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 (broad ecosystems used in this document) 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 inches DBH or greater, and measured using a 10x basal area prism or gauge at four (4) locations near the rapid assessment area center and (optionally) also at the center point of the rapid assessment area, or by measuring each longleaf pine tree 5 inches DBH or greater within the defined area plot or assessment area.

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 in forests and woodlands, and it is repeatable with several averaged measures at various locations within an assessment area 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 an estimate of basal area.

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 focal 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.

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 less than 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 less than 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 or less on average (Hinderliter 2014). Maintenance condition for longleaf pine woodlands is considered to be basal area from 40 to 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.

Measurement Protocol: Basal area is measured for the appropriate southern yellow pine species (such as longleaf pine, slash pine, South Florida slash pine, shortleaf pine, and loblolly pine) 5" diameter or greater at 4.5 feet (54”), diameter at breast height (DBH).

Option 1: A 10x factor basal area prism or gauge is used at four (4) locations 33 feet (10 meters) from the outer edge of the assessment area, such as along tapes going north, east, south, and west through the assessment area center, and (optionally) also at the center of the assessment area. If assessment area is smaller than 1/8 acre (500 square meters), then four (4) basal area points should be 10 feet (3.0 meters) from assessment area center, to the north, east, south, and west. Trees are tallied together for the appropriate southern yellow pine species, according to the Southern Open Pine Grouping ecosystem type. At each basal area point, the tallied count of longleaf pine and/or other southern yellow pine is multiplied by the basal area factor of 10 (if using the 10x prism) to get the basal area values in ft^2/acre. The final value for the metric is the average of each of the basal areas from the 10x basal area prism points in the assessment area.

Option 2: Within the assessment area measure all appropriate southern yellow pines (longleaf pine, slash pine, South Florida slash pine, shortleaf pine, and/or loblolly pine) 5” diameter or greater at 4.5 feet (54”), diameter at breast height (DBH) in inches, then convert diameter measurements to ft^2 using formula:

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

For the final value of basal area, the value for the plot area must be converted to a value of basal area in ft^2 / acre. The conversion math will depend on the assessment area and its units of measure. If basal area prism is not used, the southern yellow pine tree diameters can all be listed for the defined assessment area, and the basal area in ft^2/acre can be calculated later. Divide the basal area sum by the plot size in acres to get basal area in square feet per acre. Generally, there is no need to do the basal area calculations in the field.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor. The values below represent results in ft^2/acre. Calculated values other than multiples of 10 are accommodated. The appropriate southern yellow pine species are listed in each table.

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)	≥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 ≥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 ≥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.

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.

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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 for data collection are provided, the first is using the 10x basal area prism or gauge in ft^2/acre. The second option uses calculated basal area values from the measured diameters of all southern yellow pines of the appropriate species. A 5x basal area prism or gauge could also be used, at multiple locations within the assessment are, as described in Option 1.

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 covered by the general extent of southern yellow pine canopy trees, as determined by visual (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 5" diameter or greater at 4.5 feet (54”), diameter at breast height (DBH).

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 ranges of percent cover used here. This is a fast and easy metric which complements the measure of basal area of longleaf pine.

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 canopy 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), several birds, which are species of concern occur in open canopy pine stands (NatureServe 2015, Richardson 2014a, Tucker 2006). Higher plant diversity in longleaf pine woodlands is associated with open pine canopies (Platt et al. 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. They both declined dramatically during the 20th century and naturally grow in open stands which support focal 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.

Measurement Protocol: For assessment area, the percentage of the ground within the plot covered by the general extent of southern yellow pine canopy trees, as determined by visual (ocular) estimate. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems also count as cover. 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 5" diameter or greater at 4.5 feet (54"), diameter at breast height (DBH).

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% canopy 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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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, including the presence of old, flat topped longleaf pine and the presence of large (greater than or equal to either 12" DBH or 14" DBH) southern yellow pines characteristic of the assessed ecosystem.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Woodlands of Longleaf pine (*Pinus palustris*) and shortleaf pine (*Pinus echinata*) which have large trees have higher ecological integrity. Unlike most other pines, longleaf pine trees can continue to produce more cones as they age beyond 100 years, and the old trees tend to develop a characteristic flat top. The presence of large trees (greater than or equal to either 12" DBH or 14" DBH) indicates potential seedling recruitment and provides for a variety of wildlife in mixed shortleaf pine (*Pinus echinata*) stands (Bragg 2002, NatureServe 2006). These large, old trees are important for pine regeneration in natural stands, near natural stands, and stands that will be naturally regenerated rather than clearcut and replanted. Large old southern yellow pines also provide benefits for focal wildlife species. 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 or greater) or flat-top longleaf pine is evidence of mature characteristics in a southern open pine stand (Longleaf Partnership Council 2014). However, an additional note says, "Represents presence of mature wildlife habitat associations – tree size may be smaller, and therefore, basal area slightly lower in some community types" (Longleaf Partnership Council 2014). Due to the slow growth of longleaf pine in the Xeric Longleaf Pine Barrens and other longleaf pine ecosystems regionally, the presence of large longleaf pine 12" DBH or greater can be used for this metric rather than 14" DBH or greater. Data on basal area of trees by species is very commonly collected as part of forestry inventory. It is a widely used measure quantifying the dominance of tree species, and it is repeatable by using several measures with a 10x basal area prism or gauge. It can be measured using a 10x basal area prism or gauge at four (4) locations within the rapid assessment area, and (optionally) also at the center, or by measuring all longleaf pine trees 14" DBH or greater (and also those 12-14" DBH since in some cases foresters, ecologists and researchers prefer to define large southern yellow pine trees as 12" or greater instead of only 14" or greater) within the defined rapid assessment area.

Measurement Protocol: In longleaf pine (*Pinus palustris*) stands, determine if flat-top longleaf pines are present in the canopy and measure the basal area of southern yellow pine trees 14"

DBH or greater. In addition to longleaf pine and shortleaf pine, in the Wet Longleaf & Slash Pine Flatwoods & Savannas, slash pine is 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, and regionally in other ecosystems, the presence of large longleaf pine 12” DBH or greater can be used to define large trees and tally their basal area rather than only trees 14” DBH or greater. A 10x factor basal area prism or gauge is used at four (4) locations 33 feet (10 meters) from the outer edge of the assessment area, such as along the north, east, south, and west tapes, and (optionally) also at the center of the data collection area. If assessment area is smaller than 1/8 acre (500 square meters), then four (4) basal area points should be 10 feet (3.0 meters) from assessment area center, to the north, east, south, and west. Large pine trees are tallied by size class. At each basal area point, the tallied count of 12-14” DBH and 14” DBH or greater longleaf pine and other southern yellow pine is multiplied by the basal area factor of 10 to get the basal area values for southern yellow pines of 12-14” DBH and 14” DBH or greater in ft^2/acre. With these values this metric can be applied defining large trees as either 12” DBH or greater, or as 14” DBH or greater. The basal area of large trees 12” or greater is the basal area of trees 12-14” DBH plus the basal area of large trees 14” DBH or greater.

Metric Rating: Large trees defined as the appropriate southern yellow pine species ≥ 14” DBH

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. No flat-top longleaf pine is present.
FAIR (C)	Longleaf pine trees ≥14” DBH class are present, but <10 ft^2/acre basal area of those large trees. No flat-top longleaf pine is present.
POOR (D)	No longleaf pine trees ≥14” DBH nor 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. No flat-top longleaf pine present.
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. No flat-top longleaf pine present.
POOR (D)	No longleaf pine or South Florida slash pine trees ≥14” DBH nor 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. No flat-top longleaf pine nor slash pine present.
FAIR (C)	Longleaf pine or slash pine trees ≥14” DBH class are present, but <10 ft^2/acre basal area of those large trees. No flat-top longleaf pine nor slash pine present.
POOR (D)	No longleaf pine or slash pine trees ≥14” DBH nor 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 ≥ 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 nor 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. No flat-top longleaf pine is present.
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. No flat-top longleaf pine is present.
POOR (D)	No longleaf pine and/or shortleaf pine trees ≥14” DBH nor 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

Metric Rating: Large trees defined as the appropriate southern yellow pine species ≥ 12” DBH

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
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. No flat-top longleaf pine is present.
FAIR (C)	Longleaf pine trees ≥12” DBH class are present, but <10 ft^2/acre basal area of those large trees. No flat-top longleaf pine is present.
POOR (D)	No longleaf pine trees ≥12” DBH nor 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 ≥12” 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 ≥12” DBH class. No flat-top longleaf pine present.
FAIR (C)	Longleaf pine or South Florida slash pine trees ≥12” DBH class are present, but <10 ft^2/acre basal area of those large trees. No flat-top longleaf pine present.
POOR (D)	No longleaf pine or South Florida slash pine trees ≥12” DBH nor 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 ≥12” 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 ≥12” DBH class. No flat-top longleaf pine nor slash pine present.
FAIR (C)	Longleaf pine or slash pine trees ≥12” DBH class are present, but <10 ft^2/acre basal area of those large trees. No flat-top longleaf pine nor slash pine present.
POOR (D)	No longleaf pine or slash pine trees ≥12” DBH nor 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 nor 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 ≥12” DBH class
GOOD (B)	Basal area ≥10 ft^2/acre of shortleaf pine trees ≥12” DBH class
FAIR (C)	Shortleaf pine trees ≥12” DBH class are present, but <10 ft^2/acre basal area of those large trees
POOR (D)	No shortleaf pine trees ≥12” 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 ≥12” 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 ≥12” DBH class. No flat-top longleaf pine is present.
FAIR (C)	Longleaf pine and/or shortleaf pine trees ≥12” DBH class are present, but <10 ft^2/acre basal area of those large trees. No flat-top longleaf pine is present.
POOR (D)	No longleaf pine and/or shortleaf pine trees ≥12” DBH nor 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 ≥12” DBH class
GOOD (B)	Basal area ≥10 ft^2/acre of loblolly pine and/or shortleaf pine trees ≥12” DBH class
FAIR (C)	Loblolly pine and/or shortleaf pine trees ≥12” 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 ≥12” 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 ≥12” DBH class
GOOD (B)	Basal area ≥10 ft^2/acre of loblolly pine and/or shortleaf pine trees ≥12” DBH class
FAIR (C)	Loblolly pine and/or shortleaf pine trees ≥12” 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 ≥12” DBH are present

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

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.

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. 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.

White, D. L. and F. T. 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 or greater is used. Due to the slow growth of longleaf pine in the Xeric Longleaf Pine Barrens, the presence of large longleaf pine 12" DBH or greater is used rather than 14" DBH or greater.

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. While not required, if practical, basal area should be collected separately for both fire intolerant hardwood and fire tolerant hardwood trees. These two values can be then averaged and summed for the basal area points. More importantly, the basal area of fire intolerant hardwoods is the best version of this metric. The cross section area of hardwood tree stems (defined here as square feet /acre) for canopy trees 5 inches DBH or greater, measured using a 10x basal area prism or gauge at four (4) locations near the rapid assessment area center and (optionally) also at the center point of the rapid assessment area, or by measuring the DBH of all hardwood trees 5 inches DBH or greater within an assessment area plot of a defined area.

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 basal area is repeatable with several averaged measures at various locations within an assessment area using a 10x basal area prism or gauge. Measures of basal area need to be collected at multiple locations within a stand to get a stand level estimate of basal area. In southern open pine ecosystems, increasing hardwood dominance or codominance, especially of fire intolerant hardwoods is associated with declines of southern open pine wildlife.

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, the exotic 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 fire tolerant (pyrophytic) oaks such as southern red oak (*Quercus falcata),* post oak (*Quercus stellata*), black oak (*Quercus velutina),* turkey oak *(Quercus laevis),* sand post oak (*Quercus margarettae),* 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 hardwood dominance or codominance can result from lack of fire. 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 or less of canopy hardwoods or off-site pines 5” DBH or greater. (Longleaf Partnership Council 2014).

Measurement Protocol: **Option 1**: For an assessment area larger than 1/8 acre (or 500 square meters), a 10x factor basal area prism or gauge is used at four (4) locations 33 feet (10 meters) from the outer edge of the assessment area, such as along the north, east, south, and west tapes, and (optionally) also at the center of the data collection area. If assessment area is smaller than 1/8 acre (500 square meters), then four (4) basal area points should be 10 feet (3.0 meters) from assessment area center, to the north, east, south, and west. Hardwood trees are tallied with the 10x factor basal area prism or gauge. It is not necessary to tally hardwood trees by species, but if possible the trees for determining basal area should be separately tallied for canopy fire intolerant hardwoods and fire tolerant hardwoods. **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.** At each basal area point, the tallied count of hardwood tree species is multiplied by the basal area factor of 10 to get the basal area values in ft^2/acre. The final measure is the average of each of the data taken for each of the prism points in the assessment area.

Measurement Protocol: **Option 2**: Within the defined assessment area measure all fire intolerant hardwood and fire tolerant hardwood tree species 5” diameter or greater at 4.5 feet (54”), diameter in inches at breast height (DBH), then convert diameter measurements to ft^2 using formula:

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

Then, canopy fire intolerant hardwood and fire tolerant hardwood basal areas are totaled. For the final values of basal area in ft^2/acre, the fire intolerant hardwood and fire tolerant hardwood basal area values for the plot area must be converted to a ft^2/acre value. The conversion math will depend on the assessment area and units of measure. If basal area prism is not used, the hardwood tree diameters can all be listed for the defined assessment area, and the basal area in ft^2/acre can be calculated later. Generally, there is no need to do the basal area calculations in the field.

Metric Rating: The set of tables below accommodate basal area values such as 15, 35, 75, and 95 which result from averaging several basal area points taken with a 10x basal area prism, or from Option 2, measuring all trees within a defined assessment area. Following the Canopy Hardwood Basal Area tables are the tables for the Fire Intolerant Hardwood Basal Area (Metric Variant).

These values below represent results in ft^2/acre using Option 1 with DBH averaging the basal area values from several points, or by using Option 2. Calculated values other than multiples of 10 are accommodated.

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	≤5 ft^2/acre basal area of hardwood trees
GOOD (B)	>5 to 15 ft^2/acre basal area of hardwood trees
FAIR (C)	>15 to 25 ft^2/acre basal area of hardwood trees
POOR (D)	>25 ft^2/acre basal area of hardwood trees

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	≤5 ft^2/acre basal area of hardwood trees
GOOD (B)	>5 to 15 ft^2/acre basal area of hardwood trees
FAIR (C)	>15 to 25 ft^2/acre basal area of hardwood trees
3POOR (D)	>25 ft^2/acre basal area of hardwood trees

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	≤5 ft^2/acre basal area of hardwood trees
GOOD (B)	>5 to 15 ft^2/acre basal area of hardwood trees
FAIR (C)	>15 to 25 ft^2/acre basal area of hardwood trees
POOR (D)	>25 ft^2/acre basal area of hardwood trees

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	≤5 ft^2/acre basal area of hardwood trees
GOOD (B)	>5 to 15 ft^2/acre basal area of hardwood trees
FAIR (C)	>15 to 25 ft^2/acre basal area of hardwood trees
POOR (D)	>25 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

Fire Intolerant Hardwood Basal Area (Metric Variant)

Metric Rating	***Dry & Mesic Longleaf Pine Woodlands***
EXCELLENT (A)	0 ft^2/acre basal area of fire intolerant hardwood trees
GOOD (B)	>0 to 5 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>5 to 10 ft^2/acre basal area of fire intolerant hardwood trees
POOR (D)	>10 ft^2/acre basal area of fire intolerant hardwood trees

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	0 ft^2/acre basal area of fire intolerant hardwood trees
GOOD (B)	>0 to 5 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>5 to 10 ft^2/acre basal area of fire intolerant hardwood trees
3POOR (D)	>10 ft^2/acre basal area of fire intolerant hardwood trees

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	0 ft^2/acre basal area of fire intolerant hardwood trees
GOOD (B)	>0 to 5 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>5 to 10 ft^2/acre basal area of fire intolerant hardwood trees
POOR (D)	>10 ft^2/acre basal area of fire intolerant hardwood trees

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	0 ft^2/acre basal area of fire intolerant hardwood trees
GOOD (B)	>0 to 5 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>5 to 10 ft^2/acre basal area of fire intolerant hardwood trees
POOR (D)	>10 ft^2/acre basal area of fire intolerant hardwood trees

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	≤10 ft^2/acre basal area of fire intolerant hardwood trees
GOOD (B)	>10 to 20 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>20 to 30 ft^2/acre basal area of fire intolerant hardwood trees
POOR (D)	>30 ft^2/acre basal area of fire intolerant hardwood trees

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	≤10 ft^2/acre basal area of fire intolerant hardwood trees

GOOD (B)	>10 to 20 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>20 to 30 ft^2/acre basal area of fire intolerant hardwood trees
POOR (D)	>30 ft^2/acre basal area of fire intolerant hardwood trees

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	≤10 ft^2/acre basal area of fire intolerant hardwood trees
GOOD (B)	>10 to 20 ft^2/acre basal area of fire intolerant hardwood trees
FAIR (C)	>20 to 30 ft^2/acre basal area of fire intolerant hardwood trees
POOR (D)	>30 ft^2/acre basal area of fire intolerant 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.

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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.

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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).

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 (Optional)

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).

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 spherical 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).

Stand Density Index (SDI) was first developed in the 1930s (Reineke 1933), and it 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).

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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Ducey, M. J. and H. T. Valentine. 2007. Direct Sampling for Stand Density Index. Western Journal of Applied Forestry 23(2): 78-82.

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.

Long, J. N. 1985. A practical approach to density management. The Forestry Chronicle 61(1):23-27.

Harrington, T. B. 2001. Silvicultural approaches for thinning southern pines: method, intensity and timing. Warnell School of Forest Resources and Georgia Forestry Commission. Publication No. FSP002. <http://www.gfc.state.ga.us/resources/publications/SilviculturalApproaches.pdf>

McTague, J. P. and D. R. Patton. 1989. Stand density index and its application in describing wildlife habitat. Wildlife Society Bulletin 17(1):58-62.

Moore, M. M. and D. A. Deiter. 1992. Stand Density Index as a predictor of forage production in northern Arizona pine forests. Journal of Range Management 45:267-271.

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.

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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 or assessment area covered by fire tolerant hardwood midstory foliage, branches, and stems as determined by ocular (visual) estimate. Midstory is defined as woody stems (including tall shrubs, small trees, and vines) that are > 10 feet tall, up to the height of the bottom of the tree canopy. **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 that reach canopy size are included in the canopy basal area metrics.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: **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). However, the presence of a midstory with greater than 25% cover of hardwoods 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.

Southern open pine ecosystems with an open midstory provide habitat for many focal wildlife species, including birds and reptiles. 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).
For longleaf pine woodlands, maintenance conditions are considered to be 20% or less mid-story cover, with most of this composed of fire tolerant species and less than 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 less than 10% for Shortleaf Pine-Bluestem, less than 30% for Dry Mesic Shortleaf Pine-Oak Woodland, and 15% for Dry Shortleaf Pine-Oak. Midstory was defined as greater than 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.

Measurement Protocol: For assessment area, separately estimate percentage within the plot covered by fire intolerant hardwood and fire tolerant hardwood midstory foliage, branches, and stems as determined by ocular (visual) estimate. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems also count as cover. Midstory is defined to include any woody stems (including tall shrubs, small trees and vines) which are greater than 10 feet tall, up to the height of the bottom of the tree canopy (Blaney et al. 2015). Measure fire tolerant hardwood cover (cover of turkey oak, sand post oak, bluejack oak, blackjack oak, black oak, post oak, southern red oak, black hickory and flowering dogwood). Ocular (visual) estimate of the percent of ground within the plot covered by all aboveground parts of the midstory fire tolerant hardwoods.

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)	2 to 15% cover of midstory fire tolerant hardwoods
GOOD (B)	15 to <20%, or <2% 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)	2 to 5% cover of midstory fire tolerant hardwoods
GOOD (B)	5 to 10%, or <2% cover of midstory fire tolerant hardwoods
FAIR (C)	>10 to 15% cover of midstory fire tolerant hardwoods
POOR (D)	>15% cover of midstory fire tolerant hardwoods

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	2 to 10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-15%, or <2% 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)	2 to 10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-20% cover, or <2% 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)	2 to 10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-30%, or <2% 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)	2 to 10% cover of midstory fire tolerant hardwoods
GOOD (B)	10-20%, or <2% 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)	2 to 10% cover of midstory fire tolerant hardwoods
GOOD (B)	10 to 20%, or <2% 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.

Peet, R. K., T. R. Wentworth and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274. <http://cvs.bio.unc.edu/methods.htm>

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: This metric has been used extensively in open pine woodlands in the Interior Highlands, especially in Arkansas (Blaney et al. 2015).

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 count as cover. Midstory is defined to include any woody stem (including tall shrubs, trees and vines) that are greater than 10 feet tall, up to the height of the bottom of the tree canopy.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Southern open pine ecosystems with an open midstory can provide better habitat for many of the characteristic wildlife. 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 cover to greater than 25%. 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 less than 10% for Shortleaf Pine-Bluestem, less than 30% for Dry Mesic Shortleaf Pine-Oak Woodland, and 15% for Dry Shortleaf Pine-Oak. Midstory was defined as greater than 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 less than 5% cover of fire-intolerant hardwood or off-site pine trees over 16 feet tall (Longleaf Partnership Council 2014).

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. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems also count as cover. Midstory is defined to include any woody stem (including tall shrubs, trees and woody vines) that are greater than 10 feet tall, up to the height of the bottom of the tree canopy (Blaney et al. 2015). Ocular (visual) estimate of the percent of ground within the plot covered by all above ground parts of the midstory woody plants. 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)	2 to <15% cover of woody midstory
GOOD (B)	15 – 25%, or <2% cover of woody midstory
FAIR (C)	>25 to 35% cover of woody midstory
POOR (D)	>35% cover of woody midstory

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	2 to <5% cover of woody midstory
GOOD (B)	5 – 15%, or <2% cover of woody midstory
FAIR (C)	>15 to 30% cover of woody midstory
POOR (D)	>30% cover of woody midstory

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	<10% cover of woody midstory
GOOD (B)	10 – 15% cover of woody midstory
FAIR (C)	>15 to 30% cover of woody midstory
POOR (D)	>30% cover of woody midstory

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	2 to <10% cover of woody midstory
GOOD (B)	10 – 25%, or <2% cover of woody midstory
FAIR (C)	>25 to 35% cover of woody midstory
POOR (D)	>35% cover of woody midstory

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	2 to <20% cover of woody midstory
GOOD (B)	20-25%, or <2% 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)	2 to <20% cover of woody midstory
GOOD (B)	≥20 to 30%, or <2% 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)	2 to <20% cover of woody midstory
GOOD (B)	20 to 30%, or <2% 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.

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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>

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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.

Peet, R. K., T. R. Wentworth and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274. <http://cvs.bio.unc.edu/methods.htm>

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:

Midstory Fire Intolerant Hardwood Cover (Optional)

Definition: Midstory Fire Intolerant Hardwood Cover. Fire intolerant hardwood trees, include 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, the exotic Chinese tallow tree (*Triadica sebifera)* (Bragg 2014, NatureServe 2011). Other trees which are not naturally part of the fire maintained ecosystem are also included. The metric is the 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 count as cover. Midstory is defined to include any fire intolerant woody stem (including tall shrubs, trees and vines) that are greater than 10 feet tall, up to the height of the bottom of the tree canopy.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Southern open pine ecosystems with an open midstory can provide better habitat for many of the characteristic wildlife. 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 cover to greater than 25%. 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 less than 10% for Shortleaf Pine-Bluestem, less than 30% for Dry Mesic Shortleaf Pine-Oak Woodland, and 15% for Dry Shortleaf Pine-Oak. Midstory was defined as greater than 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 less than 5% cover of fire-intolerant hardwood or off-site pine trees over 16 feet tall (Longleaf Partnership Council 2014). Fire intolerant hardwood trees, include 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, the exotic Chinese tallow tree (*Triadica sebifera)* (Bragg 2014, NatureServe 2011). Other trees which are not naturally part of the fire maintained ecosystem are also included.

Measurement Protocol: For the assessment area, estimate the percent of the ground within the plot covered by fire intolerant hardwood midstory foliage, branches, and stems as determined by ocular (visual) estimate. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems also count as cover. Midstory is defined to include any fire intolerant woody stem (including tall shrubs, trees and woody vines) that are greater than 10 feet tall, up to the height of the bottom of the tree canopy (Blaney et al. 2015). Ocular (visual) estimate of the percent of ground within the plot covered by all above ground parts of the midstory woody plants. 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)	<5% cover of fire intolerant hardwood midstory
GOOD (B)	5 – 10% cover of fire intolerant hardwood midstory
FAIR (C)	>10 to 20% cover of fire intolerant hardwood midstory
POOR (D)	>20% cover of fire intolerant hardwood midstory

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	0% cover of fire intolerant hardwood midstory
GOOD (B)	0 – 5% cover of fire intolerant hardwood midstory
FAIR (C)	>5 to 15% cover of fire intolerant hardwood midstory
POOR (D)	>15% cover of fire intolerant hardwood midstory

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	<5% cover of fire intolerant hardwood midstory
GOOD (B)	5 – 10% cover of fire intolerant hardwood midstory
FAIR (C)	>10 to 20% cover of fire intolerant hardwood midstory
POOR (D)	>20% cover of fire intolerant hardwood midstory

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	0% cover of fire intolerant hardwood midstory
GOOD (B)	<5% cover of fire intolerant hardwood midstory
FAIR (C)	5 to 15% cover of fire intolerant hardwood midstory
POOR (D)	>15% cover of fire intolerant hardwood midstory

Metric Rating	***Dry & Mesic Highlands Pine Woodlands***
EXCELLENT (A)	<5% cover of fire intolerant hardwood midstory
GOOD (B)	5 – 10% cover of fire intolerant hardwood midstory
FAIR (C)	>10 to 20% cover of fire intolerant hardwood midstory
POOR (D)	>20% cover of fire intolerant hardwood midstory

Metric Rating	***Dry & Mesic Hilly Pine Woodlands***
EXCELLENT (A)	<10% cover of fire intolerant hardwood midstory
GOOD (B)	≥10 to 20% cover of fire intolerant hardwood midstory
FAIR (C)	>20 to 30% cover of fire intolerant hardwood midstory
POOR (D)	>30% cover of fire intolerant hardwood midstory

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	<15% cover of fire intolerant hardwood midstory
GOOD (B)	15 to 25% cover of fire intolerant hardwood midstory
FAIR (C)	>25 to 35% cover of fire intolerant hardwood midstory
POOR (D)	>35% cover of fire intolerant hardwood 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.

Peet, R. K., T. R. Wentworth and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274. <http://cvs.bio.unc.edu/methods.htm>

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 (less than 3 feet tall) and tall shrubs (3-10 feet tall).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: 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, TN in September 2015. Maintenance condition class for shrub cover in longleaf pine woodlands exists when shrubs average 30% cover or less and average 3 feet tall or less (Longleaf Partnership Council 2014).

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 thrive with frequent low intensity surface fires which provide for 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, not including 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 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 less than 10% for Shortleaf Pine-Bluestem, less than 30% for Dry Mesic Shortleaf Pine-Oak Woodland, and less than 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 shade 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 et al. 1995, Masters et al. 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 (less than 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. Visually assess the percentage of the ground within the plot covered by the general extent of woody plants including small broad-leaved trees and short shrubs (less than 3 feet tall) and tall shrubs (3-10 feet tall). 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, short shrubs, saw palmetto, scrub palmetto and woody vining plants). Spaces between leaves and stems count as cover. Because forest vegetation layers can overlap, the total of short shrub percent cover and tall shrub 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 <10% cover.
GOOD (B)	Shrubs 3-10 feet in height average 10 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	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	Shrubs 3-10 feet in height average <5% cover.
GOOD (B)	Shrubs 3-10 feet in height average 5 to <15% cover.
FAIR (C)	Shrubs 3-10 feet in height average 15 to 25% cover.
POOR (D)	Shrubs 3-10 feet in height average >25% cover.

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	Shrubs 3-10 feet in height average <5% cover.
GOOD (B)	Shrubs 3-10 feet in height average 5 to <15% cover.
FAIR (C)	Shrubs 3-10 feet in height average 15-25% cover.
POOR (D)	Shrubs 3-10 feet in height average >25% cover.

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	Shrubs 3-10 feet in height average <5% cover.
GOOD (B)	Shrubs 3-10 feet in height average 5 to <15% cover.
FAIR (C)	Shrubs 3-10 feet in height average 15 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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Jose, S., E. J. Jokela, and D. L. Miller. 2006. The longleaf pine ecosystem: an overview. Pages 3–8 in S. Jose, E. J. Jokela, and D. L. Miller, editors. The longleaf pine ecosystem: ecology silviculture and restoration. Springer Science, New York.

Landers, J., L. Van Lear, D.H. Boyer, and D. William, 1995. The longleaf pine forests of the Southeast: requiem or renaissance? J. Forestry 9, 39 – 44.

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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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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

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

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 for the habitat needs of many wildlife species which depend on 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 have herbaceous cover greater than 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, Northern 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 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. Visually assess the percentage of the ground within the plot covered by the general extent of native herbaceous plants. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems 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.

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Peet, R. K., T. R. Wentworth and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274. <http://cvs.bio.unc.edu/methods.htm>

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Scaling Rationale:

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

RANK FACTOR: VEGETATION

Metric Name:

Longleaf Pine Regeneration

Definition: This metric has two parts, longleaf pine regeneration at the larger stand level and at the smaller rapid assessment locations. Regeneration includes grass stage or saplings <2" DBH (Longleaf Partnership Council 2014). Advance longleaf pine regeneration is present in patches across the stand, these patches make up 5-15% of stand. At rapid assessment locations, cover of longleaf pine regeneration should be ≥1% cover (Nordman et al. 2016).

≥**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. Good natural regeneration of longleaf pine requires a good source of seed from adequate cone producing longleaf pines (trees generally larger than 10" DBH) and patches of bare ground in the fall when seed falls, so that seeds can come in contact with soil to germinate. Longleaf pine produces large seed crops certain years, on average about every 7 years. During these years a smaller portion of the seed crop is eaten by animals. For this reason, presence of advance regeneration is an important metric.

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) and by NatureServe, and the US Fish & Wildlife Service, with partners (Nordman et al. 2016). At rapid assessment locations cover of longleaf pine regeneration should be 1% cover or greater, but this may require careful looking for grass stage seedings, especially if saplings are not present. At the stand level the percent cover of longleaf regeneration is not assessed, only the presence of longleaf pine regeneration in patches. Adequate advance regeneration of longleaf pine should be in patches across the larger stand, and these patches should make up 5-15% of the larger stand, or between 1/20 and 1/6 of the stand. In uneven aged longleaf pine stands, natural regeneration often occurs in patches in small openings which are near cone producing trees. Without regeneration, and without cone producing or mature longleaf pine trees, the sustainability of a longleaf pine stand is limited. Longleaf pine trees > 10" DBH tend to be good seed producers, and these trees will produce more seed as they get older and larger (Croker and Boyer 1975).

Measurement Protocol: This includes both a metric for the rapid assessment location and a stand level metric. Advance longleaf pine regeneration includes grass stage longleaf pine and small longleaf pine regeneration less than 2" DBH (Longleaf Partnership Council 2014). Grass stage longleaf pine can be difficult to see when sparse. The percent cover of advance regeneration of longleaf pine is assessed at the rapid assessment location, generally a circular or rectangular plot. The assessment area should be at least 0.1 acre or 400 m2, this is the same rapid assessment area used for other metrics. Advance longleaf pine regeneration cover is 1% or greater at rapid assessment locations. At the stand level, longleaf pine recruitment may be very patchy, and regeneration might not be found in small assessment plots. At the stand level the percent cover of longleaf regeneration is not assessed, look only for the presence of longleaf pine regeneration in patches in the larger stand. Adequate advance regeneration should be in patches across the larger stand, and these patches should make up 5-15% (patches are 1/20 and 1/6) of the larger stand (Longleaf Partnership Council 2014).

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor. The rapid assessment location (percent cover of longleaf pine regeneration) and stand level (presence of longleaf pine regeneration in patches) metric values are averaged for summarizing with the other ground layer metrics.

Metric Rating	***All Open Longleaf Pine Ecosystems***
	Rapid Assessment Location (percent cover of longleaf pine regeneration)
EXCELLENT (A)	Longleaf pine regeneration (<2” DBH) cover is ≥1% at rapid assessment location
GOOD (B)	Longleaf pine regeneration (<2” DBH) cover is present but is <1% at rapid assessment location
FAIR (C)	No regeneration seen, but cone producing longleaf pine or longleaf pine >10” DBH are present rapid assessment location
POOR (D)	Longleaf pine regeneration (<2” DBH) cover is apparently absent, and no cone producing longleaf pine or any mature longleaf pine >10” DBH are present at the rapid assessment location

Metric Rating	***All Open Longleaf Pine Ecosystems***
	Stand Level (presence of longleaf pine regeneration in patches)
EXCELLENT (A)	Longleaf pine regeneration is present in patches across the stand, these patches are 5-15 % of the stand (about 1/20 to 1/6 of the stand)
GOOD (B)	Longleaf pine regeneration is present in patches across the stand, these patches are 1-5 % of the stand or >15% of the stand (less than 1/20 or more than 1/6 of the stand)
FAIR (C)	Longleaf pine regeneration is very sparse across stand, patches of longleaf pine regeneration are <1% of stand, or cone producing longleaf pine or longleaf pine >10” DBH are present
POOR (D)	Longleaf pine regeneration is apparently absent in stand, and apparently no cone producing longleaf pine or any mature longleaf pine >10” DBH are present in the stand

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

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RANK FACTOR: VEGETATION

Metric Name:

Native Warm Season Grass Cover

Definition: Native warm season grass cover may also be called cover of pyrophytic graminoids which include grasses and grass-like plants (sedges etc.). This metric is the percent cover of native warm season grasses and other perennial graminoids that are maintained by periodic fire. These native grasses and grass-like plants (mostly native warm season grasses) are the natural groundcover in southern open pine stands. For a list of example species to include and which to exclude, see the Measurement Protocol below.

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).

Fire is a natural disturbance 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 photosynthesis (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). Maintenance condition class for herbaceous cover in longleaf pine woodlands is herbaceous cover greater than 35% with native pyrogenic species present in stand (Longleaf Partnership Council 2014).

Measurement Protocol: For the assessment area, estimate total cover of all native warm season grass and grass-like species (FNAI and FFS 2014, NatureServe 2011). Visually assess the percentage of the ground within the plot covered by the general extent of native herbaceous plants. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems also count as cover.

Few-flowered beaksedge (*Rhynchospora rariflora*) is an example of a graminoid, which is difficult to distinguish from wiregrass (*Aristida stricta*). In Wet Pine Savannas and Flatwoods various graminoids (e.g. *Juncus spp., Rhynchospora spp.*) other than native warm season grasses are included here and have similar functions. For open longleaf pine woodlands in Florida, these include wiregrass (*Aristida stricta, Aristida beyrichiana*), 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*) and broomsedge (*Andropogon virginicus*) are not included. Switchgrass (*Panicum virgatum*) can become so dominant that other grasses, legumes and small bare ground areas are crowded out. Broomsedge (*Andropogon virginicus*) is excluded, because it is weedy and ruderal, commonly found in old fields, pastures and in recently logged pine stands. 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*), 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*) and broomsedge (*Andropogon virginicus*), but broomsedge is excluded here due to its weediness (Brewer et al. 2015, Maynard and Brewer 2013).

A summary of species in two tables:

🛇 **Always exclude**	
switchgrass	*Panicum virgatum*
broomsedge	*Andropogon virginicus*

☑ **Examples of typical warm season grasses, not an exhaustive list**	
chalky bluestem	*Andropogon capillipes*
big bluestem	*Andropogon gerardii*
Elliott's bluestem	*Andropogon gyrans*
other bluestems	*Andropogon* spp.

splitbeard bluestem	*Andropogon ternarius*
Southern wiregrass or Beyrich's threeawn	*Aristida beyrichiana*
Carolina wiregrass or pineland threeawn	*Aristida stricta*
wiregrass	*Aristida stricta, Aristida beyrichiana*
bearded shorthusk	*Brachyelytrum erectum*
toothache grass	*Ctenium aromaticum*
Florida toothache grass	*Ctenium floridanum*
cutover muhly	*Muhlenbergia capillaris* var. *trichopodes,* *Muhlenbergia expansa*
blackseed speargrass	*Piptochaetium avenaceum*
Chapman's beaksedge	*Rhynchospora chapmanii*
little bluestem	*Schizachyrium scoparium*
slender little bluestem	*Schizachyrium tenerum*
slender Indiangrass	*Sorghastrum elliottii*
Indiangrass	*Sorghastrum nutans*
lopsided Indiangrass	*Sorghastrum secundum*
rough dropseed	*Sporobolus clandestinus*
composite dropseed	*Sporobolus compositus*
Florida dropseed	*Sporobolus floridanus*
pineywoods dropseed	*Sporobolus junceus*
Carolina dropseed	*Sporobolus pinetorum*
wireleaf dropseed	*Sporobolus teretifolius*

There are many other native warm season grasses in these genera: *Andropogon, Anthaenantia, Aristida, Calamovilfa, Coelorachis, Ctenium, Gymnopogon, Muhlenbergia, Panicum, Paspalum, Saccharum, Schizachyrium, Sorghastrum, Sporobolus, Steinchisma, Tridens, Triplasis,* and *Tripsacum* (Osborne et al. 2014).

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% cover of all native warm season grasses
GOOD (B)	>15 to 25% or >97% cover of all native warm season grasses
FAIR (C)	10-15% cover of all native warm season grasses
POOR (D)	<10% cover of all native warm season grasses

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

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***

EXCELLENT (A)	25-97% cover of all native warm season grasses
GOOD (B)	>15 to <25% or >97% cover of all native warm season grasses
FAIR (C)	10-15% cover of all native warm season grasses
POOR (D)	<10% cover of all native warm season grasses

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

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

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

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

Metric Rating	***Upper Coastal Plain Pine Flatwoods***
EXCELLENT (A)	>25% cover of all native warm season grasses
GOOD (B)	20 to 25% cover of all native warm season grasses
FAIR (C)	10 to <20% cover of all native warm season grasses
POOR (D)	<10% 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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Peet, R. K., T. R. Wentworth and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274. <http://cvs.bio.unc.edu/methods.htm>

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 is based on literature and the input of experts in the southern open pine ecosystems and the wildlife using these ecosystems.

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

RANK FACTOR: VEGETATION

Metric Name:

Native Wiry Graminoid Cover

Definition: Percent cover of wiregrass (*Aristida stricta,* or *Aristida beyrichiana*), and other similar native wiry graminoid plants. Native wiry graminoids are grasses or grass-like plants which have very narrow, wiry leaves. Native wiry graminoid plants include grasses, and beakrushes that resemble wiregrass, and have wiry, rolled, or round in cross section (involute) leaves. Some native wiry graminoids are hairgrass muhly (*Muhlenbergia capillaris*), southern arrowfeather three-awn grass (*Aristida tenuispica*), dropseeds (*Sporobolus junceus, Sporobolus teretifolius),* and beakrushes (*Rhynchospora chapmanii, Rhynchospora debilis, Rhynchospora rariflora, Rhynchospora oligantha, Rhynchospora stenophylla, Rhynchospora capillacea, Rhynchospora gracilenta*).

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: Wiregrass (*Aristida stricta,* or *Aristida beyrichiana*) is considered a keystone species in the longleaf pine ecosystem (Hardin & White 1989), in part due to its role as a fine fuel for wildland fire (James et al 2001, Kirkman et al. 2004, Rasser 2003). Wiregrass cover amount is associated with habitat quality for rare animals such as the Red-cockaded woodpecker (*Picoides borealis*) and Gopher tortoise (*Gopherus polyphemus*), whose recovery are important conservation goals (James et al 2001, Aresco & Guyer 1999). The estimate of the percent cover of wiregrass (*Aristida stricta, Aristida beyrichiana*) and other native wiry graminoid ground cover, has been used as a longleaf pine ecosystem rapid assessment monitoring metric for the past decade on conservation lands in Florida (FNAI and Florida FWC 2007) and elsewhere in the Southeast (NatureServe 2006, NatureServe 2011). It is fast to apply as part of a rapid assessment. Pineland areas that have been plowed tend to lack wiregrass (Hedman et al. 2000, Ostertag & Robertson 2007). Certain intensive forestry site preparation, also can reduce or eliminate wiregrass. Site preparation practices to reduce competition with pines have been used in southern forestry over the last 60 years, "The biggest immediate job is to find inexpensive ways to eradicate wiregrass competition, so that pines can be grown. Chemicals will do the job, but so far, the amounts required make the cost excessive. Heavy machines, particularly tandem brush choppers, and root rakes, do an effective job" (Hebb 1957). Double chopping was considered the most successful type of mechanical site preparation applied on a northwest Florida sandhill site in 1955, and it effects were studied over the next decade. On the untreated area wiregrass was found in 96% of the 1/4 milacre (1.01 m^2) plots and had an average density of 14.8 plants per plot, the chopped area had wiregrass in 4% of the plots with <0.1 plant per plot. At that time double chop had become the accepted procedure for preparing sites for planting pines in the sandhills (Hebb 1971).

Wiregrass was also reduced with fertilization in pine plantations (White 1977). Intensive soil disturbance associated with site preparation and conversion to pine plantation, destroyed much of the native ground cover at a south-central Alabama site where gopher tortoise (*Gopherus polyphemus*) were studied. These tortoises grew more slowly than in any other documented study, this was attributed to the poor forage quality and sparse ground cover, especially legumes and other forbs (Aresco & Guyer 1999).

There are numerous examples of pine plantations where minimal site preparations occurred, and wiregrass has continued to thrive. A sandhill site on Goethe State Forest (Florida Forest Service) was planted in slash pine with small tractors with a drag-type setter (1968 – 1970) and the only site preparation was hand girdling of the oaks. After 25 years the plantation was clearcut and planted in longleaf in 1999. This site had the highest importance value for wiregrass of any sites studied on Goethe State Forest, including the nearby sandhill reference sites (Rasser 2003).

Measurement Protocol: For the assessment area, estimate the percent cover of all native wiry graminoid herbaceous ground cover (FNAI and Florida FWC 2007). This includes wiregrass (*Aristida stricta, Aristida beyrichiana*), and all native wiry graminoids (including some grasses and beakrushes). Visually assess the percentage of the ground within the plot covered by the general extent of the wiregrass and other native wiry graminoids. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems 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)	20-95% cover of all wiry graminoids
GOOD (B)	10 to <20% or >95% cover of all wiry graminoids
FAIR (C)	2 to <10% cover of all wiry graminoids
POOR (D)	<2% cover of all wiry graminoids

Metric Rating	***Mesic Longleaf Pine Flatwoods***
EXCELLENT (A)	20-95% cover of all wiry graminoids
GOOD (B)	10 to <20% or >95% cover of all wiry graminoids
FAIR (C)	2 to <10% cover of all wiry graminoids
POOR (D)	<2% cover of all wiry graminoids

Metric Rating	***Wet Longleaf & Slash Pine Flatwoods & Savannas***
EXCELLENT (A)	20-95% cover of all wiry graminoids
GOOD (B)	15 to <20% or >95% cover of all wiry graminoids
FAIR (C)	5 to <15% cover of all wiry graminoids
POOR (D)	<5% cover of all wiry graminoids

Metric Rating	***Xeric Longleaf Pine Barrens***
EXCELLENT (A)	20-95% cover of all wiry graminoids
GOOD (B)	10 to <20% or >95% cover of all wiry graminoids
FAIR (C)	2 to <10% cover of all wiry graminoids
POOR (D)	<2% cover of all wiry graminoids

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

Aresco, Matthew J., and Graig Guyer. 1999. Growth of the tortoise Gopherus polyphemus in slash pine plantations in south central Alabama. Herpetologica 55(4): 499-506.

FNAI and Florida FWC. 2007. Objective-Based Vegetation Management (OBVM) Program, Vegetation Monitoring, Standard Operating Procedure. Florida Natural Areas Inventory and Florida Fish and Wildlife Commission. <http://myfwc.com/conservation/terrestrial/obvm/>, <http://myfwc.com/media/119340/OBVM_Monitoring_Standard_Operating_Procedure.pdf >

Hardin, E.D., and D.L. White. 1989. Rare vascular plant taxa associated with wiregrass (Aristida stricta) in the southeastern United States. Natural Areas Journal 9:234—245.

Hebb, E. A. 1957. Regeneration in the sandhills. Journal of Forestry 55:210-212.

Hebb, E.A. 1971. Site preparation decreases game food plants in Florida sandhills. Journal of Wildlife Management 35: 155–162.

Hedman, C.W., S.L. Grace, and S.E. King. 2000. Vegetation composition and structure of southern Coastal Plain forests: an ecological comparison. Forest Ecology and Management 134: 233–247.

James, Frances C., Charles A. Hess; Bart C. Kicklighter; 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.

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.

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.

Ostertag, T.E., and K.M. Robertson. 2007. A comparison of native versus old-field vegetation in upland pinelands managed with frequent fire, South Georgia, USA. Pages 109–120 in R.E. Masters and K.E.M. Galley (eds.). Proceedings of the 23rd Tall Timbers Fire Ecology Conference: Fire in Grassland and Shrubland Ecosystems. Tall Timbers Research Station, Tallahassee, Florida, USA.

Peet, R. K., T. R. Wentworth and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63:262-274. <http://cvs.bio.unc.edu/methods.htm>

Rasser, M.K. 2003. Monitoring and assessing longleaf pine ecosystem restoration: A case study in north-central Florida. Master of Science thesis, University of Florida, Gainesville, FL. 63 p.

U.S. Fish and Wildlife Service. 2014. Fire Management Species Profile, Wiregrass (Aristida stricta Michaux & Aristida beyrichiana Trinius & Ruprecht). Division of Strategic Resource Management & the Division of Fire Management, USFWS, Southeast Region, Atlanta, GA.

White, Larry D. 1977. Forage Production in a Five-Year –Old Fertilized Slash Pine Plantation. Journal of Range Management 30(2): 131-134.

Scaling Rationale: These cover classes were selected to be broad, meaningful and easily measurable.

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

RANK FACTOR: VEGETATION

Metric Name:

Herbaceous Indicators of Soil Disturbance (Optional)

Definition: Presence of certain plant species considered to be indicators of soil disturbance.

Metric Type: Condition

Tier: 2 (rapid field measure)

Rationale for Selection of the Variable: The status of understory composition is a critical indicator of future condition of the longleaf pine forest (James et al. 2001). Certain mostly native herbaceous species are indicators of soil disturbance. These species may be found most commonly in areas where pineland soils have had some form of physical disturbance. These mostly native herbaceous indicators of soil disturbance respond positively to these physical soil disturbances, but they are otherwise not common or characteristic components of high quality Longleaf Pine (*Pinus palustris*) ecosystems. Types of disturbances include vehicular impacts, such as may occur in log loading areas or logging decks (Hedman, Grace & King 2000), military tracked vehicle training areas, or areas of off road vehicle use (i.e. ORV, ATV, and 4x4). Other soil disturbances could result from forestry intensive site preparation, such as disking, heavy roller drum chop, double chop, push pile and burn, and bedding. While many of these activities negatively impact Wiregrass (*Aristida beyrichiana, Aristida stricta*), that is handled in another metric.

Measurement Protocol: These species are considered herbaceous indicators of soil disturbance, followed by the references, **exotic species are bold**:

Bulbostylis barbata	Archer 2003
Bulbostylis ciliatifolia	Dale et al. 2002
Chrysoma pauciflosculosa	Personal observation (Brett Williams Eglin AFB)
Cynodon dactylon	Dale et al. 2002
Cyperus croceus	Archer 2003
Dichanthelium aciculare	Dale et al. 2002, Kindell et al. 1997
Diodia teres	Archer 2003, Dale et al. 2002
Eragrostis curvula	Dale et al. 2002, Provencher et al 2001
Eragrostis refracta	Personal observation (Gary Kaufmann, NFs in NC)
Eremochloa ophiuroides	Rasser 2003
Eupatorium capillifolium	Archer 2003, Kindell et al. 1997, Rasser 2003
Eupatorium compositifolium	Kindell et al. 1997, Provencher et al 2001
Froelichia gracilis	Archer 2003, Dale et al. 2002
Haplopappus divaricatus	Dale et al. 2002
Hypericum gentianoides	Dale et al. 2002, Hiers et al. 2003, Provencher et al 2001
Lespedeza cuneata	Dale et al. 2002
Liatris elegans	Archer 2003
Mollugo verticillata	Archer 2003, Dale et al. 2002

Panicum verrucosum	Personal observation (Gary Kaufmann, NFs in NC)
Paronychia patula	Provencher et al. 2001
Paspalum notatum	Archer 2003, Dale et al. 2002
Polypremum procumbens	Archer 2003, Dale et al. 2002
Rubus cuniefolius, Rubus argutus	Rasser 2003
Triplasis purpurea	Dale et al. 2002

Measurement protocol is to record the presence/absence and percent cover (Brakenhielm and Qinghong 1995) of any of these species encountered.

Metric Rating: Specify the narrative and numerical ratings for the metric, from excellent to poor. The percent covers used here are rather low, but the list of indicators of soil disturbance does not include Broomsedge (*Andropogon virginicus*) which is commonly associated with soil disturbance and early succession, but which has a variable role in Longleaf Pine (Pinus palustris) ecosystems, and is sometimes found at high cover in areas which otherwise have high quality ground cover.

Metric Rating	***All Southern Open Pine Ecosystems***
EXCELLENT (A)	Total cover for herbaceous indicators of soil disturbance <2%
GOOD (B)	Total cover for herbaceous indicators of soil disturbance 2-5%
FAIR (C)	Total cover for herbaceous indicators of soil disturbance >5-10%
POOR (D)	Total cover for herbaceous indicators of soil disturbance >10%

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

Archer, Jessica Kipp. 2003. Understory vegetation and soil response to silvicultural activity in a southeastern mixed pine forest: a chronosequence study. A thesis presented to the Graduate School of the University of Florida in partial fulfillment of the requirements for the Degree of Master of Science University of Florida.

Dale, Virginia H., Suzanne C. Beyeler, and Barbara Jackson. 2002. Understory vegetation indicators of anthropogenic disturbance in longleaf pine forests at Fort Benning, Georgia, USA. Ecological Indicators 1 (2002) 155–170.

Hedman, C.W., S. L. Grace, S.E. King. 2000. Vegetation composition and structure of southern coastal plain pine forests: an ecological comparison. Forest Ecology and Management 134 (2000) 233-247.

Hiers, J. Kevin, et al. 2003. Progress Report of Eglin AFB Ecological Monitoring Program. Air Armament Center - Natural Resources Management, Jackson Guard Eglin AFB.

Kindell, C. E., B. J. Herring, C. Nordman, J. Jensen, A.R. Schotz, L.G. Chafin. 1997. Natural Community Survey of Eglin Air Force Base, 1993 – 1996: Final Report. Florida Natural Areas Inventory, Tallahassee, Florida.

Provencher, L., A.R. Litt, K.E.M. Galley, D.R. Gordon, G.W. Tanner, L.A. Brennan, N.M. Gobris, S.J. McAdoo, J.P. McAdoo, and B.J. Herring. 2001. Restoration of fire-suppressed longleaf pine sandhills at Eglin Air Force Base, Florida. Final Report to the Natural Resources Management Division, Eglin Air Force Base, Niceville, Florida. Science Division, The Nature Conservancy, Gainesville, Florida.

Rasser, M.K. 2003. Monitoring and assessing longleaf pine ecosystem restoration: A case study in north-central Florida. Master of Science thesis, University of Florida, Gainesville, FL. 63 p.

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> but references are available for other states.

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 (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. The metric and scaling are based on the detection likely on a cursory or rapid field visit to a site. 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 less than 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 greater than 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). In South Carolina, use the Invasive Plant Species of South Carolina booklet from Clemson (Lund et al. 2015). 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, including rose Natal grass (*Melinis repens*) and small carpetgrass (*Arthraxon hispidus*) 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).

Measurement Protocol: Describe the extent and distribution of invasive exotic plants within the site and/or along the perimeter of the site. In particular, estimate a percent cover value for your assessment area of invasive plant species. Cover is defined as the percentage of ground surface obscured by the vertical projection of all aboveground parts of a given species onto that surface, estimated visually by the field researcher (Peet et al. 1998). Spaces between leaves and stems also count as cover. 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> There also are other references for outside Florida (Lund et al. 2015, Miller 2003).

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
GOOD (B)	Invasive nonnative plant species present in any stratum but sporadic (<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.

Brewer, J. S., M. J. Abbott, and S. Moyer. 2015. Effects of oak-hickory woodland restoration treatments on native groundcover vegetation and the invasive grass *Microstegium vimineum*. Ecological Restoration 33(3): 256-265.

Bryson, C. T. and R. Carter. 1993. Cogongrass *Imperata cylindrica,* in the United States. Weed Technology 7:1005-1009.

Faber-Langendoen, D., W. Nichols, K. Strakosch Walz, J. Rocchio, J. Lemly, L. Gilligan, and G. Kittel. 2015. NatureServe Ecological Integrity Assessment Protocols: Wetland Rapid Assessment Method [revisions in progress]. NatureServe. Arlington, VA.

FLEPPC. 2017. List of Invasive Plant Species. Florida Exotic Pest Plant Council. http://www.fleppc.org/list/list.htm

Lippincott, C. L. 2000. Effects of *Imperata cylindrica* (L.) Beauv. (Cogongrass) Invasion on Fire Regime in Florida Sandhill (USA). Natural Areas Journal 20:140-149.

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.

Lund, M., D. Soriano, L. S. Pile, S. D. Thomas, and G. G. Wang. 2015. Invasive Plant Species of South Carolina. Clemson, SC. 76 pages. <https://www.se-eppc.org/southcarolina/Publications/InvasivePlantsBooklet.pdf>

Miller J. H. 2003. Nonnative invasive plants of southern forests: a field guide for identification and control. Asheville, NC. Southern Research Station, USDA Forest Service. Revised General Technical Report SRS-62.

Miller, S. J. and D. H. Wardrop. 2006. Adapting the floristic quality assessment index to indicate anthropogenic disturbance in central Pennsylvania wetlands. Ecological Indicators 6(2): 313–326.

Rejmánek, M., D. M. Richardson, S. I. Higgins, M. J. Pitcairn, and E. Grotkopp. 2005. Ecology of invasive plants: State of the art. Pp 104–161 In H. Mooney, R. N. Mack, J. A. McNeely, L. E. Neville, P. J. Schei, and J. K. Waage. Invasive alien species: A new synthesis. SCOPE 63. Island Press, Washington, DC.

Richardson, D. M., P. Pysek, M. Rejmánek, M. G. Barbour, F. D. Panetta, and C. J. West. 2000. Naturalization and invasion of alien plants: Concepts and definitions. Diversity and Distributions 6: 93–107.

Tierney, G. L., D. Faber-Langendoen, B. R. Mitchell, W. G. Shriver, and J. P. Gibbs. 2009. Monitoring and evaluating the ecological integrity of forest ecosystems. Frontiers in Ecology and the Environment 7: 308–316.

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

RANK FACTOR: SIZE

Metric Name:

Absolute Patch Size

Definition: A measure of the current absolute size of the contiguous open pine/longleaf pine polygon or patch, which may be larger than the assessment area. The metric is assessed with respect to expected patch sizes for the type across its range. This metric is one aspect of the size of specific occurrences of an open pine/longleaf type. The metric rating is taken from NatureServe's Ecological Integrity Assessment Working Group (Faber-Langendoen et al. 2008). Assessors are sometimes hesitant of using absolute size as part of an EIA out of concern that a small, high quality example will be down-ranked unnecessarily. We address these concerns to a degree by providing a pattern-type scale, so that types that typically occur as small patches (seepage fens) can use a different rating than types that may occur over large, extensive areas (e.g., marshes or boreal bogs/fens). Size is also more accurately assessed at finer scales of classification (e.g., Systems or Groups). Then, for example, Midwest fens are compared separately from boreal fens.

Metric Type: Condition

Tier: 1 (remote sensing); 2 (rapid field measure)

Rationale for Selection of the Variable: The role of absolute size in assessing integrity is complex. First, higher ratings for size may not always indicate increased integrity. For some types absolute size can vary widely for entirely natural reasons (e.g., a forest type may have very large occurrences on rolling landscapes and be restricted in other landscapes to small occurrences on north slopes or ravines).

Second, size overlaps with landscape context as a metric, depending on the scale of the vegetation type. Size and landscape context both address spatial aspects of an occurrence. Very large sized, matrix occurrences essentially define the landscape context. Standards for establishing the size metric ratings sometimes can be confounded with criteria for Landscape Context. For example, the use of Minimum Dynamic Area (MDA) as the basis for the Size criteria is misleading, at least at the system or natural community level, because MDA is really assessing the landscape area within which an occurrence is embedded and on which it depends for its persistence (Leroux et al. 2007). MDA is typically applied to types at very broad classification scales (e.g., northern hardwood and boreal forest landscapes).

Nonetheless, size can be an important aspect of integrity. For some types, diversity of animals or plants may be higher in larger occurrences than in small occurrences that are otherwise similar. For occurrences in mosaics, the larger occurrences often have more micro-habitat features. Larger areas are more resistant to stressors in general, and are more resistant to invasion by exotics specifically, since they buffer their own interior portions. Thus size can serve as a readily measured proxy for some ecological processes and the diversity of interdependent assemblages of plants and animals.

Note that NatureServe's methodology for evaluation patches or polygons (the "Element Occurrence Rank") includes integrity and conservation values, so with respect to size, larger occurrences are generally presumed to be more value for conservation purposes, as they provide a better representation of the type being conserved. We keep the Size metrics separate within a Primary "Size Rank Factor" so that users can readily determine the role of these metrics in the overall EIA scores. Some consideration had been given to combining size metrics with a broader "landscape context and size rank factor," so that interactions between size and landscape context could be dealt with first, before considering their joint interaction with condition. Users focused strictly on ecological integrity may find this an appealing option.

Measurement Protocol: The choice of patch type for the particular vegetation being assessed is an important first step and should be based on knowledge of the typical sizes of mid to broad scale ecological types (Formations, Groups, Systems) found in excellent sites. Knowledgeable ecologists in the state or region should be consulted. Ecological System and Group types have all been assigned to a pattern type, so if the site is classified to Ecological System or Group, that information can be readily attained (www.natureserve.org/explorer).

Absolute Size can be measured in GIS using aerial photographs, orthophoto quads, National Wetland Inventory maps, or other data layers. Size can also be estimated in the field using 7.5 minute topographic quads, NPS Vegetation Mapping maps, National Wetland Inventory maps, or a global positioning system. Boundaries are not delineated using jurisdictional methods (U.S. Army Corps of Engineers 1987); rather, they are delineated by ecological guidelines for delineating the boundaries of the vegetation type, based on the International Vegetation Classification, equivalent National Vegetation Classifications, National Wetland Inventory, or other classifications.

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

Metric Rating	***All Southern Open Pine Ecosystems***
EXCELLENT (A)	>10,000 acres
GOOD (B)	2,000-10,000 acres
FAIR (C)	500-2,000 acres
POOR (D)	0-500 acres

Data for Metric Rating: See Faber-Langendoen et al. (2011) for an evaluation of the discriminatory power of this metric based on an assessment of 277 wetlands in Michigan and Indiana. Lemly and Rocchio (2009) tested user variability and the performance of this metric in relation to a Level 3 EIA (e.g., vegetation index of biotic integrity).

Faber-Langendoen,D., G. Kudray, C. Nordman, L. Sneddon, L. Vance, E. Byers, J. Rocchio, S. Gawler, G. Kittel, S. Menard, P. Comer, E. Muldavin, M. Schafale, T. Foti, C. Josse, and J. Christy. 2008. Ecological Performance Standards for Wetland Mitigation based on Ecological Integrity Assessments. NatureServe, Arlington, VA. + Appendices.

Faber-Langendoen, D., C. Hedge, M. Kost, S. Thomas, L. Smart, R. Smyth, J. Drake, and S. Menard. 2011. Assessment of wetland ecosystem condition across landscape regions: A multi-metric approach. NatureServe, Arlington VA.+ Appendices.

Faber-Langendoen, D., J. Rocchio, S. Thomas, M. Kost, C. Hedge, B. Nichols, K. Strakosch Walz, G. Kittel, S. Menard, J. Drake, and E. Muldavin. 2012. Assessment of Wetland Ecosystem Condition across Landscape Regions: A Multi-metric Approach Part B. Ecological Integrity Assessment Protocols for Rapid Field Methods (L2). EPA/600/R-12/021b. U.S. Environmental Protection Agency Office of Research and Development Washington, DC.

Lemly, J.M. and Rocchio, J.R. 2009. Field Testing and Validation of the Subalpine-Montane Riparian Shrublands Ecological Integrity Assessment (EIA) Scorecard in the Blue River Watershed, Colorado. Report prepared for the Colorado Division of Wildlife and US EPA Region 8 by the Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. Online: http://www.cnhp.colostate.edu/download/reports.asp

Lemly, J., L. Gilligan, and C. Wiechmann. 2016. Ecological Integrity Assessment (EIA) for Colorado Wetlands. Field Manual, Version 2.1. Colorado Natural Heritage Program. Accessed August 27, 2018. https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.

Leroux, S.J., F.K.A. Schmiegelowa, R. B. Lessard, and S. G. Cumming. 2007. Minimum dynamic reserves: A framework for determining reserve size in ecosystems structured by large disturbances. Biological Conservation 138: 464–473.

U.S. Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Environmental Laboratory, U.S. Army Corps of Engineers Waterways Exp. Stn. Tech. Rep. Y-87-1.

Scaling Rationale: Scaling criteria are based on the NatureServe Ecological Integrity Assessment Working Group (Faber-Langendoen et al. 2008). Our scaling has been informed by considerations of spatial pattern types, but no general guidelines have yet been established to assess wetland patch size.

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

RANK FACTOR: LANDSCAPE CONTEXT

Metric Name:

Contiguous Natural Land Cover

Definition: This metric measures the percent of the landscape within 500 meters of the assessment area that is contiguous with (and thus forms an unfragmented connection to) the assessment area itself. Fragmentation can dramatically impact natural processes such as seed dispersal, animal movement, and genetic diversity (Lindenmayer and Fischer 2006).

Metric Type: Condition

Tier: Level 1 (remote sensing)

Rationale for Selection of the Variable: The intensity of human activity in the landscape often has a proportionate impact on the ecological processes of natural systems. The percentage of cultural land use (e.g., agricultural and developed urban/suburban patches) within the surrounding landscape provides an indirect estimate of connectivity among natural ecological systems. Landscapes that retain more connectivity among patches of otherwise isolated vegetation types, and therefore have higher levels of connectivity, are assumed to be more likely to maintain populations of various species that inhabit the natural patch. Studies have shown that lack of landscape connectivity reduces pollination and seed dispersal, animal movements, ecological processes, and ultimately genetic diversity (Lindenmayer and Fischer 2006).

The integrity of the landscape context can be critically important to certain biota. Amphibians and reptiles are especially sensitive to the matrix of habitats surrounding a wetland because they spend the majority of their lives foraging, resting, and hibernating in the adjacent terrestrial habitat (Semlitsch 1998). Upland habitats immediately surrounding wetlands serve as important dispersal corridors and are also used as foraging and aestivation areas for many amphibian species (Semlitsch 1998). Total unaltered area around the wetland also seems to be an important landscape component in the maintenance of wetland fauna. Guerry and Hunter (2002) found that wood frogs, green frogs, eastern newts, spotted salamanders, and salamanders of the blue-spotted/Jefferson's complex (*Ambystoma laterale/A. jeffersonianum*) were more likely to occupy ponds in unaltered landscapes (i.e., intact forested areas).

Measurement Protocol: To assess this metric, examine land use patterns within a 500 m envelope of the assessment area. This is best done using the most recent aerial photography available. GIS layers of land use or land cover can also be used, but may not be as accurate as interpretation of aerial photography. When possible, walk through portions of the 500 m envelop to ground truth the photo. Identify the largest unfragmented block that contains the assessment area and estimate its percentage of the total area within the 500 m envelope. This percent of unfragmented landscape can have small fragmentation inclusions (e.g., individual houses in a forested landscape, etc.), but roads that bisect the landscape form a hard boundary to the unfragmented block. Well-traveled dirt roads and major canals count as fragmentation, but hiking paths, non-tilled hayfields, open fences, and small lateral ditches can be included in unfragmented blocks. For larger roads, such as highways where road fill and trash borders the road, the zone of the road's influence should also be considered as fragmentation.

Metric Rating: Assign the metric rating and associated score based on the thresholds below.

Metric Rating	***All Southern Open Pine Ecosystems***
EXCELLENT (A)	Intact: embedded in 90–100% contiguous natural landscape.
GOOD (B)	Variegated: embedded in 60–90% contiguous natural landscape
FAIR (C)	Fragmented: embedded in 20–60% contiguous natural landscape
POOR (D)	Relictual: embedded in <20% contiguous natural landscape.

Data for Metric Rating: See McIntyre and Hobbs (1999); also see Faber-Langendoen et al. (2011) for an evaluation of the discriminatory power of this metric based on an assessment of 277 wetlands in Michigan and Indiana. Lemly and Rocchio (2009) tested user variability and the performance of this metric in relation to a Level 3 EIA (e.g., vegetation index of biotic integrity).

Metric concept and thresholds adapted from Rondeau (2001), Rocchio (2006a-g), and Faber-Langendoen et al. (2008). The categorical ratings are based on McIntyre and Hobbs (1999) and Heinz Center (2002).

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Guerry, A. D. and M. L. Hunter. 2002. Amphibian Distributions in a Landscape of Forests and Agriculture: An Examination of Landscape Composition and Configuration. Conservation Biology 16:745–754.

Heinz Center. 2002. The State of the Nation's Ecosystems: Measuring the Lands, Waters and Living Resources of the United States. Cambridge University Press, NY.

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Region 8 by the Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. Online: http://www.cnhp.colostate.edu/download/reports.asp

Lemly, J., L. Gilligan, and C. Wiechmann. 2016. Ecological Integrity Assessment (EIA) for Colorado Wetlands. Field Manual, Version 2.1. Colorado Natural Heritage Program. Accessed August 27, 2018. https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.https://ecos.fws.gov/ServCat/DownloadFile/101684?Reference=61246.

Lindenmayer, D. B. and Fischer, J. 2006. Habitat fragmentation and landscape change: an ecological and conservation synthesis. Island Press, Washington, DC

McIntyre S. and R. Hobbs. 1999. A framework for conceptualizing human effects on landscapes and its relevance to management and research models. ConservBiol 13:1282–1292.

Rocchio, J. (2006a) Intermountain Basin Playa ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rocchio, J. (2006b) North American Arid West Freshwater Marsh ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rocchio, J. (2006c) Rocky Mountain Alpine-Montane Wet Meadow ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rocchio, J. (2006d) Rocky Mountain Lower Montane Riparian Woodland and Shrubland ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rocchio, J. (2006e) Rocky Mountain Subalpine-Montane Fen ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rocchio, J. (2006f) Rocky Mountain Subalpine-Montane Riparian Shrubland ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rocchio, J. (2006g) Rocky Mountain Subalpine-Montane Riparian Woodland ecological system: Ecological Integrity Assessment. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Rondeau, R. 2001. Ecological system viability specifications for Southern Rocky Mountain ecoregion. First Edition. Colorado Natural Heritage Program, Colorado State University, Fort Collins, CO. 181 pp.

Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding amphibians. Conservation Biology 12:1113–1119.

Scaling Rationale: Less fragmentation increases connectivity between natural ecological systems and thus allow for natural exchange of species, nutrients, and water. The categorical ratings are based on McIntyre and Hobbs (1999).

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

RANK FACTOR: LANDSCAPE CONTEXT

Metric Name:

Land Use Index

Definition: This metric measures the intensity of human dominated land uses in the surrounding landscape and is based on Hauer et al. (2002) and Mack (2006).

Metric Type: Stressor

Tier: Level 1 (remote sensing)

Rationale for Selection of the Variable: The intensity of human activity in the landscape has a proportionate impact on the ecological processes of natural ecosystems. Assessing land use incorporates both the aspect of "habitat destruction" and "habitat modification" (sensu McIntyre and Hobbs 1999), at least for the non-natural habitats. That is, in addition to the effect of converting natural habitat to agricultural, urban and other land use modifications, there is the additional aspect of the intensity of that land use. Human land uses often directly or indirectly alter many natural ecological processes.

Tests of this metric in conjunction with the Landscape Connectivity metric found a high level of correlation (redundancy), suggesting that perhaps both are not needed (Faber-Langendoen et al. 2011). Landscape Connectivity is a simpler metric to apply. However, the tests were done in a fairly homogeneous region of land uses, and further tests should be conducted across a wider range of land use types.

Measurement Protocol: The Land Use Index is measured by documenting surrounding land uses within 500 m of the assessment area. The assessment should be completed in the office using remote sensing imagery, such as aerial photographs, satellite imagery, or landcover datasets. Where feasible, the rating should be verified in the field, using roads or transects to verify land use categories. Ideally, both field data as well as remote sensing tools are used to identify an accurate percent of each land use within the landscape area, but remote sensing data alone can be used. This metric can be calculated as an automated GIS process using the National Land Cover Dataset or the LANDFIRE Dataset, though both should be reviewed for accuracy.

To calculate a Land Use Index, estimate the percent of each land use category and calculate the corresponding category score based on land use coefficients and the following equation:
Land use category score = $\sum$ LU x PC/100
LU = Land use coefficient for each category
PC = % of adjacent area in each category
Do this for each land use category separately, then sum each category score to calculate the Total Land Use Score. If land uses overlap, use the more intensive land use for the calculation. For example, if 10% of the landscape contains unpaved roads (1 * 0.10 = 0.1), 30% is under

moderate grazing (6 * 0.30 = 1.8), and 60% is natural vegetation (10 * 0.60 = 6.0), the Total Land Use Score would be 7.9 (0.1 + 1.8 + 6.0), for a rating of C.

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

Metric Rating	***All Southern Open Pine Ecosystems***
EXCELLENT (A)	Land Use Index = 9.5–10.0.
GOOD (B)	Land Use Index = 8.0–9.49.
FAIR (C)	Land Use Index = 4.0–7.99.
POOR (D)	Land Use Index = <4.0.

Data for Metric Rating: The National Land Cover Dataset 2011 is available for download at: http://www.mrlc.gov/nlcd2011.php. The LANDFIRE Dataset is available for download at: http://www.landfire.gov.

Metric and thresholds adapted from Hauer et al. (2002) and Faber-Langendoen et al. (2012).

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Hauer, F.R., B.J. Cook, M.C. Gilbert, E.J. Clairain Jr., and R.D. Smith. 2002. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Riverine Floodplains in the Northern Rocky Mountains. U.S. Army Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS. ERDC/EL TR-02-21.

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Mack, J.J. 2006. Landscape as a predictor of wetland condition: An evaluation of the Landscape Development Index (LDI) with a large reference wetland dataset from Ohio. Environmental Monitoring and Assessment 120: 221–241.

McIntyre S. and R. Hobbs. 1999. A framework for conceptualizing human effects on landscapes and its relevance to management and research models. ConservBiol 13:1282–1292.

Scaling Rationale: Land uses have differing degrees of potential impact on ecological patterns and processes. Some land uses have minimal impact, such as simply altering the integrity of native vegetation (e.g., recreation and low intensity grazing), while other activities (e.g., hay production and agriculture) may replace native vegetation with nonnative or cultural vegetation yet still provide potential cover for species movement. Intensive land uses (e.g., urban development, roads, and mining) may completely destroy vegetation and drastically alter ecological processes (Hauer et al. 2002, Mack 2006).

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

RANK FACTOR: LANDSCAPE

Metric Name:

Perimeter with Natural Buffer

Definition: This metric measures the percent of the assessment area perimeter that is immediately surrounded by natural buffer land covers.

Metric Type: Condition

Tier: Level 1 (remote sensing)

Rationale for Selection of the Variable: Perimeter with Natural Buffer is one of three submetrics in NatureServe's Ecological Integrity Assessment Buffer Index metric; the other two submetrics are Average Buffer Width and Buffer Condition. The Buffer Index metric was developed for wetlands, and in applying the metrics to open pine and longleaf vegetation, the Perimeter with Natural Buffer seemed most practical to calculate and assess due to potential limitations of direct access to lands surrounding a site and to the geospatial calculation complexity of the other two submetrics.

The Environmental Law Institute (2008) summarizes extensive data on the rationale for the role of buffers in maintaining ecological integrity of wetlands. Many studies have looked at specific effects of buffers on water quality, birds and other attributes of ecosystems. For example, Semlitsch (1998) monitored terrestrial migrations for six Ambystomid salamander species and found that buffers were critical to permitting their passage into uplands. They found that buffer areas 164 m from wetland edges were needed to encompass 95% of population forays.

Measurement Protocol: Estimate the length of the assessment area perimeter contiguous with a natural buffer. Use a 5 m minimum buffer width. Perimeter includes open water. Metric is adapted from Collins et al. (2006) and US EPA (2011).

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

Metric Rating	***All Southern Open Pine Ecosystems***
EXCELLENT (A)	Natural buffer surrounds 100% of the site perimeter
GOOD (B)	Natural buffer surrounds 75–99% of the site perimeter
FAIR (C)	Natural buffer surrounds 25–74% of the site perimeter
POOR (D)	Natural buffer surrounds <25% of the site perimeter

Data for Metric Rating: See Environmental Law Institute (2008); also see Faber-Langendoen et al. (2011) for an evaluation of the discriminatory power of this metric based on an assessment of 277 wetlands in Michigan and Indiana. Lemly and Rocchio (2009) tested user variability and the performance of a variant of this metric in relation to a Level 3 EIA (e.g., vegetation index of biotic integrity).

Collins, J.N., E.D. Stein, M. Sutula, R. Clark, A.E. Fetscher, L. Grenier, C. Grosso, and A. Wiskind. 2006. California Rapid Assessment Method (CRAM) for Wetlands and Riparian Areas. Version 4.2.3. 136 pp.

Environmental Law Institute. 2008. Planner's Guide to Wetland Buffers for Local Governments. Washington, DC. 25 pp.

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Semlitsch, R. D. 1998. Biological delineation of terrestrial buffer zones for pond-breeding amphibians. Conservation Biology 12:1113–1119.

U.S. EPA. 2011. USA RAM Manual, Version 11. (co-authors, J. Collins, S. Fennessy). U.S. Environmental Protection Agency, Washington, DC.

Scaling Rationale: There is abundant evidence on the value of even narrow buffers between 5 and 25 m (Environmental Law Institute 2008).

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