Rapid Assessment Metrics to Enhance Wildlife Habitat and Biodiversity within Southern Open Pine Ecosystems

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Much of the work featured here was based on or influenced by previous projects. In 2006, with support from Office Depot, NatureServe conducted literature review and rapid assessment metric development for certain ecological systems in the Alabama and Mississippi (NatureServe 2006). The Southern Region of the US Forest Service worked closely with NatureServe to produce an interim report on longleaf pine rapid assessment metrics that influenced our current work (NatureServe 2011). In particular, NatureServe collaborated with the late Erik Johnson of USFS prior to 2011 on rapid assessment metrics for longleaf pine dominated communities (NatureServe 2011). His input was important for the development of metrics included here. In addition, our core team used Florida Natural Areas Inventory's longleaf pine ecosystem metrics (FNAI and FFS 2014), the Longleaf Partnership Council metrics (Longleaf Partnership Council 2014), and the West Gulf Coastal Plain/Ouachitas Open Pine Landbird Plan (Lower Mississippi Valley Joint Venture WGCPO Landbird Working Group 2011) to inform our initial drafts that were presented for review to key stakeholders and experts.

Finally (and most importantly), we are thankful for the many experts who agreed to review our products at various stages in the process. Although we don't have the room to name everyone in the acknowledgments, we would like to point out experts who were instrumental in helping us edit the original metrics and create a stronger final version. These include Andy Vanderyacht, Brian Camposano, Bryan Rupar, Carol Denhof, Chris Oswalt, Chuck Hunter, Clarence Coffey, Dan Hipes, Amy Knight, Doug Zollner, Doyle Shook, Gary Burger, Jim Guldin, Joan Walker, Joanne Baggs, Jon Scott, Kevin Mcintyre, Lora Smith, Martin Blaney, Matt Hinderliter, McRee Anderson, Mike Black, Mike Conner, Russ Walsh, Tom Foti, Wally Akins, Will McDearman, Al Schotz, Amity Bass, Ben Wigley, Carl Schmidt, Forbes Boyle, Gary Kauffman, Haven Barnhill, Jack Culpepper, Jeff Marcus, Joanne Baggs, John Gruchy, Joseph Reinman, Lisa Kruse, Matt Elliott, Nancy Jordan, Randy Browning, and Sara Aicher. The full list of workshop attendees and reviewers can be found in Appendix D.

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Cover Photo: Bobwhite photo courtesy of Dr. John Brunjes of Kentucky Dept. of Fish and Wildlife Resources, controlled burn photo courtesy of Louisiana Dept. of Wildlife and Fisheries, longleaf community photo in Croatan National Forest courtesy of Milo Pyne, NatureServe.

Executive summary

Open woodlands dominated by southern yellow pine were historically a large component of the landscape across the southeastern United States. These woodlands have an open canopy of longleaf, slash, shortleaf, and/or loblolly pines, with scattered shrubs and a grassy understory. These southern open pine ecosystems support many species of wildlife, many of which have declined in recent years as the amount and condition of their habitat has declined. This troubling decline in wildlife species has led to a focus on regional conservation efforts by America's Longleaf, the National Fish and Wildlife Foundation, Landscape Conservation Cooperatives, state wildlife agencies, the U.S. Forest Service, National Bobwhite Quail Initiative, regional Bird Conservation Joint Ventures, The Nature Conservancy, the Shortleaf Pine Initative, and other conservation partners. These groups all agree that there is a need for more high quality open pine acreage, but until now there has been no efficient, agreed upon, way to identify those tracts that are providing the best habitat for key wildlife species.

In partnership with the Gulf Coastal Plain and Ozarks Landscape Conservation Cooperative (GCPO LCC), NatureServe, the U.S. Fish and Wildlife Service and the East Gulf Coastal Plain Joint Venture have developed desired forest condition (rapid assessment) metrics to measure wildlife habitat value and ecological integrity of tracts of land, with a primary focus on those lands being managed primarily for conservation. These desired forest condition metrics help conservation-minded landowners understand how their properties are contributing to the habitat needs of priority wildlife of southern open pine ecosystems, as determined by the Gulf Coastal Plain and Ozarks Landscape Conservation Cooperative (GCPO LCC).

To create this metrics based approach, our team first reviewed previous studies and reports pertaining to the condition of southern open pine ecosystems and the habitat needs of priority wildlife. We then incorporated their findings into a draft set of desired forest condition metrics. The project partners then reached out to wildlife conservation stakeholders and experts to review these metrics at two regional in-person meetings (at Newton, GA and Knoxville, TN), and through other outreach efforts. Stakeholders and experts participated in a structured method that allowed all participants to contribute input on the proposed desired forest condition metrics for southern open pine ecosystems. The team used the information and viewpoints gathered from all interactions to revise the draft metrics. In late 2015, the team shared the revised metrics and introductory material with an additional broad set of reviewers, many of whom were local land managers and other stakeholders who did not attend the two regional meetings. The team compiled the review comments received and used them to finalize the desired forest condition metrics.

Included in this final report are thirteen desired forest condition metrics, subdivided into sets of metrics for the condition of the canopy, midstory and ground layer (the full metrics are found in Appendix C, this document). These metrics can be applied to any of seven broad ecosystems we are calling "Southern Open Pine Groupings" (Appendix B). These are stand level metrics, and generally can be applied at sets of points or small plots across stands, in a manner similar to a timber cruise.

These metrics are an important new tool that is intended for use by conservation-focused landowners and managers to evaluate the wildlife habitat value and ecological integrity of southern open pine ecosystems that they own and manage.

Introduction

Savannas and woodlands dominated by longleaf, slash, shortleaf, and loblolly pines (open pine) were historically a large component of the overall landscape across the southeastern United States. As human populations increased and land management practices and land use patterns changed, these once dominant open pine ecosystems were cleared for agriculture and/or development, resulting in significant declines in both extent and quality of pine systems across the southeast (Oswald 2012). In fact, longleaf dominated pine systems have declined so that only a small fraction of their original historic acreage remains today. With so little healthy open pine forests left, the stakes are already very high. These open pine communities support extremely high plant, reptile, and amphibian diversity, with over 900 plant species considered endemic to this and adjacent ecosystems (America's Longleaf 2009). This project will facilitate identification, prioritization, and enhancement of sites to advance the conservation of these precious systems.

In 2009, a Range-wide Conservation Plan for Longleaf Pine was created (http://www.americaslongleaf.org/media/86/conservation_plan.pdf) with a 15-year goal of increasing longleaf acreage from 3.4 million to 8 million acres. But even more important, a goal was also established to specifically move at least 3 million acres into good health/quality to serve as vital habitat for key/representative species found within this iconic ecosystem (America's Longleaf 2009). Longleaf dominated forest is the main focus of much of the effort to restore and maintain open-canopied natural pine stands in the Southeast (open pine), but there are other similar open pine stands dominated by shortleaf, slash, and loblolly pines in this region as well. These pine stands also contribute to the overall conservation effort by providing habitat for many of the same target species, so we have included all of these stands in our current region-wide metrics-based effort.

Our team has prepared this document to further the conservation goals and objectives of the Gulf Coastal Plain and Ozarks Landscape Conservation Cooperative (GCPO LCC) across the West Gulf Coastal Plain, East Gulf Coastal Plain, Mississippi Alluvial Valley and Ozarks physiographic regions (Figure 1). The GCPO LCC is a self-directed, non-regulatory partnership that exists for the purpose of advancing science and landscape-level planning as community of practice representing private, state, and federal agencies and organizations to support and sustain endemic fish and wildlife populations and the ecological functions and processes on which they depend (GCPO LCC 2009). To facilitate and advance this "conservation agenda" the GCPO LCC partnership put forth an integrated science agenda (GCPO LCC Adaptation Science Management Team 2013; http://tinyurl.com/GCPOLCC-Sci-Agenda) that outlined science needs across resources and disciplines with pine systems. More specifically, the integrated science agenda identified the desire and need to articulate stand-level metrics that define desired habitat conditions to support priority wildlife species with longleaf pine systems.

Purpose and Use of this Document

To provide the GCPO LCC partnership with information to advance the conservation of open pine systems, our team set out to address three specific needs/goals: (1) provide a common framework for delineating open pine systems; (2) define desired forest conditions that result from management of pine systems where the primary objective is conservation of wildlife and biodiversity maintenance; and (3) provide a rapid assessment protocol to allow land managers to quickly assess stand conditions. We envision these products will aid not only public land managers but also private landowners who target wildlife conservation as part of their overall land stewardship objectives (e.g., lands under conservation easements). The data presented herein is not intended to be regulatory or administratively prescriptive, nor to conflict with any GCPO LCC partner's ability to meet their underlying legislative mandates. As the

data and recommendations put forth here reflect the contemporary, collective expertise of many foresters, biologists and researchers, we encourage the GCPO LCC partnership to iteratively update and refine these data and recommendations as we increase our knowledge and understanding of wildlife species habitat needs and management strategies within open pine systems across the southeastern United States.

Study Area / Scope and Scale of Project

In the southeastern United States, there are several large-scale (or formerly large-scale) ecosystems dominated by an open canopy of pine trees that are used by a great variety of game and non-game wildlife species and plants. Due to changes in land use and fire regime, these open pine ecosystems have undergone extensive declines over the last 100 years and continue to be threatened with further decline. These ecosystems are found from the West Gulf Coastal Plain and Ozark and Ouachita Mountains to the Southern Appalachians, Piedmont, Atlantic and Southeastern Coastal Plains, and south into the Florida Peninsula. In the past, these ecosystems have consisted of open pine stands with a diverse ground cover composed of native warm-season grasses and forbs, often with some low shrubs and only sparse tall shrubs. These open conditions were historically maintained by natural processes, including fire and grazing. Today, these ecosystems require active management to maintain or to restore the open herbaceous conditions preferred by the many wildlife species adapted to these systems.

Utilizing the aforementioned definition of open pine, the geographic footprint of this project includes all open pine dominated ecosystems within the administrative boundary of the GCPO LCC (see below for concessions), as well as the historic range of longleaf pine (*Pinus palustris*) and slash pine (*Pinus elliottii*). More specifically, we included mixed longleaf pine-shortleaf pine woodlands found in limited areas of the Piedmont and southernmost Appalachians as well as peninsular Florida flatwoods (e.g. spodosol woodlands) dominated by South Florida slash pine (*Pinus elliottii* var. *densa*) whereas we excluded the pine rocklands along the Miami Rock Ridge. These pine rocklands represent a fundamentally different type of open pine ecosystem that is associated with a subtropical climate, calcareous substrate, and a distinct suite of wildlife species; hence we did not address them within this project. Additionally, we did not address forests dominated by pond pine (*Pinus serotina*), sand pine (*Pinus clausa*), spruce pine (*Pinus glabra*), pitch pine (*Pinus rigida*), table mountain pine (*Pinus pungens*), white pine (*Pinus strobus*) or Virginia pine (*Pinus virginiana*).

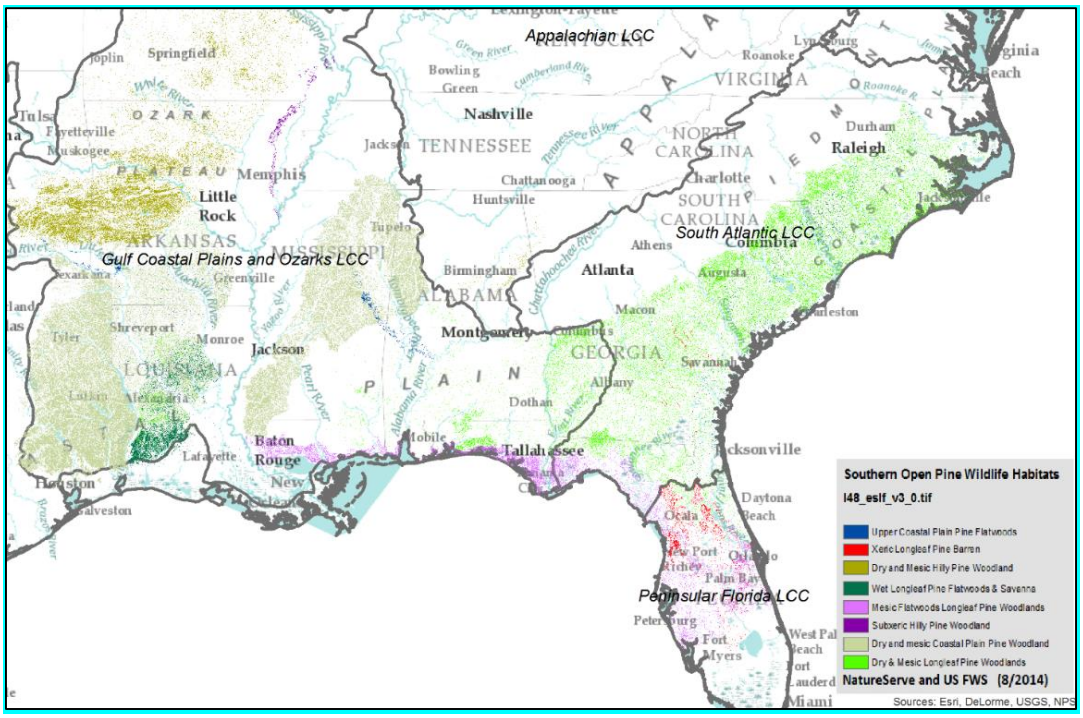

Figure 1. Areas currently having open pine communities in the Gulf Coast and Ozarks LCC as well as longleaf dominated communities in the South Atlantic and Peninsular Florida LCCs.

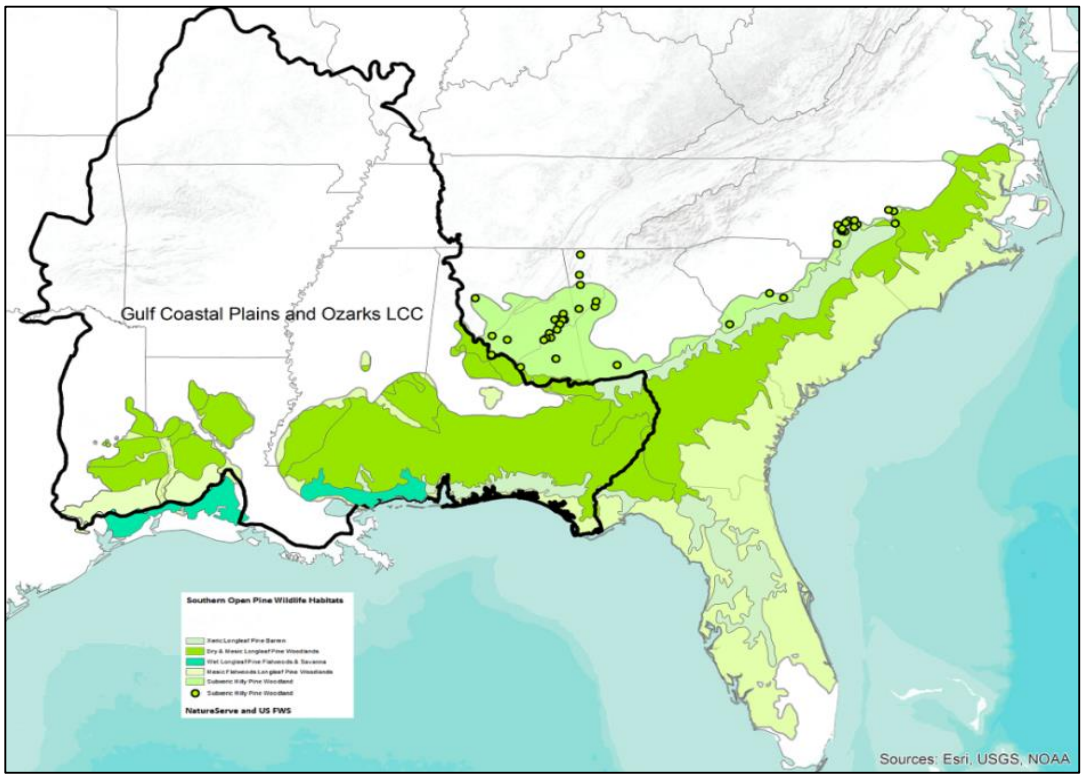

Figure 2. Areas historically dominated by open longleaf and slash pine groupings (tree ranges from Little 1971) as well as the footprint of the Gulf Coastal Plains and Ozarks LCC. Shortleaf pine areas not included in this map.

Priority Species

The GCPO LCC identified sets of species associated with general ecosystems (GCPO LCC Adaptation Science Management Team 2013) as part of their integrated science agenda. This list included 43 fish and wildlife species (see Table 1 and Appendix F), the representative species pool for Coastal Plain Open Pine Woodland and Savanna. From the representative species pool, 12 terrestrial wildlife species serve

Table 1. Representative Species Pool for Coastal Plain Open Pine Woodland and Savanna (GCPO LCC), with Priority Species in bold.

Scientific Name	Common Name	Taxon
Ambystoma bishopi	Flatwoods Salamander	Amphibians
Ambystoma talpoideum	Mole Salamander	Amphibians
Ambystoma tigrinum	Tiger Salamander	Amphibians
Anaxyrus (Bufo) quercicus	Oak Toad	Amphibians
Eurycea cf. quadridigitata	Bog Dwarf Salamander	Amphibians
Eurycea quadridigitata	Dwarf Salamander	Amphibians
Hyla andersonii	Pine Barrens Treefrog	Amphibians
Rana areolata areolata	Southern Crawfish Frog	Amphibians
Rana capito	Gopher Frog	Amphibians
Rana sevosa	Mississippi Gopher Frog	Amphibians
Aimophila aestivalis	**Bachman's Sparrow**	**Birds**
Ammodramus henslowii	Henslow's Sparrow	Birds
Caprimulgus carolinensis	Chuck-will's-widow	Birds
Caprimulgus vociferus	Whip-poor-will	Birds
Coccyzus americanus	Yellow-billed Cuckoo	Birds
Colinus virginianus	**Northern Bobwhite**	**Birds**
Dendroica discolor	**Prairie Warbler**	**Birds**
Dendroica dominica	Yellow-throated Warbler	Birds
Dendroica pinus	**Pine Warbler**	**Birds**
Dryocopus pileatus	Pileated Woodpecker	Birds
Falco sparverius paulus	Southeastern American Kestrel	Birds
Geococcyx californianus	Greater Roadrunner	Birds
Grus canadensis pulla	Mississippi Sandhill Crane	Birds
Melanerpes erythrocephalus	Red-headed Woodpecker	Birds
Meleagris gallopavo	Wild Turkey	Birds
Picoides borealis	**Red-cockaded Woodpecker**	**Birds**
Picoides villosus	Hairy Woodpecker	Birds
Pipilo erythrophthalmus	Eastern Towhee	Birds
Sitta pusilla	**Brown-headed Nuthatch**	**Birds**
Geomys pinetis	**Southeastern Pocket Gopher**	**Mammals**
Sciurus niger niger	Southeastern Fox Squirrel	Mammals
Cemophora coccinea	Scarlet Snake	Reptiles
Crotalus adamanteus	**Eastern Diamondback Rattlesnake**	**Reptiles**
Drymarchon couperi	Eastern Indigo Snake	Reptiles
Gopherus polyphemus	**Gopher Tortoise**	**Reptiles**
Lampropeltis getula	Common Kingsnake	Reptiles
Masticophis flagellum	Eastern Coachwhip	Reptiles
Micrurus fulvius	Coral Snake	Reptiles
Micrurus tener tener	Texas Coral Snake	Reptiles
Pituophis melanoleucus	**Northern Pine Snake**	**Reptiles**
Pituophis ruthveni	**Louisiana Pine Snake**	**Reptiles**
Sistrurus miliarius	Pygmy Rattlesnake	Reptiles
Tantilla coronata	Southeastern Crowned Snake	Reptiles

as priority species to guide this project (Table 2). Because this project area also includes the southeastern coastal plain, some additional subspecies of pocket gophers and pine snakes have been included.

Common name	Scientific name	Project area states where it occurs	States where listed as Species of Greatest Conservation Need (SGCN) in 2005 State Wildlife Action Plan	Open Pine Groupings
Red-cockaded Woodpecker	*Picoides borealis*	All project area states, except MO (Extirpated)	AL, AR, FL, GA, KY (Extirpated) , LA, MD, MO (Extirpated), MS, NC, OK, SC, TX, VA	All?
Louisiana Pine Snake	*Pituophis ruthveni*	LA, TX	LA, TX	Xeric Longleaf Pine Barrens
Black Pine Snake	*Pituophis melanoleucus lodingi*	AL, LA, MS	AL, LA, MS	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands
Florida Pine Snake	*Pituophis melanoleucus mugitus*	AL, FL, GA, SC	AL, FL, GA, SC	Xeric Longleaf Pine Barrens
Brown-headed Nuthatch	*Sitta pusilla*	All project area states, except MO (Extirpated)	AR, DE, FL, LA, MD, MO (Extirpated), MS, NC, OK, SC, TN, TX, VA	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Mesic Longleaf Pine Flatwoods, Wet Longleaf & Slash Pine Flatwoods & Savannas, Dry & Mesic Hilly Pine Woodlands (East Gulf), Dry & Mesic Hilly Pine Woodlands (West Gulf), Upper Coastal Plain Pine Flatwoods
Bachman's Sparrow	*Peucaea* (*Aimophila*) *aestivalis*	All project area states	AL, AR, FL, GA, KY, LA, MD, MO, MS, NC, OH (Extirpated), OK, SC, TN, TX, VA, WV	All?
Northern Bobwhite	*Colinus virginianus*	All project area states	AR, CT, DC, DE, FL, GA, IA, IL, KS, KY, LA, MA, MD, MI, MS, NC, NE, NJ, NY, OH, OK, PA, RI, SC, TX, VA, WI, WV	All?
Pine Warbler	*Setophaga pinus*	All project area states	NJ, OH	All?
Gopher Tortoise	*Gopherus polyphemus*	AL, FL, GA, LA, MS, SC	AL, FL, GA, LA, MS, SC	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Mesic Longleaf Pine Flatwoods
Prairie Warbler	*Setophaga discolor*	All project area states	AR, CT, DE, IL, KY, LA, MA, MD, ME, MI, MS, NC, NJ, NY, OH, OK, PR, RI, SC, TN, TX, VA, VI, VT, WV	All?
Eastern Diamondback Rattlesnake	*Crotalus adamanteus*	AL, FL, GA, LA, MS, NC, SC	AL, FL, GA, LA, MS, NC	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Mesic Longleaf Pine Flatwoods
Southeastern Pocket Gopher	*Geomys pinetis*	AL, FL, GA	AL, FL, GA	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands
Baird's Pocket Gopher	*Geomys breviceps*	LA, TX		Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Dry & Mesic Hilly Pine Woodlands (West Gulf)
Plains Pocket Gopher	*Geomys bursarius*	AR (Izard County), MO	IN, WY	Dry & Mesic Highlands Pine Woodlands
Ozark Pocket Gopher	*Geomys bursarius ozarkensis*	AR	AR	Dry & Mesic Highlands Pine Woodlands

Table 2. Priority Species of Open Pine Woodlands of the Gulf Coastal Plain and Ozarks LCC; relationships derived from literature searches, including US Fish and Wildlife Service Species Profiles

Summary information for Priority Wildlife Species

Brown-headed Nuthatch

Brown-headed nuthatch primarily uses mature pine forests and woodlands, both longleaf pine (*Pinus palustris*) and loblolly pine (*Pinus taeda*). Stands less than 35 years old are probably unsuitable, and deciduous forest does not support the species. The primary management concern is the loss of habitat as a result of lack of fire, conversion of old-growth forest to short-rotation pine plantations, urbanization, and agricultural conversion. Successful management requires the preservation and controlled burning of existing mature pine stands and selective thinning of pole-sized plantation timber. In all suitable habitats, the creation and preservation of snags is essential. Due to its dependence on snags, a site with sufficient standing deadwood to sustain brown-headed nuthatch populations will also likely provide sufficient standing deadwood for other primary and secondary cavity nesting species (NatureServe 2016).

Northern Bobwhite

Within open pine habitats, northern bobwhite requires a well-developed herbaceous layer for nesting and brood cover but also exhibits a negative response to an herbaceous layer that is too dense or shrubby. As the lack of frequent fire allows encroachment of woody species; frequent (2 – 5 year intervals) prescribed fires contribute to development of a robust and diverse herbaceous layer favored by this species. The presence or absence of this species can be used as an indicator of the quality of the herbaceous component in open pine habitat and provides feedback on prescribed management actions.

Bachman's Sparrow

Conversion of longleaf pine stands to plantations of fast-growing pines (mainly loblolly pine and slash pine), shortage of newly abandoned farmland, and urbanization apparently are important factors in the population declines of Bachman's sparrow (Dunning 1993). Bachman's sparrow appears to readily colonize new habitats, although high connectivity among open pine patches likely enhances their dispersal, thus isolated patches of habitat are less likely to support populations. The species requires frequent fire, a well-developed herbaceous understory, and is negatively affected by lack of fire which increases understory and its shrubby components (NatureServe 2016).

Prairie Warbler

Most populations of prairie warbler (*Setophaga discolor*) prefer early successional, shrubby vegetation. Active management with prescribed burning can encourage a broad ecotone or shrubby transition from southern open pine into adjacent vegetative communities. Small areas cannot provide enough suitable habitat, thus a landscape should be managed to provide a mosaic of sites in different stages of succession or time since last prescribed fire. Transitions (including ecotones) or edges of southern open pine areas which are burned less frequently can provide shrubby vegetation for prairie warbler. Declines of the prairie warbler might be influenced by resources in winter (such as on islands in the Caribbean) or by a decrease in old field breeding habitat. Loss of breeding habitat to succession or conversion is the most immediate threat. A loss of early-successional habitats across the range has occurred, as young forests matured and land was converted to residential or industrial uses. Lack of fire is also a cause of habitat loss. Predation and parasitism by cowbirds likely also contribute to declines of prairie warbler (NatureServe 2016).

Red-cockaded Woodpecker

The Red-cockaded woodpecker (*Picoides borealis*) has a fairly large range in the southeastern United States, but both quantity and quality of suitable habitat are much reduced; historical extents of suitable

habitat and probably population size have been reduced by about 97 percent. Short-term rotation timber management eliminated mature pines required for roosting, nesting, and foraging; lack of fire has allowed invasion of pine stands by hardwoods. This rare bird is threatened by the loss of habitat (either gradually through incompatible forest management or rapidly through the outright destruction of old-growth forests), forest fragmentation, competition with other species for cavities, catastrophic events such as hurricanes, and demographic and genetic processes affecting populations confined to isolated conservation areas (U.S. Fish and Wildlife Service 2003, Ligon et al. 1986, Walters 1991). Recent management innovations (e.g., more prescribed burns, cavity management) have alleviated certain threats and resulted in population increases in most areas managed for the species, but a stable or increasing trend independent of continuing artificial cavity installation (a short-term solution) can be achieved only when large old pines are available in abundance. Further population increases, independent from continuing artificial cavity installation, eventually should allow the conservation status to become more secure (NatureServe 2016).

Louisiana Pinesnake

The primary factors leading to degradation of Louisiana pinesnake (*Pituophis ruthveni*) habitat are intensive pine silviculture and alteration of the pre-European fire regime (Rudolph et al. 2006), with the lack of prescribed fire. Over time, the extensive loss, degradation, and fragmentation of the longleaf pine ecosystem, coupled with the disruption of natural fire regimes, have resulted in extant Louisiana pinesnake populations that are isolated and small. These remnant populations are now vulnerable to factors associated with low population sizes and demographic isolation, such as reduced genetic heterozygosity. Intensive silviculture and reduction in fire frequency eliminate or reduce the microhabitat conditions needed by pinesnakes and also may result in declines of Baird's pocket gopher (*Geomys breviceps*), a primary prey of Louisiana pinesnake (Rudolph et al. 2006). Restoration measures should include prescribed burning, thinning, and replanting of longleaf pine in appropriate areas (NatureServe 2016).

Northern Pinesnake

The Northern pinesnake (*Pituophis melanoleucus melanoleucus*) uses open areas with early successional vegetation, especially upland pine and pine-oak forests subjected to occasional fire, and prefers dry, forested, or partially forested areas where soil is fairly sandy or loose and gravelly. Closed-canopy forest is often avoided. Northern pinesnakes have been well-studied in the northern part of their range (i.e. New Jersey), although specific habitat characteristics have not been established anywhere throughout its range. In the Coastal Plain, life history and ecology are not as well-documented (Godwin 2016. http://www.outdooralabama.com/northern-pine-snake). Threats to northern pinesnakes include habitat fragmentation, habitat alteration, excessive collecting, and road mortality. Loss of habitat occurs when land is converted to agriculture, housing, or densely planted pine, and remaining areas are often degraded so that their suitability for pinesnakes is greatly diminished. Exclusion of fire leads to the oak component becoming too dominant, and densely stocked stands may not provide adequate openings for nesting or hibernacula.

Black Pinesnake

The Black pinesnake (*Pituophis melanoleucus lodingi*) is associated with dry to xeric, fire-maintained longleaf pine forest with sandy, well-drained soils preferred, usually on hilltops, ridges, and toward the tops of slopes, with open canopy, reduced midstory, and dense herbaceous understory. Riparian areas, hardwood forests, or other closed-canopy conditions are not regularly used (Duran 1998). It will use dry, periodically burned open pine or mixed pine-scrub oak forest with abundant groundcover vegetation. The limited distribution of the Black pinesnake has dwindled with the decline of the longleaf pine

ecosystem (Duran 1998). Much habitat has been eliminated through urban development, or conversion to agricultural fields and pine plantations. Most remaining longleaf pine forests on private land are fragmented and degraded by lack of fire. In addition, forest management practices which increase tree stocking densities, and remove downed trees and stumps continue to degrade preferred Black pinesnake habitats. The Black pinesnake was listed as threatened under the Endangered Species Act in 2015 by the U.S. Fish and Wildlife Service (Nelson and Bailey 2016; http://www.outdooralabama.com/black-pine-snake).

Florida Pinesnake

The Florida pinesnake (*Pituophis melanoleucus mugitus*) inhabits areas with well-drained sandy soils and a moderate to open canopy (Franz 1992, Ernst and Ernst 2003). This species can be found from southern South Carolina, west to Mobile Bay in Alabama, south to south Florida (excluding the Everglades) (Conant and Collins 1991, Ernst and Ernst 2003, Florida Natural Areas Inventory 2001). Florida pinesnakes prefer natural habitats including upland pine forests and sandhills, but they are also found in scrubby flatwoods, oak scrub, dry oak forests, old fields, and agricultural borders. Studies have shown that Florida pine snakes, like other species in the genus, are extremely fossorial. Similar to the Louisiana pinesnake, the Florida pinesnake is highly dependent on the southeastern pocket gopher (Geomys pinetis) for food and refugia; a study in southern Georgia found snakes predominantly used G. pinetis burrows as refugia. The Florida pinesnake suffers from loss of habitat: by 1987, 88% of scrub habitat in Florida had been lost to development (Kautz et al. 1993). Habitat loss and fragmentation can result from commercial and residential development, silviculture, mining, and road construction. The lack of fire leads to habitat degradation for the Florida pinesnake due to the encroachment of hardwoods and reduciton in herbaceous vegetation vital for cover and prey. (http://myfwc.com/wildlifehabitats/imperiled/profiles/reptiles/florida-pine-snake/)

Pine Warbler

Perhaps no bird is more characteristic of the pine forests of eastern North America than the Pine warbler (*Setophaga pinus*). This species rarely occurs in purely deciduous vegetation, except uncommonly during migration and occasionally during winter. The Pine warbler is a common breeding bird and permanent resident in the southeastern United States. It breeds at lower densities as far north as southeastern Canada and the northeastern United States, where it is migratory and among the earliest warblers to arrive in spring and latest to depart in fall (Poole and Gill 1992). Some forest management practices, such as clearcutting, should adversely affect the warbler because of its dependence on forest habitat. Single-tree and group-selection cutting, while removing fewer canopy trees from forest areas, may cause increased nest predation from birds and mammals, and nest parasitism from brown-headed cowbirds (*Molothrus ater*). Spread of suburban areas in pine forest regions could also cause local declines or extirpation through increased fragmentation and/or loss of forest habitat (NatureServe 2016).

Gopher Tortoise

The gopher tortoise (*Gopherus polyphemus*) is a large, long-lived, herbivorous terrestrial turtle that is found in six states in the southeastern United States. Gopher tortoises are most commonly found in upland fire-maintained longleaf pine forests and sandhills that are characterized by a deep, well-drained, sandy substrate suitable for construction of burrows. The gopher tortoise prefers relatively open-canopied habitats that provide sunlit areas for nesting and thermoregulation, and ample herbaceous groundcover vegetation for forage (NatureServe 2016).
Historically, gopher tortoises were considered common in upland habitats throughout their range, however, they now have numerous threats including habitat destruction, degradation, and

fragmentation; overharvesting by humans; and disease. Due to low fecundity, gopher tortoise populations which have declined are slow to recover. Management schemes must be formulated to address the needs of the specific population under consideration.

Eastern Diamondback Rattlesnake

The original range of the eastern diamondback rattlesnake (*Crotalus adamanteus*) has been reduced and fragmented by agriculture, forestry practices, urbanization, and plant succession resulting from lack of fire (Martin and Means 2000). Current threats to local populations include conversion of native habitat to planted slash or loblolly pine plantations, agricultural fields, and urban and suburban uses. Human alteration of native longleaf pine upland ecosystems, including fire suppression and lack of prescribed fire, is shrinking and fragmenting the suitable habitat base for this species. Preferred habitats include pine and wiregrass flatwoods, pine-palmetto flatwoods, longleaf pine-turkey oak sandhills, rosemary scrub, mesophytic and coastal maritime hammocks, xeric hammocks, barrier islands and coastal scrub habitats, vicinity of wet savannas, wet prairies (during dry periods), dry prairie, mixed pine-hardwood successional woodland, and abandoned farms and fields (especially near pine-dominated habitats), particularly areas with abundant cover (Mount 1975, Dundee and Rossman 1989, Palmer and Braswell 1995, Tennant 1997, Ernst and Ernst 2003, Campbell and Lamar 2004). Large tracts of habitat are most suitable. Controlled burning that mimics the natural fire frequency and season of burning is the principal management requirement necessary to maintain the landscape in the condition most suitable for this species (NatureServe 2016).

Pocket Gophers

(Consisting of Southeastern Pocket Gopher, Baird's Pocket Gopher, Plains Pocket Gopher, and Ozark Pocket Gopher)

Pocket gophers (*Geomys* spp.) are fossorial rodents named for their fur-lined cheek pouches. Their cheek pouches, or pockets, are used for transporting bits of plant food that they gather while foraging underground. They have special adaptations for their burrowing lifestyle, including clawed front paws for digging, small eyes and ears, and sensitive whiskers and tails. They are also able to close their lips behind their long incisors so that they can use their teeth to loosen soil without getting any dirt in their mouths. Most pocket gopher species are relatively common and not of conservation concern, but serve as a major food source for species of pinesnakes. (National Wildlife Federation) http://www.nwf.org/Wildlife/Wildlife-Library/Mammals/Pocket-Gophers.aspx

Methods

This project began in May of 2014 with the goal of developing rapid assessment desired forest condition metrics for southern open pine ecosystems. It was clear from the start that, in order to be successful, our project core team would need to clearly define goals and terminology, review and incorporate previous research and reports, identify a large group of experts to rely on for additional input and feedback, and engage an even larger group in final review. These steps were necessary to ensure that the resulting protocols were both scientifically sound and widely accepted by stakeholders.

Our project core team began by discussing the project's geographic footprint and our definition of open pine ecosystems. Based on discussions with the project funder (Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative) we determined that the geographic footprint would include all open pine dominated ecosystems of the Gulf Coastal Plains and Ozarks LCC footprint. In addition, we agreed to include all longleaf pine (*Pinus palustris*) and slash pine (*Pinus elliottii*)dominated ecosystems within and outside of the Gulf Coastal Plain and Ozarks LCC footprint (see Figures 1 and 2).

Priority Species

Our team believed it was important to ensure that our approach addressed key priority species dependent on open pine conditions in the Southeast. The wildlife of southern open pine includes birds, mammals, reptiles, and amphibians which depend on these typically grassy, fire prone woodlands.

We heavily borrowed from the Gulf Coastal Plain and Ozarks science agenda when creating our list of species to focus on for the project. As part of developing their science agenda, the Gulf Coastal Plain and Ozarks Landscape Conservation Cooperative had already identified sets of species associated with general ecosystems. This was part of a larger effort to sustain natural resources at desired levels (GCPO LCC Adaptation Science Management Team 2013).

To build the final species list, we started with the "representative species pools" developed for Coastal Plain Open Pine Woodland and Savanna (Appendix F and Table 1), which includes 43 wildlife taxa (GCPO LCC Adaptation Science Management Team. 2013). From the representative species pool, there are about a dozen priority taxa, listed in bold (Appendix F and Table 1). Priority wildlife species of the southern open pine ecosystems are the focus of this project.

Through the science agenda planning process of the Gulf Coastal Plain and Ozarks Landscape Conservation Cooperative (GCPO LCC), the representative species pool had been further focused on a subset of priority species (bold in Appendix F and Table 1, listed in Appendix G and Table 2). We chose these species as the wildlife priorities for our project. Since our project area also includes the southeastern coastal plain, we included additional taxa of pocket gopher and pine snakes. These taxa better represent the similar taxa of the southeastern coastal plain. To see more detailed information about the species, please refer to Appendix G and Table 2. Status reviews for the wildlife species in the above tables can be found on NatureServe Explorer.

Definition of Southern Open Pine

To ensure that our protocols were based on clearly defined parameters, we next worked to create a draft definition of open pine. Our core team used a combination of expert opinion and definitions from previous reports (see Table 4) to craft a draft definition for southern open pine. We then identified additional experts outside of the group to review the open pine draft and submit additional edits before finalizing the definition in Summer 2014. The project definition of southern open pine is as follows:

In the southeastern United States, there are several large-scale (or formerly large-scale) ecosystems dominated by an open canopy of pine trees that are used by a great variety of game and non-game wildlife species and plants. Due to changes in land use and fire regime, these open pine ecosystems have undergone extensive declines over the last 100 years and continue to be threatened with further decline. These ecosystems are found from the West Gulf Coastal Plain and Ozark and Ouachita Mountains to the Southern Appalachians, Piedmont, Atlantic and East Gulf Coastal Plains, and south into the Florida Peninsula. In the past, these ecosystems have consisted of open pine stands with a diverse ground cover composed of native warm-season grasses and forbs, often with some low shrubs and only sparse tall shrubs. These open conditions were historically maintained by natural processes, including fire and grazing. Today, these ecosystems require active management to maintain or to restore the open herbaceous conditions preferred by a large suite of wildlfe species. While these ecosystems occur across the southeastern United States, this current project more specifically focuses on southern open pine wildlife systems dominated by southern yellow pines, particularly longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*), which occur in the southern coastal plains and the Ozark and Ouachita mountains. We also focus on natural stands of slash pine (*Pinus elliottii*) and loblolly pine (*Pinus taeda*).

Southern Open Pine Groupings

Once we determined the geographic footprint of the study and the definition of open pine, we then needed to compile and finalize the ecological community types that would be included as open pine types so that we could focus effort on those types and avoid getting distracted by other adjacent community types that are out of scope. NatureServe ecologists queried the latest version of the United States National Vegetation Classification (USNVC) (NatureServe 2016) to identify and list all associations that were considered to be part of “open pine” ecosystems. Since the list included many associations, it was impractical to develop separate sets of metrics for each ecosystem at the association scale. Instead, USFWS and NatureServe ecologists grouped associations that shared key ecological and geographical characteristics to create seven groupings of associations called “Southern Open Pine Groupings”.

Our development and definition of the Southern Open Pine Groupings was built upon previous work that had been completed on the Terrestrial Ecological Systems Classification by NatureServe ecologists and state partners (Comer et al. 2003). Ecological systems represent recurring groups of biological communities that are found in similar physical environments and are influenced by similar dynamic ecological processes, such as fire or flooding. They are intended to provide a classification unit that is readily mappable, often from remote imagery, and readily identifiable by conservation and resource managers in the field. A previous collaboration between NatureServe and the Southeast Region of the U.S. Fish and Wildlife Service had resulted in an arrangement that placed the Terrestrial Ecological Systems of the Southeastern United States into an informal hierarchy for habitat classification purposes (M. Pyne and C. Hunter pers. comm.). The upper levels of this informal hierarchy are known as “Groups of Ecological Systems” (GES) and “Broadly Defined Habitats” (BDH).

This arrangement of Broadly Defined Habitats as a habitat framework has been adopted by the Gulf Coast Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC). It is available at: http://tinyurl.com/GCPOLCC-Sci-Agenda. This habitat type delineation was adopted by the LCC because it is broadly applicable geographically for both terrestrial and aquatic systems, has a limited subset of habitat types that are universally recognizable, and these habitat types are readily mappable to many existing classification systems (GCPO LCC 2013).

These units served as a useful reference point to resolve and refine the conceptual limits of the final Southern Open Pine Groupings that we used for this project. While this process of refining the units was underway, NatureServe was also finalizing the concepts and descriptions of new middle level units of the USNVC at a global scale. These units immediately above the Alliance are known as the Group and Macrogroup, and are based on combinations of dominant and diagnostic growth forms, compositional similarity, and dominant and diagnostic plant species that reflect continental and regional biogeographic factors. The final suite of Open Pine Groupings (Table 3) bears a close relationship to the related Groups of the revised USNVC (G009 Dry-Mesic Loamy Longleaf Pine Woodland, G013 Loblolly & Shortleaf Pine - Oak Forest & Woodland, G130 Loblolly Pine & Hardwood Wet Flatwoods, G596 Mesic Longleaf Pine Flatwoods - Spodosol Woodland, G012 Shortleaf Pine - Oak Forest, G190 Wet-Mesic Longleaf Pine Woodland, and G154 Xeric Longleaf Pine Woodland).

After additional expert review and edits, these seven Southern Open Pine Groupings became our base units for developing rapid assessment metrics, allowing us to be most efficient in development and application of metrics while also allowing flexibility where there was a need to apply metrics in different ways to different habitat groupings.

Southern Open Pine Groupings	**US NVC Group**
Dry & Mesic Longleaf Pine Woodlands	G009
Mesic Longleaf Pine Flatwoods	G596
Wet Longleaf & Slash Pine Flatwoods & Savannas	G190
Xeric Longleaf Pine Barrens	G154
Dry & Mesic Highlands Pine Woodlands	G012
Dry & Mesic Hilly Pine Woodlands	G012, G013
Upper Coastal Plain Pine Flatwoods	G130

Table 3. Crosswalk of Southern Open Pine Groupings, and US NVC Group codes.

Review of Literature and Previous Studies

Throughout 2014, our team compiled all relevant literature and previous studies pertaining to open pine condition and drafted a list of metrics and descriptions to be proposed for inclusion in our final products (see Literature Cited for a full list of the references used in this study and Table 4 below for a subset of the key projects that we drew from most heavily for this work).

Important Background Reports and Studies
Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.
Bragg, Don C. 2002. Reference conditions for old-growth pine forests in the Upper West Gulf Coastal Plain. Jour. Torrey Botanical Society 129(4):261-288.
Bragg, Don C., Ricky O'Neill, William Holimon, Joe Fox, Gary Thornton, and Roger Mangham. 2014. Moro Big Pine: Conservation and Collaboration in the Pine Flatwoods of Arkansas. Journal of Forestry 112(5):446–456.
FNAI and FFS. 2014. Longleaf Pine Ecosystem Geodatabase v.1 Final Report. A cooperative project between Florida Natural Areas Inventory and the Florida Forest Service. <http://www.fnai.org/LongleafGDB.cfm>
GCPO LCC Adaptation Science Management Team. 2013. Integrated Science Agenda, Draft v4. Gulf Coastal Plains & Ozarks Landscape Conservation Cooperative. 5/6/2013. Starkville, MS. <http://lccnetwork.org/sites/default/files/Resources/GCPO_draft_integrated_science_agenda_5-6-2013.pdf> Accessed 7 January 2016.
Hinderliter, M. 2014. Gopher Tortoise Open Pine DFCs. US Fish and Wildlife Service. Jackson, MS.
James, Frances C., Charles A. Hess; Bart C. Kicklighter; and Ryan A. Thum. 2001. Ecosystem Management and the Niche Gestalt of the Red-Cockaded Woodpecker in Longleaf Pine Forests. Ecological Applications 11(3): 854-870.
Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.
Lower Mississippi Valley Joint Venture WGCPO Landbird Working Group. 2011. West Gulf Coastal Plain/Ouachitas Open Pine Landbird Plan. A Report to the Lower Mississippi Valley Joint Venture Management Board. <http://www.lmvjv.org/library/WGCPO_Landbird_Open_Pine_Plan_Oct_2011.pdf>
McIntyre, R.K. 2012. Longleaf Pine Restoration Assessment: Conservation Outcomes and Performance Metrics. Final Report with financial support provided by the National Fish and Wildlife Foundation and the Robert W. Woodruff Foundation. Joseph W. Jones Ecological Research Center.
NatureServe. 2006. International Ecological Classification Standard: Terrestrial Ecological Classifications. Classification and Integrity Indicators for Selected Forest Types of Office Depot's Sourcing Areas of the Southeastern United States. NatureServe Central Databases. Arlington, VA. Data current as of 29 March 2006.
NatureServe. 2011. Rapid Assessment Metrics for Longleaf Pine Dominated Woodlands. Draft Report to the USDA Forest Service, Region 8. NatureServe Central Databases. Durham, NC. U.S.A.
Richardson, D. 2014a. Fire Management Species Profile, Bachman's Sparrow (Peucaea aestivalis). Division of Strategic Resource Management & the Division of Fire Management, USFWS, Southeast Region, Atlanta, GA.
The National Bobwhite Technical Committee. 2011. Palmer, W. E., T. M. Terhune, and D. F. McKenzie (eds.). The National Bobwhite Conservation Initiative: A range-wide plan for recovering bobwhites. National Bobwhite Technical Committee Technical Publication, ver. 2.0 , Knoxville, TN.
U.S. Fish and Wildlife Service. 2003. Recovery plan for the red-cockaded woodpecker (*Picoides borealis*): second revision. U.S. Fish and Wildlife Service, Atlanta, GA. 296 pp.

Table 4. Important Background Reports and Studies

Stakeholder and Expert Meetings to Refine Metrics

To ensure that our overall process included broad stakeholder and expert input, we sponsored two in-person meetings (in Newton, GA and Knoxville, TN) in 2015. At these meetings, our team used a highly inclusive process to engage as many voices as possible. We presented draft metrics and metric descriptions derived from literature and expert opinion, and facilitated a multi-day discussion to collect input on the metrics themselves as well as input on the wildlife habitat value and ecological integrity value for different measures for each metric. Key questions we explored included:

- Which metrics are most important in determining overall wildlife habitat value or ecological integrity?
- How do we best define each metric?
- What are the metric values that are associated with high, medium, and low wildlife habitat value in southern open pine ecosystems?

Table 5. Participants at in-person project meetings in Newton, GA and Knoxville, TN.

Name	Affiliation	State
Sara Aicher	US Fish & Wildlife Service	GA
Wally Akins	Tennessee Wildlife Resources Agency	TN
McRee Anderson	The Nature Conservancy	AR
Joanne Baggs	US Forest Service	GA
Haven Barnhill	US Fish & Wildlife Service	GA
Amity Bass	Natural Heritage Program, Louisiana Department of Wildlife and Fisheries	LA
Mike Black	Shortleaf Initiative	TN
Martin Blaney	Arkansas Game and Fish Commission	AR
Forbes Boyle	US Fish & Wildlife Service	GA
Randy Browning	US Fish & Wildlife Service	MS
Gary Burger	South Carolina DNR	SC
Brian Camposano	Florida Forest Service	FL
Clarence Coffey	Tennessee Wildlife Resources Agency (Retired)	TN
Mike Conner	Jones Center	GA
Jack Culpepper	US Fish & Wildlife Service	SC
Carol Denhof	Longleaf Alliance	AL
Matt Elliott	Georgia DNR, Wildlife Resources Division	GA
Tom Foti	Arkansas Natural Heritage Commission	AR
John Gruchy	Mississippi Department of Wildlife, Fisheries, and Parks	MS
Jim Guldin	USFS Research Station	AR
Matt Hinderliter	US Fish & Wildlife Service	MS
Dan Hipes	Florida Natural Areas Inventory	FL
Chuck Hunter	US Fish & Wildlife Service	GA
Nancy Jordan	US Fish & Wildlife Service	SC
Gary Kauffman	US Forest Service	NC
Amy Knight	Florida Natural Areas Inventory	FL
Lisa Kruse	Georgia DNR, Wildlife Resources Division	GA
Jeff Marcus	The Nature Conservancy	NC
Will McDearman	US Fish & Wildlife Service	MS
Kevin McIntyre	Jones Center	GA
Carl Nordman	NatureServe	NC

Name	Affiliation	State
Chris Oswalt	US Forest Service	TN
Milo Pyne	NatureServe	NC
Joseph Reinman	US Fish & Wildlife Service	FL
Catherine Rideout	East Gulf Coastal Plain Joint Venture	GA
Bryan Rupar	Arkansas Natural Heritage Commission	AR
Carl Schmidt	US Fish & Wildlife Service	GA
Al Schotz	Alabama Natural Heritage Program, Auburn University	AL
Jon Scott	National Fish and Wildlife Foundation	DC
Doyle Shook	Lower Mississippi Joint Venture	AR
Lora Smith	Jones Center	GA
Andy Vanderyacht	Center for Native Grasslands Management	TN
Joan Walker	USFS Research Station	SC
Russ Walsh	US Fish & Wildlife Service	MS
Clay Ware	US Fish & Wildlife Service	GA
Rickie White	NatureServe	NC
Ben Wigley	NCASI	SC
Randy Wilson	US Fish & Wildlife Service	MS
Doug Zollner	The Nature Conservancy	AR

For each workshop, we invited more than 50 potential participants who represented key stakeholder and expert groups. During the workshops, we applied the Delphi method (Hsu and Sandford 2007), which was designed to maximize participant input in complex scenarios in a structured way. We then summarized the input and presented it back to the group to allow for a second round of expert input. From this process we created graphs that summarized mean and median perceived values to wildlife for each metric in each Southern Open Pine Grouping. We also used measures of variation (standard error and maximum and minimum scores) to assess whether scores were relatively bunched together or widely divergent (see figures 3 and 4). For any scores that were widely divergent, we circled back with experts to determine what might be causing this lack of consensus and attempted to address and reintroduce the metric descriptions.

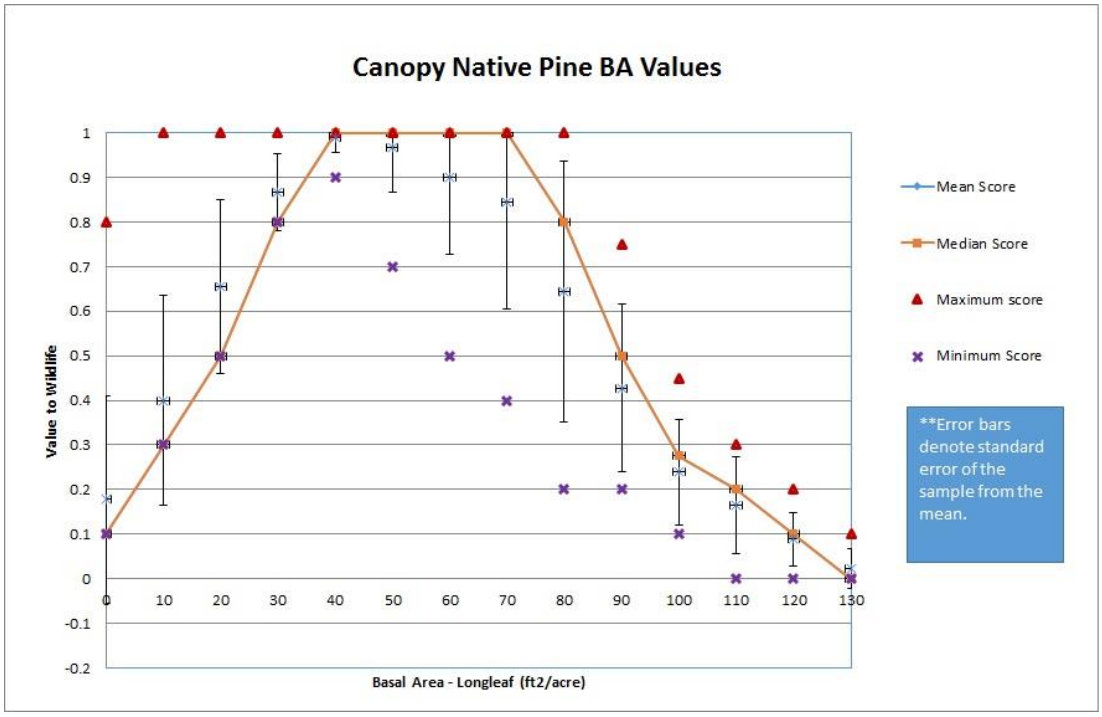

Figure 3. Example graph showing scores developed based on expert input.

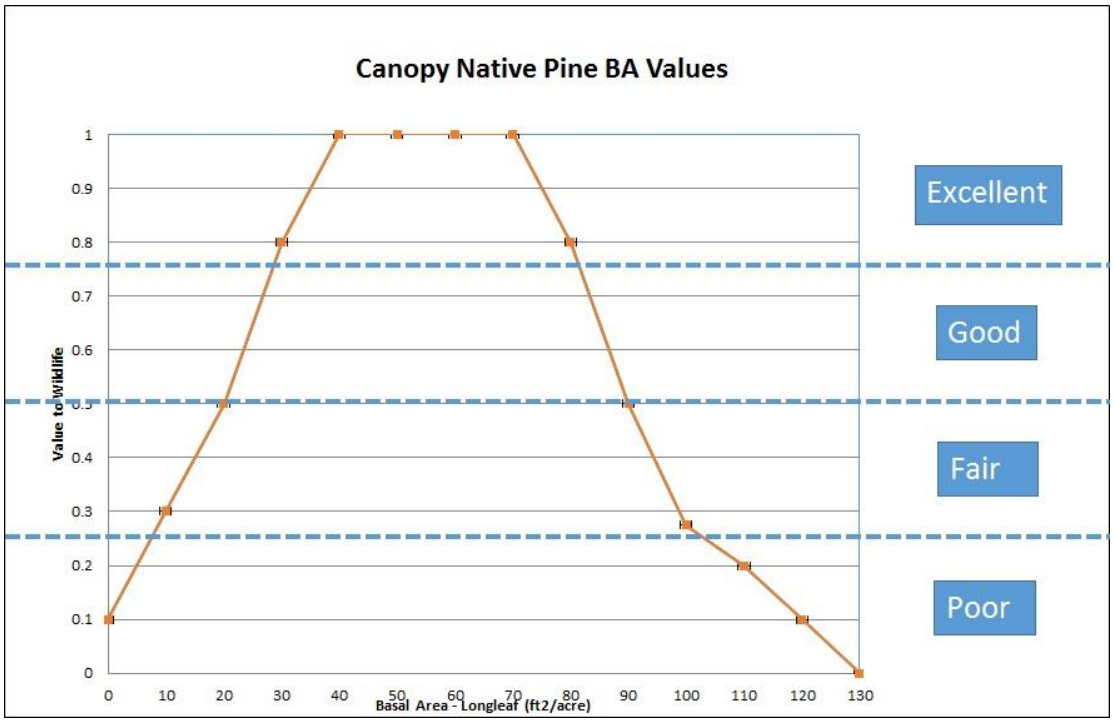

Figure 4. Example of output of Delphi process.

Our starting point for all scoring, for longleaf and other pines, was the Longleaf Partnership Council longleaf metrics (where they applied). We then used the Delphi process (Hsu and Sandford 2007) with experts to generate the value curves (i.e., habitat suitability curves) using median values (see Figure 3

above), then vetted these initial scores with additional experts for review to generate the final curves (see Figure 4 above). Because the y-axis represents values scored 0-1 with 1 being optimum, we used 25th percentiles to determine excellent (>0.75), good (0.5-0.75), fair (0.25-0.5), and poor (<0.25). Because these break points results in very specific and non-intuitive metric scores (e.g., 28 BA), we rounded up or down to the nearest whole number using increments of 5 for the x-axis values (e.g., 30BA). As a result, these metric values represent general approximations of habitat suitability for priority wildlife species and ecological integrity.

Our project core team considered all final input (both potential edits to metrics and changes to metric value "cutoffs") and incorporated these as best as possible into the final version of the metrics. In addition, we worked with the same team of experts to determine which metrics deserved further development, which ones should be considered optional rather than core metrics, and which were to be dropped altogether.

External Review of Metrics

The process of engaging experts and refining metrics into a draft suitable for final review lasted from January 2015 to October 2015. At that point, we had incorporated input from over 60 expert participants from the full range of stakeholder sectors. We identified a larger set of teams and individuals from which to solicit further input. We sent the metrics out to all Migratory Bird Joint Ventures in the region, longleaf implementation teams, and a long list of additional stakeholders for further input. Once that input was received, we compiled it and used it to improve the final metrics that are being released in this report.

Based on expert input, we dropped some metrics that we had considered to be important and added at least one new metric. We removed downed coarse woody debris and snag metrics due to consensus from reviewers that these were not helpful or reliable indicators since scores for these metrics are often highly variable between stands with similar condition and wildlife habitat value. In addition, we removed fire frequency since reviewers felt that other metrics captured the effects of fire better than any rapid field based fire frequency estimate. Fire frequency is better used as a natural resource management benchmark than as a stand condition metric. We added the stand density index at the urging of a sizable number of reviewers to help address concerns reviewers have about the ability of basal area and cover measures to adequately indicate ecosystem health.

Results

Our effort to develop rapid assessment metrics culminated in choosing a set of 13 metrics that serve as the best indicators of ecological health. When taken together, these indicators can help land managers and other interested parties understand the ecological health of their open pine forest stands. These 13 metrics are in three subsets representing the canopy, midstory, and ground layer. This approach of grouping metrics by strata allows users to assess the condition of the canopy, midstory, and ground layer separately (Longleaf Partnership Council 2014).

This document focuses on stand-level metrics. These metrics are best implemented within a similarly managed stand to assess the ecological health at that scale. We have not addressed the landscape scale, an equally important part of ecological health. Landscape scale metrics such as size, landscape context, and buffers help us distinguish between areas that may have high levels of integrity at a smaller scale but may not sustain priority wildlife long term because of their small stand size. We hope to address landscape scale metrics in future work.

To implement these rapid assessment metrics, users must first choose the open pine habitat grouping which best fits the area they are managing (in essence, the ecosystem type). This could be implemented in one of two ways: 1) the area of interest is currently considered to be in one or more of these habitat groupings or 2) the manager wishes to restore one of these habitat groupings in an area that has been degraded and whose current land cover is not open pine. Below is a summary of the seven habitat groupings we have developed.

Summary Descriptions of Open Pine Habitat Groupings

Southern Open Pine Groupings are broad ecological classification units for southern open pine wildlife habitats, encompassing woodlands with relatively open, pine-dominated canopies and grassy understories. These woodlands are fire dependent and many examples occur on infertile soils. These Southern Open Pine Groupings are related to the variation in vegetation structure or physiognomy, dominant and characteristic species, soils, landform, and biogeography of open pine habitats across the southeastern United States. They are comparable to Groups of the U.S. National Vegetation Classification and are compliant with the standards for vegetation from the Federal Geographic Data Committee (Faber-Langendoen et al. 2009, Faber-Langendoen et al. 2012, Faber-Langendoen et al. 2014, FGDC 2008). These Southern Open Pine Groupings are also closely related to the Groups of Ecological Systems used by the U.S. Fish and Wildlife Service (Pyne et al. 2013) and are related to several widely used classifications of vegetation, natural communities, and ecological systems (Comer et al. 2003, Edwards et al. 2013, Eyre 1980, FNAI 2010, Palmquist et al. 2016, Peet 2006).

The Groups of Ecological Systems (GES) referred to below lump significantly different ecosystems together under Shortleaf-Loblolly Woodlands and under Longleaf - Slash Flatwoods. The Southern Open Pine Groupings were supported in the stakeholder and expert meetings. There was consensus that the Dry & Mesic Highlands Pine Woodlands, Dry & Mesic Hilly Pine Woodlands, and Upper Coastal Plain Pine Flatwoods should be used for the application of metrics. Likewise, the Mesic Longleaf Pine Flatwoods, and Wet Longleaf & Slash Pine Flatwoods & Savannas were also recognized as distinct. These Southern Open Pine Groupings seem to appropriately represent the broadly distinguished southern open pine ecosystems for the purposes of defining the desired future condition rapid assessment metrics.

Groups of Ecological Systems (GES)	Southern Open Pine Groupings	US NVC Group
Longleaf Woodlands	Dry & Mesic Longleaf Pine Woodlands	G009
Longleaf - Slash Flatwoods	Mesic Longleaf Pine Flatwoods	G596
Longleaf - Slash Flatwoods	Wet Longleaf & Slash Pine Flatwoods & Savannas	G190
Longleaf-Turkey Oak Sandhills	Xeric Longleaf Pine Barrens	G154
Mountain Longleaf	Dry & Mesic Highlands Pine Woodlands	G012
Shortleaf-Loblolly Woodlands	Dry & Mesic Highlands Pine Woodlands	G012
Shortleaf-Loblolly Woodlands	Dry & Mesic Hilly Pine Woodlands	G012
Shortleaf-Loblolly Woodlands	Dry & Mesic Hilly Pine Woodlands	G013
Shortleaf-Loblolly Woodlands	Upper Coastal Plain Pine Flatwoods	G130

Table 6. Crosswalk of Groups of Ecological Systems, Southern Open Pine Groupings, and US NVC Group codes.

The general information provided for each of the seven Southern Open Pine Groupings comes from the Type Concept and Geographic Range fields of NatureServe's Ecology Element Databases (NatureServe 2015). These data have been edited to follow the Southern Open Pine Groupings. These different ways of organizing information about "open pine" vegetation and other plant community and habitat types is presented as a way of referencing the other arrangements, which were developed at different times and for different purposes. The Southern Open Pine Groupings were designed specifically for this project and differ in some respects from the other arrangements which are part of classifications which are more comprehensive both conceptually and in a regional sense.

Dry & Mesic Longleaf Pine Woodlands

These stands of longleaf pine are on sandy to loamy soils on gently rolling uplands, broad ridgetops, side slopes, and in mesic swales and terraces. The canopy is open, with irregularly scattered longleaf pine trees, clumps of midstory scrub oaks and a grassy understory of wiregrass, bluestems, Indian grasses, with a variety of composites and legumes. It is found from southeastern Virginia to east Texas, including most of Florida.

Mesic Longleaf Pine Flatwoods

These open pine woodlands are found on flat sites on soils with a spodic horizon which can cause sites to be wet in the winter and dry in the summer. Sites are mostly mesic upland flats but also include moist flats. These open woodlands have irregularly scattered longleaf pine, slash pine or South Florida slash pine and an herbaceous layer with wiregrass, bluestems, Indian grasses, and with a variety of composites and legumes. Low shrubs, including saw palmetto, blueberries, huckleberries and hollies may be abundant. Mesic Longleaf Pine Flatwoods are found from southeastern Virginia to southern Mississippi, including most of Florida. It might occur in Louisiana, and occurs only in very small areas in eastern Texas.

Wet Longleaf & Slash Pine Flatwoods & Savannas

Wet pine flatwoods and savannas are characterized by wet mineral soils with seasonally high water tables, on a wide range of soil textures in low elevation areas of the outer coastal plains. In natural condition, canopies are open and mostly dominated by longleaf pine. There is a diverse mix of grasses, herbs, and low shrubs in high-quality stands. Among the grasses, wiregrass often dominates high quality sites, but toothache grass, cutover muhly, little bluestem, Florida dropseed, Carolina dropseed, wireleaf dropseed, chalky bluestem, other bluestems, or other grasses may also dominate. The Wet Longleaf &

Slash Pine Flatwoods & Savannas range from eastern Texas across the Gulf Coastal Plain to Florida, and north in the Atlantic Coastal Plain to southern Virginia.

Xeric Longleaf Pine Barrens

Xeric Longleaf Pine Barrens are open woodlands dominated by longleaf pine with an understory of turkey oak. Bluejack oak and sand post oak occur in the subcanopy, but not on the coarsest dry sands. Turkey oak is absent west of the Mississippi River, where it is replaced by bluejack oak. Sites are consistently dry and have low nutrient availability. All but the driest associations have a well-developed grass layer with little bluestem common throughout, often with wiregrass. The gopher tortoise is a keystone protected species that digs extensive subterranean burrows in deep dry sandy soils within this habitat; hundreds of other species rely on its burrows for shelter. This vegetation occurs in the coastal plain from North Carolina south to Florida and west to eastern Texas.

Dry & Mesic Highlands Pine Woodlands

Dry & Mesic Highlands Pine Woodlands have their most extensive areas in the Ozark-Ouachita Highlands, with shortleaf pine (*Pinus echinata*) as the canopy dominant. Also included, in certain areas of Alabama, Georgia, and the Carolinas are Mountain and Piedmont longleaf pine woodlands, which generally are mixed with oaks, shortleaf pine, hickories, and other hardwoods. In more open stands the understory is characterized by big bluestem, little bluestem, and other prairie grasses and forbs.

Dry & Mesic Hilly Pine Woodlands

These Coastal Plain upland woodlands are dominated by a mix of shortleaf pine and loblolly pine with hardwoods, primarily white oak, southern red oak, post oak, and the scrub oaks bluejack oak, sand post oak, and Arkansas oak. Other trees include black oak, mockernut hickory, black hickory, hawthorn, and hophornbeam. Some typical grasses include woodoats, roundseed panicgrass, and little bluestem.

Upper Coastal Plain Pine Flatwoods

These are nonriverine wetland pine-hardwood forests of the Atlantic and Gulf coastal plains, and are well known from the coastal plain of southern Arkansas and northern Louisiana. Stands are primarily dominated by loblolly pine with shortleaf pine interspersed with laurel oak, swamp chestnut oak, and willow oak, and also with a variety of other hardwoods, including sweetgum, swamp tupelo, and blackgum. It occurs on Pleistocene high terraces or other high flat landforms. Wet hardwood flatwoods occur on seasonally flooded depressions within these terraces. Both types are precipitation driven wetlands in a hydrogeomorphic classification. Within its range, dwarf palmetto (*Sabal minor*) will be abundant in the lower strata of some stands.

Summaries of Metrics by Habitat Grouping

As part of our collaborative process to create metrics, we determined that each habitat grouping varied enough to justify its own set of metrics. The metrics are summarized for each of the seven habitat groupings below. Please refer to Appendix C for more detailed information on each of the metrics.

Dry & Mesic Longleaf Pine Woodlands				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	30-80 ft^2/acre basal area of longleaf pine	20 to <30 or >80 to 90 ft^2/acre basal area of longleaf pine	10 to <20 or >90 to 105 ft^2/acre basal area of longleaf pine	<10 or >105 ft^2/acre basal area of longleaf pine
Southern Yellow Pine Canopy Cover	30-65% canopy cover of longleaf pine	>20 to <30% canopy cover or >65 to 75% canopy cover of longleaf pine	10-20% canopy cover or >75 to 85% canopy cover of longleaf pine	<10% cover or >85% cover of longleaf pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥14" DBH class	BA ≥10 ft^2/acre of longleaf pine trees ≥14" DBH class	Longleaf pine trees ≥ 14" DBH class are present, but at <10 ft^2/acre BA	No longleaf pine trees ≥14" DBH or flat-top longleaf pine are present
Canopy Hardwood Basal Area	<20 ft^2/acre BA of hardwood trees	≥20 to 25 ft^2/acre BA of hardwood trees	>25 to 35 ft^2/acre BA of hardwood trees	>35 ft^2/acre BA of hardwood trees
Stand Density Index (applies to longleaf pine)	SDI = 60 – 125 (15 - 31% of Maximum SDI of 400)	SDI = 40 – 60 or 125 - 160 (10-15% or 31-40% of Maximum SDI of 400)	SDI = 20 – 40 or 160 - 200 (5-10% or 40-50% of maximum SDI)	SDI <20 or >200 (<5% or >50%, 240 is 60% of Maximum SD of 400)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<15% cover of midstory fire tolerant hardwoods	15 to <20% cover of midstory fire tolerant hardwoods	20-25% cover of midstory fire tolerant hardwoods	>25% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20 to <30% cover of woody midstory	30-40% cover of woody midstory	>40% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <30% cover	Short shrubs average 30 to 35% cover	Short shrubs average >35 to 45% cover	Short shrubs average >45% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average <20% cover.	Tall shrubs average 20 to 30% cover.	Tall shrubs average >30 to 40% cover.	Tall shrubs average >40% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	40-98% herbaceous cover	30 to <40% or >98% herbaceous cover	20 to <30% herbaceous cover	<20% herbaceous cover
Longleaf Pine Regeneration	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regen cover is present but is <1% of stand, or no regen seen, but cone producing longleaf pine are present	Longleaf pine regen cover is apparently absent, and no cone producing longleaf pine are present in the stand
Native Warm Season Grass Cover	>25 to 97% foliar cover of all native warm season grasses	>15 to 25% or >97% foliar cover of native warm season grasses	10-15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Mesic Longleaf Pine Flatwoods				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	30-80 ft^2/acre basal area of longleaf or slash pine	20 to <30 or >80 to 90 ft^2/acre basal area of longleaf or slash pine	10 to <20 or >90 to 105 ft^2/acre basal area of longleaf or slash pine	<10 or >105 ft^2/acre basal area of longleaf or slash pine
Southern Yellow Pine Canopy Cover	30 to 65% canopy cover of longleaf or slash pine	20 to <30% canopy cover or >65 to75% canopy cover of longleaf or slash pine	10 to <20% canopy cover or >75 to 85% canopy cover of longleaf or slash pine	<10% cover or >85% cover of longleaf or slash pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of flat-top longleaf or slash pine of any diameter and/or longleaf or slash pine trees ≥14" DBH class	BA ≥10 ft^2/acre of longleaf or slash pine trees ≥ 4" DBH class	Longleaf or slash pine trees ≥14" DBH class are present, but at < 10 ft^2/acre BA	No longleaf or slash pine trees ≥14" DBH or flat-top slash or longleaf pine
Canopy Hardwood Basal Area	<20 ft^2/acre BA of hardwood trees	≥20 to 25 ft^2/acre BA of hardwood trees	>25 to 35 ft^2/acre BA of hardwood trees	>35 ft^2/acre BA of hardwood trees
Stand Density Index (applies to longleaf and slash pine)	SDI = 60 – 125 (15 - 31% of Maximum SDI of 400)	SDI = 40 – 60 or 125 - 160 (10-15% or 31-40% of Maximum SDI of 400)	SDI = 20 – 40 or 160 - 190 (5-10% or 40-48% of maximum SDI)	SDI <20 or >190 (<5% or >48%, 240 is 60% of Maximum SD of 400)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10 to <20% cover of midstory fire tolerant hardwoods	20 to 25% cover of midstory fire tolerant hardwoods	>25% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20 to <30% cover of woody midstory	30-40% cover of woody midstory	>40% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <30% cover	Short shrubs average 30 to <40% cover	Short shrubs average 40-45% cover	Short shrubs average >45% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average <20% cover.	Tall shrubs average 20 to <30% cover.	Tall shrubs average 30-35% cover.	Tall shrubs average >35% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	40-98% herbaceous cover	30 to <40% or >98% herbaceous cover	20 to <30% herbaceous cover	<20% herbaceous cover
Longleaf Pine Regeneration	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regen cover is present but is <1% of stand, or no regen seen, but cone producing longleaf pine are present	Longleaf pine regen cover is apparently absent, and no cone producing longleaf pine are present in the stand
Native Warm Season Grass Cover	>25 to 97% foliar cover of all native warm season grasses	>15 to 25% or >97% foliar cover of native warm season grasses	10-15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Wet Longleaf & Slash Pine Flatwoods & Savannas				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	20-80 ft^2/acre basal area of longleaf or slash pine	10 to <20 or >80 to <90 ft^2/acre basal area of longleaf or slash pine	5 to <10 or 90 to <100 ft^2/acre basal area of longleaf or slash pine	<5 or ≥100 ft^2/acre basal area of longleaf or slash pine
Southern Yellow Pine Canopy Cover	20-65% canopy cover of longleaf or slash pine	15 to <20% canopy cover or >65-75% canopy cover of longleaf or slash pine	10 to <15% canopy cover or >75-85% canopy cover of longleaf or slash pine	<10% cover or >85% cover of longleaf or slash pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of flat-top longleaf or slash pine of any diameter and/or longleaf or slash pine trees ≥14" DBH class	BA ≥10 ft^2/acre of longleaf or slash pine trees ≥14" DBH class	Longleaf or slash pine trees ≥14" DBH class present, but at <10 ft^2/acre BA	No longleaf or slash pine trees ≥14" DBH or with flat-top slash or longleaf pine
Canopy Hardwood Basal Area	<20 ft^2/acre BA of hardwood trees	≥20 to 25 ft^2/acre BA of hardwood trees	>25 to 35 ft^2/acre BA of hardwood trees	>35 ft^2/acre BA of hardwood trees
Stand Density Index (applies to longleaf and slash pine)	SDI = 35 – 120 (9 - 30% of Maximum SDI of 400)	SDI = 20 – 35 or 120 - 155 (5-9% or 30-39% of Maximum SDI of 400)	SDI = 10 – 20 or 155 - 180 (2.5-5% or 39-45% of maximum SDI)	SDI <10 or >180 (<2.5% or > 45%, 240 is 60% of Maximum SD of 400)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10-15% cover of midstory fire tolerant hardwoods	>15 to 25% cover of midstory fire tolerant hardwoods	>25% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20-30% cover of woody midstory	>30 to 40% cover of woody midstory	>40% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <30% cover	Short shrubs average 30 to <40% cover	Short shrubs average 40-45% cover	Short shrubs average >45% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average < 15% cover.	Tall shrubs average 15 to <25% cover.	Tall shrubs average 25-35% cover.	Tall shrubs average >35% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	40-100% herbaceous cover	30 to <40% herbaceous cover	20 to <30% herbaceous cover	<20% herbaceous cover
Longleaf Pine Regeneration	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regen cover is present but is <1% of stand, or no regen seen, but cone producing longleaf pine are present	Longleaf pine regen cover is apparently absent, and no cone producing longleaf pine are present in the stand
Native Warm Season Grass Cover	25-97% foliar cover of all native warm season grasses	>15 to <25% or >97% foliar cover of native warm season grasses	10-15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Xeric Longleaf Pine Barrens				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	25-80 ft^2/acre basal area of longleaf pine	>15 to <25 or >80 to 90 ft^2/acre basal area of longleaf pine	10 to 15 or >90 to <100 ft^2/acre basal area of longleaf pine	<10 or ≥100 ft^2/acre basal area of longleaf pine
Southern Yellow Pine Canopy Cover	>20 to 55% canopy cover of longleaf pine	>15 to 20% canopy cover or >55 to 70% canopy cover of longleaf pine	5-15% canopy cover or >70 to 80% canopy cover of longleaf pine	<5% cover or >80% cover of longleaf pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of flat-top longleaf pine of any diameter and/or longleaf pine trees ≥12" DBH class	BA ≥10 ft^2/acre of longleaf pine trees ≥12" DBH class	Longleaf pine trees ≥12" DBH class are present, but at <10 ft^2/acre BA	No longleaf pine trees ≥12" DBH or flat-top longleaf pine are present
Canopy Hardwood Basal Area	<20 ft^2/acre BA of hardwood trees	≥20 to 25 ft^2/acre BA of hardwood trees	>25 to 35 ft^2/acre BA of hardwood trees	>35 ft^2/acre BA of hardwood trees
Stand Density Index (applies to longleaf pine)	SDI = 50 – 120 (13 - 30% of Maximum SDI of 400)	SDI = 30 – 50 or 120 - 160 (8-13% or 30-40% of Maximum SDI of 400)	SDI = 20 – 30 or 160 - 180 (5-8% or 40-45% of maximum SDI)	SDI <20 or >180 (<5% or >45%, 240 is 60% of Maximum SD of 400)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10-20% cover of midstory fire tolerant hardwoods	>20 to 25% cover of midstory fire tolerant hardwoods	>25% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20 to <30% cover of woody midstory	30-40% cover of woody midstory	>40% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <25% cover	Short shrubs average 25 - 35% cover	Short shrubs average >35 to 45% cover	Short shrubs average >45% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average <15% cover.	Tall shrubs average 15 to <25% cover.	Tall shrubs average 25-30% cover.	Tall shrubs average >30% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	40-100% herbaceous cover	>25 to <40% herbaceous cover	>15 to 25% herbaceous cover	0-15% herbaceous cover
Longleaf Pine Regeneration	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regeneration cover is ≥1% of stand (Good and Excellent)	Longleaf pine regen cover is present but is <1% of stand, or no regen seen, but cone producing longleaf pine are present	Longleaf pine regen cover is apparently absent, and no cone producing longleaf pine are present in the stand
Native Warm Season Grass Cover	25-95% foliar cover of all native warm season grasses	15 to <25% or >95% foliar cover of native warm season grasses	10 to <15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Dry & Mesic Highlands Pine Woodlands				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	>35 to 75 ft^2/acre basal area of shortleaf pine	30 to 35 or >75 to 90 ft^2/acre basal area of shortleaf pine	10 to <30 or >90 to 110 ft^2/acre basal area of shortleaf pine	<10 or >110 ft^2/acre basal area of shortleaf pine
Southern Yellow Pine Canopy Cover	>25 to 70% canopy cover of shortleaf pine	20-25% or >70 to 80% canopy cover of shortleaf pine	10 to <20% or >80 to 90% canopy cover of shortleaf pine	<10% or >90% canopy cover of shortleaf pine
Southern Yellow Pine Stand Age Structure	Basal area ≥20 ft^2/acre of shortleaf pine trees ≥14" DBH class	Basal area ≥10 ft^2/acre of shortleaf pine trees ≥14" DBH class	Shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees	No shortleaf pine trees ≥14" DBH are present
Canopy Hardwood Basal Area	≤20 ft^2/acre BA of hardwood trees	>20 to 40 ft^2/acre BA of hardwood trees	>40 to 50 ft^2/acre BA of hardwood trees	>50 ft^2/acre BA of hardwood trees
Stand Density Index (applies to shortleaf pine)	SDI = 65 – 135 (14 - 30% of Maximum SDI of 450)	SDI = 45 – 65 or 135 - 180 (10-14% or 30-40% of Maximum SDI of 450)	SDI = 20 – 45 or 180 - 225 (4-10% or 40-50% of maximum SDI of 450)	SDI <20 or >225 (<4% or >50%, 270 is 60% of Maximum SD of 450)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10-30% cover of midstory fire tolerant hardwoods	>30 to 40% cover of midstory fire tolerant hardwoods	>40% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20-25% cover of woody midstory	>25 to 35% cover of woody midstory	>35% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <20% cover	Short shrubs average 20 - 25% cover	Short shrubs average >25 to 40% cover	Short shrubs average >40% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average < 15% cover.	Tall shrubs average 15 - 20% cover.	Tall shrubs average >20 to 30% cover.	Tall shrubs average >30% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	>45 to 80% herbaceous cover	30-45% or >80% herbaceous cover	15 to <30% herbaceous cover	<15% herbaceous cover
Native Warm Season Grass Cover	>25 to 85% foliar cover of all native warm season grasses	>15 to 25% or >85% foliar cover of native warm season grasses	10-15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Dry & Mesic Highlands Pine Woodlands (Mountain Longleaf)				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	>35 to 75 ft^2/acre basal area of longleaf & shortleaf pine	30 to 35 or >75 to 90 ft^2/acre basal area of longleaf & shortleaf pine	10 to <30 or >90 to 110 ft^2/acre basal area of longleaf & shortleaf pine	<10 or >110 ft^2/acre basal area of longleaf & shortleaf pine
Southern Yellow Pine Canopy Cover	>25 to 70% canopy cover of longleaf & shortleaf pine	20-25% or >70 to 80% canopy cover of longleaf & shortleaf pine	10 to <20% or >80 to 90% canopy cover of longleaf & shortleaf pine	<10% or >90% canopy cover of longleaf & shortleaf pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of flat-top longleaf pine of any diameter and/or longleaf or shortleaf pine trees ≥14" DBH class	BA ≥10 ft^2/acre of longleaf or shortleaf pine trees ≥14" DBH class	Longleaf or shortleaf pine trees ≥14" DBH class are present, but at<10 ft^2/acre BA	No longleaf or shortleaf pine trees ≥14" DBH or flat-top longleaf pine are present
Canopy Hardwood Basal Area	≤20 ft^2/acre BA of hardwood trees	>20 to 40 ft^2/acre BA of hardwood trees	>40 to 50 ft^2/acre BA of hardwood trees	>50 ft^2/acre BA of hardwood trees
Stand Density Index (applies to longleaf pine)	SDI = 55 – 120 (14 - 30% of Maximum SDI of 400)	SDI = 40 – 55 or 120 - 160 (10-14% or 30-40% of Maximum SDI of 400)	SDI = 15 – 40 or 160 - 200 (4-10% or 40-50% of maximum SDI)	SDI <15 or >200 (<4% or >50%, 240 is 60% of Maximum SD of 400)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10-30% cover of midstory fire tolerant hardwoods	>30 to 40% cover of midstory fire tolerant hardwoods	>40% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	≥20 to 25% cover of woody midstory	>25 to 35% cover of woody midstory	>35% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <20% cover	Short shrubs average 20- 25% cover	Short shrubs average >25 to 40% cover	Short shrubs average >40% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average < 15% cover.	Tall shrubs average 15 - 20% cover.	Tall shrubs average >20 to 30% cover.	Tall shrubs average >30% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	>45 to 80% herbaceous cover	30-45% or >80% herbaceous cover	15 to <30% herbaceous cover	<15% herbaceous cover
Longleaf Pine Regeneration	Longleaf pine regeneration cover is >1% of stand (Good and Excellent)	Longleaf pine regeneration cover is >1% of stand (Good and Excellent)	Longleaf pine regen cover is present but is <1% of stand, or no regen seen, but cone producing longleaf pine are present	Longleaf pine regen cover is apparently absent, and no cone producing longleaf pine are present in the stand
Native Warm Season Grass Cover	>25 to 85% foliar cover of all native warm season grasses	20-25% or >85% foliar cover of all native warm season grasses	10 to <20% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Dry & Mesic Hilly Pine Woodlands				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	30-85 ft^2/acre basal area of loblolly or shortleaf pine	20 to <30 or >85 to 100 ft^2/acre basal area of loblolly or shortleaf pine	10 to <20 or >100 to 115 ft^2/acre basal area of loblolly or shortleaf pine	<10 or >115 ft^2/acre basal area of loblolly or shortleaf pine
Southern Yellow Pine Canopy Cover	>25 to 75% canopy cover of loblolly or shortleaf pine	>15 to 25% canopy cover or >75 to 85% canopy cover of loblolly or shortleaf pine	10-15% canopy cover or >85 to 95% canopy cover of loblolly or shortleaf pine	<10% cover or >95% cover of loblolly or shortleaf pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of loblolly and/or shortleaf pine trees ≥14" DBH class	BA ≥10 ft^2/acre of loblolly and/or shortleaf pine trees ≥14" DBH class	Loblolly and/or shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees	No loblolly and/or shortleaf pine trees ≥14" DBH are present
Canopy Hardwood Basal Area	≤20 ft^2/acre BA of hardwood trees	>20 to 30 ft^2/acre BA of hardwood trees	>30 to 50 ft^2/acre BA of hardwood trees	>50 ft^2/acre BA of hardwood trees
Stand Density Index (applies to shortleaf and loblolly pine)	SDI = 55 – 155 (12 - 34% of Maximum SDI of 450)	SDI = 35 – 55 or 155 - 205 (8-12% or 34-45% of Maximum SDI of 450)	SDI = 20 – 35 or 205 - 225 (4-8% or 45-50% of maximum SDI of 450)	SDI <20 or >225 (<4% or >50%, 270 is 60% of Maximum SD of 450)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10-20% cover of midstory fire tolerant hardwoods	>20 to 35% cover of midstory fire tolerant hardwoods	>35% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	≥20 to 30% cover of woody midstory	>30 to 50% cover of woody midstory	>50% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <20% cover	Short shrubs average 20 - 30% cover	Short shrubs average >30 to 45% cover	Short shrubs average >45% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average <15% cover.	Tall shrubs average 15 to 20% cover.	Tall shrubs average >20 to 30% cover.	Tall shrubs average >30% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	35-80% herbaceous cover	20 to <35% or >80% herbaceous cover	10 to <20% herbaceous cover	<10% herbaceous cover
Native Warm Season Grass Cover	25-100% foliar cover of all native warm season grasses	>15 to <25% foliar cover of all native warm season grasses	10-15% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Upper Coastal Plain Pine Flatwoods				
Canopy Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Canopy Southern Yellow Pine Basal Area	30-80 ft^2/acre basal area of loblolly or shortleaf pine	20 to <30 or >80 to 90 ft^2/acre basal area of loblolly or shortleaf pine	10 to <20 or >90 to 110 ft^2/acre basal area of loblolly or shortleaf pine	<10 or >110 ft^2/acre basal area of loblolly or shortleaf pine
Southern Yellow Pine Canopy Cover	>25 to 70% canopy cover of loblolly or shortleaf pine	>15 to 25% canopy cover or >70 to 80% canopy cover of loblolly or shortleaf pine	10-15% canopy cover or >80 to 90% canopy cover of loblolly or shortleaf pine	<10% cover or >90% cover of loblolly or shortleaf pine
Southern Yellow Pine Stand Age Structure	BA ≥20 ft^2/acre of loblolly and/or shortleaf pine trees ≥14" DBH class	BA ≥10 ft^2/acre of loblolly and/or shortleaf pine trees ≥14" DBH class	Loblolly and/or shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees	No loblolly and/or shortleaf pine trees ≥14" DBH are present
Canopy Hardwood Basal Area	≤20 ft^2/acre BA of hardwood trees	>20 to 30 ft^2/acre BA of hardwood trees	>30 to 50 ft^2/acre BA of hardwood trees	>50 ft^2/acre BA of hardwood trees
Stand Density Index (applies to shortleaf and loblolly pine)	SDI = 55 – 145 (12 - 32% of Maximum SDI of 450)	SDI = 35 – 55 or 145 - 180 (8-12% or 32-40% of Maximum SDI of 450)	SDI = 20 – 35 or 180 - 225 (4-8% or 40-50% of maximum SDI of 450)	SDI <20 or >225 (<4% or >50%, 270 is 60% of Maximum SD of 450)
Midstory/Shrub Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Midstory Fire Tolerant Hardwood Cover	<10% cover of midstory fire tolerant hardwoods	10 to 20% cover of midstory fire tolerant hardwoods	>20 to 35% cover of midstory fire tolerant hardwoods	>35% cover of midstory fire tolerant hardwoods
Midstory Overall Cover	<20% cover of woody midstory	20-30% cover of woody midstory	>30 to 50% cover of woody midstory	>50% cover of woody midstory
Short Shrub (<3 ft tall) Cover	Short shrubs average <20% cover	Short shrubs average 20 to 30% cover	Short shrubs average >30 to 45% cover	Short shrubs average >45% cover
Tall Shrub (3-10 ft tall) Cover	Tall shrubs average <15% cover.	Tall shrubs average 15 - 20% cover.	Tall shrubs average >20 to 30% cover.	Tall shrubs average >30% cover.
Ground Layer Metrics				
	Excellent	**Good**	**Fair**	**Poor**
Overall Native Herbaceous Ground Cover	35-80% herbaceous cover	20 to <35% or >80% herbaceous cover	10 to <20% herbaceous cover	<10% herbaceous cover
Native Warm Season Grass Cover	>25% foliar cover of all native warm season grasses	20-25% foliar cover of all native warm season grasses	10 to <20% foliar cover of all native warm season grasses	<10% foliar cover of all native warm season grasses
Invasive Plant Presence / Distribution	Invasive nonnative plant species absent or cover is very low (≤1% cover)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)	Invasive nonnative plant species in any stratum common (>10% cover)

Discussion/Summary

Open pine habitats, especially those dominated by longleaf pine, provide the last refuge for a large number of at-risk and declining vertebrates and an even larger number of at-risk and declining plant species. A few species that depend upon this habitat wholly or in part include red-cockaded woodpecker (*Picoides borealis*), Bachman's sparrow (*Aimophilus aestivalis*), northern bobwhite (*Colinus virginianus*), gopher frog (*Rana sevosa*), gopher tortoise (*Gopherus polyphemus*), brown-headed nuthatch (*Sitta pusilla*), pine warbler (*Setophaga pinus*), prairie warbler (*Setophaga discolor*), Eastern diamondback rattlesnake (*Crotalus adamanteus*), pocket gopher (*Geomys pinetis*), and pine snake/Louisiana pine snake (*Pituophis ruthveni* and *Pituophis melanoleucus*). The America's Longleaf Restoration Initiative's (ALRI) Longleaf Partnership Council recently developed a region-wide approach to ensuring the future viability of longleaf-dominated communities and the species reliant upon them by establishing definitions of high quality longleaf acreage. However, until now, no single region-wide metrics-based approach existed to assess condition of longleaf. Furthermore, other open pine habitat types dominated by shortleaf, slash, and loblolly were not always included in the discussion of longleaf pine even though they often provide habitat to similar types of wildlife. Land managers and private landowners need guidance on how to efficiently and accurately quantify the condition and wildlife habitat value of the pine stands they manage. The Shortleaf Pine Initiative plans to formally release their Shortleaf Pine Restoration Plan in the near future at the 2016 Southeast Conference for Land and Community Conservation http://shortleafpine.net/shortleaf-pine-initiative/news-from-director.

Furthermore, because of limited resources, landowners and land managers need metrics that are easy to collect and analyze with limited time and staff. By finalizing a single set of desired forest condition/rapid assessment metrics for wildlife habitat and ecological integrity, we can help conservation-minded land managers efficiently assess wildlife habitat and ecological integrity and also better understand how key lands are contributing to the regional goals set in the ALRI *Range-Wide Conservation Plan for Longleaf Pine* (America's Longleaf 2009) and other open pine habitats.

Our work combines existing metrics developed by USFS and NatureServe with metrics developed to assess wildlife habitat value as part of the East Gulf Coastal Plain Joint Venture's desired forest conditions project. The final desired forest condition metrics address wildlife habitat and ecological integrity for the full range of open pine ecosystems within the study area. Our approach provides an important new way to rapidly assess ecosystem health for lands primarily being managed for wildlife habitat and biodiversity and to help the GCPO LCC and the Longleaf Partnership Council more accurately document progress towards their acreage goals for open pine (GCPO LCC Adaptation Science Management Team 2013).

Our intent is for this approach to provide an ecological habitat –based solution to species management. For instance, we believe a stand that scores high using the rapid assessment metrics will likely be a better area for bobwhite quail habitat than a stand that scores low. Providing habitat for characteristic wildlife species of southern open pine ecosystems is a goal for many land managers in the South. The metrics presented here can assist land managers who have conservation as an objective on lands being managed for wildlife or for multiple uses. Prescribed fire, thinning, targeted use of herbicides, and planting for reforestation or wildlife food are some of the land management actions used to promote the wildlife of southern open pine ecosystems. By reevaluating stands before and after management, landowners will be able to determine how effective their actions are in improving the ecosystem and the habitat needs of open-pine dependent wildlife.

NatureServe has conducted extensive tests of the Ecological Integrity Assessment (EIA) methodology for wetlands across the United States (Faber-Langendoen et al. 2016). We recently completed a rigorous evaluation from 220 sites across six states (CO, IN, MI, NH, NJ, WA), testing for both the discriminatory power of the metrics and major ecological factors and the levels of redundancy. These have also been investigated for upland forest systems (Tierney et al. 2009). This testing has given us confidence that our use of this methodology for open pine systems can also be an efficient and scientifically valid way to assess open pine stands for overall wildlife habitat value and ecological integrity.

Although we believe that the rapid assessment approach can help conservation-minded landowners to understand and manage the health of their open pine stands, we also believe it is important to understandits limitations and potential pitfalls.

1) We consider this current document to be version 1.0. Since the testing of the methodology for this project has been based on an initial dataset, we feel that the document and metrics can and should be revisited and adjusted with new information. We hope to test the metrics in all key ecosystems in 2016 by collecting data from multiple stands and multiple condition classes so that we can adjust the metrics and metric cutoff values as necessary and issue a new version in the future.
2) There are different vegetation and environmental classifications for open pine. We have involved many partners and put considerable effort into the definition of a workable set of units (general open pine groupings) that encompass the variation in open pine habitats and communities across the geographic range of the project. These groupings are general types which are largely equivalent to vegetation group types of the United States National Vegetation Classification (USNVC). We recognize that other classification categories may also be useful.
3) It is important to understand the implications of current or existing vs. potential vegetation and what one's management goals are when applying these metrics. In areas where open pine was historically present, current vegetation could be something different (old field, fire-suppressed hardwood dominated forest, etc.). When applying these metrics, the manager should use the metrics that apply to the ecosystem type/ habitat grouping that they are managing towards rather than the current type.

Now that this report has been issued, we have a number of future objectives:

1) Issue a companion document that shows how to implement rapid assessment metrics in open pine using the metrics detailed in this report.
2) Identify partners to collect data on a range of open pine sites and summarize that data. Use the summary information to assess how well the metrics are performing and adjust the metrics if needed.
3) Incorporate landscape scale metrics such as size, landscape context, etc. to complement stand scale work

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Appendices

Appendix A. Key to Southern Open Pine Habitat Groupings

This key should enable a user of the desired forest condition metrics for southern open pine to easily determine what set of metrics is most appropriate for their lands. It is necessary that a user of the key be familiar with where their land(s) are located in terms of state and USDA Forest Service ecoregions (Cleland et al. 2007), at least to the section level. Some of the habitat groupings, by definition, occur within the range of longleaf pine (*Pinus palustris*) as defined by Little (1971). This general range is not precise in all places, so it is certainly possible that a genuine stand of a longleaf grouping could be found in an area that is not included in this range, but in the vast majority of cases, a user should be able to place a stand in a grouping.

The key is specifically designed for use within the boundaries of the Gulf Coast Plains and Ozarks Landscape Conservation Cooperative (GCPO LCC), which includes the Missouri and Arkansas highlands of the Ozark, Boston and Ouachita mountain ranges, and the Gulf Coastal Plains, which extend from eastern Texas to the Florida panhandle. It also applies to stands dominated by Longleaf Pine (*Pinus palustris*) throughout the range of this species, but makes no attempt to accommodate other related vegetation east and north of the GCPO LCC footprint.

The key will lead a user through a series of choices ("couplets") related to the geographic location of the area under consideration, as well as choices about stand composition and environment. At its higher levels, the key is constructed around these Forest Service regions. Further into the key, the choices related to stand composition and environment come into play. A user should read both statements and see which one best applies to the area and stands under question. If an obviously incorrect answer is obtained, it may be necessary to repeat the exercise.

Common terms rather than highly technical ones are used (wet, dry, sandy, upland, seasonally, etc.). One term that may be unfamiliar to some users is "mesic". This is a kind of shorthand for an environment that is neither very dry nor very wet (i.e. "in the middle" of a broad ecological moisture continuum). It is most frequently applied to species-rich hardwood stands ("coves"), but in this context it would refer to stands that are not "wet", i.e. without standing water), but have enough available soil moisture to support diverse and possibly dense herbaceous layers. Similarly "dry-mesic" refers to stands that are on the dry side of mesic, but not notably dry. These terms may roughly correlate with soil texture, in that under similar hydrological conditions, coarser-textured soils are more likely to be drier that those with finer particle size.

Following the key, a table of distributions of the open pine groupings by state and region (Table A-1), a map of the relevant USDA Forest Service Sections (Figure A-1), and a table of USDA Forest Service Provinces and Sections referred to in the key (Table A-2) are provided to assist in its use.

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Key to Open Pine Groupings

1a. Forests and woodlands in the coastal plains (Outer Coastal Plains Mixed Forest Province 232; Southeastern Mixed Forest Province 231, southern parts of Sections 231B, 231E and 231H within the range of Longleaf Pine [*Pinus palustris*] as defined by Little [1971]), typically dominated by Longleaf Pine (*Pinus palustris*) and/or Slash Pine (*Pinus elliottii*), habitat ranging from very dry sandy uplands, mesic finer-textured soils, and seasonally wet or saturated flatwoods and savannas..... 2

1b. Forests and woodlands landward of the coastal plains (Southeastern Mixed Forest Province 231, Sections 231A, 231C, 231D, 231G, 231I; also Central Interior Broadleaf Forest Province 223, Section 223A; Ozark Broadleaf Forest Province M223, and Ouachita Mixed Forest-Meadow Province M231); or in the inner portions of the coastal plains landward of the range of Longleaf Pine (Southeastern Mixed Forest Province 231, most of Sections 231B, 231E, lowland parts of Section 231G, 231H) dominated by Shortleaf Pine (*Pinus echinata*) and/or Loblolly Pine (*Pinus taeda*), OR dominated by Longleaf Pine (*Pinus palustris*) and found landward of the coastal plains as mentioned above..... 3

2a. Longleaf Pine / Slash Pine Woodlands (wet and mesic flatwoods and savannas); the wet examples found on poorly drained, somewhat poorly drained, and seasonally saturated mineral soils with seasonally high water tables; the mesic examples found on flat sites with spodic horizons (Spodosols) or some factor impeding drainage which can cause sites to be wet in the winter and dry in the summer 4

2b. Stands of longleaf pine (*Pinus palustris*) on sandy to loamy soils on upland sites ranging from gently rolling lands, broad ridgetops to steeper side slopes, and in mesic swales and terraces 5

3a. Stands with Longleaf Pine (*Pinus palustris*) in combination with Shortleaf Pine (*Pinus echinata*) and dry Oak (*Quercus*) species, found landward of the coastal plains (Southeastern Mixed Forest Province 231, Sections 231A, 231C, 231D, 231I) ..... "**Mountain Longleaf"** ..... **Dry & Mesic Highlands Pine Woodlands, in part; [part of US NVC GROUP G012]**

3b. Forests and woodlands dominated by Shortleaf Pine (*Pinus echinata*) and/or Loblolly Pine (*Pinus taeda*) found landward of the coastal plains (Southeastern Mixed Forest Province 231, Sections 231E, 231G); and in the inner portions of the coastal plains landward of the range of Longleaf Pine (Southeastern Mixed Forest Province 231, most of Sections 231B, 231E and 231H); also west of the Mississippi River in the Central Interior Broadleaf Forest Province 223, Section 223A; Ozark Broadleaf Forest Province M223, and Ouachita Mixed Forest-Meadow Province M231, as well as the Crowley's Ridge Subsection 234Db) 6

4a. Mesic Longleaf Pine flatwood woodlands found on flat sites with spodic horizons (Spodosols) or some factor impeding drainage which can cause sites to be wet in the winter and dry in the summer.. .....**Mesic Longleaf Pine Flatwoods [US NVC GROUP G596]**

4b. Wet Longleaf Pine / Slash Pine flatwoods and savannas found on poorly drained, somewhat poorly drained, and seasonally saturated mineral soils with seasonally high water tables..... ..... **Wet Longleaf & Slash Pine Flatwoods & Savannas [US NVC GROUP G190]**

5a. Stands of longleaf pine (*Pinus palustris*) on deep sandy soils, in the fall-line sandhills (Subsection 232Bq) as well as on other sandy sites in the outer coastal plains, typically with scrub oaks (Turkey Oak, Bluejack Oak, Sand Post Oak) in the subcanopy ....**Xeric Longleaf Pine Barrens [US NVC GROUP G154]**

5b. Other stands of longleaf pine (*Pinus palustris*) on sandy to loamy soils on upland sites ranging from gently rolling lands, broad ridgetops to steeper side slopes, and in mesic swales and terraces. Subcanopy oaks include White Oak, Southern Red Oak, Black Oak, Blackjack Oak ....**Dry & Mesic Longleaf Pine Woodlands [US NVC GROUP G009]**

6a. Dry and dry-mesic forests and woodlands dominated by Shortleaf Pine (*Pinus echinata*) found west of the Mississippi River in the Central Interior Broadleaf Forest Province 223, Section 223A; Ozark Broadleaf Forest Province M223; Ouachita Mixed Forest-Meadow Province M231; Southeastern Mixed Forest Province 231, Section 231G .....**"Shortleaf-Loblolly Woodlands"** ..... **Dry & Mesic Highlands Pine Woodlands, in part; [part of US NVC GROUP G012]**

6b. Forests and woodlands, including flatwoods, dominated by Shortleaf Pine (*Pinus echinata*) and/or Loblolly Pine (*Pinus taeda*) found in the inner portions of the coastal plains landward of the range of Longleaf Pine (Southeastern Mixed Forest Province 231, most of Sections 231B, 231E, 231H), as well as in portions of the Mississippi River Alluvial Basin Section 234A. [this Grouping would also apply to the lower/outer parts of the Piedmont (Sections 231A, 231I but this area is not within the GCPO LCC footprint] 7

7a. Dry and dry-mesic forests and woodlands dominated by Shortleaf Pine (*Pinus echinata*) and/or Loblolly Pine (*Pinus taeda*) found in the inner portions of the coastal plains landward of the range of Longleaf Pine (Southeastern Mixed Forest Province 231, most of Sections 231B, 231E, 231H), as well as the Crowley's Ridge Subsection 234Db (Lower Mississippi Riverine Forest Province 234) [this Grouping would also apply to the lower/outer parts of the Piedmont (Sections 231A, 231I) but this area is not within the GCPO LCC footprint]..... ..... **Dry and Mesic Hilly Pine Woodlands [US NVC GROUP G013, part of G012]**

7b. Flatwoods (nonriverine wetland or seasonally wet pine-hardwood forests) in the coastal plains (Outer Coastal Plains Mixed Forest Province 232; Southeastern Mixed Forest Province 231, most of Sections 231B, 231E, 231H) and the Lower Mississippi Riverine Forest Province 234 .... **Upper Coastal Plain Flatwoods [US NVC GROUP G130]**

States	Region	Dominant Pines	Site	Southern Open Pine Grouping
AR, MO, OK	Ozark and Ouachita Highlands	Shortleaf Pine	Dry & Mesic Uplands	Dry & Mesic Highlands Pine Woodlands
AR, LA, TX	Coastal Plain	Shortleaf Pine, Loblolly Pine	Dry & Mesic Uplands	Dry & Mesic Hilly Pine Woodlands
AR, LA, TX	Coastal Plain	Shortleaf Pine, Loblolly Pine	Wet-Mesic to Wet Flats	Upper Coastal Plain Pine Flatwoods
LA, TX	Coastal Plain	Longleaf Pine	Xeric Uplands on deep sandy soils	Xeric Longleaf Pine Barrens
LA, TX	Coastal Plain	Longleaf Pine	Dry & Mesic Uplands	Dry & Mesic Longleaf Pine Woodlands
LA, TX	Coastal Plain	Longleaf Pine	Wet Flats	Wet Longleaf & Slash Pine Flatwoods & Savannas
AL, GA, NC, SC	Appalachians and Piedmont	Longleaf Pine	Dry Uplands, on ridges and upper slopes	Dry & Mesic Highlands Pine Woodlands
AL, GA, NC, SC	Piedmont	Shortleaf Pine, Loblolly Pine	Dry & Mesic Uplands	Dry & Mesic Hilly Pine Woodlands
AL, GA, FL, MS, NC, SC	Coastal Plain	Shortleaf Pine, Loblolly Pine	Dry & Mesic Uplands	Dry & Mesic Hilly Pine Woodlands
AL, GA, MS, NC, SC	Coastal Plain	Longleaf Pine	Xeric Uplands on deep sandy soils	Xeric Longleaf Pine Barrens
AL, GA, MS, NC, SC	Coastal Plain	Longleaf Pine	Dry & Mesic Uplands	Dry & Mesic Longleaf Pine Woodlands
AL, GA, MS, NC, SC	Coastal Plain	Longleaf Pine, Slash Pine	Mesic to Wet Flats, Spodosols	Mesic Longleaf Pine Flatwoods
AL, GA, MS, NC, SC	Coastal Plain	Longleaf Pine, Slash Pine	Wet Flats	Wet Longleaf & Slash Pine Flatwoods & Savannas
FL	Coastal Plain	Longleaf Pine	Dry & Mesic Uplands	Dry & Mesic Longleaf Pine Woodlands
FL	Coastal Plain	Longleaf Pine	Xeric Uplands on deep sandy soils	Xeric Longleaf Pine Barrens
FL	Coastal Plain	Longleaf Pine, Slash Pine, South Florida Slash Pine	Mesic to Wet Flats, Spodosols	Mesic Longleaf Pine Flatwoods
FL	Coastal Plain	Longleaf Pine, Slash Pine, South Florida Slash Pine	Wet Flats	Wet Longleaf & Slash Pine Flatwoods & Savannas

Table A-1. States, Regions, and Southern Open Pine Groupings

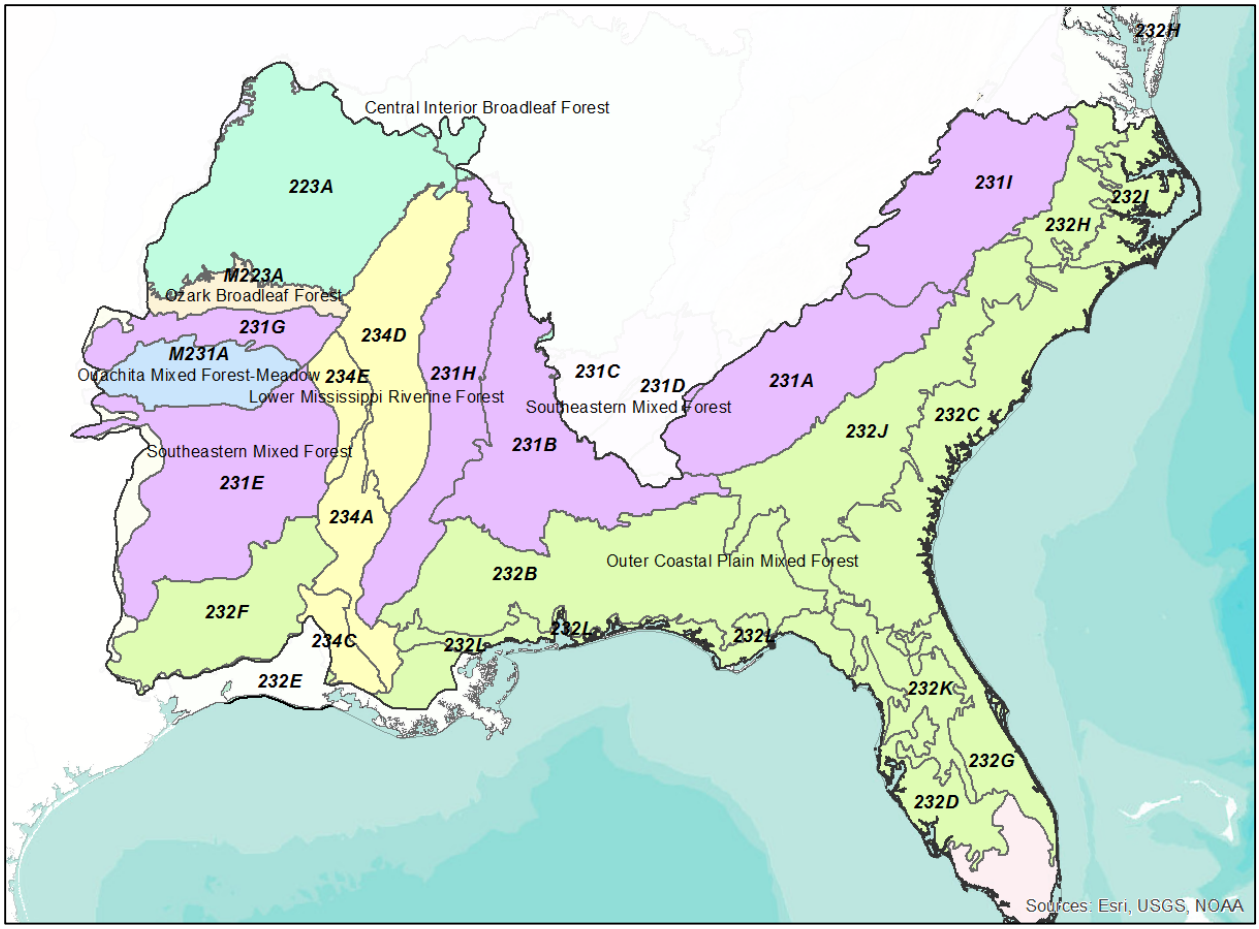

Figure A-1. USDA Forest Service Provinces and Sections (from Cleland et al. 2007)

PROVINCE /SECTION	**PROVINCE**/SECTION_NAME
223	**Central Interior Broadleaf Forest**
223A	Ozark Highlands
M223	**Ozark Broadleaf Forest**
M223A	Boston Mountains
231	**Southeastern Mixed Forest**
231A	Southern Appalachian Piedmont
231B	Coastal Plains-Middle
231C	Southern Cumberland Plateau
231D	Southern Ridge and Valley
231E	Mid Coastal Plains-Western
231G	Arkansas Valley
231H	Coastal Plains-Loess
231I	Central Appalachian Piedmont
M231	**Ouachita Mixed Forest-Meadow**
M231A	Ouachita Mountains

232	**Outer Coastal Plain Mixed Forest**
232B	Gulf Coastal Plains and Flatwoods
232C	Atlantic Coastal Flatwoods
232D	Florida Coastal Lowlands-Gulf
232F	Coastal Plains and Flatwoods-Western Gulf
232G	Florida Coastal Lowlands-Atlantic
232H	Middle Atlantic Coastal Plains and Flatwoods
232I	Northern Atlantic Coastal Flatwoods
232J	Southern Atlantic Coastal Plains and Flatwoods
232K	Florida Coastal Plains Central Highlands
232L	Gulf Coastal Lowlands
234	**Lower Mississippi Riverine Forest**
234A	Southern Mississippi Alluvial Plain
234C	Atchafalaya and Red River Alluvial Plains
234D	White and Black River Alluvial Plains
234E	Arkansas Alluvial Plains

Table A-2. USDA Forest Service Provinces and Sections referred to in the Key

Notes on Some Ambiguous or Confusing Habitats

There are some possible situations related to open pine habitats in the southeastern United States which are ambiguous or may present uncertainties in terms of which habitat is best managed for in a particular locale.

1. Sites found landward of the coastal plains (Southeastern Mixed Forest Province 231, Sections 231A, 231C, 231D) with Longleaf Pine as a dominant or codominant should be treated as examples of "Mountain Longleaf". These could be proximal to, or interfingered with, stands dominated by Shortleaf Pine without Longleaf Pine. The issue here is that "Mountain Longleaf" would be evaluated with the metrics for the Dry & Mesic Highlands Pine Woodlands Grouping, and the adjacent Shortleaf Pine stands would be evaluated with the metrics for the Dry & Mesic Hilly Pine Woodlands Grouping. In this area, both of these Groupings are related to US NVC GROUP G012. A distinction may need to be made between stands dominated by Shortleaf Pine without Longleaf Pine which are landward of the coastal plain and do **not** have loblolly pine or are outside the range of loblolly pine, versus stands dominated by Shortleaf Pine that are **within** the range of Loblolly Pine. In the first case they should be assigned to Dry & Mesic Highlands Pine Woodlands Grouping, and in the second case, these stands within the range of Loblolly Pine would be part of the Dry & Mesic Hilly Pine Woodlands Grouping. This is an issue we are investigating in South Carolina, in regard to Shortleaf Pine stands in the western versus the eastern Piedmont.

2. In a portion of the Southeastern Mixed Forest Province (Section 231B), there are quite rugged landforms found north of the black belt region and southwest of the southern end of the Ridge and Valley (this is within the ranges of both Longleaf Pine and Chestnut Oak [*Quercus prinus*]). Using our key to Open Pine Groupings, this would be part of the Dry & Mesic Longleaf Pine Woodlands, but has some characteristics of the "Mountain Longleaf" discussed above. This area

includes the Oakmulgee District of the Talladega National Forest in Bibb, Hale, Perry, and Tuscaloosa counties of Alabama. It is not clear which metrics are better applied in this area.

3. The third exception or anomaly would be stands dominated by Shortleaf Pine found within the range of Longleaf Pine in Provinces 231 and 232, the Southeastern Mixed Forest Province and Outer Coastal Plain Mixed Forest Province, respectively. This type of stand would have been far less common in the outer coastal plain, and more likely in the inner coastal plain. More information is needed about this vegetation and its characteristics and environment. One example is Shortleaf Pine vegetation of the Red Hills of Florida and Georgia. In this case, the metrics for Dry & Mesic Hilly Pine Woodlands [US NVC GROUP G012] would apply.

Appendix B. Full Descriptions of Southern Open Pine Groupings

Southern Open Pine Groupings are broad ecological classification units for southern open pine wildlife habitats, encompassing woodlands with relatively open, pine-dominated canopies and grassy understories. These woodlands are fire dependent and many examples occur on low fertility soils. These Southern Open Pine Groupings are related to the variation in vegetation structure or physiognomy, dominant and characteristic species, soils, landform, and biogeography of open pine habitats across the southeastern United States. They are comparable to Groups of the U.S. National Vegetation Classification and are compliant with the standards for vegetation from the Federal Geographic Data Committee (Faber-Langendoen et al. 2009, Faber-Langendoen et al. 2012, Faber-Langendoen et al. 2014, FGDC 2008). These Southern Open Pine Groupings are also closely related to the Groups of Ecological Systems used by the U.S. Fish and Wildlife Service (Pyne et al. 2013) and are related to several widely used classifications of vegetation, natural communities, and ecological systems (Comer et al. 2003, Edwards et al. 2013, Eyre 1980, FNAI 2010, Palmquist et al. 2016, Peet 2006).

Groups of Ecological Systems (GES)	**Southern Open Pine Groupings**	**US NVC Group**
Longleaf Woodlands	Dry & Mesic Longleaf Pine Woodlands	G009
Longleaf - Slash Flatwoods	Mesic Longleaf Pine Flatwoods	G596
Longleaf - Slash Flatwoods	Wet Longleaf & Slash Pine Flatwoods & Savannas	G190
Longleaf-Turkey Oak Sandhills	Xeric Longleaf Pine Barrens	G154
Mountain Longleaf	Dry & Mesic Highlands Pine Woodlands	G012
Shortleaf-Loblolly Woodlands	Dry & Mesic Highlands Pine Woodlands	G012
Shortleaf-Loblolly Woodlands	Dry & Mesic Hilly Pine Woodlands	G012
Shortleaf-Loblolly Woodlands	Dry & Mesic Hilly Pine Woodlands	G013
Shortleaf-Loblolly Woodlands	Upper Coastal Plain Pine Flatwoods	G130

Table B-1. Crosswalk of Groups of Ecological Systems, Southern Open Pine Groupings, and US NVC Group codes.

The general information provided for each of the seven Southern Open Pine Groupings comes from the Type Concept and Geographic Range fields of NatureServe's Ecology Element Databases (NatureServe 2015). These data have been edited to follow the Southern Open Pine Groupings.

Dry & Mesic Longleaf Pine Woodlands

This Southern Open Pine Grouping represents stands of longleaf pine (*Pinus palustris*) on sandy to loamy soils on upland sites ranging from gently rolling lands, broad ridgetops to steeper side slopes, and in mesic swales and terraces. The canopy is generally open, with irregularly scattered longleaf pine trees, clumps of midstory oak (*Quercus* spp.) and a grassy understory. Scrub oaks, such as bluejack oak (*Quercus incana*) and sand post oak (*Quercus margarettiae*), as well as blackjack oak (*Quercus marilandica*), southern red oak (*Quercus falcata*), and sometimes turkey oak (*Quercus laevis*) form a sparse or clumped understory in all but the most mesic stands. Low shrubs may be abundant. East of the Mississippi River, Carolina wiregrass or pineland threeawn (*Aristida stricta*) (in North and South Carolina) or Southern wiregrass or Beyrich's threeawn (*Aristida beyrichiana*) (from South Carolina to Mississippi) are usually the dominant or at least a characteristic species. Some typical grasses include splitbeard bluestem (*Andropogon ternarius*), Elliott's bluestem (*Andropogon gyrans var. gyrans*), broomsedge bluestem (*Andropogon virginicus*), pineywoods dropseed (*Sporobolus junceus*), rough dropseed (*Sporobolus clandestinus*), little bluestem (*Schizachyrium scoparium*), slender little bluestem (*Schizachyrium tenerum*), Indiangrass (*Sorghastrum nutans*), slender Indiangrass (*Sorghastrum elliottii*),

lopsided Indiangrass (*Sorghastrum secundum*), and switchgrass (*Panicum virgatum*). There tends to be a fairly high diversity of forbs (broadleaf herbaceous plants), especially in sites that have been burned frequently (i.e., three or more times per decade). This Southern Open Pine Grouping does not include the xeric and subxeric longleaf pine - turkey oak habitats (Xeric Longleaf Pine Barrens).
The Dry & Mesic Longleaf Pine Woodlands are found from southeastern Virginia to east Texas, including most of Florida. This type does not occur in the Mississippi Alluvial Plain.

Mesic Longleaf Pine Flatwoods

This Southern Open Pine Grouping represents open longleaf pine woodlands found on flat sites with Spodosol soils. These are soils which have a spodic horizon which can cause sites to be wet in the winter and dry in the summer. Sites within Mesic Longleaf Pine Flatwoods are mostly uplands but also include moist flatwoods. These open woodlands have irregularly scattered longleaf pine trees and a grass-dominated herbaceous layer. Low shrubs, including blueberries (*Vaccinium*) and hollies (*Ilex*), may be abundant. In addition, saw palmetto (*Serenoa repens*) is a characteristic species, particularly in South Carolina, Georgia, and Florida. East of the Mississippi River, Carolina wiregrass or pineland threeawn (*Aristida stricta*) (in North and South Carolina) or Southern wiregrass or Beyrich's threeawn (*Aristida beyrichiana*) (from South Carolina to Mississippi) is usually the dominant or at least a characteristic herb. Some additional typical grasses include slender bluestem (*Schizachyrium tenerum*), splitbeard bluestem (*Andropogon ternarius*), Elliott's bluestem (*Andropogon gyrans var. gyrans*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). Stands in south-central Florida may contain cutthroat grass (*Panicum abscissum*). There tends to be a high diversity of forbs (broadleaf herbaceous plants), especially in sites that have been burned frequently (i.e., every one to three years).

This Southern Open Pine Grouping does not include dry nor dry-mesic longleaf pine (Dry & Mesic Longleaf Pine Woodlands), but represents those that have more available moisture, at least seasonally. It also does not include the wettest flatwoods, which are included in Wet Longleaf & Slash Pine Flatwoods & Savannas.

These Mesic Longleaf Pine Flatwoods are found from southeastern Virginia to eastern Texas, including most of Florida. It does not occur in the Mississippi Alluvial Plain, might not occur in Louisiana, and occurs only in very small areas in eastern Texas.

Wet Longleaf & Slash Pine Flatwoods & Savannas

This Southern Open Pine Grouping includes wet pine flatwoods and wet pine savannas of the coastal plains. These habitats are characterized by poorly drained, somewhat poorly drained, and seasonally saturated mineral soils with seasonally high water tables. Examples occur on a wide range of soil textures, mostly in low elevation areas of the outer coastal plains. This variability in soil texture strongly affects the composition of the ground cover vegetation, which accounts for various different plant associations in this grouping. In natural condition, canopies are open and dominated by longleaf pine, sometimes with slash pine (*Pinus elliottii var. elliottii*), pond pine (*Pinus serotina*), or loblolly pine (*Pinus taeda*). In south Florida, very open stands are naturally dominated by South Florida slash pine (*Pinus elliottii var. densa*). There is a diverse mix of grasses, herbs, and low shrubs in the ground layer in high-quality stands of this vegetation. Grasses are typically dominant, but there is often a large diversity of other herbs. Among the grasses, Carolina wiregrass or pineland threeawn (*Aristida stricta*) or Southern wiregrass or Beyrich's threeawn (*Aristida beyrichiana*) often dominates within its ranges, but toothache grass (*Ctenium aromaticum*), cutover muhly (*Muhlenbergia expansa*), little bluestem (*Schizachyrium scoparium*), Florida dropseed (*Sporobolus floridanus*), Carolina dropseed (*Sporobolus pinetorum*), wireleaf dropseed (*Sporobolus teretifolius*), chalky bluestem (*Andropogon capillipes*), other bluestems

(*Andropogon* spp.), or other grasses may also dominate. Understory conditions are influenced by fire frequency and seasonality.

Exposure to frequent, low-intensity fires (every one to two years, and less commonly to three or four years) in the transition from a dry Spring to a wet Summer is the dominant natural ecological process maintaining the open savanna and promoting local biodiversity. Historically, in some parts of the coastal plain, this vegetation was dominant over large areas. Extensive alterations to ecological processes following European settlement, including the interruption of natural fire regimes, have significantly degraded the quality of remaining examples of Wet Longleaf & Slash Pine Flatwoods & Savannas. The remaining large, intact examples are managed using frequent prescribed fire. Stands which have not burned for long periods of time show greater dominance by shrubs, including saw palmetto, and may have denser canopies of slash pine rather than longleaf pine. The ground cover of low-elevation pine savannas also are being invaded by non-native plant species, including cogongrass (*Imperata cylindrica*), Chinese privet (*Ligustrum sinense*) Chinese tallow (*Triadica sebifera*), Japanese climbing fern (*Lygodium japonicum*), and small-leaf climbing fern (*Lygodium microphyllum*).

The Wet Longleaf & Slash Pine Flatwoods & Savannas range from eastern Texas across the Gulf Coastal Plain to Florida (with one distinctive set of associations ranging into south Florida), and north in the Atlantic Coastal Plain to southern Virginia.

Xeric Longleaf Pine Barrens

This Southern Open Pine Grouping encompasses dry upland forest or woodland vegetation on deep, coarse sands and loamy sands on the Southern Coastal Plain from North Carolina south to central Florida and west to eastern Texas. Generally, these are open woodlands dominated by longleaf pine with an understory of turkey oak, though sites that have not been burned frequently or have experienced high-grading of the pine canopy can be dominated by turkey oak. Bluejack oak and sand post oak occur in the subcanopy, most commonly on somewhat silty sites. Turkey oak is absent west of the Mississippi River, where it is replaced by bluejack oak. These habitats are consistently dry and have low nutrient availability. As a result, longleaf pine grows slower and reaches smaller stature than in Dry & Mesic Longleaf Pine Woodlands (G009), Wet Longleaf & Slash Pine Flatwoods & Savannas (G190) and Mesic Longleaf Pine Flatwoods (G596).

On the driest sites, often referred to as barrens, the natural frequency of fire is less than in other longleaf pine habitats; therefore, the grass layer is minimal and litter accumulation is slower than in other habitats where longleaf pine grows. All but the driest associations have a well-developed grass layer with little bluestem (*Schizachyrium scoparium*) common throughout, often with one of the wiregrass forms of threeawn (*Aristida* spp.). The dominant threeawn (*Aristida* sp.) shifts geographically with Carolina wiregrass or pineland threeawn (*Aristida stricta*) important in the southern two-thirds of North Carolina and northern-most South Carolina and Southern Wiregrass or Beyrich's threeawn (*Aristida beyrichiana*) dominant in southern South Carolina and west across southern Georgia and Florida, to eastern Mississippi, although west of the Apalachicola River it is confined to the lower regions of the coastal plain. In southern South Carolina and west across Georgia, Florida, Alabama, and Mississippi to eastern Louisiana, gopher tortoise (*Gopherus polyphemus*) is a keystone protected species that digs extensive subterranean burrows in suitable soils within this habitat; hundreds of other species rely on its burrows for shelter. This vegetation occurs in the coastal plain from North Carolina south to Florida and west to eastern Texas.

Dry & Mesic Highlands Pine Woodlands

This Southern Open Pine Grouping encompasses forests and woodlands with most extensive areas in the Ozark-Ouachita Highlands, as well as the northern portion of Crowley's Ridge in which shortleaf pine (*Pinus echinata*) is the canopy dominant species or an important component. In Alabama, Georgia, and the Carolinas, Mountain and Piedmont longleaf pine woodlands are also included in this grouping, which generally are mixed with oaks and shortleaf pine. Examples can occur on a variety of acidic soils or bedrock types, and on a variety of topographic and landscape positions, including ridgetops, upper and midslopes, and at lower elevations (generally below 2300 feet). Stands may be codominated by oaks, hickories (*Carya* spp.), and other hardwoods, with the varying proportion of pine versus hardwood species depending on both forestry practices and ecological management, as well as natural disturbances, particularly the length of time since fire. There is considerable local variation in the extent of the Dry & Mesic Highlands Pine Woodlands in the landscape and in their structure and composition. In the Ozark-Ouachita Highlands, communities range from pine-bluestem to dry mesic shortleaf pine woodlands to dry rock outcrops with shortleaf pine. Pine-bluestem is open canopied, the southern yellow pine canopy cover metric and the canopy hardwood basal area metric values will generally be lower than those for the dry mesic shortleaf woodlands (see Blaney et al. 2015 for further clarification). In more open stands (such as ones in naturally drier regions or ones which have experienced more recent or frequent fire), the understory is characterized by big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and other prairie grasses and forbs. Species of blueberries (*Vaccinum* spp.) may be present in the shrub layer along with forbs including cream wild indigo (*Baptisia bracteata*), goldenrod (*Solidago odora*), and Pale purple coneflower (*Echinacea pallida*). In the lower elevations of the Southern Appalachians, and under current conditions, stands may be dominated by shortleaf pine or Virginia pine (*Pinus virginiana*). Stands found outside of the coastal plains in which longleaf pine is a component are included here. Hardwoods are sometimes abundant, especially dry-site oaks such as southern red oak, chestnut oak (*Quercus prinus*), post oak (*Quercus stellata*), and scarlet oak (*Quercus coccinea*), but also mockernut hickory (*Carya glabra*) and other hickories. The shrub layer may be well-developed, with Blue Ridge blueberry (*Vaccinium pallidum*), farkleberry (*Vaccinium arboreum*), deerberry (*Vaccinium stamineum*), or other acid-tolerant species being most characteristic of this habitat type. Herbaceous cover can be sparse but component species may include narrowleaf silkgrass (*Pityopsis graminifolia*) and goat's-rue (*Tephrosia virginiana*).

There is some regional variation in composition across the range of this Dry & Mesic Highlands Pine Woodlands, with examples in the Ozark-Ouachita Highlands and Crowley's Ridge lacking pitch pine (*Pinus rigida*), Virginia pine, and chestnut oak. Where fire is more frequent, stands may develop a relatively pure and open canopy of shortleaf pine with scattered overstory trees and an herbaceous-dominated understory, but such examples are rare on the modern landscape unless maintained by ecological management such as on Ouachita National Forest, as well as the Ozark and Mark Twain National Forests. More typical are examples in which oaks, hickories (*Carya*), sweetgum (*Liquidambar styraciflua*), tuliptree (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and blackgum (*Nyssa sylvatica*) have become prominent in the midstory and overstory and in which herbaceous vegetation is sparse.

Examples of this Southern Open Pine Grouping mainly occur in the Ozark-Ouachita Highland areas of Arkansas, adjacent Oklahoma, and southeastern Missouri. It also occurs on Crowley's Ridge, and in small areas of the southern Piedmont and Appalachians, where examples have longleaf pine interspersed with oaks. Shortleaf pine dominated or codominated vegetation in the Upper East Gulf Coastal Plain of Alabama and Mississippi, and the West Gulf Coastal Plain of Arkansas, Louisiana and Texas, and the East Gulf and Atlantic Coastal Plains and Piedmont is accommodated in the Dry & Mesic Hilly Pine Woodlands (G013) Southern Open Pine Grouping.

Dry & Mesic Hilly Pine Woodlands

This Southern Open Pine Grouping consists of vegetation typically dominated by a mix of shortleaf pine and/or loblolly pine in combination with a suite of dry- to dry-mesic-site hardwood species, primarily white oak (*Quercus alba*), southern red oak, and post oak, but also the scrub oaks bluejack oak, sand post oak, and Arkansas oak (*Quercus arkansana*). It is primarily found in the Gulf Coastal Plain and Upper East and West Gulf Coastal Plains of Alabama, Mississippi, southern Arkansas, northwestern Louisiana, and parts of eastern Texas. It also occurs in the East and Upper East Gulf Coastal Plains, Atlantic Coastal Plain and Piedmont. The range of this type is predominantly north of the historic range of longleaf pine, and was the historic matrix vegetation type for large portions of the Upper West Gulf Coastal Plain. Within this area, this type was historically present on nearly all upland sites in the region (except on the most edaphically limited sites, such as droughty sands, calcareous clays, and shallow soil barrens/rock outcrops). The upland sites are underlain by loamy to fine-textured soils of variable depths. On ridgetops and adjacent sideslopes, it occurs on soils with moderate fertility and moisture retention. In more limited areas of the West Gulf Coastal Plain (USFS Section 232F), stands typically are confined to sideslopes and other less fire-prone locations not dominated by longleaf pine. Other tree species that may occur include black oak (*Quercus velutina*), mockernut hickory (*Carya alba*), black hickory (*Carya texana*), hawthorn (*Crataegus*), and hophornbeam (*Ostrya virginiana*). Typical shrubs include common sweetleaf (*Symplocos tinctoria*), wax-myrtle (*Morella cerifera*), farkleberry, Elliott's blueberry (*Vaccinium elliottii*), mapleleaf viburnum (*Viburnum acerifolium*), and southern arrow-wood (*Viburnum dentatum*). Some typical grasses include longleaf woodoats (*Chasmanthium sessiliflorum*), roundseed panicgrass (*Dichanthelium sphaerocarpon*), and little bluestem (*Schizachyrium scoparium*).
This vegetation is primarily found in the Gulf Coastal Plain and Upper East and West Gulf Coastal Plains of Alabama, Mississippi, southern Arkansas, northwestern Louisiana, and parts of eastern Texas. In the Upper East Gulf Coastal Plain, this vegetation was the historical matrix in large areas of the region in Alabama and Mississippi, north to the Tennessee state line. It also occurs in the East Gulf Coastal Plain, Atlantic Coastal Plain and Piedmont.

Upper Coastal Plain Pine Flatwoods

These are nonriverine wetland pine-hardwood forests of the Atlantic and Gulf coastal plains, and are well known from the coastal plain of southern Arkansas and northern Louisiana. Stands are primarily dominated by loblolly pine with shortleaf pine interspersed with laurel oak (*Quercus laurifolia*), swamp chestnut oak (*Quercus michauxii*), and willow oak (*Quercus phellos*), and also with a variety of other hardwoods, including sweetgum, swamp tupelo (*Nyssa biflora*), and blackgum. Spruce pine (*Pinus glabra*) may be codominant in some examples. This also includes mesic flatwoods, which are drier forests and woodlands of the upper coastal plains and adjacent regions; their canopies are dominated by southern red oak and post oak, with mockernut hickory and white oak. It occurs on Pleistocene high terraces or other high flat landforms. Wet hardwood flatwoods occur on seasonally flooded depressions within these terraces. Both types are precipitation driven wetlands in a hydrogeomorphic classification. Some other examples in southern Arkansas, Alabama and Mississippi encompass a mosaic of open forests dominated by loblolly pine interspersed with patches of willow oak (*Quercus phellos*) and other tree species. Within its range, dwarf palmetto (*Sabal minor*) will be abundant in the lower strata of some stands. These communities are generally known as "flatwoods," and are found on a variety of sites which are generally flat to very gently sloping, including broad upland flats and terraces. These sites typically have poor internal drainage and/or strata in the soil that limit permeability (claypans, hardpans, etc.). This limited permeability of the soil contributes to shallowly perched water tables during portions of the year when precipitation is greatest and evapotranspiration is lowest. The hydrologic regime is primarily influenced by groundwater and rainwater rather than overbank flooding. Soil moisture

fluctuates widely throughout the growing season, from saturated to very dry, a condition which is sometimes referred to as xerohydric or hydroxeric. Soils are primarily mineral but may have some organic matter or muck. In some areas (e.g., the coastal plain of Arkansas), the local topography is a complex of ridges and swales, often in close proximity to one another (Bragg et al. 2014). Ridges are typically drier than swales. Swales may hold water for varying periods of time. Within both ridges and swales, vegetation is influenced by soil texture, soil moisture and disturbance history.

Upper Coastal Plain Pine Flatwoods are well known from the coastal plain of southern Arkansas (Bragg et al. 2014) and are also found in the Atlantic and Gulf coastal plains from the Embayed Region of northeastern North Carolina and southeastern Virginia (south of the James River) to Arkansas and Texas, the Florida peninsula, and may occur in southeastern Oklahoma, and the Missouri "Bootheel."

Appendix C. Full Descriptions of all Metrics.

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RANK FACTOR: VEGETATION

Metric Name:

Canopy Southern Yellow Pine Basal Area

Definition: Combined basal area of southern yellow pine species appropriate to the Southern Open Pine Grouping of the site, primarily longleaf pine or shortleaf pine. The cross section area of longleaf pine, slash pine, South Florida slash pine, shortleaf pine, and/or loblolly pine tree stems (defined here as square feet /acre) for trees > 4 inches DBH, and measured using a 10x basal area prism or gauge at the center point of the plot or rapid assessment area or by measuring all longleaf pine trees > 4 inches DBH within a plot of a defined area.

Background: An open canopy of southern yellow pine is important for the functioning of southern open pine ecosystems, and it is especially important for management with fire and promoting the grassy herbaceous understory and associated wildlife. This metric accommodates each of the Southern Open Pine Groupings, which may have longleaf pine, slash pine, shortleaf pine, and/or loblolly pine tree stems. This metric emphasizes longleaf pine and shortleaf pine basal area. These two pines have large natural ranges, have declined dramatically during the 20th century and naturally grow in open stands which support characteristic wildlife species. Basal area of trees by species is data very commonly collected as part of forestry inventory. It is a widely used measure quantifying the dominance of tree species, and is repeatable using a 10x basal area prism or gauge.

Certain ranges of southern yellow pine basal area have been identified as characteristic of optimal habitat for southern open pine wildlife species. For red-cockaded woodpecker, open pine with large trees and <90 ft^2/acre of pine is optimal (Lower Mississippi Valley Joint Venture WGCPO Landbird Working Group 2011, USFWS 2003). For brown-headed nuthatch 20-70 ft^2/acre of pine is optimal, and for Bachman's sparrow <60 ft^2/acre of pine (Richardson 2014a). The prairie warbler prefers low canopy basal area, which includes open pine woodlands, thinned pine stands, and cut over areas (NatureServe 2015, Thompson et al. 1992). However for the pine warbler, habitat quality increases with higher southern yellow pine basal area (Schroeder 1985). The prairie warbler and pine warbler occur in sites which are on the low and high ends, respectively of the range of southern yellow pine basal area which is best suited to the other open pine dependent wildlife species. Although rare throughout its range, the gopher tortoise occurs most commonly in stands which have ≤70 ft^2/acre basal area on average (Hinderliter 2014). Maintenance condition for longleaf pine woodlands is considered to be basal area ≤ 40-70 ft^2/acre of longleaf pine. (Longleaf Partnership Council 2014). Shortleaf pine basal area is measured in stands of Dry & Mesic Highlands Pine Woodlands, however in Mountain Longleaf examples, longleaf pine and shortleaf pine basal area should be measured. In Dry & Mesic Hilly Pine Woodlands, shortleaf pine and loblolly pine basal area should be measured (Bragg 2002). This metric is applied to Upper Coastal Plain Pine Flatwoods based on the basal area of shortleaf pine and loblolly pine (Bragg et al. 2014). In Dry & Mesic Longleaf Pine Woodlands, and Xeric Longleaf Pine Barrens, longleaf pine basal area is measured. In Mesic

Longleaf Pine Flatwoods and in Wet Longleaf & Slash Pine Flatwoods & Savannas, basal area is measured for longleaf pine, slash pine, and South Florida slash pine.

The values for canopy tree basal area, tree stems per acre, and canopy cover are interrelated, and can be shown in a Gingrich table (Gingrich 1967). A Gingrich table for Dry & Mesic Highlands Pine Woodlands was developed as part of the Interior Highlands Shortleaf Pine Restoration Initiative, Desired Future Conditions effort (Blaney et al. 2015), shown below.

	Percent Canopy Closure for forest grown Shortleaf Pine Stands											
	10%		20%		25%		30%		40%		50%	
DBH	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA
10	30	16	59	32	74	40	89	49	119	65	148	81
12	14	11	28	22	35	28	42	33	57	44	71	56
14	10	11	21	22	26	27	31	33	41	44	51	55
16	9	12	17	24	22	30	26	36	35	49	44	61
18	7	12	14	25	17	31	21	37	28	49	35	62
20	7	15	14	30	17	37	20	45	27	59	34	74
22	6	17	13	34	16	42	19	51	26	68	32	84
24	4	14	9	28	11	35	13	42	18	57	22	71

	Percent Canopy Closure for forest grown Shortleaf Pine Stands									
	60%		70%		80%		90%		100%	
DBH	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA
10	178	97	208	113	237	129	267	146	297	162
12	85	67	99	78	113	89	127	100	142	111
14	62	66	72	77	82	88	92	99	103	110
16	52	73	61	85	70	97	78	109	87	122
18	42	74	49	86	56	99	63	111	70	123
20	41	89	48	104	55	119	61	134	68	149
22	38	101	45	118	51	135	58	152	64	169
24	27	85	31	99	36	113	40	127	45	141

These Gingrich tables show average tree diameter at breast height (DBH) as rows, and in columns show percent tree canopy cover, number of trees per acre (#/ac), and basal area (BA). By using Gingrich tables, the relationships between these measures can be seen, and the measures can be applied to southern open pine wildlife habitat in a more informed way. Also, the canopy cover of 1 sq. foot BA of hardwood equals the canopy cover of 2 sq. feet of BA of shortleaf pine. Keep this in mind when assigning canopy cover metric values.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Basal area is a widely used measure quantifying the dominance of tree species, and is repeatable using a 10x basal area prism or gauge. Since many stands of longleaf pine (or other southern yellow pines) have uneven tree sizes and spacing, measures of basal area need to be collected at multiple locations to get a stand level estimate of basal area.

Measurement Protocol: Basal area by species of trees of longleaf pine, slash pine, South Florida slash pine, shortleaf pine, and loblolly pine greater than 4" diameter at 4.5 feet (54"), diameter at breast height (DBH). **Option 1**: A 10x factor basal area prism or gauge is used from the center of the data collection area, and trees are tallied by species. The tallied count of longleaf pines is multiplied by the basal area factor of 10 to get the basal area in ft^2/acre. **Option 2**: Delineate a plot of at least 0.1 acre or 400 m^2 and measure all longleaf pine, slash pine, South Florida slash pine, shortleaf pine, and loblolly pine greater than 4" diameter at 4.5 feet (54"), diameter at breast height (DBH), then convert diameter measurements to ft^2/acre using formula:

Basal area (ft^2/acre) = $0.005454*DBH^2$

For the final value of basal area the per plot size value must be converted to a per acre value.

A value of "0" should be listed for species with stems > 4" DBH within the plot which are not included in the tallied basal area (i.e., not picked up in prism or gauge sample). This attribute is directly linked to the respective canopy species as indicated by the ending number designation.

These values below represent results in ft^2/acre using Option 2. Calculated values other than multiples of 10 are accommodated.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	30-80 ft^2/acre basal area of longleaf pine (*Pinus palustris*)
GOOD (B)	20 to <30 or >80 to 90 ft^2/acre basal area of longleaf pine (*Pinus palustris*)
FAIR (C)	10 to <20 or >90 to 105 ft^2/acre basal area of longleaf pine (*Pinus palustris*)
POOR (D)	<10 or >105 ft^2/acre basal area of longleaf pine (*Pinus palustris*)

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	30-80 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
GOOD (B)	20 to <30 or >80 to 90 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
FAIR (C)	10 to <20 or >90 to 105 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
POOR (D)	<10 or >105 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	20-80 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
GOOD (B)	$\geq$10 to <20 or >80 to <90 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), or South Florida slash pine (*Pinus elliottii* var. *densa*)
FAIR (C)	5 to <10 or 90 to <100 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), or South Florida slash pine (*Pinus elliottii* var. *densa*)
POOR (D)	<5 or $\geq$100 ft^2/acre basal area of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	25-80 ft^2/acre basal area of longleaf pine (*Pinus palustris*)
GOOD (B)	>15 to <25 or >80 to 90 ft^2/acre basal area of longleaf pine (*Pinus palustris*)
FAIR (C)	10 to 15 or > 90 to <100 ft^2/acre basal area of longleaf pine (*Pinus palustris*)
POOR (D)	<10 or $\geq$100 ft^2/acre basal area of longleaf pine (*Pinus palustris*)

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	>35-75 ft^2/acre basal area of shortleaf pine (*Pinus echinata*)
GOOD (B)	30 to 35 or >75 to 90 ft^2/acre basal area of shortleaf pine (*Pinus echinata*)
FAIR (C)	10 to <30 or >90 to 110 ft^2/acre basal area of shortleaf pine (*Pinus echinata*)
POOR (D)	<10 or >110 ft^2/acre basal area of shortleaf pine (*Pinus echinata*)

Metric Rating	***Dry & Mesic Highlands Pine Woodlands (Mountain Longleaf)***
EXCELLENT (A)	>35-75 ft^2/acre basal area of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)
GOOD (B)	30 to 35 or >75 to 90 ft^2/acre basal area of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)
FAIR (C)	10 to <30 or >90 to 110 ft^2/acre basal area of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)
POOR (D)	<10 or >110 ft^2/acre basal area of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	30-85 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)
GOOD (B)	20 to <30 or >85 to 100 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)
FAIR (C)	10 to <20 or >100 to 115 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)
POOR (D)	<10 or >115 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	30-80 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)

GOOD (B)	20 to <30 or >80 to 90 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)
FAIR (C)	10 to <20 or >90 to 110 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)
POOR (D)	<10 or >110 ft^2/acre basal area of shortleaf pine (*Pinus echinata*) and/or loblolly pine (*Pinus taeda*)

Data for Metric Rating: Published data that support the basis for the metric rating

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.

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Schroeder, R. L. 1985. Habitat suitability index models: Pine Warbler. Biol. Rep. 82(10.28). U.S. Fish and Wildlife Service. 8 pp.

Thompson, F. R., III, W. D. Dijak, T. G. Kulowiec, and D. A. Hamilton. 1992. Breeding bird populations in Missouri Ozark forests with and without clearcutting. Journal of Wildlife Management 56(1): 23-29. <http://www.nrs.fs.fed.us/pubs/jrnl/1992/nc_1992_thompson_001.pdf>

U.S. Fish and Wildlife Service. 2003. Recovery plan for the red-cockaded woodpecker (*Picoides borealis*): second revision. U.S. Fish and Wildlife Service, Atlanta, GA. 296 pp.

Scaling Rationale: Two options are provided, the first is using the 10x basal area prism or gauge in ft^2/acre. The second option uses calculated values, or the 5x basal area prism or gauge in ft^2/acre.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Southern Yellow Pine Canopy Cover

Definition: Percentage of the ground within the plot or rapid assessment area covered by canopy foliage, branches, and stems of southern yellow pine, (primarily longleaf pine or shortleaf pine) as determined by ocular estimate. Southern yellow pine canopy is defined as the canopy trees of longleaf pine, slash pine, South Florida slash pine, shortleaf pine, or loblolly pine with stems greater than 4" at 4.5 feet (54”), diameter at breast height (DBH).

Background: A variety of characteristic wildlife species occur in open canopy longleaf pine and shortleaf pine dominated woodlands. These include reptiles such as Louisiana pine snake, Florida pine snake, black pine snake, eastern diamondback rattlesnake, and gopher tortoise (Hinderliter 2015, NatureServe 2015). Eastern diamondback rattlesnake prefers upland longleaf pine woodlands, managed with prescribed fire. These reptiles require enough longleaf pine to provide needle drop and resulting fine fuels adequate for burning every few years. The gopher tortoise can do well in upland longleaf pine woodlands with 20-70% canopy cover of longleaf pine (Hinderliter 2014). While the pine warbler does well in dense pine stands (Schroeder 1985), other bird species of concern occur in open canopy pine stands (NatureServe 2015, Richardson 2014a, Tucker 2006).

The values for canopy tree basal area, tree stems per acre, and canopy cover are interrelated, and can be shown in a Gingrich table (Gingrich 1967). A Gingrich table for Dry & Mesic Highlands Pine Woodlands was developed as part of the Interior Highlands Shortleaf Pine Restoration Initiative, Desired Future Conditions effort (Blaney et al. 2015), shown below.

	Percent Canopy Closure for forest grown Shortleaf Pine Stands											
	10%		20%		25%		30%		40%		50%	
DBH	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA
10	30	16	59	32	74	40	89	49	119	65	148	81
12	14	11	28	22	35	28	42	33	57	44	71	56
14	10	11	21	22	26	27	31	33	41	44	51	55
16	9	12	17	24	22	30	26	36	35	49	44	61
18	7	12	14	25	17	31	21	37	28	49	35	62
20	7	15	14	30	17	37	20	45	27	59	34	74
22	6	17	13	34	16	42	19	51	26	68	32	84
24	4	14	9	28	11	35	13	42	18	57	22	71

	Percent Canopy Closure for forest grown Shortleaf Pine Stands									
	60%		70%		80%		90%		100%	
DBH	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA
10	178	97	208	113	237	129	267	146	297	162
12	85	67	99	78	113	89	127	100	142	111
14	62	66	72	77	82	88	92	99	103	110
16	52	73	61	85	70	97	78	109	87	122
18	42	74	49	86	56	99	63	111	70	123
20	41	89	48	104	55	119	61	134	68	149
22	38	101	45	118	51	135	58	152	64	169
24	27	85	31	99	36	113	40	127	45	141

These Gingrich tables show average tree diameter at breast height (DBH) as rows, and in columns show percent tree canopy cover, number of trees per acre (#/ac), and basal area (BA). By using Gingrich tables, the relationships between these measures can be seen, and the measures can be applied to southern open pine wildlife habitat in a more informed way. Also, the canopy cover of 1 sq. foot BA of hardwood equals the canopy cover of 2 sq. feet of BA of shortleaf pine. Keep this in mind when assigning canopy cover metric values.

This metric emphasizes longleaf pine and shortleaf pine canopy cover. These two pines have large natural ranges, have declined dramatically during the 20th century and naturally grow in open stands which support characteristic wildlife species. Other southern yellow pines are also included. Shortleaf pine canopy cover is measured in stands of Dry & Mesic Highlands Pine Woodlands, however in Mountain Longleaf examples, longleaf pine and shortleaf pine canopy cover should be measured. In Dry & Mesic Hilly Pine Woodlands, shortleaf pine and loblolly pine canopy cover should be measured (Bragg 2002). This metric is applied to Upper Coastal Plain Pine Flatwoods based on the canopy cover of shortleaf pine and loblolly pine (Bragg et al. 2014). In Dry & Mesic Longleaf Pine Woodlands, and Xeric Longleaf Pine Barrens, longleaf pine canopy cover is measured. In Mesic Longleaf Pine Flatwoods and in Wet Longleaf & Slash Pine Flatwoods & Savannas, canopy cover is measured for longleaf pine, slash pine, and South Florida slash pine.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: The measure of canopy cover by ocular estimate (by eye), is repeatable to the precision of the cover classes used here. This is a fast and easy metric which complements the measure of basal area of longleaf pine.

Measurement Protocol: For assessment area, percentage of the ground within the plot covered by canopy foliage, branches, and stems as determined by ocular estimate. Southern yellow pine canopy is

defined as only the canopy trees of longleaf pine, slash pine, South Florida slash pine, shortleaf pine, or loblolly pine with stems greater than 4" at 4.5 feet (54”), diameter at breast height (DBH). Cover estimate classes will be used. Ocular estimate of the percent of ground within the plot covered by foliage and branches.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	30-65% canopy cover of longleaf pine (*Pinus palustris*)
GOOD (B)	>20 to <30% canopy cover or >65 to 75% canopy cover of longleaf pine (*Pinus palustris*)
FAIR (C)	10-20% canopy cover or >75 to 85% canopy cover of longleaf pine (*Pinus palustris*)
POOR (D)	<10% cover or >85% cover of longleaf pine (*Pinus palustris*)

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	30 to 65% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
GOOD (B)	20 to <30% canopy cover or >65 to 75% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
FAIR (C)	10 to <20% canopy cover or >75 to 85% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
POOR (D)	<10% canopy cover or >85% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	20-65% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
GOOD (B)	15 to <20% canopy cover or >65 to 75% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
FAIR (C)	10 to <15% canopy cover or >75 to 85% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
POOR (D)	<10% canopy cover or >85% canopy cover of longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	>20 to 55% canopy cover of longleaf pine (*Pinus palustris*)
GOOD (B)	>15 to 20% canopy cover or >55 to 70% canopy cover of longleaf pine (*Pinus palustris*)

FAIR (C)	5-15% canopy cover or >70 to 80% canopy cover of longleaf pine (*Pinus palustris*)
POOR (D)	<5% canopy cover or >80% canopy cover of longleaf pine (*Pinus palustris*)

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	>25 to 70% canopy cover of shortleaf pine (*Pinus echinata)*
GOOD (B)	20-25% canopy cover or >70 to 80% canopy cover of shortleaf pine (*Pinus echinata)*
FAIR (C)	10 to <20% canopy cover or >80 to 90% canopy cover of shortleaf pine (*Pinus echinata)*
POOR (D)	<10% canopy cover or >90% canopy cover of shortleaf pine (*Pinus echinata)*

Metric Rating	***Dry & Mesic Highlands Pine Woodlands (Mountain Longleaf)***
EXCELLENT (A)	>25 to 70% canopy cover of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)
GOOD (B)	20-25% canopy cover or >70 to 80% canopy cover of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)
FAIR (C)	10 to <20% canopy cover or >80 to 90% canopy cover of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)
POOR (D)	<10% canopy cover or >90% canopy cover of longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*)

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	>25 to 75% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
GOOD (B)	>15 to 25% canopy cover or >75 to 85% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
FAIR (C)	10-15% canopy cover or >85 to 95% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
POOR (D)	<10% canopy cover or >95% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	>25 to 70% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
GOOD (B)	>15 to 25% canopy cover or >70 to 80% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
FAIR (C)	10 to 15% canopy cover or >80 to 90% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
POOR (D)	<10% canopy cover or >90% canopy cover of shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)

Data for Metric Rating: Published data that support the basis for the metric rating

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.

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Bragg, Don C., Ricky O'Neill, William Holimon, Joe Fox, Gary Thornton, and Roger Mangham. 2014. Moro Big Pine: Conservation and Collaboration in the Pine Flatwoods of Arkansas. Journal of Forestry 112(5):446–456.

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Scaling Rationale: Scaling of this metric is informed by the cited literature, and by expert input from a project experts meeting held in March 2015.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Southern Yellow Pine Stand Age Structure

Definition: Southern yellow pine, especially longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) stand age structure.

Background: Age structure for southern yellow pine, especially longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) is an important ecological integrity metric for woodlands where it is naturally present. This is combined with abundance of large trees, to better reflect actual life history functions in the mixed shortleaf pine (*Pinus echinata*) stands (Bragg 2002, NatureServe 2006). This metric is applied to Upper Coastal Plain Pine Flatwoods based on the age structure of shortleaf pine or loblolly pine (Bragg et al. 2014). Presence of large (basal area at least 20 ft^2/acre of trees ≥ 14" DBH class) or flat-top longleaf pine is evidence of mature characteristics in a southern open pine stand (Longleaf Partnership Council 2014). Due to the slow growth of longleaf pine in the Xeric Longleaf Pine Barrens, the presence of large longleaf pine ≥ 12" DBH is used rather than ≥ 14" DBH.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Age structure for the southern yellow pines, especially longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) is an important ecological integrity metric for woodlands where it is naturally present in stands (Bragg 2002, NatureServe 2006). Presence of large (basal area at least 20 ft^2/acre of trees ≥ 14" DBH class) or flat-top longleaf pine is evidence of mature characteristics in a stand (Longleaf Partnership Council 2014).

Measurement Protocol: In longleaf pine (*Pinus palustris*) stands determine if flat-top longleaf pine are present in the canopy, and measure the basal area of southern yellow pine trees in the ≥ 14" DBH class. In addition to longleaf pine and shortleaf pine, in the Wet Longleaf & Slash Pine Flatwoods & Savannas, slash pine in included, in Mesic Longleaf Pine Flatwoods, slash pine, and South Florida slash pine is included, in Dry & Mesic Hilly Pine Woodlands and in Upper Coastal Plain Pine Flatwoods, loblolly pine is included. Due to the slow growth of longleaf pine in the Xeric Longleaf Pine Barrens, the presence of large longleaf pine ≥ 12" DBH is used rather than ≥ 14" DBH.

Metric Rating:

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	Basal area ≥20 ft^2/acre of longleaf pine trees ≥14" DBH class or flat-top longleaf pine is present
GOOD (B)	Basal area ≥10 ft^2/acre of longleaf pine trees ≥14" DBH class
FAIR (C)	Longleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No longleaf pine trees ≥14" DBH or flat-top longleaf pine are present

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	Basal area ≥20 ft^2/acre of longleaf pine, slash pine or South Florida slash pine trees ≥14" DBH class or flat-top longleaf pine or South Florida slash pine is present
GOOD (B)	Basal area ≥10 ft^2/acre of longleaf pine or South Florida slash pine trees ≥14" DBH class
FAIR (C)	Longleaf pine or South Florida slash pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No longleaf pine or South Florida slash pine trees ≥14" DBH or flat-top longleaf pine or South Florida slash pine are present

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	Basal area ≥20 ft^2/acre of longleaf pine or slash pine trees ≥14" DBH class or flat-top longleaf pine or slash pine is present
GOOD (B)	Basal area ≥10 ft^2/acre of longleaf pine or slash pine trees ≥14" DBH class
FAIR (C)	Longleaf pine or slash pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No longleaf pine or slash pine trees ≥14" DBH or flat-top longleaf pine or slash pine are present

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	Basal area ≥20 ft^2/acre of longleaf pine trees ≥ 12" DBH class or flat-top longleaf pine is present
GOOD (B)	Basal area ≥10 ft^2/acre of longleaf pine trees ≥ 12" DBH class
FAIR (C)	Longleaf pine trees ≥12" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No longleaf pine trees ≥12" DBH or flat-top longleaf pine are present

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	Basal area ≥20 ft^2/acre of shortleaf pine trees ≥14" DBH class
GOOD (B)	Basal area ≥10 ft^2/acre of shortleaf pine trees ≥14" DBH class
FAIR (C)	Shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No shortleaf pine trees ≥14" DBH are present

Metric Rating	***Dry & Mesic Highlands Pine Woodlands (Mountain Longleaf)***
EXCELLENT (A)	Basal area ≥20 ft^2/acre of longleaf pine and/or shortleaf pine trees ≥14" DBH class or flat-top longleaf pine is present
GOOD (B)	Basal area ≥10 ft^2/acre of longleaf pine and/or shortleaf pine trees ≥14" DBH class
FAIR (C)	Longleaf pine and/or shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No longleaf pine and/or shortleaf pine trees ≥14" DBH or flat-top longleaf pine are present

Metric Rating	*Dry & Mesic Hilly Pine Woodlands*
EXCELLENT (A)	Basal area ≥20 ft^2/acre of loblolly pine and/or shortleaf pine trees ≥14" DBH class
GOOD (B)	Basal area ≥10 ft^2/acre of loblolly pine and/or shortleaf pine trees ≥14" DBH class
FAIR (C)	Loblolly pine and/or shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No loblolly pine and/or shortleaf pine trees ≥14" DBH are present

Metric Rating	*Upper Coastal Plain Pine Flatwoods*
EXCELLENT (A)	Basal area ≥20 ft^2/acre of loblolly pine and/or shortleaf pine trees ≥14" DBH class
GOOD (B)	Basal area ≥10 ft^2/acre of loblolly pine and/or shortleaf pine trees ≥14" DBH class
FAIR (C)	Loblolly pine and/or shortleaf pine trees ≥14" DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No loblolly pine and/or shortleaf pine trees ≥14" DBH are present

Data for Metric Rating: Published data that support the basis for the metric rating

Bragg, Don C. 2002. Reference conditions for old-growth pine forests in the Upper West Gulf Coastal Plain. Jour. Torrey Botanical Society 129(4):261-288.

Bragg, Don C., Ricky O'Neill, William Holimon, Joe Fox, Gary Thornton, and Roger Mangham. 2014. Moro Big Pine: Conservation and Collaboration in the Pine Flatwoods of Arkansas. Journal of Forestry 112(5):446–456.

Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.

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White, David L. and F. Thomas Lloyd. 1998. An Old-Growth Definition for Dry and Dry-Mesic Oak Pine Forests. USDA Forest Service - Southern Research Station. Gen. Tech. Rept. SRS-23.

Scaling Rationale: Scaling is consistent and based on recent literature, for nearly all ecosystems the presence of large pine ≥ 14" DBH is used. Due to the slow growth of longleaf pine in the Xeric Longleaf Pine Barrens, the presence of large longleaf pine ≥ 12" DBH is used rather than ≥ 14" DBH.

Confidence that reasonable logic and/or data support the index: Moderate to high.

RANK FACTOR: VEGETATION

Metric Name:

Canopy Hardwood Basal Area

Definition: Combined basal area of all canopy hardwood trees. The cross section area of hardwood tree stems (defined here as square feet /acre) for canopy trees ≥ 5 inches DBH, and measured using a 10x basal area prism or gauge at the center point of the plot or rapid assessment area or by measuring all canopy hardwood trees ≥ 5 inches DBH within a plot of a defined area.

Background: Basal area of trees by species is data very commonly collected as part of forestry inventory. It is a widely used measure quantifying the dominance of tree species, and is repeatable using a 10x basal area prism or gauge. Hardwood trees in southern open pine can include ruderal and fire-intolerant hardwood trees, including red maple (*Acer rubrum),* sweetgum (*Liquidambar styraciflua),* tulip-tree (*Liriodendron tulipifera),* blackgum (*Nyssa sylvatica),* water oak (*Quercus nigra),* and especially in wet flatwoods and savannas, Chinese tallow tree (*Triadica sebifera)* (Bragg 2014, NatureServe 2011). A small amount of hardwood tree basal area naturally occurs in many upland southern open pine ecosystems, especially oaks such as southern red oak (*Quercus falcata),* post oak (*Quercus stellata*), black oak (*Quercus velutina),* turkey oak *(Quercus laevis),* sand post oak (*Quercus margarettiae),* and blackjack oak (*Quercus marilandica)* (Bragg 2002, Bragg 2014, Hiers et al. 2014, NatureServe 2015b). There are various wildlife benefits to retention of some fire tolerant hardwoods, especially oaks, in southern open pine ecosystems (Hiers et al. 2014). Increasing dominance or codominance by hardwoods can result from lack of fire, and is associated with declines of southern open pine wildlife. For brown-headed nuthatch and pine warbler, hardwood basal area less than 22 ft^2/acre is best, when deciduous hardwoods begin to reach the canopy of stands, these birds are rarely present (Richardson 2014). Bachman's sparrow and prairie warbler habitat should lack or have a low proportion of hardwood in the canopy (Richardson 2014a). In good red-cockaded woodpecker areas, the canopy lacks hardwood, or has low proportion of hardwoods, only 10 to 30% of the canopy trees (USFWS 2003). Several declining reptiles prefer open canopy longleaf pine dominated woodlands, these include Louisiana pine snake, Florida pine snake, black pine snake, eastern diamondback rattlesnake, and gopher tortoise (Hinderliter 2015, NatureServe 2015b). The eastern diamondback rattlesnake also uses hardwood dominated areas, in addition to southern open pine woodlands. Maintenance condition for longleaf pine woodlands is considered to be basal area ≤ 10 ft^2/acre of canopy hardwoods or off-site pines ≥ 5" DBH. (Longleaf Partnership Council 2014).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Basal area is a widely used measure quantifying the dominance of tree species, and is repeatable using a 10x basal area prism or gauge. Measures of basal area need to be collected at multiple locations to get a stand level estimate of basal area.

Measurement Protocol: Basal area of canopy hardwood trees ≥ 5" diameter at 4.5 feet (54”), diameter at breast height (DBH). **Option 1**: A 10x factor basal area prism or gauge is used from the center of the data collection area, and trees are tallied by species. The tallied counts of canopy hardwood tree species are multiplied by the basal area factor of 10 to get the basal area in ft^2/acre, and all canopy hardwood species basal areas are totaled. **Option 2**: Delineate a plot of at least 0.1 acre or 400 m^2 and measure all canopy tree species ≥5" diameter at 4.5 feet (54”), diameter at breast height (DBH), then convert diameter measurements to ft^2/acre using formula:

Basal area (ft^2/acre) = 0.005454*DBH^2

Then, all canopy hardwood species basal areas are totaled. For the final value of basal area the per plot size value must be converted to a per acre value.

A value of “0” should be listed for species with stems > 5” DBH within the plot, but that are not included in the tallied basal area (i.e., not picked up in prism or gauge sample). This attribute is directly linked to the respective canopy species as indicated by the ending number designation.

Metric Rating: These values represent results in ft^2/acre using Option 1, the 10x basal area prism or gauge. Basal area values such as 15, 35, 75, and 95 are not accommodated.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	0 to 10 ft^2/acre basal area of hardwood trees
GOOD (B)	20 ft^2/acre basal area of hardwood trees
FAIR (C)	30 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 40 ft^2/acre basal area of hardwood trees

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	0 to 10 ft^2/acre basal area of hardwood trees
GOOD (B)	20 ft^2/acre basal area of hardwood trees
FAIR (C)	30 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 40 ft^2/acre basal area of hardwood trees

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	0 to 10 ft^2/acre basal area of hardwood trees
GOOD (B)	20 ft^2/acre basal area of hardwood trees
FAIR (C)	30 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 40 ft^2/acre basal area of hardwood trees

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	0 to 10 ft^2/acre basal area of hardwood trees
GOOD (B)	20 ft^2/acre basal area of hardwood trees
FAIR (C)	30 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 40 ft^2/acre basal area of hardwood trees

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	$\leq$ 20 ft^2/acre basal area of hardwood trees
GOOD (B)	30-40 ft^2/acre basal area of hardwood trees
FAIR (C)	50 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 60 ft^2/acre basal area of hardwood trees

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	$\leq$ 20 ft^2/acre basal area of hardwood trees
GOOD (B)	30 ft^2/acre basal area of hardwood trees
FAIR (C)	40 to 50 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 60 ft^2/acre basal area of hardwood trees

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	$\leq$ 20 ft^2/acre basal area of hardwood trees
GOOD (B)	30 ft^2/acre basal area of hardwood trees
FAIR (C)	40-50 ft^2/acre basal area of hardwood trees
POOR (D)	$\geq$ 60 ft^2/acre basal area of hardwood trees

These values below represent results in ft^2/acre using Option 2. Calculated values other than multiples of 10 are accommodated.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	<20 ft^2/acre basal area of hardwood trees
GOOD (B)	$\geq$20 to 25 ft^2/acre basal area of hardwood trees
FAIR (C)	>25 to 35 ft^2/acre basal area of hardwood trees
POOR (D)	>35 ft^2/acre basal area of hardwood trees

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	<20 ft^2/acre basal area of hardwood trees
GOOD (B)	$\geq$20 to 25 ft^2/acre basal area of hardwood trees
FAIR (C)	>25 to 35 ft^2/acre basal area of hardwood trees
3POOR (D)	>35 ft^2/acre basal area of hardwood trees

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	<20 ft^2/acre basal area of hardwood trees
GOOD (B)	$\geq$20 to 25 ft^2/acre basal area of hardwood trees

FAIR (C)	>25 to 35 ft^2/acre basal area of hardwood trees
POOR (D)	>35 ft^2/acre basal area of hardwood trees

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	<20 ft^2/acre basal area of hardwood trees
GOOD (B)	≥20 to 25 ft^2/acre basal area of hardwood trees
FAIR (C)	>25 to 35 ft^2/acre basal area of hardwood trees
POOR (D)	>35 ft^2/acre basal area of hardwood trees

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	≤20 ft^2/acre basal area of hardwood trees
GOOD (B)	>20 to 40 ft^2/acre basal area of hardwood trees
FAIR (C)	>40 to 50 ft^2/acre basal area of hardwood trees
POOR (D)	>50 ft^2/acre basal area of hardwood trees

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	≤20 ft^2/acre basal area of hardwood trees
GOOD (B)	>20 to 30 ft^2/acre basal area of hardwood trees
FAIR (C)	>30 to 50 ft^2/acre basal area of hardwood trees
POOR (D)	>50 ft^2/acre basal area of hardwood trees

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	≤20 ft^2/acre basal area of hardwood trees
GOOD (B)	>20 to 30 ft^2/acre basal area of hardwood trees
FAIR (C)	>30 to 50 ft^2/acre basal area of hardwood trees
POOR (D)	>50 ft^2/acre basal area of hardwood trees

Data for Metric Rating: Published data that support the basis for the metric rating

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.

Bragg, D. C. 2002. Reference conditions for old-growth pine forests in the Upper West Gulf Coastal Plain. Jour. Torrey Botanical Society 129(4):261-288.

Bragg, D. C., R. O'Neill, W. Holimon, J. Fox, G. Thornton, and R. Mangham. 2014. Moro Big Pine: Conservation and Collaboration in the Pine Flatwoods of Arkansas. Journal of Forestry 112(5):446–456.

Florida Natural Areas Inventory and the Florida Forest Service. 2014. Longleaf Pine Ecosystem Geodatabase v.1 Final Report. A cooperative project between Florida Natural Areas Inventory and the Florida Forest Service. <http://www.fnai.org/LongleafGDB.cfm>

Hinderliter, M. 2014. Gopher Tortoise Open Pine DFCs. US Fish and Wildlife Service. Jackson, MS.

Hinderliter, M. 2015. Black Pine Snake Questions and Answers. US Fish and Wildlife Service. Jackson, MS. < http://www.fws.gov/mississippies/_pdf/Black%20Pinesnake%20-%20QUESTIONS%20AND%20ANSWERS.pdf>

Hiers, J. K., J. R. Walters, R. J. Mitchell, J. M. Varner, L. M. Conner, L. A. Blanc, and J. Stowe. 2014. Commentary: Ecological Value of Retaining Pyrophytic Oaks in Longleaf Pine Ecosystems. The Journal of Wildlife Management 78(3):383–393.

Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.

Lower Mississippi Valley Joint Venture WGCPO Landbird Working Group. 2011. West Gulf Coastal Plain/Ouachitas Open Pine Landbird Plan. A Report to the Lower Mississippi Valley Joint Venture Management Board. <http://www.lmvjv.org/library/WGCPO_Landbird_Open_Pine_Plan_Oct_2011.pdf>

Elledge, J. and B. Barlow. 2012. Basal Area: A Measure Made for Management. ANR-1371. Alabama Cooperative Extension System (Alabama A&M University and Auburn University). <http://www.aces.edu/pubs/docs/A/ANR-1371/ANR-1371.pdf>

NatureServe. 2011. Rapid Assessment Metrics for Longleaf Pine Dominated Woodlands. Draft Report to the USDA Forest Service, Region 8. NatureServe Central Databases. Durham, NC. U.S.A.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 28, 2015).

NatureServe. 2015b. International Ecological Classification Standard: Terrestrial Ecological Classifications. U.S. National Vegetation Classification. Southern Open Pine Groupings. NatureServe Central Databases. Arlington, VA. Data current as of 10 March 2015.

Richardson, D. 2014a. Fire Management Species Profile, Bachman's Sparrow (*Peucaea aestivalis*). Division of Strategic Resource Management & the Division of Fire Management, USFWS, Southeast Region, Atlanta, GA.

Scaling Rationale: The scaling here for stands with less than 10 basal area of hardwood may need more work. It might be worth clarifying in the metric scoring, the differences between hardwoods which may be a natural component of dry site southern open pine woodlands, and those which are ruderal or indicative of lack of fire.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Stand Density Index

Definition: Stand Density Index (SDI) is a measure of tree density which incorporates the size (quadratic mean diameter) and density (trees per acre) of trees in a stand. Trees per acre (TPA) alone is not as useful a measure of stand density since it does not account for differences in tree diameter (Ziede 2005). The tree count must incorporate some measure of tree size to have meaning in forest management. SDI has two significant advantages over basal area (BA): 1) BA varies in equally dense stands (stands of equal BA can have differing amounts of competition for resources since TPA may vary), and 2) BA is not independent of site and age (BA values that indicate a need for thinning vary with stand age and site quality). A primary benefit to SDI is its independence of stand age and site quality (Harrington 2001, Ziede 2005).

Background: Stand Density Index (SDI) was first developed in the 1930s (Reineke 1933), and has been used more in forestry during recent years (Ducey and Valentine 2008, Shaw and Long 2010). SDI has been used in the assessment and management of goshawk nesting habitat (Lilieholm et al. 1993, Lilieholm et al. 1994) and elk thermal cover, in both ponderosa pine (McTague and Patton 1989) and lodgepole pine (Smith and Long 1987). More recently, SDI has been shown to be useful in managing longleaf pine for the recovery of red-cockaded woodpecker (Shaw and Long 2007) and as a measure of canopy trees in relation to functioning herbaceous groundcover in longleaf pine woodlands in Georgia (Mulligan et al. 2002). Commercial forestry uses SDI for scheduling thinning in intensively managed southern pine stands (Doruska and Nolan 1999, Harrington 2001, Williams 1996).

Stand Density Index (SDI) is calculated:

$$SDI = TPA * (Dq/10)^{1.6}$$

where TPA is the density, in trees per acre
Dq is quadratic mean stand diameter in inches at breast height
10 is the reference diameter in inches
1.6 is the slope factor

Quadratic mean diameter is different from the common arithmetic mean diameter. Quadratic mean diameter is the diameter of a tree of average basal area, and is calculated:

$$Dq = \sqrt{BA/(0.005454 * n)}$$

Where *BA* is the basal area in square feet per acre
n is the corresponding number of trees

Quadratic mean diameter is also simply calculated as the square root of the average of the squared diameters of the tallied trees, calculated:

$$Dq = \sqrt{(\sum d_i^2)/n}$$

Where *d* is the diameter of each tree
n is the number of trees

Stand Density Index is grounded in the "-3/2 self-thinning law", which describes the inverse relationship between the average mass of plants, and their density (Shaw and Long 2010). For use in forestry, the quadratic mean diameter (*Dq*) is substituted for average mass of trees.

For many kinds of trees, maximum SDI values have been calculated. The maximum SDI values for longleaf pine and slash pine are 400 (Harrington 2001, Reineke 1933, Shaw and Long 2007), and the maximum SDI values for shortleaf pine and loblolly pine are 450 (Harrington 2001, Reineke 1933). Various percentages of the maximum SDI values relate to levels of canopy closure, effects of canopy trees on understory plants, and density dependent mortality in forest stands. For instance:

- 25% SDI is where the overstory begins to have significant negative effects on the understory (Mulligan et al. 2002, Shaw and Long 2007), and is associated with the transition from open-grown to competing trees (Long 1985, Shaw and Long 2007)
- 35% SDI is the lower limit of full site occupancy, i.e. stand growth continues to increase with increasing relative density above this point, but at a decreasing rate (Long 1985)
- 35 – 40% SDI is the range of maximum stand tree growth (Long 1985, Shaw and Long 2007)
- 60% SDI is the onset of self-thinning, i.e. density dependent tree mortality (Long 1985, Shaw and Long 2007)

In practice, larger diameter stands of southern pines do not follow the maximum SDI, but follow a lower curve called mature stand boundary (Shaw and Long 2007, Shaw and Long 2010). This relates to higher mortality of large trees which is not density dependent, and perhaps is due to the inability of tree growth to quickly recapture the canopy gaps were large pines have died (Shaw and Long 2010).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Forest managers who have been managing southern open pine for wildlife have found that Stand Density Index (Shaw and Long 2007) has many advantages over basal area, or measures of canopy cover (such as visual estimates, or densiometer). Research indicates that Stand Density Index has a predicable relationship to grassy herbaceous groundcover conditions in open pine stands (Moore and Deiter 1992, Mulligan et al. 2002).

Measurement Protocol: Stand Density Index is calculated from the density in trees per acre (TPA) and the quadratic mean diameters (*Dq*) at breast height of the pine trees in sample plots. Within a stand, SDI can be calculated from either a set of fixed area plots or variable area plots (i.e. prism sampling), where trees are tallied and the diameters of each tree is measured. Both are easy to apply. Simple calculations in the office can average values across the stand, spreadsheets make this easier. Silvicultural treatments occur at the scale of the stand, not a specific point within a stand, so the stand level data is most useful for informing management.

Metric Rating: Values are calculated and averaged from sample plots within a stand.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands*** applies to longleaf pine (*Pinus palustris)*
EXCELLENT (A)	SDI = 60 – 125 (15 - 31% of Maximum SDI of 400)
GOOD (B)	SDI = 40 – 60 or 125 -160 (10-15% or 31-40% of Maximum SDI of 400, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 20 – 40 or 160 - 200 (5-10% or 40-50% of Maximum SDI, 240 is 60% of Maximum SD of 400, *which is the onset of self-thinning*)
POOR (D)	SDI <20 or >200 (<5% or > 50%, 240 is 60% of Maximum SD of 400, *the onset of self-thinning*)

Metric Rating	***Mesic Longleaf Pine Flatwoods*** applies to longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
EXCELLENT (A)	SDI = 60 – 125 (15-31% of Maximum SDI of 400)
GOOD (B)	SDI = 40 – 60 or 125 -160 (10-15% or 31-40% of Maximum SDI of 400, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 20 – 40 or 160 - 190 (5-10% or 40-48% of Maximum SDI, 240 is 60% of Maximum SD of 400, *which is the onset of self-thinning*)
POOR (D)	SDI <20 or >190 (<5% or > 48%, 240 is 60% of Maximum SD of 400, *the onset of self-thinning*)

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas*** applies to longleaf pine (*Pinus palustris*), slash pine (*Pinus elliottii*), and/or South Florida slash pine (*Pinus elliottii* var. *densa*)
EXCELLENT (A)	SDI = 35 – 120 (9-30% of Maximum SDI of 400)
GOOD (B)	SDI = 20 – 35 or 120 -155 (5-9% or 30-39% of Maximum SDI of 400, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 10 – 20 or 155 - 180 (2.5-5% or 39-45% of Maximum SDI, 240 is 60% of Maximum SD of 400, *which is the onset of self-thinning*)
POOR (D)	SDI <10 or >180 (<2.5% or > 45%, 240 is 60% of Maximum SD of 400, *the onset of self-thinning*)

Metric Rating	***Xeric Longleaf Pine Barrens*** applies to longleaf pine (*Pinus palustris)*
EXCELLENT (A)	SDI = 50 – 120 (13-30% of Maximum SDI of 400)
GOOD (B)	SDI = 30 – 50 or 120 -160 (8-13% or 30-40% of Maximum SDI of 400, *35 – 40% SDI is near maximum of stand growth*)

FAIR (C)	SDI = 20 – 30 or 160 - 180 (5-8% or 40-45% of Maximum SDI, 240 is 60% of Maximum SD of 400, *which is the onset of self-thinning*)
POOR (D)	SDI <20 or >180 (<5% or > 45%, 240 is 60% of Maximum SD of 400, *the onset of self-thinning*)

Metric Rating	***Dry & Mesic Highlands Pine Woodlands*** applies to shortleaf pine (*Pinus echinata)*
EXCELLENT (A)	SDI = 65 – 135 (14-30% of Maximum SDI of 450)
GOOD (B)	SDI = 45 – 65 or 135 -180 (10-14% or 30-40% of Maximum SDI of 450, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 20 – 45 or 180 - 225 (4-10% or 40-50% of Maximum SDI, 270 is 60% of Maximum SD of 450, *which is the onset of self-thinning*)
POOR (D)	SDI <20 or >225 (<4% or > 50%, 270 is 60% of Maximum SD of 450, *the onset of self-thinning*)

Metric Rating	***Dry & Mesic Highlands Pine Woodlands*** applies to mountain longleaf pine (*Pinus palustris*)
EXCELLENT (A)	SDI = 55 – 120 (14-30% of Maximum SDI of 400)
GOOD (B)	SDI = 40 – 55 or 120 -160 (10-14% or 30-40% of Maximum SDI of 400, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 15 – 40 or 160 - 200 (4-10% or 40-50% of Maximum SDI, 240 is 60% of Maximum SD of 400, *which is the onset of self-thinning*)
POOR (D)	SDI <15 or >200 (<4% or > 50%, 240 is 60% of Maximum SD of 400, *the onset of self-thinning*)

Metric Rating	***Dry & Mesic Hilly Pine Woodlands*** applies to shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
EXCELLENT (A)	SDI = 55 – 155 (12-34% of Maximum SDI of 450)
GOOD (B)	SDI = 35 – 55 or 155 -205 (8-12% or 34-45% of Maximum SDI of 450, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 20 – 35 or 205 - 225 (4-8% or 45-50% of Maximum SDI, 270 is 60% of Maximum SD of 450, *which is the onset of self-thinning*)
POOR (D)	SDI <20 or >225 (<4% or > 50%, 270 is 60% of Maximum SD of 450, *the onset of self-thinning*)

Metric Rating	***Upper Coastal Plain Pine Flatwoods*** applies to shortleaf pine (*Pinus echinata)* and/or loblolly pine (*Pinus taeda*)
EXCELLENT (A)	SDI = 55 – 145 (12-32% of Maximum SDI of 450)
GOOD (B)	SDI = 35 – 55 or 145 -180 (8-12% or 32-40% of Maximum SDI of 450, *35 – 40% SDI is near maximum of stand growth*)
FAIR (C)	SDI = 20 – 35 or 180 - 225 (4-8% or 40-50% of Maximum SDI, 270 is 60% of Maximum SD of 450, *which is the onset of self-thinning*)
POOR (D)	SDI <20 or >225 (<4% or > 50%, 270 is 60% of Maximum SD of 450, *the onset of self-thinning*)

Data for Metric Rating: Published data that support the basis for the metric rating

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Lilieholm, R. J., W. B. Kessler, and K. Merrill. 1993. Stand density index applied to timber and goshawk habitat objectives in Douglas-fir. Environmental Management 17(6): 773-779.

Lilieholm, R. J., J. N. Long, and S. Patla. 1994. Assessment of goshawk nest area habitat using stand density index. Pp. 18-23 *In* Block, W.M., M.L. Morrison, and M.H. Rieser, eds. The northern goshawk: ecology and management. Proceedings of a Symposium of the Cooper Ornithological Society. Studies in Avian Biology No. 16.

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Mulligan, M. K., L. K. Kirkman, and R. J. Mitchell. 2002. *Aristida beyrichiana* (wiregrass) establishment and recruitment: implications for restoration. Restoration Ecology 10(1): 68-76.

Reineke, L. H. 1933. Perfecting a stand-density index for even-aged forests. Journal of Agricultural Research. 46(7): 627–637.

Shaw, J. D. and J. N. Long. 2007. A density management diagram for longleaf pine stands with application to red-cockaded woodpecker habitat. Southern Journal of Applied Forestry 31(1): 28–38.

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Smith, F. W. and J. N. Long. 1987. Elk hiding and thermal cover guidelines in the context of lodgepole pine stand density. Western Journal of Applied Forestry 2(1):6-10.

Williams, R. A. 1996. Stand density index for loblolly pine plantations in North Louisiana. Southern Journal of Applied Forestry 20(2): 110-113.

Zeide. B. 2005. How to measure stand density. Trees 19(1):1-14.

Scaling Rationale: Scaling is informed by the research pertaining to SDI in open pine stands which have a grass dominated ground cover (Moore and Deiter 1992, Mulligan et al. 2002, Shaw and Long 2007). The range of 15–30 % of maximum SDI correlates well with the ranges of basal area considered to indicate excellent condition by external expert reviewers. Values below 25% of maximum SDI are best for the functioning of native wiregrass (Mulligan et al. 2002), but in longleaf pine ecosystems adequate basal area is needed to provide needle drop which is necessary as fuel for frequent prescribed fire.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Midstory Fire Tolerant Hardwood Cover

Definition: Midstory Fire Tolerant Hardwood Cover. Percentage of the ground within the plot covered by fire tolerant hardwood midstory foliage, branches, and stems as determined by ocular (visual) estimate. Midstory is defined as any woody stems (including tall shrubs, small trees, and vines) which are > 10 feet tall, up to the height of the bottom of the tree canopy. Young trees of this size are commonly called saplings. Fire tolerant hardwood tree species include turkey oak, sand post oak, bluejack oak, blackjack oak, black oak, post oak, southern red oak, black hickory and flowering dogwood. Individuals which grow into the canopy are considered to be tree size and are included in the canopy basal area metrics.

Background: Southern open pine ecosystems with an open midstory can provide better habitat for many of the characteristic wildlife. Metrics similar to this have been used successfully on other southern open pine projects (FNAI and FFS 2014, NatureServe 2011). Many of these wildlife species rely on grassy herbaceous groundcover with some dwarf shrubs, often associated with open midstory and open canopy of longleaf pine. Wildlife which prefer an open midstory include reptiles such as Louisiana pine snake, Florida pine snake, black pine snake, eastern diamondback rattlesnake, and gopher tortoise (Hinderliter 2014, Hinderliter 2015, NatureServe 2015). While also preferring an open midstory, the northern bobwhite and Bachman's sparrow both use scattered tall shrubs and saplings for perching, including oaks, sassafras, black cherry and persimmon (NatureServe 2015, Richardson 2014a). Fire tolerant hardwood species naturally occur in upland southern open pine ecosystems, and include turkey oak, sand post oak, bluejack oak, blackjack oak, post oak, southern red oak and flowering dogwood. There are various wildlife benefits to retention of some fire tolerant hardwoods in southern open pine ecosystems (Hiers et al. 2014). For longleaf pine woodlands, maintenance conditions are considered to be 20% or less mid-story cover, with most of this fire tolerant species and < 5% cover of fire-intolerant hardwood or off-site pine trees over 16 feet tall (Longleaf Partnership Council 2014). To recover the biodiversity associated with shortleaf pine natural communities of the Interior Highlands (Ozark and Ouachita region), desired future conditions for cover of the midstory layer were determined to be <10% for Shortleaf Pine-Bluestem, <30% for Dry Mesic Shortleaf Pine-Oak Woodland, and 15% for Dry Shortleaf Pine-Oak. Midstory was defined as >10 feet (>3 m) tall and below the bottom of the canopy (Blaney et al. 2015), which is followed here. Most of the midstory would be composed of fire tolerant or fire resistant trees and tall shrubs.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: The presence of a midstory greater than 25% cover is associated with the decline in habitat quality for many wildlife species of southern open pine ecosystems. Generally there is a decline in herbaceous groundcover with an increase in midstory greater than 25% cover.

Measurement Protocol: For assessment area, estimate percentage of the ground within the plot covered by fire tolerant hardwood midstory foliage, branches, and stems as determined by ocular (visual) estimate. Midstory is defined to include any woody stems (including tall shrubs, small trees and vines) which are > 10 feet tall, up to the height of the bottom of the tree canopy. Measure fire tolerant hardwood cover (turkey oak, sand post oak, bluejack oak, blackjack oak, black oak, post oak, southern red oak, black hickory and flowering dogwood). Cover estimate classes will be used. Ocular (visual) estimate of the percent of ground within the plot covered by foliage and branches. Because forest vegetation layers can overlap, total percent cover may exceed 100%.

Metric Rating: This metric might not apply well to Wet Longleaf & Slash Pine Flatwoods & Savannas, since the fire tolerant hardwoods listed are upland species, not generally found in wetter areas.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	<15% cover of midstory fire tolerant hardwoods
GOOD (B)	15 to <20% cover of midstory fire tolerant hardwoods
FAIR (C)	20 to 25% cover of midstory fire tolerant hardwoods
POOR (D)	>25% cover of midstory fire tolerant hardwoods

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	<10% cover of midstory fire tolerant hardwoods
GOOD (B)	10 to <20% cover of midstory fire tolerant hardwoods
FAIR (C)	20 to 25% cover of midstory fire tolerant hardwoods
POOR (D)	>25% cover of midstory fire tolerant hardwoods

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	<10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-15% cover of midstory fire tolerant hardwoods
FAIR (C)	>15 to 25% cover of midstory fire tolerant hardwoods
POOR (D)	>25% cover of midstory fire tolerant hardwoods

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	<10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-20% cover of midstory fire tolerant hardwoods
FAIR (C)	>20 to 25% cover of midstory fire tolerant hardwoods
POOR (D)	>25% cover of midstory fire tolerant hardwoods

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	<10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-30% cover of midstory fire tolerant hardwoods
FAIR (C)	>30 to 40% cover of midstory fire tolerant hardwoods
POOR (D)	>40% cover of midstory fire tolerant hardwoods

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***

EXCELLENT (A)	<10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-20% cover of midstory fire tolerant hardwoods
FAIR (C)	>20 to 35% cover of midstory fire tolerant hardwoods
POOR (D)	>35% cover of midstory fire tolerant hardwoods

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	<10% cover of midstory fire tolerant hardwoods
GOOD (B)	10 to 20% cover of midstory fire tolerant hardwoods
FAIR (C)	>20 to 35% cover of midstory fire tolerant hardwoods
POOR (D)	>35% cover of midstory fire tolerant hardwoods

Data for Metric Rating: Published data that support the basis for the metric rating

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.

Bragg, D. C., R. O'Neill, W. Holimon, J. Fox, G. Thornton, and R. Mangham. 2014. Moro Big Pine: Conservation and Collaboration in the Pine Flatwoods of Arkansas. Journal of Forestry 112(5):446–456.

FNAI and FFS. 2014. Longleaf Pine Ecosystem Geodatabase v.1 Final Report. A cooperative project between Florida Natural Areas Inventory and the Florida Forest Service. <http://www.fnai.org/LongleafGDB.cfm>

Hinderliter, M. 2014. Gopher Tortoise Open Pine DFCs. US Fish and Wildlife Service. Jackson, MS.

Hinderliter, M. 2015. Black Pine Snake Questions and Answers. US Fish and Wildlife Service. Jackson, MS. < http://www.fws.gov/mississippies/_pdf/Black%20Pinesnake%20-%20QUESTIONS%20AND%20ANSWERS.pdf>

Hiers, J. K., J. R. Walters, R. J. Mitchell, J. M. Varner, L. M. Conner, L. A. Blanc, and J. Stowe. 2014. Commentary: Ecological Value of Retaining Pyrophytic Oaks in Longleaf Pine Ecosystems. The Journal of Wildlife Management 78(3):383–393.

Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 28, 2015).

NatureServe. 2011. Rapid Assessment Metrics for Longleaf Pine Dominated Woodlands. Draft Report to the USDA Forest Service, Region 8. NatureServe Central Databases. Durham, NC. U.S.A.

Richardson, D. 2014a. Fire Management Species Profile, Bachman's Sparrow (Peucaea aestivalis). Division of Strategic Resource Management & the Division of Fire Management, USFWS, Southeast Region, Atlanta, GA.

Scaling Rationale: The scaling of this metric may need to be reviewed and edited depending on the final midstory definition used. Here this is defined as woody plants of tree sapling size, 1-4” DBH. These will be above the height of shrubs, > 6 feet tall and are not considered trees for the basal area measures used in other metrics (which are limited to trees > 4” DBH).

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Midstory Overall Cover

Definition: Midstory Overall Cover. Percentage of the ground within the plot covered by midstory foliage, branches, and stems as determined by ocular (visual) estimate. Spaces between leaves and stems do NOT count as cover. Midstory is defined to include any woody stem (including tall shrubs, trees and vines) which are > 10 feet tall, up to the height of the bottom of the tree canopy.

Background: Southern open pine ecosystems with an open midstory can provide better habitat for many of the characteristic wildlife. Metrics similar to this have been used successfully on other southern open pine projects (FNAI and FFS 2014, NatureServe 2011). Many of these wildlife species rely on grassy herbaceous groundcover with some dwarf shrubs, often associated with open midstory and open canopy of longleaf pine. Wildlife which prefer an open midstory include reptiles such as Louisiana pine snake, Florida pine snake, black pine snake, eastern diamondback rattlesnake, and gopher tortoise (Hinderliter 2014, Hinderliter 2015, NatureServe 2015). While also preferring an open midstory, the northern bobwhite and Bachman's sparrow both use scattered tall shrubs and saplings for perching, including oaks, sassafras, black cherry and persimmon (NatureServe 2015, Richardson 2014a). To recover the biodiversity associated with Shortleaf Pine natural communities of the Interior Highlands (Ozark and Ouachita region), desired future conditions for cover of the midstory layer were determined to be <10% for Shortleaf Pine-Bluestem, <30% for Dry Mesic Shortleaf Pine-Oak Woodland, and 15% for Dry Shortleaf Pine-Oak. Midstory was defined as >10 feet (>3 m) tall and below the bottom of the canopy (Blaney et al. 2015). For longleaf pine woodlands, maintenance conditions are considered to be 20% or less mid-story cover, with < 5% cover of fire-intolerant hardwood or off-site pine trees over 16 feet tall (Longleaf Partnership Council 2014).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: The presence of a midstory greater than 25% cover is associated with the decline in habitat quality for many wildlife species of southern open pine ecosystems. Generally there is a decline in herbaceous groundcover with an increase in midstory greater than 25% cover.

Measurement Protocol: For the assessment area, estimate the percent of the ground within the plot covered by midstory foliage, branches, and stems as determined by ocular (visual) estimate. Midstory is defined to include any woody stem (including tall shrubs, trees and woody vines) which are > 10 feet tall, up to the height of the bottom of the tree canopy. Cover estimate classes will be used. Ocular (visual) estimate of the percent of ground within the plot covered by foliage and branches. Because forest vegetation layers can overlap, total percent cover of the canopy, midstory and shrub layers may exceed 100%.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	20 to 30% cover of woody midstory
FAIR (C)	>30 to 40% cover of woody midstory
POOR (D)	>40% cover of woody midstory

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	20 to <30% cover of woody midstory
FAIR (C)	30 to 40% cover of woody midstory
POOR (D)	>40% cover of woody midstory

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	20-30% cover of woody midstory
FAIR (C)	>30 to 40% cover of woody midstory
POOR (D)	>40% cover of woody midstory

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	20 to <30% cover of woody midstory
FAIR (C)	30 to 40% cover of woody midstory
POOR (D)	>40% cover of woody midstory

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	20-25% cover of woody midstory
FAIR (C)	>25 to 35% cover of woody midstory
POOR (D)	>35% cover of woody midstory

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	≥20 to 30% cover of woody midstory
FAIR (C)	>30 to 50% cover of woody midstory
POOR (D)	>50% cover of woody midstory

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	<20% cover of woody midstory
GOOD (B)	20 to 30% cover of woody midstory
FAIR (C)	>30 to 50% cover of woody midstory

POOR (D)	>50% cover of woody midstory

Data for Metric Rating: Published data that support the basis for the metric rating.

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.

Bragg, D. C., R. O'Neill, W. Holimon, J. Fox, G. Thornton, and R. Mangham. 2014. Moro Big Pine: Conservation and Collaboration in the Pine Flatwoods of Arkansas. Journal of Forestry 112(5):446–456.

FNAI and FFS. 2014. Longleaf Pine Ecosystem Geodatabase v.1 Final Report. A cooperative project between Florida Natural Areas Inventory and the Florida Forest Service. <http://www.fnai.org/LongleafGDB.cfm>

Hinderliter, M. 2014. Gopher Tortoise Open Pine DFCs. US Fish and Wildlife Service. Jackson, MS.

Hinderliter, M. 2015. Black Pine Snake Questions and Answers. US Fish and Wildlife Service. Jackson, MS. < http://www.fws.gov/mississippies/_pdf/Black%20Pinesnake%20-%20QUESTIONS%20AND%20ANSWERS.pdf>

Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.

NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 28, 2015).

NatureServe. 2011. Rapid Assessment Metrics for Longleaf Pine Dominated Woodlands. Draft Report to the USDA Forest Service, Region 8. NatureServe Central Databases. Durham, NC. U.S.A.

Richardson, D. 2014a. Fire Management Species Profile, Bachman's Sparrow (Peucaea aestivalis). Division of Strategic Resource Management & the Division of Fire Management, USFWS, Southeast Region, Atlanta, GA.

Scaling Rationale: Scaling includes a definition of excellent which has a low amount of midstory, such as might provide perching sites for Bachman's sparrow and northern bobwhite.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Short Shrub (<3 feet tall) Cover and Tall Shrub (3-10 feet tall) Cover

Definition: An assessment of cover by shrubs and small broad-leaved trees less than 10 feet tall. Percentage of the ground within the plot covered by the general extent of woody plants including small broad-leaved trees and short shrubs (< 3 feet tall) and tall shrubs (3-10 feet tall).

Background: This metric is drafted to accommodate both longleaf pine and shortleaf pine-bluestem vegetation and all other Southern Open Pine Groupings. Information is incorporated from Southern Open Pine workshops held at the Jones Center in March 2015 and Knoxville in September 2015. Maintenance condition class for shrub cover in longleaf pine woodlands exists when shrubs average ≤ 30% cover and average ≤ 3 feet tall (Longleaf Partnership Council 2014).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable:
Both longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) are shade-intolerant species, and both species are canopy dominants in fire-maintained southern open pine ecosystems. Both require a regime of frequent low intensity surface fires to provide open structure and adequate regeneration of the overstory trees. In addition, fire exposes mineral soil which is necessary for seed germination and seedling recruitment.

The natural range of Virginia pine (*Pinus virginiana*) is broadly Appalachian, and does not include the Coastal Plain or areas west of the Mississippi River, such as the Ozarks or Ouachita Mountains. On open sites where both shortleaf pine and Virginia pine occur, and in the absence of fire, shortleaf pine is badly out-competed by Virginia pine (*Pinus virginiana*) due to several factors. Shortleaf pines generally bear seeds at a much later age than Virginia pine (Carter and Snow 1990, Lawson 1990). Although mature shortleaf produce some seed almost every year, abundant crops occur only sporadically (Haney 1957), and these seeds may not be disseminated far from the original seed source (Stephenson 1963). This example points to the special conditions which are needed to sustain open woodlands dominated by shortleaf pine, throughout its natural range.

A dense and tall shrub layer shades the ground, inhibiting both the regeneration of longleaf pine and shortleaf pine seedlings as well as the vigor and reproduction of native warm season grasses and forbs that constitute the fuels needed to carry fire in the stand. Competition from woody plants (including shrubs) is highly detrimental to the growth and development of these pine seedlings and saplings (Lawson 1986, Lowery 1986). To recover the biodiversity associated with shortleaf pine natural communities of the Interior Highlands (Ozark and Ouachita region), desired future conditions for shrubs of the understory (1-3 m tall) were determined to be <10% for Shortleaf Pine-Bluestem, <30% for Dry Mesic Shortleaf Pine-Oak Woodland, and <30% for Dry Shortleaf Pine-Oak in the Ouachita and Boston Mountains, and 20-80% shrub cover in the Ozarks, further north (Blaney et al. 2015).

Longleaf pine (*Pinus palustris*) is a very intolerant pioneer species (Landers et al. 1995, cited in Jose et al. 2006) and does not compete well with other more aggressive canopy species (Boyer 1990). Fire

exclusion results in accumulation of litter that hinders proper germination of longleaf pine seeds (Croker 1975 cited in Jose et al. 2006). With the absence of fire (or other disturbance), the less fire-adapted shrubs can spread into the understory, competing for site resources, nutrients, and light and hindering the growth and regeneration of longleaf pine seedlings, as well as inhibiting and suppressing the vigor and growth of grasses and forbs in the ground layer (LMJV WGCPO Landbird Working Group 2011). Mature shortleaf pine-bluestem stands with abundant herbaceous ground cover and little to no hardwood midstory, managed with late-dormant season fire at 3-year intervals, show dramatic increases in both richness and density of small mammals and songbirds (Wilson and others 1995, Masters and others 1998, 2001, 2002; cited in Masters 2007). Periodic fire can control the size of understory hardwoods, but only annual summer burning (for decades) is likely to completely remove hardwood sprouts (Waldrop et al., 1992, cited in Van Lear et al. 2005).

Measurement Protocol: This metric consists of a visual evaluation of the cover and height of shrubs and small broad-leaved trees (less than 10 feet tall) within a delimited assessment area, including small broad-leaved trees and short shrubs (< 3 feet tall) and small trees and tall shrubs (3-10 feet tall). This assessment area should be at least 0.1 acre or 400 m^2 and can be delimited either with tapes, by pacing distances, or with a range-finder. Within this area, a visual assessment is made of the cover of shrubs, including small individuals of broad-leaved trees. This should not include longleaf pine or shortleaf pine regeneration. For assessment area, estimate percentage of the ground within the plot covered by the general extent of the foliage, branches, and stems from all shrubs (all woody plants, single- or multi-stemmed, including woody seedlings, tree saplings, saw palmetto, scrub palmetto and woody vining plants). Spaces between leaves and stems count as cover. Cover estimate classes will be used. Ocular (visual) estimate of the percent of ground within the plot covered by foliage and branches. Because forest vegetation layers can overlap, total percent cover may exceed 100%.

Shrub Cover Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor. Variants are provided.

Short Shrubs (<3 feet tall)

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	Shrubs < 3 feet in height average <30% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 30 to 35% cover in the assessment area
FAIR (C)	Shrubs < 3 feet in height average >35 to 45% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >45% cover in the assessment area

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	Shrubs < 3 feet in height average <30% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 30 to <40% cover in the assessment area
FAIR (C)	Shrubs < 3 feet in height average 40 to 45% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >45% cover in the assessment area

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	Shrubs < 3 feet in height average <30% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 30 to <40% cover in the assessment area

FAIR (C)	Shrubs < 3 feet in height average 40 to 45% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >45% cover in the assessment area

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	Shrubs < 3 feet in height average <25% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 25 to 35% cover in the assessment area
FAIR (C)	Shrubs < 3 feet in height average >35 to 45% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >45% cover in the assessment area

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	Shrubs < 3 feet in height average <20% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 20 to 25% cover in the assessment area
FAIR (C)	Shrubs < 3 feet in height average >25 to 40% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >40% cover in the assessment area

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	Shrubs < 3 feet in height average <20% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 20 to 30% cover in the assessment area
FAIR (C)	Shrubs < 3 feet in height average >30 to 45% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >45% cover in the assessment area

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	Shrubs < 3 feet in height average <20% cover in the assessment area
GOOD (B)	Shrubs < 3 feet in height average 20 to 30% cover in the assessment area
FAIR (C)	Shrubs < 3 feet in height average >30 to 45% cover in the assessment area
POOR (D)	Shrubs < 3 feet in height average >45% cover in the assessment area

Tall Shrubs (3-10 feet tall)

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	Shrubs 3-10 feet in height average <20% cover.
GOOD (B)	Shrubs 3-10 feet in height average 20 to 30% cover.
FAIR (C)	Shrubs 3-10 feet in height average >30 to 40% cover.
POOR (D)	Shrubs 3-10 feet in height average >40% cover.

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	Shrubs 3-10 feet in height average <20% cover.
GOOD (B)	Shrubs 3-10 feet in height average 20 to <30% cover.
FAIR (C)	Shrubs 3-10 feet in height average 30 to 35% cover.
POOR (D)	Shrubs 3-10 feet in height average >35% cover.

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	Shrubs 3-10 feet in height average <15% cover.
GOOD (B)	Shrubs 3-10 feet in height average 15 to <25% cover.
FAIR (C)	Shrubs 3-10 feet in height average 25-35% cover.
POOR (D)	Shrubs 3-10 feet in height average >35% cover.

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	Shrubs 3-10 feet in height average <15% cover.
GOOD (B)	Shrubs 3-10 feet in height average 15 to <25% cover.
FAIR (C)	Shrubs 3-10 feet in height average 25 to 30% cover.
POOR (D)	Shrubs 3-10 feet in height average >30% cover.

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	Shrubs 3-10 feet in height average <15% cover.
GOOD (B)	Shrubs 3-10 feet in height average 15 to 20% cover.
FAIR (C)	Shrubs 3-10 feet in height average >20 to 30% cover.
POOR (D)	Shrubs 3-10 feet in height average >30% cover.

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	Shrubs 3-10 feet in height average <15% cover.
GOOD (B)	Shrubs 3-10 feet in height average 15 to 20% cover.
FAIR (C)	Shrubs 3-10 feet in height average >20 to 30% cover.
POOR (D)	Shrubs 3-10 feet in height average >30% cover.

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	Shrubs 3-10 feet in height average <15% cover.
GOOD (B)	Shrubs 3-10 feet in height average 15 to 20% cover.
FAIR (C)	Shrubs 3-10 feet in height average >20 to 30% cover.
POOR (D)	Shrubs 3-10 feet in height average >30% cover.

Data for Metric Rating: Published data that support the basis for the metric rating

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior Highlands Shortleaf Pine Restoration Initiative: An Overview (6 August 2015 Draft). Central Hardwoods Joint Venture.

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Lawson, E. R. 1986. Natural Regeneration of Shortleaf Pine. pp. 53-63 In: Murphy, P. A. 1986. Proceedings, Symposium on the Shortleaf Pine Ecosystem. Arkansas Cooperative Extension Service, Monticello.

Lawson, E. R. 1990. *Pinus echinata* Mill. Shortleaf Pine. Pages 316-326. In: Burns, R. M., and B. H. Honkala, technical coordinators. 1990. Silvics of North America: Volume 1. Conifers. USDA Forest Service. Agriculture Handbook 654. Washington, DC. 675 pp.

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Lower Mississippi Valley Joint Venture (LMJV) WGCPO Landbird Working Group. 2011. West Gulf Coastal Plains/Ouachitas Open Pine Landbird Plan. Report to the Lower Mississippi Valley Joint Venture Management Board. 33 pp. http://www.lmvjv.org/library/WGCPO_Landbird_Open_Pine_Plan_Oct_2011.pdf

Lowery, R. F. 1986. Woody competition control. pp. 147-148 In: Murphy, P. A. 1986. Proceedings, Symposium on the Shortleaf Pine Ecosystem. Arkansas Cooperative Extension Service, Monticello.

Van Lear, D. H., W. D. Carroll, P. R. Kapeluck, and R. Johnson. 2005. History and restoration of the longleaf pine-grassland ecosystem: Implications for species at risk. Forest Ecology and Management. 211:150-165.

Scaling Rationale: This metric has been scaled based on scientific judgment of NatureServe ecologists and other expert ecologists and wildlife biologists. The metric is scaled based on the similarity between the observed vegetation structure and what is expected based on reference (or appropriately managed natural disturbance) conditions. Reference conditions reflect the accumulated experience of field ecologists, studies from sites where natural processes are intact, regional surveys and historic sources. The basis for assigning the ratings should be documented on the field forms.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Overall Native Herbaceous Ground Cover (foliar cover)

Definition: Percentage cover of all (native) species in the ground layer.

Background: The native herbaceous groundcover is an important part of the habitat needs of many species of wildlife found in southern open pine ecosystems.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Native herbaceous groundcover provides fine fuel which can allow frequent low intensity fires. The amount of native herbaceous groundcover is an important part of the habitat needs of many species of wildlife found in southern open pine ecosystems. Some southern open pine woodlands have many species of herbaceous legumes. These legumes provide food for wildlife and fix nitrogen which helps maintain site productivity. Maintenance condition class for herbaceous cover in longleaf pine woodlands is considered to be herbaceous cover > 35% with native pyrogenic species present in stand (Longleaf Partnership Council 2014). Birds of southern open pine ecosystems that benefit from native herbaceous ground cover include northern bobwhite (McIntyre 2012), Bachman's sparrow (Richardson 2014a), prairie warbler (NatureServe 2015), and red-cockaded woodpecker (James et al. 2001). Reptiles of southern open pine ecosystems that benefit from native herbaceous ground cover include Louisiana pine snake, black pine snake, Florida pine snake, eastern diamondback rattlesnake, and gopher tortoise (Hinderliter 2014, Hinderliter 2015, NatureServe 2015). To recover the biodiversity associated with shortleaf pine natural communities of the Interior Highlands (Ozark and Ouachita region), desired future conditions for cover of the ground layer were determined to be 80-100% for Shortleaf Pine-Bluestem, 50-80% for Dry Mesic Shortleaf Pine-Oak Woodland, and 40-60% for Dry Shortleaf Pine-Oak (Blaney et al. 2015).

Measurement Protocol: For assessment area, estimate the foliar cover of all native herbaceous ground cover (FNAI and FFS 2014). This includes all native non-woody, soft-tissued plants regardless of height, including non-woody vines, legumes, composites, graminoids (grasses, sedges, and rushes, including beaked rushes), and other herbaceous plants. Cover estimate classes will be used. Note: Foliar cover is the ocular (visual) estimate of the percent of ground within the plot covered by foliage and stems. Spaces between leaves and stems do NOT count as cover.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	40-98% herbaceous cover
GOOD (B)	30 to <40% or >98% herbaceous cover
FAIR (C)	20 to <30% herbaceous cover
POOR (D)	<20% herbaceous cover

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	40-98% herbaceous cover
GOOD (B)	30 to <40% or >98% herbaceous cover
FAIR (C)	20 to <30% herbaceous cover
POOR (D)	<20% herbaceous cover

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	40-100% herbaceous cover
GOOD (B)	30 to <40% herbaceous cover
FAIR (C)	20 to <30% herbaceous cover
POOR (D)	<20% herbaceous cover

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	40-100% herbaceous cover
GOOD (B)	>25 to <40% herbaceous cover
FAIR (C)	>15 to 25% herbaceous cover
POOR (D)	0-15% herbaceous cover

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	>45 to 80% herbaceous cover
GOOD (B)	30-45% or >80% herbaceous cover
FAIR (C)	15 to <30% herbaceous cover
POOR (D)	<15% herbaceous cover

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	35-80% herbaceous cover
GOOD (B)	20 to <35% or >80% herbaceous cover
FAIR (C)	10 to <20% herbaceous cover
POOR (D)	<10% herbaceous cover

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	35-80% herbaceous cover
GOOD (B)	20 to <35% or >80% herbaceous cover
FAIR (C)	10 to <20% herbaceous cover
POOR (D)	<10% herbaceous cover

Data for Metric Rating: Published data that support the basis for the metric rating.

Blaney, M., B. Rupar, T. Foti, J. Fitzgerald, P. Nelson, S. Hooks, M. Lane, W. Carromero, and T. Witsell. 2015. Appendix 1. Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. Pages 12-31 in Fitzgerald, J. and T. Foti. 2015. The Interior

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Kirkman, L. K., K. L. Coffey, R. J. Mitchell and E. B. Moser. 2004. Ground cover recovery patterns and life-history traits: implications for restoration obstacles and opportunities in a species-rich savanna. Journal of Ecology 92:409-421.

Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.

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NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 28, 2015).

Richardson, D. 2014a. Fire Management Species Profile, Bachman's Sparrow (Peucaea aestivalis). Division of Strategic Resource Management & the Division of Fire Management, USFWS, Southeast Region, Atlanta, GA.

Scaling Rationale:

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Longleaf Pine Regeneration

Definition: Advance longleaf pine regeneration cover is 5-15% of stand. Includes grass stage or regeneration < 2" DBH (Longleaf Partnership Council 2014).

Background: This metric has gone through extensive review and was adopted as part of the longleaf pine maintenance class definitions by the Longleaf Partnership Council (Longleaf Partnership Council 2014).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Regeneration of longleaf pine is critical to the maintenance of stands (Brockway and Outcalt 1998, Brockway et al. 2004, Brockway et al. 2005). Large scale disturbances such as hurricane force winds can break many canopy trees, and dramatically reduce seed trees. For this reason, presence of advance regeneration is an important metric.

Measurement Protocol: Advance longleaf pine regeneration cover is ≥1% of stand. Includes grass stage or regeneration < 2" DBH (Longleaf Partnership Council 2014). This is a stand level metric, longleaf pine recruitment may be very patchy, and regeneration may not be found in small assessment plots.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor.

Metric Rating	***All Open Longleaf Pine Ecosystems***
EXCELLENT (A) or GOOD (B)	Longleaf pine regeneration cover is ≥1% of stand
FAIR (C)	Longleaf pine regeneration cover is present but is <1% of stand, or no regeneration seen, but cone producing longleaf pine are present
POOR (D)	Longleaf pine regeneration cover is apparently absent, and no cone producing longleaf pine are present in the stand

Data for Metric Rating: Published data that support the basis for the metric rating

Brockway, D. G., and K. W. Outcalt. 1998. Gap-phase regeneration in longleaf pine wiregrass ecosystems. Forest Ecology and Management 106: 125–139.

Brockway, D. G., K. W. Outcalt, J. M. Guldin, W. D. Boyer, J. L. Walker, D. C. Rudolph, R. B. Rummer, J. P. Barnett, S. Jose, J. Nowak. 2005. Uneven-aged management of longleaf pine forests: a scientist and manager dialogue. Gen. Tech. Rep. SRS-78. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 38 p. <http://www.srs.fs.usda.gov/pubs/9636>

Brockway, D. G., K. W. Outcalt, D. J. Tomczak, and E. E. Johnson. 2004. Restoring longleaf pine forest ecosystems in the southern U.S. Chapter 32 in Stanturf, John A. and Palle Madsen, eds. 2004. Restoration of Boreal and Temperate Forests. CRC Press. <http://www.srs.fs.usda.gov/pubs/ja/uncaptured/ja_brockway032.pdf>

Brockway, D. G., K. W. Outcalt, D. J. Tomczak, and E. E. Johnson. 2005. Restoration of Longleaf Pine Ecosystems Gen. Tech. Rep. SRS-83. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 34 p.

Longleaf Partnership Council. 2014. Longleaf Pine Maintenance Condition Class Definitions: A Guide to Assess Optimal Forest Habitat Conditions for Associated Plant and Wildlife Species. October 2014. America's Longleaf Restoration Initiative, Longleaf Partnership Council.

RANK FACTOR: VEGETATION

Metric Name:

Native Warm Season Grass Cover

Definition: Native warm season grass cover is also called cover of pryrophytic graminoids which include grasses and grass-like plants. This metric is the percent cover of native warm season grasses and other perennial graminoids that are maintained by periodic fire. These are the native grasses and grass-like plants (mostly native warm season grasses) which are natural groundcover in southern open pine stands. For open longleaf pine woodlands in Florida, these include wiregrass (*Aristida stricta*), pineywoods dropseed (*Sporobolus junceus*), Florida dropseed (*Sporobolus floridanus*), Chapman's beaksedge (*Rhynchospora chapmanii*), cutover muhly (*Muhlenbergia capillaris* var. *trichopodes*), toothache grass (*Ctenium aromaticum*), little bluestem (*Schizachyrum scoparium*) and Florida toothache grass (*Ctenium floridanum*). However, switchgrass (*Panicum virgatum*) is not included, as it can become so dominant that other grasses, legumes and small bare ground areas are crowded out. Some typical wide ranging southern native warm season grasses of Dry & Mesic Longleaf Pine Woodlands include splitbeard bluestem (*Andropogon ternarius*), Elliott's bluestem (*Andropogon gyrans var. gyrans*), broomsedge bluestem (*Andropogon virginicus*), pineywoods dropseed (*Sporobolus junceus*), rough dropseed (*Sporobolus clandestinus*), little bluestem (*Schizachyrium scoparium*), slender little bluestem (*Schizachyrium tenerum*), Indiangrass (*Sorghastrum nutans*), slender Indiangrass (*Sorghastrum elliottii*), and lopsided Indiangrass (*Sorghastrum secundum*). In the Wet Longleaf & Slash Pine Flatwoods & Savannas, Carolina wiregrass or pineland threeawn (*Aristida stricta*) or Southern wiregrass or Beyrich's threeawn (*Aristida beyrichiana*) often dominates, but toothache grass (*Ctenium aromaticum*), cutover muhly (*Muhlenbergia expansa*), little bluestem (*Schizachyrium scoparium*), Florida dropseed (*Sporobolus floridanus*), Carolina dropseed (*Sporobolus pinetorum*), wireleaf dropseed (*Sporobolus teretifolius*), chalky bluestem (*Andropogon capillipes*), other bluestems (*Andropogon* spp.), or other grasses may also dominate. In the Ozarks and Ouachitas (Interior Highlands), native warm season grasses include little bluestem (*Schizachyrum scoparium*), big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), bearded shorthusk (*Brachyelytrum erectum*), Elliott's bluestem (*Andropogon gyrans*), blackseed speargrass (*Piptochaetium avenaceum*), composite dropseed (*Sporobolus compositus*), and other grasses (Blaney et al. 2015, Farrington 2010, Nelson 1985). In open shortleaf pine woodlands in northern Mississippi, native warm season grasses include little bluestem (*Schizachyrum scoparium*), Bosc's witchgrass (*Dichanthelium boscii*) and broomsedge (*Andropogon virginicus*) (Brewer et al. 2015, Maynard and Brewer 2013).

Background: Grasses and grass-like plants provide much of the fine fuels which allow frequent low intensity fire to occur in southern open pine ecosystems (Kirkman et al. 2004). Fires are an important natural disturbance and process which helps maintain longleaf pine ecosystems. Native grasses and grass-like plants which provide the fine fuels in southern open pine are called pyrophytic graminoids. These are mostly native perennial warm season grasses, which can resprout fairly quickly following fire during the growing season. Native warm season grasses use the four Carbon, C_4 pathway in photosythesis (not the more common three Carbon C_3 pathway used by cool season grasses) and generally are associated with prairies and open woodlands. The C_4 pathway is more efficient for photosynthesis in warmer temperatures (Edwards et al. 2010). For most southern open pine ecosystems, there is broad overlap between native warm season grasses (using the C_4 pathway), and the plants measured in this metric, which have been called pyrophytic graminoids. Areas with good cover of native warm season grasses can be foraging areas for gopher tortoise (Hinderliter 2014), nesting and feeding areas for Bachman's sparrow, and bobwhite quail (McIntyre 2012, Richardson 2014a), and

habitat for the eastern diamondback rattlesnake (NatureServe 2015). This metric has been useful in other assessments (FNAI and FFS 2014, NatureServe 2011). Maintenance condition class for herbaceous cover in longleaf pine woodlands is considered to be herbaceous cover >35% with native pyrogenic species present in stand (Longleaf Partnership Council 2014).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Grasses and grass-like plants provide much of the fine fuels which allow frequent low intensity fire to occur in southern open pine ecosystems (Kirkman et al. 2004). This metric has been useful in other assessments (FNAI and FFS 2014, NatureServe 2011).

Measurement Protocol: For the assessment area, estimate total foliar cover of all native warm season grass and grass-like species (FNAI and FFS 2014, NatureServe 2011). Examples from Florida include wiregrass (*Aristida stricta*), pineywoods dropseed (*Sporobolus junceus*), Florida dropseed (*Sporobolus floridanus*), Chapman's beaksedge (*Rhynchospora chapmanii*), cutover muhly (*Muhlenbergia capillaris* var. *trichopodes*), toothache grass (*Ctenium aromaticum*), little bluestem (*Schizachyrum scoparium*) and Florida toothache grass (*Ctenium floridanum*), **but not switchgrass (*Panicum virgatum*)**. Some typical wide ranging southern native warm season grasses of Dry & Mesic Longleaf Pine Woodlands include splitbeard bluestem (*Andropogon ternarius*), Elliott's bluestem (*Andropogon gyrans var. gyrans*), broomsedge bluestem (*Andropogon virginicus*), pineywoods dropseed (*Sporobolus junceus*), rough dropseed (*Sporobolus clandestinus*), little bluestem (*Schizachyrium scoparium*), slender little bluestem (*Schizachyrium tenerum*), Indiangrass (*Sorghastrum nutans*), slender Indiangrass (*Sorghastrum elliottii*), and lopsided Indiangrass (*Sorghastrum secundum*). In the Wet Longleaf & Slash Pine Flatwoods & Savannas, Carolina wiregrass or pineland threeawn (*Aristida stricta*) or Southern wiregrass or Beyrich's threeawn (*Aristida beyrichiana*) often dominates, but toothache grass (*Ctenium aromaticum*), cutover muhly (*Muhlenbergia expansa*), little bluestem (*Schizachyrium scoparium*), Florida dropseed (*Sporobolus floridanus*), Carolina dropseed (*Sporobolus pinetorum*), wireleaf dropseed (*Sporobolus teretifolius*), chalky bluestem (*Andropogon capillipes*), other bluestems (*Andropogon* spp.), or other grasses may also dominate. In the Ozarks and Ouachitas (Interior Highlands), native warm season grasses include little bluestem (*Schizachyrum scoparium*), big bluestem (*Andropogon gerardii*), Indian grass (*Sorghastrum nutans*), bearded shorthusk (*Brachyelytrum erectum*), Elliott's bluestem (*Andropogon gyrans*), blackseed speargrass (*Piptochaetium avenaceum*), composite dropseed (*Sporobolus compositus*), and other grasses (Blaney et al. 2015, Farrington 2010, Nelson 1985). In open shortleaf pine woodlands in northern Mississippi, native warm season grasses include little bluestem (*Schizachyrum scoparium*) Bosc's witchgrass (*Dichanthelium boscii*) and broomsedge (*Andropogon virginicus*) (Brewer et al. 2015, Maynard and Brewer 2013). Percent cover classes will be used. Note: Foliar cover is the ocular (visual) estimate of the percent of ground covered by foliage and branches. Spaces between leaves and stems do NOT count as cover.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	>25 to 97% foliar cover of all native warm season grasses
GOOD (B)	>15 to 25% or >97% foliar cover of all native warm season grasses
FAIR (C)	10-15% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	>25 to 97% foliar cover of all native warm season grasses
GOOD (B)	>15 to 25% or >97% foliar cover of all native warm season grasses
FAIR (C)	10-15% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	25-97% foliar cover of all native warm season grasses
GOOD (B)	>15 to <25% or >97% foliar cover of all native warm season grasses
FAIR (C)	10-15% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	25-95% foliar cover of all native warm season grasses
GOOD (B)	15 to <25% or >95% foliar cover of all native warm season grasses
FAIR (C)	10 to <15% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	>25 to 85% foliar cover of all native warm season grasses
GOOD (B)	>15 to 25% or >85% foliar cover of all native warm season grasses
FAIR (C)	10 -15% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Dry & Mesic Highlands Pine Woodlands (Mountain Longleaf)***
EXCELLENT (A)	>25 to 85% foliar cover of all native warm season grasses
GOOD (B)	20 to 25% or >85% foliar cover of all native warm season grasses
FAIR (C)	10 to <20% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	25- 100% foliar cover of all native warm season grasses
GOOD (B)	>15 to <25% foliar cover of all native warm season grasses
FAIR (C)	10-15% foliar cover of all native warm season grasses

POOR (D)	<10% foliar cover of all native warm season grasses

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	>25% foliar cover of all native warm season grasses
GOOD (B)	20 to 25% foliar cover of all native warm season grasses
FAIR (C)	10 to <20% foliar cover of all native warm season grasses
POOR (D)	<10% foliar cover of all native warm season grasses

Data for Metric Rating: Published data that support the basis for the metric rating

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Scaling Rationale: This metric is based on live foliar cover, as observed looking down at the plants. For the data collection to be repeatable, include only live material foliar cover seen by looking down towards the ground.

Confidence that reasonable logic and/or data support the metric: High

RANK FACTOR: VEGETATION

Metric Name:

Invasive Plant Presence/Distribution

Definition: Invasive plant presence/distribution. Describes the extent and distribution of invasive exotic plants within or along the perimeter of the polygon; includes only Florida EPPC category I and II listed species. <http://www.fleppc.org/list/list.htm>

Background: Invasive exotic species are a major threat to biological integrity in a wide variety of ecosystems (Miller 2003). These species can out compete the native species, alter ecological functions (Bryson and Carter 1993, Lippincott 2000) and contribute to decline in biological integrity. For wetlands, NatureServe has used cover of invasive nonnative plants for rapid ecological integrity assessment (Faber-Langendoen et al. 2015). NatureServe's categories are excellent if absent or < 1% cover, good if sporadic or 1-3% cover, fair if somewhat abundant with 4-10% cover, between fair and poor if abundant with 11-30% cover, and poor if very abundant with >30% cover of invasive nonnative plants (Faber-Langendoen et al. 2015). Less than or equal to 1% cover of invasive exotic plant species or ongoing progress towards this indicates maintenance condition for longleaf pine woodlands (Longleaf Partnership Council 2014). The Florida Exotic Pest Plant Council reviews and updates their list of invasive exotic plants every two years. The distributions within Florida are listed for north, central, and south Florida (FLEPPC 2015). For areas outside of Florida, refer to those invasive exotic species listed for north Florida. Exotic subtropical grasses are a particular threat to longleaf pine ecosystems. Tallow tree (*Triadica sebifera*) and cogongrass (*Imperata cylindrica*) are threats to Wet Longleaf & Slash Pine Flatwoods & Savannas (Brewer 2008, Wang et al. 2011). Cogongrass is also a threat to other longleaf pine ecosystems. Japanese stiltgrass (*Microstegium vimineum*) and Japanese honeysuckle (*Lonicera japonica*) are threats during restoration of open woodlands in northern Mississippi, such as the Dry & Mesic Hilly Pine Woodlands (Brewer, Abbott and Moyer 2015).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Invasive exotic species are a major threat to biological integrity in a wide variety of ecosystems. The metric and scaling is based on the type detection likely on a cursory or rapid field visit to a site.

Measurement Protocol: Describe the extent and distribution of invasive exotic plants within or along the perimeter of the site. If time allows, GPS locations of invasive exotic plant species which are encountered. This can facilitate the prompt control of these plants and simplify their management. Determine the presence only of Florida EPPC category I and II listed species. For areas outside of Florida, refer to those invasive exotic species listed for north Florida. <http://www.fleppc.org/list/list.htm>

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor.

Metric Rating	***All Southern Open Pine Ecosystems***
EXCELLENT (A)	Invasive nonnative plant species absent or cover in any stratum is very low (≥1% absolute cover)
GOOD (B)	Invasive nonnative plant species in any stratum present but sporadic (1-5 % cover)
FAIR (C)	Invasive nonnative plant species in any stratum uncommon (5-10% cover)
POOR (D)	Invasive nonnative plant species in any stratum common (>10% cover)

Data for Metric Rating: Published data that support the basis for the metric rating

Brewer, S. 2008. Declines in plant species richness and endemic plant species in longleaf pine savannas invaded by *Imperata cylindrica*. Biological Invasions 10:1257–1264.

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Wang, H., W. E. Grant, T. M. Swannack, J. Gan, W. E. Rogers, T. E. Koralewski, J. H. Miller and J.W. Taylor, Jr. 2011. Predicted range expansion of Chinese tallow tree (Triadica sebifera) in forestlands of the southern United States. Diversity and Distributions 17: 552–565.

Scaling Rationale: The scaling is based on the type of detection likely on a cursory or rapid field visit to a site. In order to detect invasive exotic plants, it is important to be familiar with those plants, and how to differentiate them from native plants. The metric can be applied to small assessment areas (fixed radius areas around points) or larger stands or conservation sites.

Confidence that reasonable logic and/or data support the metric: High

Appendix D. Participant list (including affiliations) for Meetings and Review

Name	Affiliation	State
Andy Vanderyacht	Center for Native Grasslands Management	TN
Brian Camposano	Florida Forest Service	FL
Bryan Rupar	Arkansas Natural Heritage Commission	AR
Carl Nordman	NatureServe	NC
Carol Denhof	Longleaf Alliance	AL
Catherine Rideout	USFWS	GA
Chris Oswalt	US Forest Service	TN
Chuck Hunter	USFWS	GA
Clarence Coffey	TWRA (Retired)	TN
Clay Ware	USFWS	GA
Dan Hipes	Florida Natural Areas Inventory	FL
Doug Zollner	TNC Arkansas	AR
Doyle Shook	Lower Miss JV	AR
Gary Burger	SCDNR	SC
Jim Guldin	USFS Research Station	AR
Joan Walker	USFS Research Station	SC
Joanne Baggs	US Forest Service	GA
Jon Scott	National Fish and Wildlife Foundation	DC
Kevin Mcintyre	Jones Center	GA
Lora Smith	Jones Center	GA
Martin Blaney	Arkansas Game and Fish	AR
Matt Hinderliter	USFWS	MS
McRee Anderson	TNC Arkansas	AR
Mike Black	Shortleaf Initiative	TN
Mike Conner	Jones Center	GA
Milo Pyne	NatureServe	NC
Randy Wilson	USFWS	MS
Rickie White	NatureServe	NC
Russ Walsh	USFWS	MS
Tom Foti	Arkansas Natural Heritage Program	AR
Wally Akins	Tennessee Wildlife	TN
Will McDearman	USFWS	MS

Appendix E: Associations and Alliances of the Southern Open Pine Groupings

The Associations of the United States National Vegetation Classification (USNVC) (Jennings et al. 2009) are plant community types that are based on field data (observations, plots of varying dimensions) taken by NatureServe, the state Natural Heritage Programs or by other plant community ecologists. Thanks to the work of Dr. Robert Peet and many others, the associations for Longleaf Pine communities in particular constitute a representative if not complete suite of types. Alliances and Vegetation Groups are successively broader USNVC units, with their own descriptions, including vegetation, habitat and geographic distribution attributes, into which the Associations nest. In the table below, the database code (e.g. CEGL007126) and colloquial name of the Association are given beneath their Alliance and Vegetation Group. These are presented below the related Southern Open Pine Grouping. More information is available at http://usnvc.org/.

Grouping/Group	Identifier	Association Colloquial Name
Xeric Longleaf Pine Barrens		
G154 - Xeric Longleaf Pine Woodland		
	A4074	**Pinus palustris / Quercus laevis / Aristida stricta Woodland Alliance**
	CEGL007126	Atlantic Coastal Plain Subxeric Sandy Longleaf Pine - Pond Pine Ecotonal Woodland
	CEGL003592	Longleaf Pine / Scrub Oak Sandhill (Northern Type)
	CEGL003577	Carolina Coastal Longleaf Pine Sandhill
	CEGL003589	Atlantic Coastal Plain Longleaf Sandhill Scrub
	CEGL003590	Atlantic Coastal Plain Xeric Sandhill Scrub
	CEGL007125	Wiregrass Gap Xeric Longleaf Pine Sand Woodland
	CEGL003591	Carolina Longleaf Pine / Mixed Scrub Oak Sandhill
	CEGL003586	Fall-line Sandhills Dry Longleaf Pine Woodland
	CEGL003584	Atlantic Coastal Plain Xeric Longleaf Pine Sand Woodland
	A3122	**Pinus palustris / Quercus incana Woodland Alliance**
	CEGL008566	West Gulf Coastal Plain Xeric Post Oak Woodland
	CEGL008571	West Gulf Coastal Plain Fire-Infrequent Mixed Longleaf Pine Forest/Woodland
	CEGL007513	West Gulf Coastal Plain Fire-Infrequent Xeric Sandhill
	CEGL003602	West Gulf Coastal Plain Xeric Longleaf Pine Sandhill
	CEGL008572	West Gulf Coastal Plain Subxeric Longleaf Pine Sandhill
	CEGL003580	Western Upland Longleaf Pine Forest (Stream Terrace Sandy Woodland Type)
	CEGL004957	Eastern Louisiana Xeric Longleaf Woodland
	A4076	**Pinus palustris / Quercus laevis - Quercus geminata Woodland Alliance**
	CEGL003604	Florida Panhandle Fire-Suppressed Sandhill
	CEGL007137	Northern Florida Peninsula Longleaf Pine Red Oak Woodland
	CEGL007133	Western Florida Panhandle Xeric Lowland Sandhill Woodland
	CEGL004490	South Atlantic Coastal Plain Dry Longleaf Pine Sandhill
	CEGL007132	Florida Peninsula Xeric Sandhills
	CEGL003583	Longleaf Pine / Turkey Oak Woodland
	CEGL007135	Florida Red Hills Submesic Longleaf Pine Woodland
	CEGL007141	Florida Panhandle Lowlands Subxeric Longleaf Pine Woodland
	CEGL007254	Florida Central Sand Ridge Ruderal Turkey Oak Woodland

CEGL004689	Ruderal Turkey Oak Xeric Sandhill Scrub

A4077 **Pinus palustris / Quercus laevis / Aristida condensata Woodland Alliance**

CEGL003587	East Gulf Coastal Plain Xeric Longleaf Pine Sandhill
CEGL003601	East Gulf Coastal Plain Subxeric Longleaf Pine Sandhill
CEGL003588	East Gulf Coastal Plain Longleaf Sandhill Woodland

A4075 **Pinus palustris / Quercus laevis / Schizachyrium scoparium Woodland Alliance**

CEGL004488	Atlantic Inner Coastal Plain Yellow Sand Longleaf Pine Woodland
CEGL004492	Georgia Dry Longleaf Pine - Scrub Oak Sand Woodland
CEGL007127	Georgia Xeric Fall-line Sandhills Longleaf Pine Woodland
CEGL007844	South Atlantic Dry Longleaf Pine Sandhill
CEGL003593	South Carolina Central Longleaf Woodland
CEGL007129	Southern Inner Coastal Plain Silty Longleaf Pine / Sand Post Oak Woodland
CEGL007842	South Atlantic Sandhills Subxeric Silty Longleaf Pine Woodland
CEGL004487	Georgia Outer Coastal Plain Subxeric Longleaf Pine Woodland
CEGL008491	Xeric Upper East Gulf Coastal Plain Longleaf Pine Woodland

Dry & Mesic Longleaf Pine Woodlands

G009 - Dry-Mesic Loamy Longleaf Pine Woodland

A3127 **Pinus palustris / Aristida spp. - Schizachyrium scoparium Southeastern Coastal Plain Woodland Alliance**

CEGL007738	Atlantic Coastal Plain Mesic Longleaf Pine / Little Bluestem Woodland
CEGL004774	East Gulf Coastal Plain Lorman Soil Longleaf Pine Woodland
CEGL003664	Longleaf Pine Savanna (Lumbee Type)
CEGL003570	Fall-line Mesic Longleaf Pine Woodland
CEGL004485	East Gulf Coast Dougherty Plain Dry-Mesic Longleaf Pine Woodland
CEGL004496	Mesic Atlantic Coastal Plain Longleaf Pine - Little Bluestem Woodland
CEGL004945	East Gulf Coastal Plain Clayhill Longleaf Pine Woodland
CEGL003575	East Gulf Coastal Plain Loamy Longleaf Pine Woodland
CEGL004084	Dry Atlantic Coastal Plain Longleaf Pine - Little Bluestem Woodland
CEGL007749	Tifton Uplands Submesic Longleaf Pine / Running Oak Woodland
CEGL004955	Western East Gulf Coastal Plain Silt Loam Longleaf Pine Woodland
CEGL008452	Upper East Gulf Coastal Plain Loamhill Longleaf Woodland
CEGL003573	Carolina Fall-line Mesic Longleaf Pine Terrace Woodland

A3124 **Pinus palustris / Schizachyrium scoparium West Gulf Coastal Plain Woodland Alliance**

CEGL003609	West Gulf Coastal Plain Fire-Suppressed Longleaf - Mixed Pine Forest
CEGL008482	Texas Upper West Gulf Coastal Plain Longleaf Pine Woodland
CEGL003576	West Gulf Coastal Plain Fire-Suppressed Longleaf Forest
CEGL003571	West Gulf Coastal Plain Mesic Upland Longleaf Pine Woodland
CEGL003572	West Gulf Coastal Plain Dry-Mesic Upland Longleaf Pine Woodland
CEGL003581	Western Upland Longleaf Pine Forest (Messer Pimple Mound Type)

A3125 **Pinus palustris / Quercus margarettiae / Aristida spp. Southeastern Coastal Plain Woodland Alliance**

CEGL007511	Fire-Suppressed Longleaf Sandhill

CEGL004263	Cumberland Island Dry Longleaf Pine - Oak Woodland
CEGL008586	Munson Sandhill, Bluejack Oak Phase
CEGL003578	Carolina Sandhills Loamy Longleaf Pine / Scrub Oak Woodland
CEGL007767	Sandstone/Gravel Longleaf Pine Woodland
CEGL004083	Outer Coastal Plain Subxeric Longleaf Pine / Little Bluestem Woodland

A3123 **Pinus palustris / Quercus marilandica / Schizachyrium scoparium West Gulf Coastal Plain Woodland Alliance**

CEGL007907	West Gulf Coastal Plain Dry Post Oak Woodland
CEGL008579	West Gulf Coastal Plain Clayey Longleaf Pine Forest
CEGL003579	West Gulf Coastal Plain Clayey Longleaf Pine Woodland (Dry Type)
CEGL008580	West Gulf Coastal Plain Clayey Longleaf Pine Woodland (Moist Type)
CEGL003596	West Gulf Coastal Plain Calcareous Clay Longleaf Pine Glade
CEGL003597	Louisiana Longleaf Pine Fleming Glade

A3126 **Pinus palustris / Quercus marilandica / Aristida spp. Southeastern Coastal Plain Clayhill Woodland Alliance**

CEGL004489	Altamaha Grit Longleaf Pine Woodland
CEGL003595	Atlantic Longleaf Pine - Blackjack Oak Woodland
CEGL003598	Mississippi Loam Hills Longleaf Forest
CEGL003599	Fall-line Sandhills Longleaf Pine - Blackjack Oak Woodland

Mesic Longleaf Pine Flatwoods

G596 - Mesic Longleaf Pine Flatwoods - Spodosol Woodland

A3160 **Pinus palustris / Serenoa repens / Aristida beyrichiana Woodland Alliance**

CEGL007714	Longleaf Pine / Slash Pine Scrubby Flatwoods
CEGL006658	Mid- to Late-Successional Slash Pine - Loblolly Pine Woodland
CEGL003650	Central Florida Slash Pine Flatwoods
CEGL004658	Maritime Slash Pine - Longleaf Pine Upland Flatwoods
CEGL004969	South Atlantic Wet Slash Pine Flatwoods
CEGL004680	East Gulf Coastal Plain Maritime Slash Pine Flatwoods
CEGL003643	Slash Pine Flatwoods
CEGL003656	East Gulf Coastal Plain Wet Longleaf Pine Flatwoods
CEGL004967	South Atlantic Outer Coastal Plain Wet Longleaf Pine Flatwoods
CEGL007750	Peninsular Florida Scrubby Flatwoods
CEGL004791	Wet Longleaf Pine - Pond Pine Flatwoods
CEGL003662	Southern Atlantic Barrier Island Spodosol Pine / Oak Woodland
CEGL003808	Florida Panhandle Fragipan Longleaf Pine / Running Oak Flatwoods
CEGL003653	Longleaf Pine / Saw Palmetto Flatwoods
CEGL004486	South Atlantic Coastal Plain Longleaf Flatwoods
CEGL003795	Central Florida Pond Pine Shrubby Flatwoods

A3161 **Pinus palustris / Vaccinium crassifolium / Aristida stricta Woodland Alliance**

CEGL003647	Wet Longleaf Pine Flatwoods (Northern Type)
CEGL003658	Longleaf Pine - Pond Pine Savanna (Wet Spodosol Type)
CEGL003661	Longleaf Pine Savanna (Wet Pleea Flat Type)

CEGL003648	Wet Longleaf Pine Flatwoods (Southern Type)
CEGL003649	Wet Pine Flatwoods (Leiophyllum Type)

Wet Longleaf & Slash Pine Flatwoods & Savannas

G190 - Wet-Mesic Longleaf Pine Open Woodland

A3305 Pinus palustris - Pinus serotina Atlantic Coastal Plain Wet Open Woodland Alliance

CEGL003659	Sandhill/Pocosin Ecotone
CEGL004085	Atlantic Coastal Plain / Wet Ultisol Longleaf Pine Savanna (Curtis' Dropseed Type)
CEGL004790	South Atlantic Coastal Plain Wet Pine Flatwoods
CEGL004497	Longleaf Pine - Slash Pine Wet Swale Woodland
CEGL004498	Longleaf Pine - Pond Pine Wet Swale Woodland
CEGL003660	Longleaf Pine - Pond Pine Savanna (Wet Ultisol Type)
CEGL004499	South Atlantic Coastal Plain Wet Longleaf Pine - Pond Pine Woodland
CEGL004500	Mid-Atlantic Coastal Plain Very Wet Loamy Longleaf Pine Savanna
CEGL004501	Atlantic Coastal Plain Wet Ultisol Longleaf Pine Savanna
CEGL004502	Atlantic Coastal Plain Very Wet Clay Longleaf Pine Savanna
CEGL003663	Lower Piedmont Wet Longleaf Pine Woodland
CEGL004495	Mid-Atlantic Coastal Plain Wet Silty Longleaf Pine Savanna
CEGL004086	Atlantic Coastal Plain / Wet Ultisol Longleaf Pine Savanna
CEGL004814	Atlantic Coastal Plain Longleaf Pine Clay Savanna

A3306 Pinus palustris West Gulf Coastal Plain Wet Open Woodland Alliance

CEGL003646	West Gulf Coastal Plain Wet Longleaf Pine Savanna (High Terraces Type)
CEGL007802	Western Wet Longleaf Pine Savanna (Prairie Terraces Acidic Silt Loam Type)
CEGL003654	Western Wet Longleaf Pine Savanna (Prairie Terraces Sodic Silt Loam Type)

A4104 Pinus palustris - Pinus elliottii East Gulf Coastal Plain Wet Open Woodland Alliance

CEGL003673	East Gulf Coastal Plain Wet Pine Flatwoods
CEGL004556	Gulf Coast Wet Slash Pine Flatwoods
CEGL003645	East Gulf Coastal Plain Wet Longleaf Pine Savanna
CEGL004792	Southern Mississippi Claypan Flatwoods
CEGL003860	Southern Fall-line Sandhills Wet Longleaf Pine - Pond Pine Woodland
CEGL004956	Florida Parishes Coastal Terrace Longleaf Pine Flatwoods
CEGL003797	East Gulf Coastal Plain Pond Pine / Herbaceous Woodland

Dry & Mesic Highland Pine Woodlands

G012 - Shortleaf Pine - Oak Forest & Woodland (in part)

A3271 Pinus echinata - Quercus stellata - Quercus velutina Ozark-Ouachita Woodland Alliance

CEGL004444	Ouachita Shortleaf Pine - Oak Forest
CEGL007489	Interior Highlands Shortleaf Pine - Oak Dry-Mesic Forest
CEGL002394	Shortleaf Pine - Oak Dry-Mesic Woodland
CEGL002393	Ozark-Ouachita Shortleaf Pine - Oak Dry Woodland
CEGL002401	Interior Highlands Shortleaf Pine - Black Oak Forest
CEGL002402	Interior Highland Shortleaf Pine Woodland

CEGL007815	Ouachita Shortleaf Pine Savanna
CEGL002400	Interior Highlands Shortleaf Pine / Blueberry Forest

A3272 Pinus palustris - Pinus echinata - Quercus prinus Interior Woodland Alliance

CEGL007029	Pine Mountain Georgia Oak Woodland
CEGL003606	Montane Longleaf Pine - Heath Bluff Woodland
CEGL004432	Pine Mountain Georgia Longleaf Pine Woodland
CEGL008437	Montane Mixed Longleaf Woodland
CEGL003608	Georgia Piedmont Longleaf Pine Serpentine Woodland
CEGL007018	Georgia Piedmont Longleaf Pine Basic Woodland
CEGL004060	Southern Ridge and Valley Chestnut Oak - Longleaf Forest

Dry & Mesic Hilly Pine Woodlands

G012 - Shortleaf Pine - Oak Forest & Woodland (in part)

A3270 Pinus echinata - Quercus falcata Upper Coastal Plain Alliance

CEGL004834	Mixed Pine - Cherrybark Oak Forest
CEGL008493	East Gulf Coastal Plain Shortleaf Pine - Loblolly Pine Forest
CEGL004050	East & Upper East Gulf Coastal Plains Shortleaf Pine - Mesic Oak Forest
CEGL004052	East Gulf Coastal Plain Shortleaf Pine - Southern Red Oak Forest
CEGL004054	Interior Low Plateau Shortleaf Pine - Oak Forest
CEGL004053	East Gulf Coastal Plain Shortleaf Pine - Post Oak Forest
CEGL007919	Crowley's Ridge Shortleaf Pine Forest

G013 - Western Gulf Coastal Plain Pine - Oak Forest & Woodland

A3129 Pinus echinata - Pinus taeda - Quercus stellata Forest Alliance

CEGL007947	West Gulf Coastal Plain Dry Shortleaf Pine Forest
CEGL004713	West Gulf Coastal Plain Shortleaf - Loblolly - Mixed Oak Forest
CEGL007499	West Gulf Coastal Plain Shortleaf Pine - Post Oak Forest
CEGL007798	West Gulf Coastal Plain Calcareous Pine - Oak Woodland
CEGL007800	West Gulf Coastal Plain Shortleaf Pine - Post Oak Woodland
CEGL007528	West Gulf Coastal Plain Dry Loblolly Pine - Hardwood Forest
CEGL002112	West Gulf Coastal Plain Upland Loblolly Pine - Post Oak Woodland
CEGL007868	East Texas Catahoula Barrens Post Oak Woodland
CEGL007900	West Gulf Coastal Plain Acidic Clay Post Oak - Blackjack Oak Woodland

A0386 Quercus incana - Quercus arkansana - Pinus echinata Woodland Alliance

CEGL007973	Upper West Gulf Coastal Plain Xeric Sand Barrens
CEGL007507	West Gulf Coastal Plain Xeric Upland Shortleaf Pine - Oak Woodland
CEGL007946	West Gulf Coastal Subxeric Shortleaf Pine - Oak Woodland
CEGL003559	West Gulf Coastal Plain Xeric Stream Terrace Shortleaf Pine Woodland
CEGL007972	Upper West Gulf Coastal Plain Xeric Sandhill Complex (Mixed Oak Type)
CEGL003693	Upper West Gulf Coastal Plain Xeric Sandhill Complex (Arkansas Oak Type)

A3130 Pinus taeda - Quercus alba / Viburnum spp. Forest Alliance

CEGL008410	Upper West Gulf Coastal Plain Shortleaf - Loblolly Pine Naturally Mixed Forest
CEGL003855	West Gulf Coastal Plain Shortleaf Pine - Oak Rich Mesic Forest

CEGL008582	Neches Bluff Pine / Swamp Chestnut Oak Forest
CEGL007955	West Gulf Coastal Plain Subcalcareous Loblolly - Water Oak/Palmetto Riparian Forest
CEGL007524	West Gulf Coastal Plain Subcalcareous Pine - Hardwood Slope and Stream Bottom Forest

Upper Coastal Plain Pine Flatwoods

G130 - Hardwood - Loblolly Pine Nonriverine Wet Flatwoods

A4189	**Quercus laurifolia - Quercus phellos - Quercus michauxii Atlantic Coastal Plain Wet Flatwoods Forest Alliance**
CEGL004228	South Atlantic Willow Oak Flatwoods Forest
CEGL004831	South Atlantic Mixed Oak-Pine Calcareous Flatwoods Forest
A3445	**Quercus stellata - Quercus falcata Wet Flatwoods Forest Alliance**
CEGL008587	West Gulf Coastal Plain Post Oak - Loblolly Flatwoods
A4190	**Pinus taeda - Quercus laurifolia - Quercus phellos West Gulf Coastal Plain Wet Flatwoods Forest Alliance**
CEGL004534	Louisiana Wet Spruce Pine - Hardwood Flatwoods Forest
CEGL007069	West Gulf Coastal Plain Pine - Oak Nonriverine Flatwoods
CEGL007715	Louisiana Pleistocene Prairie Terrace Mixed Hardwood-Loblolly Flatwoods Forest

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Appendix F: Representative Species Pool for Coastal Plain Open Pine Woodland and Savanna (GCPO LCC), with Priority Species in bold

Scientific Name	Common Name	Taxon	Pine
Ambystoma bishopi	Flatwoods Salamander	Amphibians	x
Ambystoma talpoideum	Mole Salamander	Amphibians	x
Ambystoma tigrinum	Tiger Salamander	Amphibians	x
Anaxyrus (Bufo) quercicus	Oak Toad	Amphibians	x
Eurycea cf. quadridigitata	Bog Dwarf Salamander	Amphibians	x
Eurycea quadridigitata	Dwarf Salamander	Amphibians	x
Hyla andersonii	Pine Barrens Treefrog	Amphibians	x
Rana areolata areolata	Southern Crawfish Frog	Amphibians	x
Rana capito	Gopher Frog	Amphibians	x
Rana sevosa	Mississippi Gopher Frog	Amphibians	x
Aimophila aestivalis	**Bachman's Sparrow**	**Birds**	**x**
Ammodramus henslowii	Henslow's Sparrow	Birds	x
Caprimulgus carolinensis	Chuck-will's-widow	Birds	x
Caprimulgus vociferus	Whip-poor-will	Birds	x
Coccyzus americanus	Yellow-billed Cuckoo	Birds	x
Colinus virginianus	**Northern Bobwhite**	**Birds**	**x**
Dendroica discolor	**Prairie Warbler**	**Birds**	**x**
Dendroica dominica	Yellow-throated Warbler	Birds	x
Dendroica pinus	**Pine Warbler**	**Birds**	**x**
Dryocopus pileatus	Pileated Woodpecker	Birds	x
Falco sparverius paulus	Southeastern American Kestrel	Birds	x
Geococcyx californianus	Greater Roadrunner	Birds	x
Grus canadensis pulla	Mississippi Sandhill Crane	Birds	x
Melanerpes erythrocephalus	Red-headed Woodpecker	Birds	x
Meleagris gallopavo	Wild Turkey	Birds	x
Picoides borealis	**Red-cockaded Woodpecker**	**Birds**	**x**
Picoides villosus	Hairy Woodpecker	Birds	x
Pipilo erythrophthalmus	Eastern Towhee	Birds	x
Sitta pusilla	**Brown-headed Nuthatch**	**Birds**	**x**
Geomys pinetis	**Southeastern Pocket Gopher**	**Mammals**	**x**
Sciurus niger niger	Southeastern Fox Squirrel	Mammals	x
Cemophora coccinea	Scarlet Snake	Reptiles	x
Crotalus adamanteus	**Eastern Diamondback Rattlesnake**	**Reptiles**	**x**
Drymarchon couperi	Eastern Indigo Snake	Reptiles	x
Gopherus polyphemus	**Gopher Tortoise**	**Reptiles**	**x**
Lampropeltis getula	Common Kingsnake	Reptiles	x
Masticophis flagellum	Eastern Coachwhip	Reptiles	x
Micrurus fulvius	Coral Snake	Reptiles	x
Micrurus tener tener	Texas Coral Snake	Reptiles	x
Pituophis melanoleucus	**Northern Pine Snake**	**Reptiles**	**x**
Pituophis ruthveni	**Louisiana Pine Snake**	**Reptiles**	**x**
Sistrurus miliarius	Pygmy Rattlesnake	Reptiles	x
Tantilla coronata	Southeastern Crowned Snake	Reptiles	x

Appendix G: Priority Species of Open Pine Woodlands of the GCPO LCC

Common name	Scientific name	Project area states where it occurs	States where listed as Species of Greatest Conservation Need (SGCN) in 2005 State Wildlife Action Plan	Open Pine Groupings
Red-cockaded Woodpecker	*Picoides borealis*	All project area states, except MO (Extirpated)	AL, AR, FL, GA, KY (Extirpated) , LA, MD, MO (Extirpated), MS, NC, OK, SC, TX, VA	All?
Louisiana Pine Snake	*Pituophis ruthveni*	LA, TX	LA, TX	Xeric Longleaf Pine Barrens
Black Pine Snake	*Pituophis melanoleucus lodingi*	AL, LA, MS	AL, LA, MS	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands
Florida Pine Snake	*Pituophis melanoleucus mugitus*	AL, FL, GA, SC	AL, FL, GA, SC	Xeric Longleaf Pine Barrens
Brown-headed Nuthatch	*Sitta pusilla*	All project area states, except MO (Extirpated)	AR, DE, FL, LA, MD, MO (Extirpated), MS, NC, OK, SC, TN, TX, VA	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Mesic Longleaf Pine Flatwoods, Wet Longleaf & Slash Pine Flatwoods & Savannas, Dry & Mesic Hilly Pine Woodlands (East Gulf), Dry & Mesic Hilly Pine Woodlands (West Gulf), Upper Coastal Plain Pine Flatwoods
Bachman's Sparrow	*Peucaea* (*Aimophila*) *aestivalis*	All project area states	AL, AR, FL, GA, KY, LA, MD, MO, MS, NC, OH (Extirpated), OK, SC, TN, TX, VA, WV	All?
Northern Bobwhite	*Colinus virginianus*	All project area states	AR, CT, DC, DE, FL, GA, IA, IL, KS, KY, LA, MA, MD, MI, MS, NC, NE, NJ, NY, OH, OK, PA, RI, SC, TX, VA, WI, WV	All?
Pine Warbler	*Setophaga pinus*	All project area states	NJ, OH	All?
Gopher Tortoise	*Gopherus polyphemus*	AL, FL, GA, LA, MS, SC	AL, FL, GA, LA, MS, SC	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Mesic Longleaf Pine Flatwoods
Prairie Warbler	*Setophaga discolor*	All project area states	AR, CT, DE, IL, KY, LA, MA, MD, ME, MI, MS, NC, NJ, NY, OH, OK, PR, RI, SC, TN, TX, VA, VI, VT, WV	All?
Eastern Diamondback Rattlesnake	*Crotalus adamanteus*	AL, FL, GA, LA, MS, NC, SC	AL, FL, GA, LA, MS, NC	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Mesic Longleaf Pine Flatwoods
Southeastern Pocket Gopher	*Geomys pinetis*	AL, FL, GA	AL, FL, GA	Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands
Baird's Pocket Gopher	*Geomys breviceps*	LA, TX		Xeric Longleaf Pine Barrens, Dry & Mesic Longleaf Pine Woodlands, Dry & Mesic Hilly Pine Woodlands (West Gulf)
Plains Pocket Gopher	*Geomys bursarius*	AR (Izard County), MO	IN, WY	Dry & Mesic Highlands Pine Woodlands
Ozark Pocket Gopher	*Geomys bursarius ozarkensis*	AR	AR	Dry & Mesic Highlands Pine Woodlands