Desired Future Conditions (DFC) for Shortleaf Pine-bluestem and Pine-oak Restoration Sites in the Interior Highlands. (Biographies of the DFC writing team are at the end of this appendix.)

Purpose:

The purpose of this report is to provide descriptions, definitions, and assign metrics to structural and compositional variables characterizing desired future conditions (DFC) for shortleaf pine-bluestem and pine-oak natural community restoration in the Interior Highlands (Ozark/Ouachita region). The emphasis of this document is to help define goals of management rather that management approaches. The purpose of natural community restoration is to recover the biodiversity associated with these shortleaf community types, especially the highly diverse grass/forb component of the groundcover (Masters 2007). Natural communities with a shortleaf pine component are listed and metrics for desired conditions provided, along with management guidelines and decision making criteria. These are not given as absolutes, but rather as guidelines for use in adaptive management; while much has been documented regarding methods for and effects of pine-woodland restoration on the Ouachita National Forest, comparably little has been formally evaluated with regards to the restoration of pine-bluestem in the Ozarks or pine-oak natural communities throughout the region. The intended audience is resource managers that have influence over forest management plans, private land consultants and federal assistance agency, researchers, academia, and wildlife professionals. The subcommittee also recognizes that there are other techniques and approaches to growing pine for forest products, but describing those was beyond the scope of the task with which they were charged.

Shortleaf Pine Natural Communities in the Ozark/Ouachita (AR/MO) region:

Natural Community Definition: Natural communities are distinct assemblages of native plants, animals and microorganisms that occur in repeatable and often mappable patterns across the landscape. Natural communities in which shortleaf pine is dominant or important are the result of specific combinations of factors related to soils, bedrock and disturbance patterns (e.g. drought, fire, wind and ice storms). Shortleaf pine occurs primarily within dry and dry-mesic chert, sandstone and igneous woodlands across Missouri, but also occupies igneous and sandstone glades and igneous, chert and sandstone cliff tops. It occurs in similar sites in the Arkansas Ozarks, except that igneous substrates are lacking, and novaculite provides a unique substrate. In the Ouachitas, it is typically on south-facing aspects of extensive east-west trending ridges, and pine-dominated areas are typically larger than in the Ozarks. Mixed hardwood-pine communities are relatively more common in the Ozarks than in the Ouachitas (Guldin 2007).

While drought, wind and ice storms influenced shortleaf pine ecosystems, fire is the most consistent disturbance. Fire regimes are affected by site conditions described above and involve variability in intensity, seasonality (time of year), frequency (time between fires). Large scale fires occurred over portions of the landscape roughly every 20-40 years, in conjunction with severe droughts.

<u>Shortleaf Pine Community Types:</u>

While the "natural community" can be defined in various ways and levels of detail in distinguishing distinctive plant species assemblages associated with chert, sandstone and igneous woodlands in which shortleaf pine is important, the most widely used classification system has been developed by NatureServe. Nelson's classifications (Nelson 2005) are cross-walked because they often are used for the Ozarks as well.

NatureServe recognizes the following Plant Community Associations in Ozark/Ouachita in which shortleaf pine is important:

1. Shortleaf Pine/blueberry Forest
    a. Recognized in Nelson 2005 as community variant on dry chert/sandstone/igneous woodland

2. Shortleaf Pine - (White Oak, Northern Red Oak) / (Farkleberry, Hillside Blueberry) / Little Bluestem - Longleaf Woodoats - Elmleaf Goldenrod Forest
    a. Nelson 2005 typical of dry-mesic woodland types

3. Shortleaf Pine - Black Oak - Post Oak / Blueberry species Forest
    a. Nelson 2005 as dry woodland type in more dissected landscapes (Salem/Potosi Ranger Districts)

4. Shortleaf Pine / Rock Outcrop Interior Highland Woodland
    a. Variant of woodland types where excessive exposure on rock and cliff is prominent

5. Shortleaf Pine / Little Bluestem - Elmleaf Goldenrod - Red-purple Beebalm - Pale Purple Coneflower Woodland
    a. Nelson 2005; variant of chert and sandstone distinguished on gentle dissected plains: Pineknot example

6. Shortleaf Pine - White Oak / Little Bluestem Woodland
    a. Nelson 2005 similar to above but white oak increases with landscape dissection

7. Shortleaf Pine - Post Oak - Blackjack Oak / Little Bluestem Woodland
    a. Nelson 2005. More prominent near Central Plateau

8. A shortleaf pine component is associated with igneous and sandstone glade/rock outcrops where SLP is within range.

9. Delta Post Oak-Willow Oak Flatwoods Forest (includes shortleaf pine)

Although this list demonstrates the diversity of plant communities in the region in which shortleaf pine is important, the subcommittee felt that the list could be simplified for the purpose of defining DFCs for the region. The DFCs will therefore be described for the following three landscape and community types:

1. *Pine-bluestem:* Shortleaf pine communities in which warm season grasses/forbs are prominent on dissected plains. (includes plant community associations 6, and 7 above)

2. *Dry-Mesic Pine-Oak:* Shortleaf pine mixes with oak species (either can be dominant) on more deeply dissected hills, even on upper north-facing slopes. (includes plant community associations 1, 2, 3, and 9 above)

3. *Dry Pine-Oak:* SLP mixes with oak species on steep, south-facing upper slopes and ridgetops. (includes plant community associations 1, 3, 4, 5, and 8 above)

Desired Future Conditions for Shortleaf Pine Communities in the Ozark/Ouachita (AR/MO) region:

Shortleaf pine ecosystem restoration should occur at the landscape scale and therefore the DFCs presented below provide both landscape and stand level guidelines. Landscape scale DFCs were adapted from the Landfire project developed by USFS and DOI, with cooperators. Landscape conditions were developed by Landfire using state-transition computer models with input parameters provided by expert groups along with literature sources. Full documentation of the methodology has been published and reviewed (http://www.landfire.gov/). Under this process, disturbance type and frequency that would lead from each state such as mid-seral mature open to every other state such as mature closed are input into the computer. A computer then simulates a long period of community change such as 1000 years, to determine what proportion of the landscape would be occupied by each state. Disturbances include weather, within-stand competition, insect and disease outbreaks, ice, and fire, with varying severity (partial or stand-replacing disturbance or no disturbance). Landfire states or classes are based on stand age and openness. Both open and closed seral states are described as woodland conditions, that is, less than full canopy cover, with an understory dominated by native herbaceous species, the following DFCs apply only to the mature open seral stage.

THESE ARE PRESENTED THESE ONLY AS GUIDELINES. They are presented because the assumptions and methodology have been published and provide guidance on the spatial diversity of structural conditions that might occur within a community in landscapes (10,000 acres or more). When researchers and managers on the team have information indicating that local percentages differ from those calculated by Landfire, these can be updated. Note also that Landfire used a slightly different classification from what is used in this document in that Landfire has only Shortleaf Pine Oak Forest and Woodland type, along with a pine-bluestem model, whereas the classification used here distinguishes dry pine-oak from dry-mesic pine-oak woodlands. Also, the team that developed this document felt an old growth closed class was needed, but it has not been added below. This diversity of structural conditions would have occurred in a mosaic of various patch sizes across these landscapes.

Stand level conditions were developed by the DFC committee using historic data, research literature, and managers' collective experience. Research has shown that both natural and anthropogenic fires influenced historic vegetation. Fire scar research provides the most detailed fire frequency information, however, it is widely understood that many low intensity fires do not leave fire scar evidence. Therefore, fire frequencies recorded by this method likely underestimate the actual frequencies, so ranges are provided below. Some areas within the Interior Highlands have more detailed data and DFCs could be modified based on their findings.

<u>Desired Future Conditions for Shortleaf Pine-Bluestem:</u>

Site Types: This shortleaf association exhibits the most open canopy condition of the three described here, as a result of frequent fires of varying intensity and seasonality that serve to control most other woody growth. The herbaceous ground cover is abundant. These communities occur on less dissected landscapes where larger areas of relatively gentle topography allowed for greater and more frequent disturbances, especially from fire.

Desired Age and Structural Characteristics: landscape level

Early seral open – 15%

Mid-seral open – 35%

Mature open – 45%

Mid-seral closed – 3%

Mature closed – 2%

(With about 85% pines across the landscape)

Canopy Closure: Range of 30-60% overall, but could be much sparser or denser in certain locales depending on small-scale ecological factors.

Basal Area: 40-70 sq ft/ac with an average diameter of 16 inches dbh. Refer to tables below for stocking ratios.

Midstory: Coverage should be less than 10%.

Understory: Coverage should be less than 10%.

Ground Layer: Coverage should be extensive in restored sites, 80-100% cover and made up of at least 80% graminoid-forbs in composition.

Disturbance Regimes: (Frequency, Intensity & Seasonality)

Since this community occurred over larger geographic areas with great connectivity, natural and anthropogenic ignitions would burn larger units and therefore fire return intervals were shorter.

Desired Future Conditions for Dry Pine-Oak Woodland:

Site Types: In Missouri, these community types typically occur on south and west-facing slopes and ridge tops and approximately the upper third of their backslopes. In the southern Ozarks, they occur on upper south and west-facing slopes. In the Ouachitas, dry pine-oak is more prevalent in the central regions on upper south and west-facing slopes. These systems are more edaphically controlled than the other community types, although fire is still important. These sites are more dissected and therefore have more variable in fire regimes. In the Ozarks, the extent and frequency of fires often was less compared to the large connected landscapes of the Ouachitas and Boston mountains.

Desired Age and Structural Characteristics: landscape level

Early seral open – 5%

Mid-seral open – 25%

Mature open – 45%

Mid-seral closed – 5%

Mature closed – 20%

Canopy Closure: Range of 30-50%; use tables below to determine relationship among average stand DBH and canopy closure.

Basal Area: 30-60 sq ft/ac In the northern Ozark Breaks, BA would be higher due to large numbers of old growth stands with larger diameters.

Midstory: Coverage should be approximately 15%, with common plants like farkleberry, dogwood, hickories, etc.

Understory: Coverage can be 20-80% in the northern Ozark Breaks and Hills. In the southern Ozarks/Ouachitas less than 30%. Coverage may increase with restoration.

Ground Layer: Should be 40-60% in coverage with at least 80% graminoid-forbs in composition.

Disturbance Regimes: Frequency, Intensity & Seasonality

Fire is likely to occur on these drier sites (at least the larger occurrences) but drought is the primary disturbance. Typical fire return intervals were 5-10 years in the Ozark and 3-7 years in the Ouachita and Boston Mountains because of relatively smaller units.

<u>Desired Future Conditions for Dry-Mesic Pine-Oak Woodland:</u>

Site Types: In MO, typically occurs on mid-to-low, moderately steep north and east-facing slopes where fire frequency was less than pine-bluestem systems. In the southern range (Ozarks and Ouachitas), occurs on low-to-mid south and mid-north slopes and toe slopes. Percent of pine varies inversely with steepness. Shortleaf pine with white oak is typical with a red oak component increasing further south. Oaks may dominate many sites, with shortleaf pine as a minor component because oaks have a competitive advantage on moist sites.

Desired Age and Structural Characteristics: landscape level

Early seral open – 5%

Mid-seral open – 25%

Mature open – 45%

Mid-seral closed – 5%

Mature closed – 20%

Canopy Closure: Range of 50-80%, but use table below to determine relationship among average stand DBHs and canopy closure.

Basal Area: 50-90 sq ft/ac with an average diameter of 16 inches dbh.

Midstory: Coverage should be less than 30%.

Understory: Coverage should be less than 30%.

Ground Layer: The committee could not reach a consensus range of percent coverage from the wide variation experienced by those who have been engaged in restoration throughout the range. It is agreed it should be over 20% and 80- 100% is desirable but may not be feasible. The ground layer should be made up of at least 80% graminoid-forbs in composition.

Disturbance Regimes: Frequency, Intensity & Seasonality

Fire is likely to occur on these sites, depending on size, but other disturbances like windthrow, drought and insect outbreaks are also common disturbances. Typical fire return intervals were 5-10 years in the Ozark and 3-7 years in the Ouachita and Boston Mountains.

<u>Herbaceous site indicator species for the three identified SLP communities:</u>

Managers have found some sites to be resistant to restoration due to past management activities. Species that should be present may have been lost, even in the seed bank, through past management. Species uncharacteristic of the community may have become abundant, and may not be easily controlled through fire or other available management practices. The presence of species appropriate to the site and community is an important component to judge the restorability of a particular site. Using a Floristic Quality Index (Swink and Wilhelm, 1994) that considers all species present on the site is the best way to evaluate restoration potential, but below is a short list of indicator species. Presence of herbaceous species that require open canopy and frequent fire provide valuable indications of the functioning of shortleaf pine ecosystems.

Characteristic and Desired Indicators:

1. Little bluestem (Schizachyrium scoparium)

2. Big bluestem Andropogon gerardii)
3. Tick trefoil (Desmodium marilandicum)
4. Sensitive briar (Schrankia nuttallii)
5. Cream wild indigo (Baptisia bractracta)
6. Stiff-leaved aster (Aster linearifolius)
7. Spreading aster (Aster patens)
8. Turbinate aster (Aster turbinellus)
9. Goldenrod (Solidago odora)
10. Bristly sunflower (Helianthus hirsutus)

In addition these species can be used in Arkansas

11. Pale purple coneflower (Echinacea pallida)
12. Large coneflower (Rudbeckia grandiflora)

For more specifics on identifying these, refer to Common Indicator plants of Missouri (Farrington 2010).

Summary of DFCs for mature, open condition SLP communities

Community Type	Canopy Closure (%)	Basal Area* (ft^2/ac)	Trees Per Acre*	Midstory Density (%)	Understory Cover (%)	Ground Layer Cover (%)
Shortleaf Pine-Bluestem	30-60	35-70	26-52	<10	<10	80-100
Dry Mesic Shortleaf Pine-Oak Woodland	50-80	60-95	44-70	<30	<30	50-80
Dry Shortleaf Pine-Oak	30-50	35-60	26-44	15	20-80 North <30 South	40-60

*Calculated Based on an average DBH of 16”, will vary with average stand DBH see table 1 A

Management:

General Considerations: Natural community restoration cannot be accomplished on every site formally occupied by shortleaf pine, especially in those areas with a lot of damage from overgrazing and other abuses. Initial inventory should identify landscape-scale areas with a preponderance of restorable sites. Based on the collective experience of the subcommittee, the guidelines below could help to determine whether or not restoration is practical on a given site. Economic Viability, Increase Pine on Oak dominated sites. Invasive Species

Pretreatment decision making: The initial step is to determine the feasibility of restoration with managers' limited resources; efforts should focus on sites with the best chance of success. Although using a Floristic Quality Index is expensive, roadside indicators and quick herbaceous layer monitoring (rapid ecological assessment based on the indicator species listed above) will also help to determine whether the site is a good candidate for restoration. Without a good indication of a beneficial response of herbaceous indicator plants, the stand may need a prescribed silvicultural treatment (e.g. light thinning and/or creating openings) followed by dormant/growing season fires as a pretreatment to determine whether the indicator species' seedbank is present. Invasive species should be aggressively controlled. Opening the canopy and applying one burn will increase the probability that characteristic sun-loving perennial forbs will remain for the next burn treatment (Guldin 2007). If the site is determined to be restorable, continued treatment will be needed to achieve the desired future conditions. (Shortleaf pine ecosystems are fire adapted, so it is imperative that restoration sites and landscapes be burnable.) Herbicides and mechanical treatments are likely to be necessary in the restoration prescription due to the invasion of plants that were historically absent.

Managers must also decide whether to focus on getting pine back in the system first or to work to restore the grass/forb component of the understory first. Different management approaches are required to accomplish each of these. If the landscape to be restored is dominated by maturing or seed-producing pine, then managers may concentrate on thinning and applying fire to restore groundcover diversity. If shortleaf pine is essentially missing from the landscape where formerly dominant, then the site should be converted to planted pine stand and managed as such until a commercial thinning is viable. Again, managers and planners must consider what personnel and financial resources will continue to be available when determining the scale of restoration projects they can sustain over time.

Fire: Maintaining a fire regime is critical to successful ecosystem restoration. Initial high fuel loading or those that develop following management or natural disturbances need to be managed carefully to avoid undesirable overstory mortality or other adverse effects. Fire intervals will need to be kept to 1-3 years apart during the restoration process with thinning occurring early in the process. While historic fire intervals were more variable (Guyette et al. 2002, Guyette et al. 2006), current conditions resulting from decades of fire suppression and other land use have been found by restoration practitioners to require more frequent controlled burns in order to recover the ground flora and reduce competition by oaks and other hardwoods (Sparks et al. 1998). Missing scheduled management treatments can actually result in converting the system to non-pine forest types. Fire return intervals in restoration areas tend to be shorter than the historical intervals in order to remove large amounts of accumulated fuels, kill hardwood resprouts, and control fire-intolerant invasive species. Fire adapted species such as sericea lespedeza should be controlled before burning. Herbicides are an effective control treatment depending on the species. Once the vegetation community has stabilized, fire intervals can be lengthened.

Hardwood Control: A common need in restoration is to reduce the density of hardwood species in the midstory and understory. This can be achieved a number of ways, (1)) applying herbicides before burning or (2) increasing fire frequency and maintaining a higher overstory densities to reduce hardwood sprout growth or (3) using hotter fires in the growing season. On mesic mixed sites, hardwood species have a competitive advantage over shortleaf pine because of reduced fire intensity and frequency. Management strategies should focus on increasing shortleaf pine in these stands.

Herbicide: Herbicide, while having the potential for adverse effects, may be the most effective way to reduce dense hardwoods and invasive species that have increased in a site over decades of prior management and should be in the managers “toolbox”. Invasive species and hardwoods (including oak) may be fire-resistant or too large to be effectively reduced by fire and/or may resprout after cutting, resulting in a degree of shading that will hamper the desired herbaceous response. Evaluation and implementation of herbicide treatments should be undertaken carefully, following all approved uses and label recommendations.

Thinning: Numerous studies have demonstrated that existing forests and woodlands are much denser and with more shade on the ground than a century ago (Foti 2004, Nowacki and Abrams, 2008). The resulting shading conditions reduce overall species diversity and especially the species characteristic of SLP dominated communities. Restoration of these areas will often require mechanical removals to increase light resources to the herbaceous layer. The restoration process requires multiple silvicultural treatments and burns in order to reach specified conditions. Thinning toward recommended desired future conditions should be kept at a slightly higher level (10-20 BA) than DFCs to account for potential loss of overstory trees from fire damage, windthrow, lighting, insects and natural mortality.

Regeneration of Stands: Stambaugh et al. (2007) suggest that while long-term frequent burning at 1-3 year intervals results in abundant shortleaf pine regeneration, fire-free intervals of eight to fifteen years likely are necessary to provide recruitment of cohorts into the stand. Given the long age span of shortleaf pine, and the desire to maintain relatively open stands, recruitment may only need to occur every several decades. There has been little experimentation to this end in restoration efforts currently underway, however, with the focus being on frequent burns to stimulate and maintain the overstory structure and ground flora. Experimentation, research and modeling are needed to find the most appropriate approach for different communities, conditions of stands, and sites.

Decision Making Criteria:

Each site contains its own unique challenges and complication that prevents a simple "recipe" for restoration. The tables below are provided to be a guide based on years of experience from managers.

Desired future conditions for Shortleaf Pine forests based on available growing space was adapted from Rogers (1983) using regionally-specific crown data collected from various shortleaf pine stands in Arkansas. Special considerations will need to be taken when working in small diameter stand (avg DBH of 10”) where re-entry into the stand will be infrequent (<10 years). These typically younger trees respond well to thinnings and additional reductions in trees per acre may be required to prevent premature canopy closure. If there is a significant proportion of hardwood species in the stand, basal areas and trees per acre may be too high due to their larger canopy sizes.

	Percent Canopy Closure for forest grown Shortleaf Pine Stands																					
	10%		20%		25%		30%		40%		50%		60%		70%		80%		90%		100%	
DBH	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/ac	BA	#/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	178	97	208	113	237	129	267	146	297	162
12	14	11	28	22	35	28	42	33	57	44	71	56	85	67	99	78	113	89	127	100	142	111
14	10	11	21	22	26	27	31	33	41	44	51	55	62	66	72	77	82	88	92	99	103	110
16	9	12	17	24	22	30	26	36	35	49	44	61	52	73	61	85	70	97	78	109	87	122
18	7	12	14	25	17	31	21	37	28	49	35	62	42	74	49	86	56	99	63	111	70	123
20	7	15	14	30	17	37	20	45	27	59	34	74	41	89	48	104	55	119	61	134	68	149
22	6	17	13	34	16	42	19	51	26	68	32	84	38	101	45	118	51	135	58	152	64	169
24	4	14	9	28	11	35	13	42	18	57	22	71	27	85	31	99	36	113	40	127	45	141

⟷ DFCs Range for Pine-Bluestem Woodland (for 16” average stand DBH)

⟷ DFCs Range for Dry SLP-Oak Woodland (for 16” average stand DBH)

⟷ DFCs Range for Dry-Mesic SLP-Oak Woodland (for 16” average stand DBH)

Once the DFCs have been agreed to by the full committee, we can fill out this table for each of the communities to provide guidance to managers.

Forest Variables	Desired Stand Structure	Conditions that may warrant Management	If below desired	If above
Overstory Canopy Closure	30-60 %		Let regenerate	Thin/Burn
Midstory Cover				
Hardwood encroachment				

<u>Emerging issues For the Future (challenges forward)</u>

Tools for private landowners, such as USDA Farm Bill incentives should be added.

Develop commercial pine management blending restoration/economic feasibility.

Effective reforestation/afforestation techniques need to be developed where we have lost shortleaf pine.

Identify and map lands that historically supported SLP (thru GLO, soil maps, and historical records) and no longer do so.

Increase the understanding and sustainability/economic feasibility of unevenaged/evenaged management.

Develop markets for pine products.

I. Definitions

Define difference between savanna/woodland and forest

Open-

Closed-

1. Canopy Cover (%)

   There was some discussion about whether the spacing of trees should be a subcomponent of this variable. Reference was made to possible use of the Gingrich Table, which is a based upon a combination of Basal Area, Diameter, and Density. The document Paul prepared for the group to stimulate discussion suggests in Table A-1, that ranges for Open and Closed Woodlands would be 30-50% and 50-80%, respectively. *Note: everyone agreed that these were variables that helped to quantify whether stands were open enough that the amount of sunlight needed to stimulate regeneration and growth of both pine and understory species would reach the ground.*

2. Basal Area

   The group noted that basal area per se might need to be qualified with a range of desired tree diameters that reflected a balance of age classes within the stands. See the example on page 5, item b, in Paul's document.

3. Midstory

   The area 2 meters or more above the ground, but below the bottom of the canopy. This can be presented as a vertical percent cover or a horizontal percent cover ("as the crow flies" but is still indicative of light penetration thru the stand).

4. Understory (Shrub layer/advanced regeneration layer)

   The percent cover of vegetation 1-2 meters above the ground.

5. Ground layer

   The percent cover of vegetation that is less than 1 meter in height. It includes the grass-forb component (also could be sedge-forb);

6. Disturbance processes

We need to include something (quantitative or qualitative?) with regard to seasonality, intensity, and the means and ranges of fire return intervals. Michael Stambaugh (2001) has made clear that largely SLP dominated natural communities were fire-mediated; thus, fire is critical toward restoring and maintaining most SLP ecosystems.

7. Seral Conditions

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Tom Foti is a retired Plant Community Ecologist and former Chief of Research at the Arkansas Natural Heritage Commission. Tom has published articles on the presettlement and current distribution and character of plant communities in Arkansas, as well as the ecoregions of Arkansas. Tom has a Master's of Science in Botany (Ecology) from the University of Arkansas at Fayetteville and is an emeritus member of the Ecological Society of America and the American Association for the Advancement of Science.

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Mary Lane is the Forest Wildlife Biologist and Terrestrial T&E Program Manager on the Ouachita National Forest in Arkansas. She worked as Natural Resource Specialist on the Black Kettle/McClellan Creek National Grasslands in western Oklahoma for 3 ½ years and Wildlife Biologist on the Mark Twain National Forest in Missouri for 5 years. Prior to this, Mary spent 12 years as district Wildlife Biologist on the Kisatchie National Forest in Louisiana, working with the Red-cockaded Woodpecker and Louisiana pearlshell (both endangered species). Mary has over 25 years with the Forest Service. Mary has a Master of Science in Forest Wildlife Management and Bachelor of Science in Forest Recreation Management from Stephen F. Austin State University in Nacogdoches, Texas.

Paul Nelson was hired as the first Natural Areas Coordinator for the Missouri State Park System in 1978 and is credited with establishing Missouri's Natural Heritage Inventory Program in 1981. From 1980 to 1995 he served as the Chief of Natural History Program where he expanded natural area nominations, initiated Missouri's prescribed burn program in woodlands, savannas and forests, zoned ecological stewardship areas in Missouri state parks, and contracted for the development of major interpretive exhibits for six state park visitor centers, with emphasis on ecological restoration. From 1995 to 2000, Paul was the Operations and Resource Management

Program Director for Missouri State Parks. From 2002 to 2012, Paul served as Forest Ecologist for the Mark Twain National Forest, and as a member of the Forest Planning Team where he was instrumental in incorporating ecosystem restoration into the framework of the revised 2005 Forest Management Plan for the Mark Twain National Forest. He played a major role in coordinating the effort to develop the Collaborative Forest Landscape Restoration Proposal that today provides significant funding for the restoration of over 100,000 acres of shortleaf pine bluestem ecosystems on the Mark Twain National Forest. He also provided technical direction in restoring oak woodland, savanna, glade and prairie ecosystems, conducting rapid assessments of forest lands to prioritize restoration projects, mapped natural communities, worked with the Nature Conservancy to establish a vegetation sampling protocol for over 400 permanent vegetation sampling plots on the Mark Twain. Paul is the author of The Terrestrial Natural Communities of Missouri, a series first published in 1985, with updates in1987, 2005, 2010. He has a B.S. Degree in Wildlife Conservation and Biology from Southwest Missouri State University (1973), and a Master's of Science in Botany from Southern Illinois University-Carbondale.

Bryan Rupar is the Chief of Land Acquisition and Stewardship for the Arkansas Natural Heritage Commission and previously worked for the US Forest Service, and as a consulting forester in southern Arkansas. Bryan currently oversees all property acquisition and land-management projects for the Commission; In addition, Bryan oversees all stewardship and restoration projects for the 60,000 acre System of Natural Areas. Bryan received a Bachelor of Science in natural resource management from Grand Valley State University and a Master's of Science in forest resource management from the University of Arkansas at Monticello.