.

Basal area—The area of the cross-section of a tree inclusive of bark at breast height (4.5 feet or 1.37 m above the ground). Most commonly expressed as square feet per acre or square meters per hectare. Used to measure the density of a stand of trees. For shrubs and herbs, it is used to determine phytomass. Grasses, forbs, and shrubs: usually measured at or less than 1 inch above soil level.

Best available science—The 2012 Planning Rule for NFS land management, issued by the Forest Service, which defines best available scientific information (BASI), often referred to as best science, as "The most accurate, reliable, and relevant scientific information available for use in land management planning and decisionmaking."

Best management practices (BMPs) for water quality—Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. Include but are not limited to structural and nonstructural controls and operation and maintenance procedures. Can be applied before, during, and after pollution producing activities to reduce or eliminate the introduction of pollutants into receiving waters (USDA Forest Service 2012a).

Biological assessment—A biological evaluation conducted for major Federal construction projects requiring an Environmental Impact Statement, in accordance with legal requirements under section 7 of the Endangered Species Act of 1973, as amended (ESA 1973). The purpose of the assessment and resulting document is to determine whether the proposed action is likely to affect an endangered, threatened, or proposed species.

Biological opinion—An official report by the USFWS or the Department of Commerce, National Oceanic and Atmospheric Administration Fisheries Service issued in response to a formal Forest Service request for consultation or conference. It states whether an action is likely to result in jeopardy to a species or adverse modification of its critical habitat.

Biomass—Renewable organic material that comes from plants and animals. Potential biomass products from forests include wood and wood processing wastes (firewood, wood pellets, and wood chips), lumber and furniture mill sawdust and waste, and black liquor from pulp and paper mills.

Board foot—A unit of timber measurement equaling the amount of wood contained in an unfinished board 1 inch thick, 12 inches long, and 12 inches wide. Commonly 1,000 board feet is written as 1 MBF, and 1,000,000 board feet is written as 1MMBF.

Browse—Young twigs, leaves, and tender shoots of plants, shrubs, or trees that animals eat.

C

Cable logging—Any system involving transport of logs along, or by means of steel cables with the load being lifted partly or wholly off the ground.

Candidate species—A species for which the USFWS possesses sufficient information on vulnerability and threats to support a proposal to list as endangered or threatened, but for which no proposed rule has yet been published by the USFWS.

Canopy cover—The percentage of a fixed area covered by the crown of an individual plant species or delimited by the vertical projection of its outermost perimeter. Small openings in the crown are included. Used to express the relative importance of individual species within a vegetation community, or to express the canopy coverage of woody species. May be used as a measure of land-cover change or trend. Often used for wildlife habitat evaluations.

Carbon density—An estimate of forest carbon stocks per unit area.

Carbon pool—Any natural region or zone, or any artificial holding area, containing an accumulation of carbon or carbon-bearing compounds or having the potential to accumulate such substances. May include live and dead aboveground carbon, soil carbon including coarse roots, and harvested wood products.

Carbon sequestration—The process by which atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils.

Carbon stocks—The amount or quantity of carbon contained in a carbon pool. For purposes of carbon stock assessment for NFS land management planning, carbon pools do not include carbon in fossil fuel resources, lakes or rivers, emissions from agency operations, or public use of NFS lands (such as emissions from vehicles and facilities).

Clearcut—A regeneration harvest method that removes essentially all trees in a stand, producing a fully exposed microclimate for the development of a new age class of trees. May or may not have reserve trees left to attain goals other than regeneration.

Clearcut with reserves—A two-aged regeneration method in which varying numbers of reserve trees are not harvested to attain goals other than regeneration.

Climate change adaptation—Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. This includes initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects.

Climax—The culminating stage in plant succession for a given environment with the vegetation having reached a highly stable condition.

Closed road or trail—A road or trail that is closed for public use.

Codominant trees—Trees or shrubs with crowns receiving full light from above, but comparatively little from the sides. Crowns usually form the general level of the canopy.

Cohort—A group of trees developing after a single disturbance, commonly consisting of trees of similar age, although it can include a considerable range of tree ages of seeding or sprout origin and trees that predate the disturbance.

Collaboration—A structured manner in which a collection of people with diverse interests share knowledge, ideas, and resources, while working together in an inclusive and cooperative manner toward a common purpose (USDA Forest Service 2012a).

Commercial forest land—Forest land that can produce crops of industrial wood, and has not been withdrawn by Congress, the Secretary of Agriculture, or the Chief of the Forest Service.

Commercial thinning—Any type of thinning that produces merchantable material at least equal to the value of the direct cost of harvesting.

Commodity outputs—A resource output with commercial value. All resource products that are articles of commerce.

Compartment—A portion of a forest under one ownership, usually contiguous and composed of a variety of forest stand types, defined for purposes of locational reference.

Composition (stand)—The abundance of each tree species in a stand expressed as a percentage of the total number, basal area, or volume of all tree species in the stand.

Condition class—Depiction of the degree of departure from historical fire regimes, possibly resulting in alternations of key ecosystem components. These classes categorize and describe vegetation composition and structure conditions that currently exist inside the fire regime groups. Based on coarse-scale national data, they serve as generalized wildfire rankings. The risk of loss of key ecosystem components from wildfires increases from condition class 1 (lowest risk) to condition class 3 (highest risk).

Connectivity—Ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the exchange of flow, sediments, and nutrients; the daily and seasonal movements of animals within home ranges; the dispersal and genetic interchange between populations; and the long-distance range shifts of species, such as in response to climate change (USDA Forest Service 2012a).

Conservation—The protection, preservation, management, or restoration of natural environments, ecological communities, and species (USDA Forest Service 2012a).

Conversion (forest management)—A change from one forest type to another in a stand on land that has the capability of both forest types.

Critical habitat—For a threatened or endangered species:

1. The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of the Endangered Species Act (ESA1973), on which are found those physical or biological features:

    a. Essential to the conservation of the species

    b. Which may require special management considerations or protection

3. Specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the Endangered Species Act, upon a determination by the Secretary that such areas are essential for the conservation of the species. Critical habitat is designated through rulemaking by the Secretary of the Interior or Commerce.

Critical mineral—A mineral identified by the Secretary of the Interior (Executive Order 13817, 2017) to be

1. A nonfuel mineral or mineral material essential to the economic and national security of the United States

2. The supply chain of which is vulnerable to disruption

3. An essential function in the manufacturing of a product, the absence of which would have significant consequences for our economy or our national security

Culmination of mean annual increment of growth—The age in the growth cycle of an even-aged stand at which the average annual rate of increase of volume is at a maximum. See Mean annual increment of growth.

Current old growth—Forests that currently contain old-growth characteristics. These forests are sometimes called existing old growth.

D

Daylighting—The practices of cutting back edges of roads or trails by removing shrub and tree growth.

Den trees—Trees having rainproof, weather-tight cavities used by wildlife.

Designated area—An area or feature identified and managed to maintain its unique special character or purpose. Some categories of designated areas may be designated only by statute and some categories may be established administratively in the land management planning process or by other administrative processes of the Federal executive branch. Examples of statutorily designated areas are national heritage areas, national recreational areas, national scenic trails, wild and scenic rivers, wilderness areas, and wilderness study areas (USDA Forest Service 2012a). Examples of administratively designated areas are experimental forests, research natural areas, scenic byways, botanical areas, and significant caves (USDA Forest Service 2012a).

Designated old-growth network—Lands recognized as a network of large, medium, and small patches that will either perpetuate or evolve towards old-growth conditions over time. These patches are not limited to existing old growth but include lands that will become old growth and may currently be in earlier seral stages.

Desired conditions—For the purposes of the land management planning regulation at 36 CFR part 219 and this report, a description of specific social, economic, or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed. Described in terms that are specific enough to allow progress toward their achievement to be determined, but do not include completion dates (USDA Forest Service 2012a). They are achievable, and may reflect social, economic, or ecological attributes, including ecosystem processes and functions.

Developed recreation—Recreation use or opportunities occurring at developed sites.

Developed recreation site—A discrete place containing a concentration of facilities and services used to provide recreation opportunities to the public and evidencing a significant investment in facilities and management under the direction of an administrative unit in the NFS.

Development scale—An indication of site modification based on classes on the Recreation Opportunity Spectrum. Development scale 1 equates to primitive, with minimum site modification; 2 equates to semi-primitive motorized/nonmotorized, with little site modification; 3 equates to roaded, with moderate modification; 4 equates to rural, with heavy site modification; and 5 relates to urban, with a high degree of site modification.

Dispersed recreation—Recreation opportunities or use occurring in the general forest area. Does not take place in developed sites.

Disturbance—Any relatively discrete event in time that disrupts ecosystem, watershed, community, or species population structure or function and changes resources, substrate availability, or the physical environment (USDA Forest Service 2012a).

Disturbance regime—A description of the characteristic types of disturbance on a given landscape; the frequency, severity, and size distribution of these characteristic disturbance types; and their interactions (USDA Forest Service 2012a).

E

Early-successional habitat—A vegetative condition typically characterized by low density to no tree canopy cover and an abundance of herbaceous or woody ground cover. This condition may include early successional forest, maintained openings, pastures, and open woodlands.

Ecological integrity—The quality or condition of an ecosystem when its dominant ecological characteristics (e.g., composition, structure, function, connectivity, species diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence (USDA Forest Service 2012a).

Ecological restoration—The structure, pattern, and ecological processes necessary to maintain or restore ecological conditions.

Ecological sustainability evaluation (ESE) tool—A strategic conservation planning tool used by the Southern Region for forest planning.

Ecological sustainability—In the context of the ESE tool, the capability of ecosystems to maintain ecological integrity.

Ecosystem—A spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries. An ecosystem is commonly described in terms of its composition, structure, function, and connectivity (USDA Forest Service 2012a).

Ecosystem diversity—The variety and relative extent of ecosystems (USDA Forest Service 2012a).

Ecosystem services—Benefits people obtain from ecosystems, including:

- Provisioning services, such as clean air and fresh water, energy, food, fuel, forage, wood products or fiber, and minerals
- Regulating services, such as long-term storage of carbon; climate regulation; water filtration, purification, and storage; soil stabilization; flood and drought control; and disease regulation
- Supporting services, such as pollination, seed dispersal, soil formation, and nutrient cycling
- Cultural services, such as educational, aesthetic, spiritual, and cultural heritage values, recreational experiences, and tourism opportunities.

Ecozone—An ecological zone, or ecozone, is the finest scaled unit of land that can support a specific plant community or plant community group.

Eligible river—A river segment that has been evaluated, and found to be free-flowing and, in combination with its adjacent land area, possesses one or more outstandingly remarkable values.

Endangered species—Any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of the Endangered Species Act (1973) would present an overwhelming and overriding risk to people.

Endemic—Species restricted to a particular geographic area. Usually limited to one or a few small streams or a single drainage.

Environmental assessment (EA)—A public document that provides sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact. Aids an agency's compliance with the National Environmental Policy Act (NEPA) of 1969 when no EIS is necessary, and facilitates preparation of a statement when one is necessary (NEPA 1969) (USDA Forest Service 2015) (USDA Forest Service 2012a).

Environmental impact statement (EIS)—A detailed written statement as required by section 102(2)(C) of NEPA (USDA Forest Service 2012a) that describes the potential effects a proposed federal action or project may have on the environment. Key features include: 1. proposed action, 2. alternative analysis, 3. assessment of impacts, 4. mitigation measures, 5. public involvement.

Ephemeral stream—A stream that flows only in direct response to precipitation in the immediate locality (watershed or catchment basin), and whose channel is at all other times above the zone of saturation.

Erosion—The wearing away of the land surface by the action of wind, water, or gravity.

Essential habitat—Habitat in which threatened and endangered species occur, but which has not been declared as critical habitat. Occupied habitat or suitable unoccupied habitat necessary for the protection and recovery of a federally designated threatened or endangered species.

Even-aged stand—A stand of trees composed of a single age class (USDA Forest Service 2012a).

Even-aged system—A planned sequence of treatments designed to maintain and regenerate a stand with predominantly one age class. The range of tree ages is usually <20 percent of the rotation (length in years). Treatments include clearcut, seed tree, shelterwood, and coppice regeneration methods.

Extirpation—Extinction of a species from all or part of its range.

F

Federally recognized Indian Tribe—An Indian Tribe or Alaska Native Corporation, band, nation, pueblo, village, or community that the Secretary of the Interior acknowledges to exist as an Indian Tribe under the Federally Recognized Indian Tribe List Act of 1994 (Indian Tribe List Act 1994).

Fire regime—Description of the patterns of fire occurrences, frequency, size, severity, and sometimes vegetation and fire effects as well, in a given area or ecosystem. A generalization based on fire histories at individual sites. Can often be described as cycles because some parts of the histories usually get repeated, and the repetitions can be counted and measured, such as fire return interval.

Fire regime condition class (FRCC)—Also referred to as fire regime current condition class. A qualitative measure classified into three classes describing the relative degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components such as species composition, structural stage, stand age, canopy closure, and fuel loadings. Uses three condition classes to describe low departure (FRCC 1), moderate departure (FRCC 2), and high departure (FRCC 3).

Fire regime groups—A classification of fire regimes into a discrete number of categories based on frequency and severity. The national, coarse-scale classification of fire regime groups commonly used includes five groups: I: frequent (0–35 years), low severity; II: frequent (0–35 years), stand replacement severity; III: 35–100+ years, mixed severity; IV: 35–100+ years, stand replacement severity; and V: 200+ years, stand replacement severity.

Fire use—The combination of wildland fire use and prescribed fire application to meet resource objectives.

Fire return interval—Also referred to as fire-free interval or fire interval. The number of years between two successive fire events for a given area.

Fisheries habitat—Streams, lakes, and reservoirs that support fish.

Focal species—A small subset of species whose status permits inference to the integrity of the larger ecological system to which it belongs and provides meaningful information regarding the effectiveness of the plan in maintaining or restoring the ecological conditions to maintain the diversity of plant and animal communities in the plan area. Commonly selected on the basis of functional role in ecosystems (USDA Forest Service 2012a).

Forage—All browse and nonwoody plants that are available to livestock or game animals used for grazing or harvested for feeding.

Foreground—The area between the viewer and the middle ground in a landscape; generally, from 0 to 0.5-mile distance.

Forest health—The perceived condition of a forest derived from concerns about factors such as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance.

Forest land—Land that is at least 10 percent occupied by forest trees of any size or formerly having had such tree cover and not currently developed for nonforest uses.

Forest road—A road wholly or partly within or adjacent to and serving the NFS that the Forest Service determines is necessary for the protection, administration, and utilization of the NFS and the use and development of its resources (USDA Forest Service 2012a).

Forest Service Handbook (FSH)—A handbook that provides detailed instructions for proceeding with specialized phases of programs or activities for Forest Service use.

Forest Service Manual (FSM)—Agency manuals that provide direction for Forest Service activities.

Forest supervisor—The official responsible for administering the NFS lands in a Forest Service administrative unit. It may consist of two or more national forests or all the forests within a State. The supervisor reports to the regional forester.

Forest type—A classification of forest land based upon and named for the tree species that forms the plurality of live-tree stocking. For a field location, it indicates the predominant live-tree species cover for the field location. Hardwoods and softwoods are the first group to be determined a predominant group, and forest type is selected from the predominant group.

Forest-type group—A combination of forest types that share closely associated species or site requirements.

Fuel break—Any natural or constructed barrier used to segregate, stop, and control the spread of fire, or to provide a control line from which to work.

Fuel treatment—The rearrangement or disposal of fuels to reduce fire hazard. Fuels are defined as living and dead vegetative materials consumable by fire.

Fuels management—The planned treatment of fuels to achieve or maintain desired fuels conditions.

Future old growth—Forest stands or patches allocated to old growth through land management decisions, which do not currently meet one or more of the old-growth criteria in the operational definitions.

G

G2—A global conservation status term used by NatureServ to indicate that a species or community is imperiled due to low numbers of occurrences, threats, or both.

Game species—Any species of wildlife or fish for which seasons and bag limits have been prescribed, and which are normally harvested by hunters, trappers, and fishermen under State or Federal laws, codes, and regulations.

Geographic area—A spatially contiguous land area identified within the planning area. May overlap with a management area (USDA Forest Service 2012a).

Goals—An optional plan component that are broad statements of intent, other than desired conditions, usually related to process or interaction with the public. Expressed in broad, general terms, but do not include completion dates (USDA Forest Service 2012a).

Geographic information system (GIS)—An information processing technology to input, store, manipulate, analyze, and display spatial resource data to support the decision-making processes of an organization. Generally, an electronic medium for processing map information, typically used with manual processes to affect specific decisions about land base and its resources.

Groundwater—Water in a saturated zone in a geologic stratum. Water stored below the water table where the soil (or other geologic material) is saturated.

Growing season burn—Prescribed burn or use of wildland fire during the photosynthetically active growing season, where live fuel moistures are relatively high and the dominant vegetation, grasses, forbs, and herbaceous vegetation are fully greened.

Group selection—An uneven-aged regeneration method in which trees are removed periodically in small groups. Uneven age classes for trees are established in small groups. The width of groups is about twice the height of the mature trees, with small openings providing microenvironments suitable for tolerant regeneration, and larger openings providing conditions suitable for more intolerant regeneration.

Guideline—A constraint on project and activity decision making that allows for departure from its terms, so long as the purpose of the guideline is met (USDA Forest Service 2012a). Established to help achieve or maintain desired condition(s), to avoid or mitigate undesirable effects, or to meet applicable legal requirements.

H

Harvesting method—A procedure by which a stand is logged. Emphasis is on meeting logging requirements rather than silvicultural objectives.

Herbicide—A pesticide used to kill or control the growth of undesirable plants.

Highly erodible soils—Cropland, hayland, or pasture that can erode at excessive rates. Soils that have an erodibility index of eight or more (USDA NRCS 2012).

Historic properties—Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in the National Register of Historic Places. Includes artifacts, records, and remains that are related to and located within such properties. Includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria (USDA Forest Service 2012b).

Hydrologic condition—The current state of the processes controlling the yield, timing, and quality of water in a watershed.

Hydrologic function—The behavioral characteristics of a watershed described in terms of ability to sustain favorable conditions of water flow. Favorable conditions of water flow are defined in terms of water quality, quantity, and timing.

Hydric soils—Soils developed in conditions where soil oxygen is limited by the presence of saturated soil for long periods during the growing season.

I

Immediate foreground—The area in the landscape from the viewer out to 300 feet distance.

Indicator—A measure or measurement of an aspect of a sustainability criterion. A quantitative or qualitative variable that can be measured or described and, when observed periodically, shows trends. Quantifiable performance measure of outcomes or objectives for attaining criteria designed to assess progress toward desired conditions.

Indigenous Knowledge—Proprietary information owned by Tribes and requires special safeguards and permissions to ensure that it is considered and applied in a manner that is prescribed by tribes and indigenous communities.

Infestation—The attack and successful colonization by macroscopic organisms in considerable concentration. Examples are infestations of tree crowns by eastern spruce budworm, timber by termites, soil or other substrates by nematodes or weeds.

INFRA infrastructure—An integrated database for collection, storage, and use of information about features, land units, facilities and utilities, accessibility and real property.

Inherent capability of the plan area—The ecological capacity or ecological potential of an area characterized by the interrelationship of its physical elements, climatic regime, and natural disturbances (USDA Forest Service 2012a).

In-stream flow—The presence of adequate stream flow in channels necessary to maintain the integrity of the stream channel, and protection of downstream beneficial uses including fish and wildlife needs, outdoor recreation uses of water, and livestock watering needs.

Integrated pest management—A process for selecting strategies to regulate forest pests in which all aspects of a pest-host system are studied and weighed.

Integrated resource management—Multiple use management that recognizes the interdependence of ecological resources and is based on the need for integrated consideration of ecological, social, and economic factors (USDA Forest Service 2012a).

Interdisciplinary team—A group of resource specialists (e.g., forester, wildlife biologist, hydrologist) responsible for developing the Forest Plan and Environmental Statement, and for making recommendations to the forest supervisor.

Intermediate treatments—A collective term for any treatment designed to enhance growth, quality, vigor, and composition of the stand after establishment of regeneration and prior to final harvest.

Intermittent stream—A stream or reach of stream channel that flows, in its natural condition, only during certain times of the year or in several years, and is characterized by interspersed, permanent surface water areas containing aquatic flora and fauna adapted to the relatively harsh environmental conditions found in these types of environments. Identified as dashed blue lines on United States Geological Survey 7.5-minute quadrangle maps.

Interpretive services—Visitor information services designed to present inspirational, educational, and recreational values to forest visitors in an effort to promote understanding, appreciation, and enjoyment of their forest experience.

Intolerant—A plant requiring sunlight and exposure for establishment and growth.

Invasive species—An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. A species that causes or is likely to cause harm and that is exotic to the ecosystem it has infested.

Inventoried roadless area—Areas identified in a set of inventoried roadless area maps, contained in the Forest Service Roadless Area Conservation, Final Environmental Impact Statement, vol. 2, dated November 2000, and any subsequent update or revision of those maps through the land management planning process (USDA Forest Service 2001).

K

Key ecosystem characteristics—Important specific elements of an ecosystem that sustain the long-term integrity of the ecosystems (USDA Forest Service 1991).

Key ecosystem services—Ecosystem services provided by the plan area that are important in the broader landscape outside the plan area and are likely to be influenced by the land management plan.

L

Land exchange—The conveyance of non-Federal land or interests in the land in exchange for NFS land or interests in land.

Landing—A cleared area in the forest where logs are yarded or skidded for loading onto trucks for transport.

Landline location—Legal identification and accurate location of national forest property boundaries.

Lands that may be suitable for timber production—A preliminary classification in the process of determining lands that are suited for timber production. Excludes NFS lands that are not suitable for timber production based on the factors identified in the National Forest Management Act of 1976. (NFMA 1976) (USDA Forest Service 2012a).

Landscape character—Particular attributes, qualities, and traits of a landscape that give it an image and make it identifiable or unique.

Large woody debris (LWD)—Logs, sticks, branches, and other wood that falls into streams and rivers. This debris can influence the flow and the shape of the stream channel.

Late-seral (successional) stage—The stage of forest development at which overstory trees have attained most of expected height growth and have reached ecological maturity. As used in the Environmental Impact Statement and the Forest Plan, it is generally defined by stand ages >80 years for most hardwood types, and by stand ages >60 years for most pine types. Old-growth forests occur during the later periods of this seral stage at ages that vary by forest type and in response to a variety of environmental conditions. See successional stage.

Lease—A contract between the landowner and another granting the latter the right to search for and produce oil, gas, or other mineral substances (as specified in the document) on payment of an agreed rental, bonus, or royalty. This right is subject to the terms, conditions, and limitations specified in the document.

Line officer—A Forest Service official who serves in a direct line of command from the Chief (USDA Forest Service 2012a).

M

Management area—A land area identified within the planning area that has the same set of applicable plan components. Does not have to be spatially contiguous (USDA Forest Service 2012a).

Management practices (vegetation management practices)—Silvicultural practices such as reforestation, prescribed fire, or thinning to reduce stand density, and other practices designed to facilitate growth and development of trees.

Maintain—In reference to an ecological condition: to keep in existence or continuance of the desired ecological condition in terms of its desired composition, structure, and processes. Depending upon the circumstance, ecological conditions may be maintained by active or passive management or both (USDA Forest Service 2012a).

Mast tree—Generally hardwood trees of the heavy seeded variety including oaks, hickories, black walnut, and beech that are ≥25 years old and capable of producing frequent seed crops to feed a variety of wildlife species.

Mean annual increment of growth—The total increment of increase of volume of a stand (standing crop plus thinnings) up to a given age divided by that age. In land management plans, it is expressed in cubic measure and is based on the expected growth of stands according to intensities and utilization guidelines in the plan (USDA Forest Service 2012a). See culmination of mean annual increment of growth.

Mechanical site preparation—Soil disturbance by mechanical chopping, furrowing, dozing, or disking to prepare areas for reforestation. Objective is to reduce plant competition for trees to be planted.

Mesic—Sites or habitats characterized by intermediate moisture conditions, i.e., neither decidedly wet nor dry.

Middle ground—The space between the foreground and the background in a picture or landscape. Generally, 0.5 mile to 4 miles distance from the viewer.

Mineral exploration—The search for valuable minerals on lands open to mineral entry.

Mineral resource—A known or undiscovered concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Minerals (leasable)—Federally managed minerals governed by the Mineral Leasing Act of 1920, as amended (MLA 1920), or the Mineral Leasing Act for Acquired Lands of 1947 (MLAAL 1947), and include energy minerals such as oil, gas and coal, and other mineral commodities such as phosphate, potassium, sodium, gilsonite, oil shale, and sulphur.

Minerals (salable)/mineral materials—Minerals that can be sold under a mineral material contract and are common. Relatively low value per volume (e.g., sand, gravel, cinders, common building stone, flagstone).

Mitigate—To avoid, minimize, rectify, reduce, or compensate the adverse environmental impacts associated with an action.

Monitoring—A systematic process of collecting information to evaluate effects of actions or changes in conditions or relationships (USDA Forest Service 2012a).

Motor Vehicle Use Map (MVUM)—A requirement of the Travel Management Final Rule and reflects travel management decisions on each national forest and national grassland. Displays NFS routes (roads and trails), or areas designated open to motorized travel. Also displays allowed uses by vehicle class (highway-legal vehicles, vehicles <50 inches wide, and motorcycles), seasonal allowances, and other travel rule and regulation information. Routes not shown on the MVUM are not open to public motor vehicle travel. Routes designated for motorized use may not always be signed on the ground but will be identified on the MVUM.

Multiple use—The management of all the various renewable surface resources of the NFS so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output, consistent with the Multiple-Use Sustained-Yield Act of 1960 (MUSYA 1960).

N

National Environmental Policy Act (NEPA) of 1969—An act to declare a national policy that will encourage productive and enjoyable harmony between humankind and the environment. It was created to promote efforts that will prevent or eliminate damage to the environment, biosphere, and stimulate the health and welfare of humanity. In addition, the act was crafted to enrich the understanding of the ecological systems and natural resources important to the Nation and establish a Council on Environmental Quality.

National Forest Land and Resource Management Plan (Forest Plan)—A plan developed to meet the requirements of the Forest and Rangeland Renewable Resources Planning Act of 1974, as amended, that guides all natural resource management activities and establishes management standards and guidelines for the NFS lands of a given national forest (FRRRPA 1974).

National Forest Management Act (NFMA) of 1976—Act passed as an amendment to the Forest and Rangeland Renewable Resources Planning Act, requiring the preparation of regional guides and Forest Plans, and the preparation of regulations to guide them.

National Forest System (NFS)—All national forest lands reserved or withdrawn from the public domain of the United States. All national forest lands acquired through purchase, exchange, donation, or other means.

National Forest System road—A forest road other than a road which has been authorized by a legally documented right-of-way held by a State, county, or local public road authority (USDA Forest Service 2012a).

National Forest System trail—A forest trail other than a trail that has been authorized by a legally documented right-of-way held by a State, county, or local public road authority (USDA Forest Service 2012a).

National Recreation Trails—Trails designated by the Secretary of the Interior or the Secretary of Agriculture as part of the national system of trails authorized by the National Trails System Act (1968) [NTSA 1968]. National recreation trails provide a variety of outdoor recreation uses, in or reasonably accessible to urban areas.

National Register of Historic Places—The Nation's official list of cultural resources worthy of preservation. Authorized under the National Historic Preservation Act of 1966, (NHPA 1966) it is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archeological resources. Properties listed in the Register include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archeology, engineering, and culture.

National Visitor Use Monitoring (NVUM)—A systematic process to estimate annual recreation and other uses of national forest lands through user surveys.

National Wild and Scenic Rivers System—Rivers with scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values designated by Congress under the Wild and Scenic Rivers Act of 1968, for preservation of their free-flowing condition (WSRA 1968).

National Wilderness Preservation System—All lands covered by the Wilderness Act of 1964 and subsequent wilderness designations, irrespective of the department or agency having jurisdiction.

Native knowledge—A way of knowing or understanding the world, including traditional ecological, and social knowledge of the environment derived from multiple generations of Indigenous Peoples' interactions, observations, and experiences with their ecological systems. Place-based and culture-based knowledge in which people learn to live in and adapt to their own environment through interactions, observations, and experiences with their ecological system. Generally not solely gained, developed by, or retained by individuals, but is rather accumulated over successive generations and is expressed through oral traditions, ceremonies, stories, dances, songs, art, and other means within a cultural context (USDA Forest Service 2012a).

Native species—An organism that was historically present or is currently present in a particular ecosystem as a result of natural migratory or evolutionary processes, and not as a result of an accidental or deliberate introduction into that ecosystem. An organism's presence and evolution (adaptation) in an area are determined by climate, soil, and other biotic and abiotic factors (USDA Forest Service 2012a).

Natural range of variation (NRV)—The variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application.

In contrast to the generality of historical ecology, the NRV concept focuses on a distilled subset of past ecological knowledge developed for use by resource managers; it represents an explicit effort to incorporate a past perspective into management and conservation decisions (adapted from Weins et al. 2012). The pre-European influenced reference period considered is sufficiently long, often several centuries, to include the full range of variation produced by dominant natural disturbance regimes such as fire and flooding and should also include short-term variation and cycles in climate. A tool for assessing ecological integrity and does not necessarily constitute a management target or desired condition. Can help identify key structural, functional, compositional, and connectivity characteristics for which plan components may be important for either maintenance or restoration of such ecological conditions.

Natural regeneration—An age class created from natural seeding, sprouting, suckering, or layering.

Noncommodity output—A resource output that cannot be bought and sold.

Nonforest land—Land that has never supported forests and lands formerly forested where use for timber utilization is precluded by development for other use. Lands that never have had, or that are incapable of having 10 percent or more of the area occupied by forest trees, or lands previously having such cover and currently developed for nonforest use.

Nonpoint source pollution—A diffuse source of pollution not regulated as a point source. May include atmospheric deposition, agricultural runoff, and sediment from land-distributing activities.

Nontimber forest products—All forest products except timber, including resins, oils, leaves, bark, plants other than trees, fungi, and animals or animal products.

O

Old forest—Forest lands that met the minimum age threshold to be considered old seral state, but these lands may or may not have other characteristics of old growth.

P

Partnership—Voluntary, mutually beneficial and desired arrangement between the Forest Service and another or others to accomplish mutually agreed-on objectives consistent with the agency’s mission and serving the public’s interest.

Payments in lieu of taxes—Payments to local or State governments based on ownership of Federal land, and not directly dependent on production of outputs or receipt sharing.

Perennial stream—A stream or reach of a channel that flows continuously or nearly so throughout the year and whose upper surface is generally lower than the top of the zone of saturation in areas adjacent to the stream. Identified as solid blue on the United States Geological Survey 7.5-minute quadrangle maps.

Plan area—The NFS lands covered by a Forest Plan (USDA Forest Service 2012a).

Plan or land management plan—A document or set of documents that provide management direction for an administrative unit of the NFS developed under the requirements of this part or a prior planning rule (USDA Forest Service 2012a).

Plan monitoring program—Defines plan monitoring questions and associated indicators, based on plan components. Informs management of resources on the plan area and enables the responsible official to determine if a change in plan components or other plan content may be needed.

Planning record—Includes documents that support analytical conclusions made and alternatives considered throughout the planning process (USDA Forest Service 2012a).

Precommercial thinning—The selective felling, deadening, or removal of trees in a young stand not for immediate financial return, but primarily to accelerate diameter increment on the remaining stems. To maintain a specific stocking or stand density range, or to improve the vigor and quality of the remaining trees.

Prescribed fire—Any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific objectives.

Proclamation boundary—The boundary contained within the presidential proclamation that established the national forest.

Productivity—The capacity of NFS lands and their ecological systems to provide the various renewable resources in certain amounts in perpetuity. For the purposes of this report, productivity is an ecological term, not an economic term (USDA Forest Service 2012a).

Projected timber sale quantity—The estimated quantity of timber meeting applicable utilization standards that is expected to be sold during the plan period. As a subset of the projected wood sale quantity, it includes volume from timber harvest for any purpose from all lands in the plan area based on expected harvests that would be consistent with the plan components. Also based on the planning unit's fiscal capability and organizational capacity. It is not a target or a limitation on harvest and not an objective unless the responsible official chooses to make it an objective in the plan.

Projected wood sale quantity—The estimated quantity of timber and all other wood products that is expected to be sold from the plan area for the plan period. Consists of the projected timber sale quantity as well as other woody material such as fuelwood, firewood, or biomass that is also expected to be available for sale. Includes volume from timber harvest for any purpose based on expected harvests that would be consistent with the plan components. Also based on the planning unit's fiscal capability and organizational capacity. It is not a target or a limitation on harvest and not an objective unless the responsible official chooses to make it an objective in the plan.

Proposed action—In terms of the NEPA, the project, activity, or decision that a Federal agency intends to implement or undertake. The proposed action described in the Environmental Impact Statement is the Forest Plan.

Proposed species—Any species of fish, wildlife, or plant that is proposed by the USFWS or the National Marine Fisheries Service in the Federal Register to be listed under Section 4 of the Endangered Species Act (1973) (ESA 1973, USDA Forest Service 2012a).

Pulpwood—Wood cut and prepared primarily for manufacture into wood pulp.

R

Rare species—Any native or once-native species of wild animal that exists in small numbers and has been determined to need monitoring. May include peripheral species.

Reclamation—The act or process of reclaiming; the state of being reclaimed. The Forest Service manages the reclamation of lands disturbed by mineral and associated activities to:

1. Minimize the environmental impacts resulting from such activities
2. Ensure that disturbed lands are returned to a use that is consistent with long-term forest land and resource management plans

Reconstruction—Work that includes, but is not limited to, widening of roads, improving alignment, providing additional turnouts, and improving sight distance that improves the standard to which the road was originally constructed. Also undertaken to increase the capacity of the road or to provide greater traffic safety.

Record of decision—A document separate from, but associated with an Environmental Impact Statement that publicly and officially discloses the responsible official's decision on the alternative assessed in the Environmental Impact Statement chosen to implement.

Recovery—For the purposes of this report and with respect to threatened or endangered species, the improvement in the status of a listed species to the point at which listing as federally endangered or threatened is no longer appropriate (USDA Forest Service 2012a).

Recreation capacity—A measure of the number of people a site can reasonably accommodate at one time. Sometimes measured as persons at one time.

Recreation opportunity—An opportunity to participate in a specific recreation activity in a particular recreation setting to enjoy desired recreation experiences and other benefits that accrue. Include nonmotorized, motorized, developed, and dispersed recreation on land, water, and in the air (USDA Forest Service 2012a).

Recreation opportunity spectrum—A method for classifying types of recreation experiences available, or for specifying recreation experience objectives desired in certain areas. Classes are primitive, semiprimitive nonmotorized, semiprimitive motorized, roaded natural, rural, and urban.

Recreation setting—The social, managerial, and physical attributes of a place that, when combined, provides a distinct set of recreation opportunities. The Forest Service uses the **recreation opportunity spectrum** to define recreation settings and categorize them into six distinct classes: primitive, semiprimitive nonmotorized, semiprimitive motorized, roaded natural, rural, and urban (USDA Forest Service 2012a).

Recreation visit—The entry of one person upon a national forest to participate in recreation activities for an unspecified period of time. A national forest visit can be composed of multiple site visits.

Redundancy—The ability of a species to withstand catastrophic events, which is related to the number, distribution and resilience of populations.

Reforestation—The reestablishment of forest cover by seeding, planting, and natural means.

Regeneration—The act of renewing of a tree crop by establishing young trees naturally or artificially. Also, the young crop itself.

Regeneration harvest—Any removal of trees intended to assist in the regeneration of a new age class or to make regeneration of a new age class possible. Regeneration harvest may be through even-aged or uneven-aged methods.

Renewable energy—Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action (USDA Forest Service 2011).

Reserve trees—Trees, pole-sized or larger, retained after the regeneration period under the clearcut, seed-tree, shelterwood, or coppice methods.

Reserved mineral rights—Refers to those cases wherein the minerals were severed from the surface during the transaction whereby the Government acquired the land. These rights are subject to the Secretary of Agriculture's rules and regulations that were applicable at the time of the transaction.

Resilience/resiliency—The ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances through preservation, restoration, or improvement of its essential structures and functions and redundancy of ecological patterns across the landscape.

Restocked—The condition of the growing space occupancy of trees to be achieved after a disturbance that has substantially altered the existing stocking. See stocking.

Restoration, ecological—The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Focuses on re-establishing the composition, structure, pattern, and ecological processes necessary to facilitate terrestrial and aquatic ecosystems sustainability, resilience, and health under current and future conditions (USDA Forest Service 2012a).

Restoration, functional—Restoration of abiotic and biotic processes in degraded ecosystems. Focuses on the underlying processes that may be degraded, regardless of the structural condition of the ecosystem. The manipulation of interactions among process, structure, and composition in a degraded ecosystem to improve its operations. Aims to restore functions and improve structures with a long-term goal of restoring interactions between function and structure. It may be, however, that a functionally restored ecosystem will look quite different than the reference condition in terms of structure and composition and these disparities cannot be easily corrected because some threshold of degradation has been crossed or the environmental drivers, such as climate, that influenced structural and (especially) compositional development have changed. Ecosystem may have a different structure and composition than the historical reference condition. As contrasted with ecological restoration that tends to seek historical reference condition, functional restoration focuses on the dynamic processes that drive structural and compositional patterns.

Restore—To renew by the process of restoration. See restoration (USDA Forest Service 2012a).

Revegetation—The re-establishment and development of a plant cover. This may take place naturally through the reproductive processes of the existing flora or artificially through the direct action of humans (e.g., afforestation and range reseeding).

Right-of-way—Public or NFS lands authorized to be used or occupied pursuant to a right-of-way grant or special use authorization.

Riparian areas—Three-dimensional ecotones (the transition zone between two adjoining communities) of interaction that include terrestrial and aquatic ecosystems that extend down into the groundwater, up above the canopy, outward across the floodplain, up the near slopes that drain to the water, laterally into the terrestrial ecosystem, and along the water course at variable widths (USDA Forest Service 2012a).

Riparian ecosystems—A transition area between the aquatic ecosystem and the adjacent terrestrial ecosystem. Identified by soil characteristics or distinctive vegetation communities that require free or unbound water.

River classifications (Wild and Scenic Rivers)

- Wild—Rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.
- Scenic—Rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.
- Recreational—Rivers or sections of rivers that are readily accessible by road or railroad, which may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

Road—A motor vehicle travelway >50 inches wide, unless designated and managed as a trail. May be classified, unclassified, or temporary.

Road maintenance levels—A formally established set of objectives that describes the conditions necessary to achieve the planned operation of a road. Levels range from level I, basic custodial care, to level V, which is assigned to high use roads in which user safety and comfort are important considerations.

Rotation—The number of years required to establish, including the regeneration period, and grow timber crops, to a specified condition or maturity for harvest.

Runoff—The total stream discharge of water from a watershed including surface and subsurface flow, but not groundwater. Usually expressed in acre-feet.

Rural—A recreation opportunity spectrum classification for areas characterized by a substantially modified natural environment. Sights and sounds of humans are evident. Renewable resource modification and utilization practices enhance specific recreation activities or provide soil and vegetative cover protection.

S

Sacred site, Indian sacred sites—Any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion; provided that the Indian tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site (EO 13007).

Sawtimber—Trees suitable in size and quality for producing logs that can be processed into dimension lumber.

Scenery Management System—An overall framework for the orderly inventory, analysis, and management of scenery (USDA Forest Service 2003).

Scenic character—A combination of the physical, biological, and cultural images that gives an area its scenic identity and contributes to its sense of place. Scenic character provides a frame of reference from which to determine scenic attractiveness and to measure scenic integrity (USDA Forest Service 2012a).

Scenic attractiveness—The scenic importance of a landscape based on human perceptions of the intrinsic beauty of landform, rockform, waterform, and vegetation pattern. Classified as A (distinctive), B (typical or common), or C (undistinguished).

Scenic class—A system of classification describing the importance or value of a particular landscape or portions of that landscape. Values range from 1 (highest value) to 7 (lowest value).

Scenic integrity objectives and landscape character goals—A desired level of excellence based on physical and sociological characteristics of an area. Refers to the degree of acceptable alterations of the characteristic landscape. Scenic integrity objectives are classified as very high (unaltered), high (appears unaltered), moderate (slightly altered), and low (moderately altered). These are developed for Forest Plan Management Areas.

Sediment—Solid mineral and organic material that is in suspension, being transported, or has been moved from its site of origin by air, water, gravity, or ice.

Seed tree—An even-aged regeneration method where in a single cut, all merchantable trees in a stand are removed, except a small number of widely dispersed trees are retained for seed production, and to produce a new age class in a fully exposed microenvironment.

Seep—A wet area where a seasonal high water table intersects with the ground surface. Seeps that meet the definition of a wetland are included in the riparian corridor.

Seral stage—A stage of secondary successional development. Secondary succession refers to an ecological process of progressive changes in a plant community after stand-initiating disturbance.

Shelterwood—A regeneration method of regenerating an even-aged stand in which a new age class develops beneath the partially shaped microenvironment provided by the residual trees.

Shelterwood with reserves—A two-aged regeneration method in which some or all of the shelter trees are retained, well beyond the normal period of retention, to attain goals other than regeneration.

Silvicultural system—A management process whereby forests are tended, harvested, and replaced, resulting in a forest of distinctive form. Classified according to the method of carrying out the fellings that remove the mature crop and provide for regeneration, and the resulting type of forest produced.

Silviculture—The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands. Entails the manipulation of forest and woodland vegetation in stands and on landscapes to meet the diverse needs and values of landowners and society on a sustainable basis.

Single-tree selection—A regeneration method of creating new age classes in uneven-aged stands in which individual trees of all size classes are removed uniformly throughout the stand to achieve desired stand structural characteristics.

Site preparation—The preparation of the ground surface prior to reforestation. Various treatments are applied as needed to control vegetation that will interfere with the establishment of the new crop of trees or to expose the mineral soil sufficiently for the establishment of the species to be reproduced.

Site index—A series-specific measure of actual or potential forest productivity (site quality, usually for even-aged stands), expressed in terms of the average height of trees included in a specified stand component (defined as a certain number of dominants, codominants, or the largest and tallest trees per unit area) at a specified index or base age.

Site quality (productivity)—The productive capacity of a site, usually expressed as volume production of a given species.

Skid trails—A travel way through the woods formed by loggers dragging (skidding) logs from the stump to a log landing without dropping a blade and without purposefully changing the geometric configuration of the ground over which they travel.

Skidding—A term for moving logs by dragging from stump to roadside, deck, or other landing.

Slash—The residue left on the ground after felling, silvicultural operations, or as a result of storm, fire, girdling, or poisoning. All vegetative debris resulting from the purchaser's operations. Slash associated with construction of roads is subject to treatment according to construction specifications; all other is subject to the terms of contract provision B/BT6.7.

Snag—A dead or partially dead (>50 percent) hardwood or pine tree that is used by many bird species for perching, feeding, or nesting.

Soil productivity—The inherent capacity of a soil to support the growth of specified plants, plant communities, or a sequence of plant communities. May be expressed in terms of volume or weight per unit area per year, percentage of plant cover, or other measures of biomass accumulation.

Soil survey—The systematic examination of soils in the field and in laboratories; their description and classification; the mapping of kinds of soil; the interpretation of soils according to their adaptability for various crops, grasses, and trees; their behavior under use of treatment for plant production or for other purposes; and their productivity under different management systems.

Special-use authorization—A permit, term permit, or easement that allows occupancy, use, rights, or privileges of NFS land.

Special-use permit—A permit issued under established laws and regulations to an individual, organization, or company for occupancy or use of national forest land for some special purpose.

Species groups—A group of species that are associated with the same habitat conditions. Groupings are made based on the ecological conditions necessary to maintain or, in the case of federally listed threatened or endangered species, recover each group member.

Species of conservation concern—A species of conservation concern is a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area (USDA Forest Service 2012a).

Spring—A water source located where water begins to flow from the ground due to the intersection of the water table with the ground surface. Generally flows throughout the year. Those that are the source of perennial or intermittent streams are included in the riparian corridor.

Stand—A contiguous group of trees sufficiently uniform in age class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit, such as a mixed, pure, even-aged, or uneven-aged stand.

Stand density—A quantitative measure of stocking expressed either absolutely per unit of land in terms of number of trees, basal area, volume per unit area, or relative to some standard condition.

Stand improvement—A term comprising all intermediate cuttings made to improve the composition, structure, condition, health, and growth of even-aged, two-aged, or uneven-aged stands.

Standards—A standard is a mandatory constraint on project and activity decisionmaking, established to help achieve or maintain the desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements.

Stocking—An indication of growing space occupancy of trees relative to plan-defined desired conditions for the stand or area. Common indices of stocking include the number of trees by size and spacing, percentage of occupancy, basal area, relative density, or crown completion factor.

Streamside zones—Landscape unit that includes riparian areas and adjacent lands that mitigate the movement of sediment, nutrients, and other chemicals from upland forest and agricultural management areas into streams.

Stressors—Actors that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process in a manner that may impair its ecological integrity, such as an invasive species, loss of connectivity, or the disruption of a natural disturbance regime (USDA Forest Service 2012a).

Successional stage—A period, marked by distinctiveness of structure, in the development of a forest community from establishment of tree regeneration to advanced age.

Supply—The amount of a good or service that producers are willing to provide at a specified price, time period, and condition of sale.

Suitability of lands—A determination that specific lands within a plan area may be used, or not, for various multiple uses or activities, based on the desired conditions applicable to those lands. Determinations need not be made for every use or activity, but every plan can identify those lands that are not suitable for timber production.

Sustainability—The capability to meet the needs of the present generation without compromising the ability of future generations to meet their needs. For the purposes of this report **ecological sustainability** refers to the capability of ecosystems to maintain ecological integrity; **economic sustainability** refers to the capability of society to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits; and **social sustainability** refers to the capability of society to support the network of relationships, traditions, culture, and activities that connect people to the land and to one another, and support vibrant communities (USDA Forest Service 2012a).

Sustainable recreation—The set of recreation settings and opportunities on the NFS that is ecologically, economically, and socially sustainable for present and future generations (USDA Forest Service 2012a).

Sustained yield limit (SYL)—The amount of timber, meeting applicable utilization standards, which can be removed from a forest annually in perpetuity on a sustained-yield basis (NFMA 1976, USDA Forest Service 2012a). It is the volume that could be produced in perpetuity on lands that may be suitable for timber production. Calculation of the limit includes volume from lands that may be deemed not suitable for timber production after further analysis during the planning process. The calculation is not limited by land management plan desired condition, other plan components, or the planning unit's fiscal capability and organizational capacity. It is not a target but a limitation on harvest, except when the plan allows for a departure.

T

Temporary roads—Roads authorized by contract, permit, lease, other written authorization or emergency operation not intended to be part of the forest transportation system and not necessary for long-term management (USDA Forest Service 2012a).

Thinning—A cutting made to reduce stand density of trees primarily to improve growth, enhance forest health, or to recover potential mortality.

Threatened species—Any species that the Secretary of the Interior or the Secretary of Commerce has determined is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Threatened species are listed at 50 CFR sections 17.11, 17.12, 223.102 (USDI FWS 1973).

Timber harvest—The removal of trees for wood fiber use and other multiple use purposes (USDA Forest Service 2012a).

Timber production—The purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use (USDA Forest Service 2012a).

Timber stand improvement—All intermediate cuttings made to improve the composition, constitution, condition, and increment of a timber stand.

Timber supply—The amount of wood raw material available to be harvested within specified parameters of time and geographic area.

Tribal consultation—A formal government-to-government process that enables Indian Tribes and Alaska Native Corporations to provide meaningful timely input and, as appropriate, exchange views, information, and recommendations on Forest Service proposed policies or actions that may affect their rights or interests prior to a decision. A unique form of communication characterized by trust and respect (FR 2000).

Two-aged system—A planned sequence of treatments designed to regenerate or maintain a timber stand with two age classes. A two-aged system is a form of even-aged management.

U

Unauthorized trail—A trail that is not a forest trail or a temporary trail and that is not included in a forest transportation atlas (USDA Forest Service 2012a).

Understory—The trees and other vegetation growing under a more or less continuous cover of branches and foliage formed collectively by the upper portion (overstory) of adjacent trees and other woody growth.

Uneven-aged stand—A stand of trees of three or more distinct age classes, either intimately mixed or in groups.

Uneven-aged system—A planned sequence of treatments designed to regenerate or maintain a timber stand with three or more age classes. Treatments include single-tree selection and group selection regeneration methods.

Urban—An area characterized by a substantially urbanized environment. The background may have natural-appearing elements.

Utilization standards—Specifications for merchantable forest products offered in a timber sale.

V

Values, market—Prices of market goods and services measured in real dollars in terms of what people are willing to pay as evidenced by market transactions.

Values, nonmarket—Prices of nonmarket goods and services imputed from other economic values.

Vegetation management—An activity that changes the composition, structure, or other characteristics of vegetation to meet specific objectives. A variety of vegetation treatments or silvicultural prescriptions may be used, with the most common methods being timber harvest (may be regeneration, intermediate, or salvage harvests), precommercial thinning (i.e., in sapling stands), fuel reduction treatments (may be commercial or noncommercial products), prescribed fire, or tree or shrub planting.

Viable population—A population of a species that continues to persist over the long term with sufficient distribution to be resilient and adaptable to stressors and likely future environments (USDA Forest Service 2012a).

Viewshed—The total landscape seen, or potentially seen from all or a logical part of a travel route, use area, or water body.

Visual resource—The composite of basic terrain, geological features, water features, vegetative patterns, and land-use effects that typify a land unit and influence the visual appeal the unit may have for visitors.

W

Water yield—The measured output of the forest's streams expressed in acre-feet. The amount or volume of water that flows in a given period of time from a watershed.

Waterbars—A change in the grade of a roadbed, trail surface, or fire line used to divert water off the surface to prevent it from eroding ruts and possibly carrying sediment to a stream.

Watershed—A region or land area drained by a single stream, river, or drainage network; a drainage basin (USDA Forest Service 2012a).

Watershed condition—The state of a watershed based on physical and biogeochemical characteristics and processes (USDA Forest Service 2012a).

Wetlands—Those areas that are inundated by surface or ground water with a frequency sufficient to support and that, under normal circumstances, do or would support a prevalence of vegetation or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Generally includes swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Wild and Scenic River—A river designated by Congress as part of the National Wild and Scenic Rivers System that was established in the Wild and Scenic Rivers Act of 1968 (WSRA 1968) for possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values.

Wilderness—Any area of land designated by Congress as part of the National Wilderness Preservation System that was established in the Wilderness Act of 1964 (Wilderness Act 1964).

Wilderness study area—One of the areas selected by the Chief of the Forest Service from an inventory of undeveloped NFS lands as having apparent high qualities for wilderness. Lands possessing the basic characteristics of wilderness and designated by Congress for further wilderness study. A study can determine whether areas can be recommended for addition to the National Wilderness Preservation System.

Wildfire—An unplanned, unwanted wildland fire, which includes unauthorized human-caused fires, escaped wildland fire use events, escaped prescribed fire projects, and all other wildland fires where the objective is to put the fire out.

Wildland fire—Any nonstructure fire that occurs in vegetation or natural fuels. Wildland fire includes prescribed fire and wildfire.

Wildland urban interface (WUI)—The line, area, or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels. Describes an area within or adjacent to private and public property where mitigation actions can prevent damage or loss from wildfire.

Wildlife—All nondomesticated mammals, birds, reptiles, and amphibians living in a natural environment, including game species and nongame species. Does not include animals, or their progeny (i.e., feral animals including horses, burros, and hogs) that once were domesticated, but escaped captivity.

Woodlands—A forested condition with an open tree canopy. Tree crowns are not usually touching (generally forming 25 to 60 percent cover).

Woody biomass—Includes logging slash, limbs, tops, and small-diameter trees that would typically be noncommercial.

X

Xeric—Pertaining to sites or habitats characterized by decidedly dry conditions.

Y

Yarding—Operations used to move logs from stump to point where logs are loaded for transport to mill. Most commonly used in cable logging operations.

References for Glossary

Endangered Species Act of 1973 [ESA]; 16 U.S.C. 1531–1543.

Executive Order 13007 [EO]; 108 Stat. 4791. Public Law 103–454.

Federal Register [FR]. 2000. Consultation and Coordination With Indian Tribal Governments. https://www.govinfo.gov/content/pkg/FR-2000-11-09/pdf/00-29003.pdf. [Date accessed: 15 December 2025].

Forest and Rangeland Renewable Resources Planning Act of 1974 [FRRRPA]; 16 U.S.C. 1600. 93–378.

Indian Tribe List Act of 1994 [ITLA]; 108 Stat. 4791. Public Law 103–454.

Mineral Leasing Act for Acquired Lands of 1947. [MLAAL]; 30 U.S.C. 351 et seq.

Mineral Leasing Act of 1920 [MLA], as amended 1920; 30 U.S.C. 181–287.

Multiple-Use Sustained-Yield Act of 1960 [MUSYA]; 74 Stat. 215; 16 U.S.C. 528–531.

National Environmental Policy Act of 1969 [NEPA]; 42 U.S.C. 4321 et seq.

National Forest Management Act of 1976 [NFMA]; 16 U.S.C. 1600. 94–588.

National Historic Preservation Act of 1966 [NHPA]; 16 U.S.C. 89–665.

National Trails System Act 1968 [NTSA]; 82 Stat. 919. Public Law 90–543.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2001. Code of Federal Regulations, Title 36, 294. Forest Service Roadless Area Conservation. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2012a. Code of Federal Regulations, Title 36, 219.3. Parks, Forests, and Public Property, Chapter II; Part 219, Planning, Section A–National Forest System Land and Resource Management Planning; Section 219.19. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2012b. Code of Federal Regulations, Title 36, 219.3. Parks, Forests, and Public Property, Chapter II; Part 219, Planning, Section A–National Forest System Land and Resource Management Planning; Section 219.19. Part 800, Protection of Historic Properties. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2011. Division of Oil and Gas Resources Management – Oil and Gas. Permit required to drill, reopen, convert or plug back well. FSH 1509.5. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2015. Land Management Planning Handbook. FSH 1909, Chapter 10, Assessment sec. 12.14. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1991. Ecological Classification and Inventory Handbook. FSH 2090.11-05. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1992. Timber Resource Planning Handbook. FSH 2409.13-05. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1996. Timber Sale Administrative Handbook. FSH 2409.15-05. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1985. Silvicultural Practices Handbook, Chapter 9 - Timber Stocking Guides and Growth Predictions, 9.05 - Definitions. FSH 2409.17-9.05. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1992. Wildlife and Fisheries Program Management Handbook. FSH 2609.70.5. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 1985. Road Rights-of-Way Grants Handbook. FSH 2709.12-05. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2003. Scenery Management handbook. FSH 2382. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2009. Planning definitions. FSM 1905. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2005. Grazing and Livestock Use Permit System. FSM 2230. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2009. Trail, River and Similar Recreation Opportunities. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2008. Recreation, Wilderness, and Related Resource Management and Heritage Program Management. FSM 2300, 2360. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2004. Watershed and Air Management and Watershed Protection and Management. FSM 2500, 2521. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2005a. Watershed and Air Management and Watershed Protection and Management. FSM 2500, 2526. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2005b. Watershed and Air Management and Watershed Protection and Management. FSM 2500, 2527. Washington, DC.

U.S. Department of Agriculture, Forest Service [USDA Forest Service]. 2005c. Wildlife, Fish, and Sensitive Plant Habitat Management Definitions. FSM 2670. Washington, DC.

U.S. Department of Interior, Fish and Wildlife. [USDI FWS]. 1973. Endangered and threatened wildlife and plants. Washington, DC.

U.S. Department of Agriculture, Forest Service. [USDA Forest Service]. 2011. Strategic energy framework. Washington, DC: USDA Forest Service, Office of the Deputy Chief, National Forest System.

U.S. Department of Agriculture, Natural Resources Conservation Service. [USDA NRCS]. 2012. Highly Erodible Land Conservation and Wetland Conservation Compliance. highlyerodibleland_factsheet.pdf. [Date accessed: 29 September 2025].

Wildfire Coordinating Group (NWCG). 2014. Glossary of Wildland Fire Terminology. https://www.nwcg.gov/pms/pms.htm. [Date accessed: October 2014].

Wiens, J.A.; Hayward, G.D.; Safford, H.D.; Giffen, C., eds. 2012. Historical environmental variation in conservation and natural resource management. New York: John Wiley and Sons.

Wilderness Act of 1964 [Wilderness Act]; 16 U.S.C. 1131–1136.

Wild and Scenic Rivers Act of 1968 [WSRA]; 16 U.S.C. 1271-1287.

APPENDIX 1—ACRONYMS

D.b.h. – diameter at breast height
FEIS – Final Environmental Impact Statement
FIA – Forest Inventory and Analysis
FRCC – Fire Regime Condition Class
FSH – Forest Service Handbook
FSM – Forest Service Manual
FVS – Forest Vegetation Simulator
GIS – geographic information system
NEPA – National Environmental Policy Act
NF – national forest
NFMA – National Forest Management Act
NPS – National Parks Service
NRCS – Natural Resources Conservation Service
OHV – off-highway vehicle
ROW – right-of-way
USDA – U.S. Department of Agriculture
USDOI – U.S. Department of the Interior
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey
USFS RO – U.S. Forest Service Regional Office

APPENDIX 2—SPECIES LIST BY TAXONOMIC GROUP AND SCIENTIFIC NAME

Names follow those used by the USDA Natural Resources Conservation Plants Database (plants: https://plants.sc.egov.usda.gov/home), Integrated Taxonomic Information System (vertebrate animals: https://www.usgs.gov/tools/integrated-taxonomic-information-system-itis), and the Global Biodiversity Information Facility (invertebrate animals, fungi, water molds, and lichens: https://www.gbif.org/). All names reflect access as of 20 May 2024. Two species, marked with *, did not show up in any of the databases. The names reflect common usage in journal articles and USDA Forest Service publications.

All Sections Species List by Taxonomic Group by Scientific Name

BACTERIA

Scientific name	Common name
*Candidatus Phytoplasma ulmi**	Elm yellows

WATER MOLDS

Scientific name	Common name
Phytophthora cinnamomi	Littleleaf disease

FUNGI

Scientific name	Common name
Ceratocystis fagacearum	Oak wilt
Cronartium quercuum [f. sp. *fusiforme*]	Fusiform rust
Cryphonectria parasitica	Chestnut blight
Discula destructiva	Dogwood anthracnose
Harringtonia lauricola	Laurel wilt
Heterobasidion irregulare	Heterobasidion root disease
Neonectria ditissima	Beech bark disease
Neonectria faginata	Beech bark disease
Ophiostoma novo-ulmi	Dutch elm disease
Ophiostoma himal-ulmi	Dutch elm disease
Ophiostoma ulmi	Dutch elm disease
Porodaedalea pini	Red heart rot
Scirrhia acicola	Brown spot needle blight

LICHENS

Scientific name	Common name
Arthonia kermesina	Hot dots
Arthopyrenia betulicola	Old birch spots
Graphis sterlingiana	Sterling lips
Lobaria pulmonaria	Lungwort

MOSSES

Scientific name	Common name
Hypnum imponens	Log moss, carpet moss, feather moss
Hypnum curvifolium	Log moss, carpet moss, feather moss
Thuidium delicatulum	Log moss, fern moss
Sphagnum spp.	Sphagnum

VASCULAR PLANTS

Scientific name	Common name
Abies fraseri	Fraser fir
Abies spp.	Fir species
Acer floridanum	Southern sugar maple
Acer negundo	Boxelder
Acer rubrum	Red maple
Acer saccharinum	Silver maple
Acer saccharum	Sugar maple, hard maple
Acer spicatum	Mountain maple
Aesculus flava	Yellow buckeye, buckeye
Ailanthus altissima	Tree of heaven, tree-of-heaven
Allium tricoccum	Ramps
Andropogon spp.	Bluestem species
Andropogon gerardii	Big bluestem
Andropogon gyrans	Elliott's bluestem
Andropogon virginicus	Broomsedge
Aristida beyrichiana	Beyrich's threeawn, Beyrich's wiregrass
Aristida stricta	Pineland threeawn, wiregrass
Aronia arbutifolia	Red chokeberry
Aronia melanocarpa	Black chokeberry
Arundinaria gigantea	Giant cane, river cane

Scientific name	Common name
Arundinaria tecta	Switch cane
Berberis thunbergii	Japanese barberry
Betula spp.	Birch species
Betula alleghaniensis	Yellow birch
Betula lenta	Sweet birch, black birch
Betula nigra	River birch
Bignonia capreolata	Crossvine
Carex pensylvanica	Pennsylvania sedge
Carex spp.	Sedge species
Carpinus caroliniana	American hornbeam, bluebeech, musclewood
Carya spp.	Hickory species
Carya aquatica	Water hickory
Carya cordiformis	Bitternut hickory
Carya glabra	Pignut hickory
Carya illinoinensis	Pecan
Carya ovalis	Red hickory
Carya ovata	Shagbark hickory
Carya texana	Black hickory
Carya tomentosa	Mockernut hickory
Castanea dentata	American chestnut
Celtis laevigata	Sugarberry
Celtis occidentalis	Hackberry
Cephalanthus occidentalis	Common buttonbush
Chamaecyparis thyoides	Atlantic white cedar
Chimaphila maculata	Striped prince's pine, pipsissewa
Cornus amomum	Silky dogwood
Cornus florida	Flowering dogwood
Cornus foemina	Southern swamp dogwood
Crataegus spp.	Hawthorn species
Danthonia spicata	Poverty oatgrass
Danthonia spp.	Oatgrass species
Desmodium spp.	Ticktrefoil species
Dichanthelium sphaerocarpon	Roundseed panicgrass

Scientific name	Common name
Dichanthelium spp.	Panicgrass species
Elymus hystrix	Eastern bottlebrush grass
Fagus grandifolia	American beech, beech
Forestiera ligustrina	Upland swampprivet
Frangula caroliniana	Carolina buckthorn
Fraxinus spp.	Ash species
Fraxinus americana	White ash
Fraxinus caroliniana	Carolina ash
Fraxinus nigra	Black ash
Fraxinus pennsylvanica	Green ash
Fraxinus quadrangulata	Blue ash
Gaylussacia spp.	Huckleberry species
Gleditsia aquatica	Water locust
Gordonia lasianthus	Loblolly bay
Halesia tetraptera	Mountain silverbell, silverbell
Ilex decidua	Possumhaw
Ilex opaca	American holly
Ilex verticillata	Winterberry
Ilex vomitoria	Yaupon
Imperata cylindrica	Cogongrass
Juglans nigra	Black walnut, walnut
Juniperus virginiana	Eastern redcedar
Kalmia latifolia	Laurel, mountain
Lauraceae	Sassafras family
Lespedeza cuneata	Sericea lespedeza
Lindera melissifolia	Pondberry
Liquidambar styraciflua	Sweetgum, gum
Liriodendron tulipifera	Tuliptree, yellow poplar, yellow-poplar
Magnolia spp.	Magnolia species
Magnolia acuminata	Cucumber magnolia
Magnolia fraseri	Fraser magnolia
Magnolia grandiflora	Southern magnolia
Magnolia macrophylla	Magnolia bigleaf

Scientific name	Common name
Magnolia virginiana	Sweetbay
Miscanthus sinensis	Chinese silver grass
Nyssa aquatica	Water tupelo, tupelo
Nyssa biflora	Swamp tupelo, tupelo
Nyssa spp.	Tupelo species, blackgum, gum
Nyssa sylvatica	Blackgum
Ostrya virginiana	Hophornbeam
Oxydendrum arboreum	Sourwood
Panax quinquefolius	American ginseng
Panicum spp.	Panicgrass species
Panicum virgatum	Switchgrass
Parthenocissus quinquefolia	Virginia creeper
Persea borbonia	Redbay
Picea spp.	Spruce
Picea rubens	Red spruce
Pinus echinata	Shortleaf pine
Pinus elliottii var. *densa*	Florida slash pine
Pinus elliottii var. *elliottii*	Slash pine
Pinus elliottii	Slash pine
Pinus glabra	Spruce pine
Pinus palustris	Longleaf pine, longleaf
Pinus pungens	Table Mountain pine
Pinus rigida	Pitch pine
Pinus serotina	Pond pine
Pinus spp.	Pine species
Pinus subsp. *Pinus*	Yellow pines
Pinus strobus	Eastern white pine, white pine
Pinus taeda	Loblolly pine
Pinus virginiana	Virginia pine
Piptochaetium avenaceum	Blackseed speargrass, needlegrass
Planera aquatica	Planertree, waterelm
Platanus occidentalis	American sycamore, sycamore
Polygonum cuspidatum	Japanese knotweed

Scientific name	Common name
Populus deltoides	Eastern cottonwood
Populus heterophylla	Swamp cottonwood
Prunus serotina	Black cherry, cherry
Pseudotsuga menziesii	Douglas fir
Pteridium spp.	Bracken fern species
Pueraria montana	Kudzu
Quercus spp.	Oak species; scrub oak if small stature species
Quercus alba	White oak
Quercus arkansana	Arkansas oak
Quercus bicolor	Swamp white oak
Quercus coccinea	Scarlet oak
Quercus falcata	Southern red oak
Quercus geminata	Sand live oak
Quercus incana	Bluejack oak
Quercus laevis	Turkey oak
Quercus laurifolia	Laurel oak
Quercus lyrata	Overcup oak
Quercus macrocarpa	Bur oak
Quercus margarettae	Sand post oak
Quercus marilandica	Blackjack oak
Quercus michauxii	Swamp chestnut oak
Quercus mohriana	Mohr's oak
Quercus montana	Chestnut oak
Quercus muehlenbergii	Chinquapin oak
Quercus nigra	Water oak
Quercus pagoda	Cherrybark oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak
Quercus rubra	Northern red oak, red oak
Quercus shumardii	Shumard oak
Quercus stellata	Post oak
Quercus texana	Nuttall oak
Quercus velutina	Black oak

Scientific name	Common name
Quercus virginiana	Live oak
Rhododendron canescens	Piedmont azalea
Rhododendron catawbiense	Catawba rosebay
Rhododendron maximum	Great laurel, white rosebay
Rosa multiflora	Multiflora rose
Sabal minor	Dwarf palmetto
Sabal palmetto	Cabbage palmetto
Salix spp.	Willow species
Salix nigra	Black willow
Sambucus nigra spp. *canadensis*	American black elderberry
Sambucus racemosa var. *racemosa*	Red elderberry
Sassafras albidum	Sassafras
Schizachyrium spp.	Bluestems
Schizachyrium scoparium	Little bluestem
Schizachyrium tenerum	Bluestem, slender little
Smilax spp.	Greenbrier species
Sorbus americana	American mountain ash
Sorghastrum spp.	Indiangrass species
Sorghastrum nutans	Indiangrass
Symplocos tinctoria	Common sweetleaf, horse sugar
Taxodium spp.	Bald cypress, baldcypress, bald-cypress, pond cypress, pond-cypress, cypress
Taxodium ascendens	Pond cypress, pond-cypress, cypress
Taxodium distichum	Bald cypress, baldcypress, bald-cypress, cypress
Tilia americana var. *americana*	American basswood, basswood
Tilia americana var. *caroliniana*	Carolina basswood
Toxicodendron radicans	Eastern poison ivy
Triadica sebifera	Chinese tallow
Tsuga canadensis	Eastern hemlock, hemlock
Tsuga caroliniana	Carolina hemlock
Ulmus alata	Winged elm
Ulmus americana	American elm
Ulmus crassifolia	Cedar elm
Ulmus rubra	Slippery elm

Scientific name	Common name
Ulmus spp.	Elm species
Vaccinium corymbosum	Highbush blueberry
Vaccinium elliottii	Elliott's blueberry
Vaccinium erythrocarpum	Southern mountain cranberry
Vaccinium formosum	Southern highbush blueberry
Vaccinium spp.	Blueberry species
Viburnum spp.	Blackhaw species
Viburnum lantanoides	Hobblebush
Vitis spp.	Grape species
Vitis rotundifolia	Muscadine
Xanthorhiza simplicissima	Yellowroot

GASTROPODS

Scientific name	Common name
Carychium exile	Micro-snail ice thorn

SPIDERS

Scientific name	Common name
Microhexura montivaga	Spruce-fir moss spider

INSECTS

Scientific name	Common name
Adelges piceae	Balsam woolly adelgid
Adelges tsugae	Hemlock woolly adelgid
Agrilus bilineatus	Twolined chestnut borer
Agrilus planipennis	Emerald ash borer
Cryptococcus fagisuga	Beech scale
Dendroctonus frontalis	Southern pine beetle
Dendroctonus terebrans	Black turpentine beetle
Dioryctria yatesi	Mountain pinecone worm
Ips avulsus	Small southern pine engraver beetle, ips engraver beetle
Ips calligraphus	Coarsewriting engraver beetle, ips engraver beetle
Ips grandicollis	Eastern five-spined engraver beetle, ips engraver beetle
Ips spp.	Pine engraver beetles
Lymantria dispar	Spongy moth (formerly gypsy moth)
Neodiprion excitans	Blackheaded pine sawfly

Scientific name	Common name
Phellopsis obcordata	Eastern ironclad beetle
Xyleborus glabratus	Redbay ambrosia beetle
Xylococculus betulae	Beech scale

FISH

Scientific name	Common name
Oncorhynchus mykiss	Trout, rainbow trout
Salmo trutta	Trout, brown trout
Salvelinus fontinalis	Trout, brook trout

BIRDS

Scientific name	Common name
Campephilus principalis	Ivory-billed woodpecker
Conuropis carolinensis	Carolina parakeet
Ectopistes migratorius	Passenger pigeon
Falco sparverinus paulus	Southeastern American kestrel
Leuconotopicus borealis	Red cockcaded woodpecker
Seiurus aurocapilla	Ovenbird
Setophaga cerulea	Cerulean warbler
Strix occidentalis	Northern spotted owl
Vermivora bachmanii	Bachman's warbler

MAMMALS

Scientific name	Common name
Bison bison	American bison
Canis familiaris	Domestic dog
Canis lupus rufus (C. rufus)	Red wolf
Castor canadensis	Beaver
Cervus canadensis canadensis	Eastern elk
Corynorhinus rafinesquii	Rafinesque's big eared bat
Felis catus	Domestic cat
Glaucomys sabrinus coloratus	Northern flying squirrel
Myocastor coypus	Nutria
Myotis austroriparius	Southeastern myotis
Odocoileus virginianus	White-tailed deer
Puma concolor	Cougar

Scientific name	Common name
Sus scrofa	Wild boar, Eurasian wild boar, wild hog, feral hog
Sylvilagus aquaticus	Swamp rabbit
Ursus americanus	American black bear

All Sections Species List by Taxonomic Group by Common Name

BACTERIA

Common name	Scientific name
Elm yellows	*Candidatus Phytoplasma ulmi**

WATER MOLDS

Common name	Scientific name
Littleleaf disease	*Phytophthora cinnamomi*

FUNGI

Common name	Scientific name
Anthracnose, dogwood	*Discula destructiva*
Beech bark disease	*Neonectria ditissima, N. faginata*
Brown spot needle blight	*Scirrhia acicola*
Chestnut blight	*Cryphonectria parasitica*
Dutch elm disease	*Ophiostoma ulmi, O. himal-ulmi*, O. novo-ulmi*
Fusiform rust	*Cronartium quercuum* [f. sp. *fusiforme*]
Heterobasidion root disease	*Heterobasidion irregulare*
Red heart rot	*Porodaedalea pini*
Wilt, laurel	*Harringtonia lauricola*
Wilt, oak	*Ceratocystis fagacearum*

LICHENS

Common name	Scientific name
Hot dots	*Arthonia kermesina*
Lungwort	*Lobaria pulmonaria*
Old birch spots	*Arthopyrenia betulicola*
Sterling lips	*Graphis sterlingiana*

MOSSES

Common name	Scientific name
Log moss	e.g., *Hypnum imponens, H. curvifolium, Thuidium delicatulum*
Sphagnum	*Sphagnum* spp.

PLANTS

Common name	Scientific name
Alder, black	*Alnus serrulata*
Ash	*Fraxinus* spp.
Ash, American mountain	*Sorbus americana*
Ash, black	*Fraxinus nigra*
Ash, blue	*Fraxinus quadrangulata*
Ash, Carolina	*Fraxinus caroliniana*
Ash, green	*Fraxinus pennsylvanica*
Ash, white	*Fraxinus americana*
Aster or sunflower family	Asteraceae
Azalea, piedmont	*Rhododendron canescens*
Bald cypress	*Taxodium distichum*
Barberry, Japanese	*Berberis thunbergii*
Basswood	*Tilia americana*
Basswood, American	*Tilia americana* var. *americana, Tilia americana* var. *heterophylla*
Basswood, Carolina	*Tilia americana* var. *caroliniana*
Bay, loblolly	*Gordonia lasianthus*
Beech	*Fagus grandifolia*
Beech, American	*Fagus grandifolia*
Birch	*Betula* spp.
Birch, black	*Betula lenta*
Birch, river	*Betula nigra*
Birch, sweet	*Betula lenta*
Birch, yellow	*Betula alleghaniensis*
Blackgum	*Nyssa sylvatica*
Blackhaw	*Viburnum* spp.
Blueberry	*Vaccinium* spp.
Blueberry, Elliott's	*Vaccinium elliottii*
Blueberry, highbush	*Vaccinium corymbosum*
Blueberry, southern highbush	*Vaccinium formosum*
Bluestem	*Andropogon* spp., *Schizachyrium* spp.
Bluestem, Elliott's	*Andropogon gyrans*
Bluestem, little	*Schizachyrium scoparium*
Bluestem, slender little	*Schizachyrium tenerum*

Common name	Scientific name
Bottlebrush grass, eastern	*Elymus hystrix*
Boxelder	*Acer negundo*
Broomsedge	*Andropogon virginicus*
Buckeye	*Aesculus flava*
Buckeye, yellow	*Aesculus flava*
Buckthorn, Carolina	*Frangula caroliniana*
Buttonbush, common	*Cephalanthus occidentalis*
Cane, giant	*Arundinaria gigantea*
Cane, switch	*Arundinaria tecta*
Cedar, Atlantic white	*Chamaecyparis thyoides*
Cherry	*Prunus serotina*
Cherry, black	*Prunus serotina*
Cherry, pin	*Prunus pensylvanica*
Chestnut, American	*Castanea dentata*
Chokeberry, black	*Aronia melanocarpa*
Chokeberry, red	*Aronia arbutifolia*
Clearweed	*Pilea pumila*
Cogongrass	*Imperata cylindrica*
Cottonwood, eastern	*Populus deltoides*
Cottonwood, swamp	*Populus heterophylla*
Cranberry, southern mountain	*Vaccinium erythrocarpum*
Creeper, Virginia	*Parthenocissus quinquefolia*
Crossvine	*Bignonia capreolata*
Cypress	*Taxodium distichum,* possibly *T. ascendens*
Cypress, bald	*Taxodium distichum*
Cypress, pond	*Taxodium ascendens*
Dogwood, flowering	*Cornus florida*
Dogwood, silky	*Cornus amomum*
Dogwood, southern swamp	*Cornus foemina*
Elderberry, American black	*Sambucus nigra* spp. *canadensis*
Elderberry, red	*Sambucus racemosa* var. *racemosa*
Elm	*Ulmus* spp.
Elm, American	*Ulmus americana*

Common name	Scientific name
Elm, cedar	*Ulmus crassifolia*
Elm, slippery	*Ulmus rubra*
Elm, winged	*Ulmus alata*
Fern, bracken	*Pteridium* spp.
Fetterbush, coastal	*Eubotrys racemosa*
Fetterbush, shining	*Lyonia lucida*
Fir	*Abies* spp.
Fir, Douglas	*Pseudotsuga menziesii*
Fir, Fraser	*Abies fraseri*
Ginseng, American	*Panax quinquefolius*
Grapes	*Vitis* spp.
Grass, Chinese silver	*Miscanthus sinensis*
Grass, eastern bottlebrush	*Elymus hystrix*
Greenbrier	*Smilax* spp.
Gum	*Nyssa* spp., possibly *Liquidambar styraciflua*
Hackberry	*Celtis occidentalis*
Hawthorn	*Crataegus* spp.
Hemlock	*Tsuga canadensis*
Hemlock, Carolina	*Tsuga caroliniana*
Hemlock, eastern	*Tsuga canadensis*
Hickory	*Carya* spp.
Hickory, bitternut	*Carya cordiformis*
Hickory, black	*Carya texana*
Hickory, mockernut	*Carya tomentosa*
Hickory, pignut	*Carya glabra*
Hickory, red	*Carya ovalis*
Hickory, shagbark	*Carya ovata*
Hickory, water	*Carya aquatica*
Hobblebush	*Viburnum lantanoides*
Holly, American	*Ilex opaca*
Hophornbeam	*Ostrya virginiana*
Hornbeam, American	*Carpinus caroliniana*
Huckleberry	*Gaylussacia* spp.

Common name	Scientific name
Indiangrass	*Sorghastrum* spp.
Knotweed, Japanese	*Polygonum cuspidatum*
Kudzu	*Pueraria montana*
Laurel family	Lauraceae
Laurel, great	*Rhododendron maximum*
Laurel, mountain	*Kalmia latifolia*
Lespedeza, sericea	*Lespedeza cuneata*
Lizard's tail	*Saururus cernuus*
Locust, black	*Robinia pseudoacacia*
Locust, water	*Gleditsia aquatica*
Longleaf	*Pinus palustris*
Magnolia	*Magnolia* spp.
Magnolia, bigleaf	*Magnolia macrophylla*
Magnolia, cucumber	*Magnolia acuminata*
Magnolia, Fraser	*Magnolia fraseri*
Magnolia, southern	*Magnolia grandiflora*
Maple	*Acer* spp.
Maple, hard	*Acer saccharum*, possibly *A. nigrum*
Maple, mountain	*Acer spicatum*
Maple, red	*Acer rubrum*
Maple, silver	*Acer saccharinum*
Maple, southern sugar	*Acer floridanum*
Maple, sugar	*Acer saccharum*
Maple, swamp red	*Acer rubrum* var. *trilobum*
Muscadine	*Vitis rotundifolia*
Nettle, swamp	*Boehmeria cylindrica*
Oak	*Quercus* spp.
Oak, Arkansas	*Quercus arkansana*
Oak, bear	*Quercus ilicifolia*
Oak, black	*Quercus velutina*
Oak, blackjack	*Quercus marilandica*
Oak, bluejack	*Quercus incana*
Oak, bur	*Quercus macrocarpa*

Common name	Scientific name
Oak, cherrybark	*Quercus pagoda*
Oak, chestnut	*Quercus montana*
Oak, chinquapin	*Quercus muehlenbergii*
Oak, diamondleaf	*Quercus hemisphaerica*
Oak, laurel	*Quercus laurifolia*
Oak, live	*Quercus virginiana*
Oak, Mohr's	*Quercus mohriana*
Oak, northern red	*Quercus rubra*
Oak, Nuttall	*Quercus texana*
Oak, overcup	*Quercus lyrata*
Oak, pin	*Quercus palustris*
Oak, post	*Quercus stellata*
Oak, red	*Quercus rubra*
Oak, sand laurel	*Quercus hemisphaerica*
Oak, sand live	*Quercus geminata*
Oak, sand post	*Quercus margarettae*
Oak, scarlet	*Quercus coccinea*
Oak, scrub	*Quercus* spp. (small stature species)
Oak, shingle	*Quercus imbricaria*
Oak, Shumard	*Quercus shumardii*
Oak, southern red	*Quercus falcata*
Oak, swamp chestnut	*Quercus michauxii*
Oak, swamp white	*Quercus bicolor*
Oak, turkey	*Quercus laevis*
Oak, water	*Quercus nigra*
Oak, white	*Quercus alba*
Oak, willow	*Quercus phellos*
Oaks, white	*Quercus* spp. in subgenus *Leucobalanus*
Oatgrass, poverty	*Danthonia spicata*
Oatgrasses	*Danthonia* spp.
Oats, river	*Chasmanthium latifolium*
Palmetto, cabbage	*Sabal palmetto*
Palmetto, dwarf	*Sabal minor*

Common name	Scientific name
Panicgrass, roundseed	*Dichanthelium sphaerocarpon*
Panicgrasses	*Dichanthelium* spp., *Panicum* spp.
Pea family	Fabaceae
Pecan	*Carya illinoinensis*
Pepperbush, sweet	*Clethra alnifolia*
Pine	*Pinus* spp.
Pine, eastern white	*Pinus strobus*
Pine, Florida slash	*Pinus elliottii* var. *densa*
Pine, loblolly	*Pinus taeda*
Pine, longleaf	*Pinus palustris*
Pine, pitch	*Pinus rigida*
Pine, pond	*Pinus serotina*
Pine, shortleaf	*Pinus echinata*
Pine, slash	*Pinus elliottii* var. *elliottii, P. elliottii* var. *densa*
Pine, spruce	*Pinus glabra*
Pine, Table Mountain	*Pinus pungens*
Pine, Virginia	*Pinus virginiana*
Pine, white	*Pinus strobus*
Pine, yellow	native eastern *Pinus* spp. in subgenus *Pinus*
Planertree	*Planera aquatica*
Poison ivy, eastern	*Toxicodendron radicans*
Pondberry	*Lindera melissifolia*
Poplar, yellow	*Liriodendron tulipifera*
Possumhaw	*Ilex decidua*
Prince's pine, striped	*Chimaphila maculata*
Ragwort, Rugel's	*Rugelia nudicaulis*
Ramps	*Allium tricoccum*
Redbay	*Persea borbonia*
Redcedar, eastern	*Juniperus virginiana*
Rose, multiflora	*Rosa multiflora*
Rosebay, Catawba	*Rhododendron catawbiense*
Sassafras	*Sassafras albidum*
Sedges	*Carex* spp.

Common name	Scientific name
Sedge, Pennsylvania	*Carex pensylvanica*
Silverbell	*Halesia tetraptera*
Silverbell, mountain	*Halesia tetraptera*
Sourwood	*Oxydendrum arboreum*
Speargrass, blackseed	*Piptochaetium avenaceum*
Spicebush	*Lindera benzoin*
Spruce	*Picea* spp.
Spruce, red	*Picea rubens*
Steeplebush	*Spiraea tomentosa*
Sugarberry	*Celtis laevigata*
Swampprivet, upland	*Forestiera ligustrina*
Sweetbay	*Magnolia virginiana*
Sweetgum	*Liquidambar styraciflua*
Sweetleaf, common	*Symplocos tinctoria*
Switchgrass	*Panicum virgatum*
Sycamore	*Platanus occidentalis*
Sycamore, American	*Platanus occidentalis*
Tallow, Chinese	*Triadica sebifera*
Threeawn, Beyrich's	*Aristida beyrichiana*
Threeawn, pineland	*Aristida stricta*
Ticktrefoils	*Desmodium* spp.
Tree of heaven	*Ailanthus altissima*
Tuliptree	*Liriodendron tulipifera*
Tupelo	*Nyssa biflora, possibly N. aquatica*
Tupelo, swamp	*Nyssa biflora*
Tupelo, water	*Nyssa aquatica*
Walnut	*Juglans nigra*
Walnut, black	*Juglans nigra*
Wild raisin, southern	*Viburnum nudum*
Willow	*Salix* spp.
Willow, black	*Salix nigra*
Wiregrass	*Aristida beyrichiana, A. stricta*
Woodoats	*Chasmanthium sessiliflorum, C. laxum*

Common name	Scientific name
Woodoats, slender	*Chasmanthium laxum*
Yaupon	*Ilex vomitoria*
Yellow poplar	*Liriodendron tulipifera*
Yellow-poplar	*Liriodendron tulipifera*
Yellowroot	*Xanthorhiza simplicissima*

GASTROPODS

Common name	Scientific name
Micro-snail ice thorn	*Carychium exile*

SPIDERS

Common name	Scientific name
Spider, spruce-fir moss	*Microhexura montivaga*

INSECTS

Common name	Scientific name
Adelgid, balsam woolly	*Adelges piceae*
Adelgid, hemlock woolly	*Adelges tsugae*
Beech scale	*Cryptococcus fagisuga, Xylococculus betulae*
Beetle, black turpentine	*Dendroctonus terebrans*
Beetle, eastern ironclad	*Phellopsis obcordata*
Beetle, redbay ambrosia	*Xyleborus glabratus*
Beetle, southern pine	*Dendroctonus frontalis*
Beetles, pine engraver	*Ips avulsus, I. calligraphus, I. grandicollis*
Borer, emerald ash	*Agrilus planipennis*
Borer, twolined chestnut	*Agrilus bilineatus*
Coneworm, mountain pine	*Dioryctria yatesi*
Moth, spongy	*Lymantria dispar*
Sawfly, blackheaded	*Neodiprion excitans*

FISH

Common name	Scientific name
Trout	*Oncorhynchus mykiss, Salmo trutta, Salvelinus fontinalis*

BIRDS

Common name	Scientific name
Kestrel, southeastern American	*Falco sparverinus Paulus*
Northern spotted owl	*Strix occidentalis*
Ovenbird	*Seiurus aurocapilla*
Parakeet, Carolina	*Conuropis carolinensis*
Pigeon, passenger	*Ectopistes migratorius*
Warbler, Bachman's	*Vermivora bachmanii*
Warbler, cerulean	*Setophaga cerulea*
Woodpecker, ivory-billed	*Campephilus principalis*
Woodpecker, red-cockcaded	*Leuconotopicus borealis*

MAMMALS

Common name	Scientific name
Bat, Rafinesque's big eared	*Corynorhinus rafinesquii*
Bear, American black	*Ursus americanus*
Beaver	*Castor canadensis*
Bison, American	*Bison bison*
Boar, wild	*Sus scrofa*
Cat, domestic	*Felis catus*
Cougar	*Puma concolor*
Deer, white-tailed	*Odocoileus virginianus*
Dog, domestic	*Canis familiaris*
Elk, eastern	*Cervus canadensis canadensis*
Myotis, southeastern	*Myotis austroriparius*
Nutria	*Myocastor coypus*
Rabbit, swamp	*Sylvilagus aquaticus*
Squirrel, northern flying	*Glaucomys sabrinus coloratus*
Wolf (red)	*Canis lupus rufus (C. rufus)*

Bragg, D.; Woodbridge, M.; Martens, C. 2026. Identifying and Managing Old-Growth Forest Communities in the National Forests and Grasslands of the Southern Region. Gen. Tech. Rep. SRS-284. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 277 p. https://doi.org/10.2737/SRS-GTR-284.

Old-growth forests in the Southeast are diverse, highly valued, and complicate d to both define and differentiate on the landscape. In this report, we review the history of forests in the region, including how old-growth has been defined, the characteristics of old-growth communities and old trees, and the values that old-growth communities provide. We also provide information for land managers to consider: threats that old-growth forests face, examples of management strategies for maintaining and restoring ecological functions, and tools for managing old-growth characteristics in mature forests. Finally, we summarize the unique characteristics of the various old-growth community types that occur in the Southern Region and even the Eastern Region. Some differences between this report and the similarly named 1997 old-growth guidance by Gaines et al. are that this report does not include any specific management direction at the plan or project level. Instead, we focus primarily on information to support identification of old-growth conditions such as land-use history, detailed descriptions of values, and clarified terminology related to old-growth conditions. We hope this report can serve as a tool to inform a more thorough understanding of the old-growth communities in the Southern Region and beyond.

Keywords: Old growth, old-growth forest, management, old-growth communities, southern forests, historical old growth, old-growth values, old-growth threats.