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A DECISION SUPPORT TOOL FOR LONGLEAF CONSERVATION IN THE EAST GULF COASTAL PLAIN

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INTRODUCTION

The East Gulf Coastal Plain Joint Venture (EGCP) is leading the development of a decision support tool (DST) that will enable strategic conservation of open pine habitats. This DST is intended to guide decisions about where, when, how, and why conservation actions should be undertaken based upon a comprehensive landscape analysis and the application of key conservation biology principles to maximize conservation benefits for birds and other wildlife. Additionally, the fundamental elements of this DST have applicability beyond the EGCP. This DST is stimulating additional collaboration with neighboring Joint Ventures with planning boundaries and bird conservation priorities intrinsically linked to conservation of longleaf pine systems.

EGCP habitat conservation efforts are rooted in the basic assumption that habitat availability, condition, and configuration are principal factors limiting the abundance of birds in the EGCP. Thus, through widespread restoration of pine habitats to more 'natural' open conditions, the EGCP assumes a corresponding increase in numbers of birds associated with open pine ecosystems.

The target audiences for the open pine DST are programs of agencies and non-governmental organizations that either directly fund or deliver on-the-ground restoration programs in pine forests of the EGCP. Because different conservation strategies will be applied to different types of existing landcover, a final component of the DST will involve masking the priority map to only include landcover classes which are relevant to a particular organization and the conservation strategies they intend to pursue.

There is significant financial and human resource potential that can be applied to the conservation of longleaf and other open pine systems. The EGCP is improving the collective capacity of existing programs by providing tools to assist with decision-making that emphasizes priorities and maximizes conservation benefit. In addition, these tools will help build compelling arguments for additional resources by identifying where current capacity is insufficient to deliver the conservation effort necessary to achieve objectives.

Although the technical process of conservation is cyclical and iterative, biological planning activities are often viewed as an integral 'first' step upon which subsequent conservation activities are rooted. Conceptually **biological planning** consists of three

primary elements:

- Defining the ecological context of a particular region of interest, including major threats and limiting factors
- Prioritizing birds and habitat types
- Articulating population objectives and species-habitat relationships

With adequate biological planning, **conservation design** is the next element in developing strategic habitat conservation. Conceptually this step also consists of three primary elements:

- Defining the amount of habitat required to meet the population objectives
- Describing the desired configuration (landscape) of suitable habitat including the patch size for long-term sustainability and the relationship between patches required for connectivity of populations
- Determining where on the landscape these habitats should occur to best support bird population objectives.

Numerical habitat objectives can be calculated from population objectives specific to the EGCP region coupled with an understanding of the explicit habitat requirements of umbrella species for each priority habitat. Utilizing GIS, numerical habitat objectives can be spatially defined and specific areas of the landscape prioritized according to their conservation potential. Throughout this process, assumptions and uncertainties inherent to each data layer and the resultant model are articulated and recorded for future validation.

BIOLOGICAL PLANNING

ECOLOGICAL CONTEXT

Using the processes of biological planning and conservation design, we developed a DST to guide the strategic conservation of habitat towards objectives for bird population size and long-term sustainability in open pine ecosystems within the boundaries of the East Gulf Coastal Plain Joint Venture (EGCP). Open pine systems in the form of longleaf pine flatwoods and uplands once covered nearly 90 million acres in the Southeastern U.S. The EGCP (Figure. 1) was home to a significant portion (27%) of the historic range of longleaf pine (Little et al., 1971). Yet this signature habitat of the EGCP has undergone drastic declines. Alteration of natural fire regimes and widespread conversion to systems dominated by loblolly and slash pine has drastically

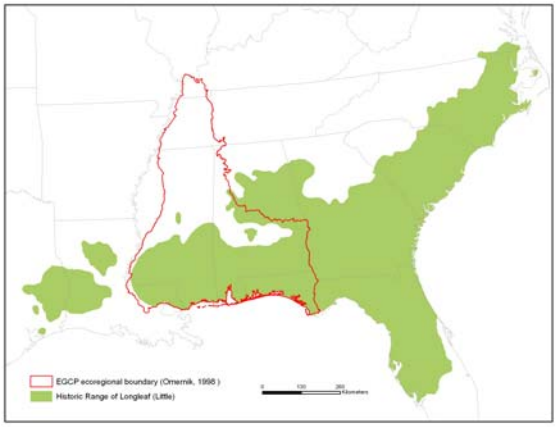

Figure 1. The historic range of longleaf pine (Little 1971) and the East Gulf Coastal Plain Joint Venture planning boundary.

altered many of the original longleaf pine habitats across the region. Today, pine woodlands in a 'natural' condition account for a mere 13.9 % of all pine-dominated forests in the EGCP (McKerrow et al., in prep). This is in stark contrast to a landscape that was once dominated by open, low-density stands of longleaf pine. Despite these changes, the EGCP is home to some of the largest remaining stands of longleaf pine habitat (Prasad and Iverson, 2003), and these ecosystems support a suite of bird species of high conservation concern for the East Gulf Coastal Plain Joint Venture (EGCP).

In the East Gulf Coastal Plain (EGCP), pine-dominated habitats encompass portions of Louisiana, Mississippi, Alabama, and Florida and account for 49.8 percent (or 6,980,152 hectares) of all forest cover (McKerrow et al., *in prep*). Mesic Pine Flatwoods and Savannas, hereafter referred to as Flatwoods, and Pine Uplands and Sandhills, hereafter referred to as Uplands, are the principal natural habitats for much of the lower portion of the EGCP. These are open, fire-dependent forest habitats. Flatwoods are wetter environments and typically occur in areas proximate to the coast. Uplands are drier and occupy from the northern boundary of the historic range of longleaf pine south to the northern extent of the range of Flatwoods (Comer et al., 2003).

Alteration of the natural fire regime, in addition to a widespread conversion from longleaf pine to loblolly and slash pines have drastically altered much of the pine habitat across the EGCP (Mississippi Museum of Natural Science, 2005; Wildlife and Freshwater Fisheries Division, Alabama Department of Conservation and Natural Resources, 2005). According to 2001 landcover data, disturbed pine habitats, including pine plantations and dense stands with closed canopies, account for 86 percent of all pine-dominated forests in the EGCP. Uplands and Flatwoods in a 'natural' condition account for a mere 4.3 and 9.6 percent, respectively, of all pine-dominated forests (McKerrow et al., *in prep*.). Frost (1993) estimates that longleaf forests encompassed over 88 million acres from southeast Virginia to Texas; totaling 52% of all uplands and 36% of the entire southeastern U.S. landscape. This decline has sparked widespread interest in the conservation of what is considered one of the most critically endangered habitats in the U.S. today.

Threats to Natural Habitats

Uplands and Flatwoods are impacted by a similar suite of threats. Alteration of the natural fire regime and forestry practices that significantly alter the composition and structure of both flatwoods and upland habitat types are the dominant drivers in decline of these habitats (Florida Fish and Wildlife Conservation Commission, 2005; Mississippi Museum of Natural Science, 2005; Wildlife and Freshwater Fisheries Division, Alabama Department of Conservation and Natural Resources, 2005).

Fire frequency in Flatwoods and Uplands is naturally high and in pre-Columbian times fire frequency is thought to have ranged from one to eight years (Florida Natural Areas Inventory and Florida Department of Natural Resources, 1990; Wildlife and Freshwater Fisheries Division, Alabama Department of Conservation and Natural Resources, 2005). A combustible leaf litter and grassy understory carried fires important to the flowering and seed and fruit production of understory vegetation (Florida Fish and Wildlife Conservation Commission, 2005; Mississippi Museum of Natural Science, 2005). Without fire, canopy closure increases and a dense growth of hardwoods, shrubs, and vines pervades and the normally diverse native grasses and forbs are shaded out

(Florida Fish and Wildlife Conservation Commission, 2005; Wildlife and Freshwater Fisheries Division, Alabama Department of Conservation and Natural Resources, 2005).

An increase in road density, human dwellings, and lack of public support due to concerns over air quality are impediments to managing pine habitats with fire today. Application of fire management during the dormant season does not effectively control stem proliferation of shrubs and hardwoods relative to growing season fires (Mississippi Museum of Natural Science, 2005).

State Wildlife Conservation Strategies from Louisiana, Mississippi, Alabama and Florida identify the following threats as of significance to the decline of pine Uplands and Flatwoods (Florida Fish and Wildlife Conservation Commission, 2005; Mississippi Museum of Natural Science, 2005; Lester et al., 2005; Wildlife and Freshwater Fisheries Division, Alabama Department of Conservation and Natural Resources, 2005):

- Altered fire regime
- Conversion to pine species other than longleaf
- Intensification of forestry practices (heavy stocking densities)
- Urban and Agricultural expansion
- Altered hydrology due to drainage ditches, raised roadbeds,
- Exotic or invasive species
- Erosion from mechanized vehicle trails

PRIORITIZING BIRDS AND HABITATS

At least 86 species of birds occur in open pine communities; of these, 35 are permanent residents, 29 are only present in nesting season, and 22 are strictly winter residents (Engstrom1993). Partners in Flight proposed a priority list of pine-dependent birds and management recommendations (see Woodrey et al., 1998). From that list, Mississippi Sandhill Crane, Red-cockaded Woodpecker, Brown-headed Nuthatch, and Bachman's Sparrow rank among the highest priority for the EGCP, and are largely sympatric with longleaf pine. Furthermore, these species commonly use a variety of micro-habitats, such as bogs and freshwater marshes, which are interspersed within pine-dominated communities. Other high priority species within the EGCP include Northern Bobwhite, Chuck-Will's-Widow, and Eastern Kingbird, as well as non-breeding species such as Henslow's and LeConte's Sparrows.

High priority bird populations in pine forests are most often limited by the structure and composition of the forest, rather than tract size, although spatial configuration of quality pine forests on the landscape is an important consideration. All pine-dominated communities are adapted to frequent fire for long-term maintenance of habitat quality. Habitat structure and composition is dictated by frequent growing season burns, which maintain the diversity and density of bunch grasses (such as wiregrasses and bluestems), and a predominantly open canopy. Fire suppression and dormant season fires were emphasized in forest management during much of the 20th Century (see Croker, 1987; Frost, 1993), and has resulted in a decline in grasses and forbs, and an increase in saw palmetto, gallberry, and bracken fern; this ground vegetation results in a reduction of habitat quality for most high priority bird species.

Spatial configuration of pine-dominated communities on the southeastern landscape also plays an important role in sustaining desired levels of priority bird distribution and densities. Although at least 50,000 ha of longleaf pine is recommended at each of six different areas in the Red-cockaded Woodpecker Recovery Plan (U.S. Fish and Wildlife Service, 2003), a minimum forest patch size and the importance of connectivity between patches is not currently known for most priority species of birds. An overarching acreage goal, proposed by Partners in Flight, is to establish at least 2.5 million ha of at least five-year old longleaf stands by the year 2025 (Woodrey et al.,1998).

For most of the highest priority species, highest densities consistently occur in high quality longleaf pine forest; however, mature, open stands of loblolly and shortleaf pine also provide a stable habitat. Throughout the historic range of longleaf pine, many pine-dominated communities have been converted from longleaf to loblolly or other pine species either intentionally for logging, lack of fire, or lack of effective management after logging.

Through targeted conservation of open pine ecosystems, the EGCP intends to ensure the sustainability of all priority birds that are dependent on these systems. However, the specific habitat requirements of all species cannot be comprehensively incorporated into a DST. Thus, a subset of species determined to appropriately represent the full range of avian habitat niches within open pine systems were selected as umbrella species (Roberge and Angelstam, 2004).

Umbrella species (Table 1) will represent the habitat needs of a broader suite of birds that together comprise the full range of avian habitat niches within a particular ecosystem. The EGCP will use these species to set population goals, define habitat relationships, and further inform the conservation design process for individual habitats. The EGCP uses the following definition in its selection of umbrella species (Roberge and Angelstam, 2004):

> "An umbrella species is defined as a species whose conservation is expected to confer protection to a large number of naturally co-occurring species….This concept has been proposed as a tool for determining the minimum size for conservation areas, selecting sites to be included in the reserve networks, and setting minimum standards for the composition, structure, and processes of ecosystems. What qualities should a 'dream team' of focal species possess to be a dependable tool of biodiversity assessment and conservation planning?.... For each landscape type, the most sensitive group of species in terms of resources, area requirements, connectivity, and natural processes (e.g. fire and flooding regimes) should be selected."

Table 1. Umbrella species selected for open pine ecosystems and characteristic habitat requirements in the East Gulf Coastal Plain.

Habitat Attribute	Bachman's sparrow	Blue grosbeak	Brown-headed nuthatch	Chuck-will's-widow	Henslow's sparrow	Northern bobwhite	Red-cockaded woodpecker	SE American Kestrel
Low % Canopy Cover[1]		X			X	X		
Diverse and Herbaceous Understory[2]	X					X		

Table 1. Umbrella species selected for open pine ecosystems and characteristic habitat requirements in the East Gulf Coastal Plain.

Habitat Attribute	Bachman's sparrow	Blue grosbeak	Brown-headed nuthatch	Chuck-will's-widow	Henslow's sparrow	Northern bobwhite	Red-cockaded woodpecker	SE American Kestrel
Low Basal Area/ Tree Density[3]		X			X	X		
Significant component of old trees[4]			X				X	X
Presence of Dead Trees[5]			X				X	X
Large Patch Size[6]							X	X
High Fire Frequency[7]					X			
Growing Season Fire[8]								
Presence of Bare Ground				X				

[1]low <10 to 30%; high = >50%

[2]Understory is dominated by forbs, herbs, and grasses. Few woody shrubs; little hardwood or pine regeneration.

[3]Basal area below 50 square feet per acre is pretty good (one 14" dbh tree = 1 sq. ft. BA) (i.e., 50-14" dbh trees on one acre = 50 BAA). Again, tree spacing or density may be a better measure because 80 BA of 22" dbh trees is reasonably open with 30 stems/acre approximately 38 feet apart. 80 BAA of 6" dbh trees is something altogether different with 408 trees per acre spaced 10 feet apart.

[4]On average, 6-10 trees per acre greater than 80 years old.

[5]1-2 per acre across a stand should be sufficient. Some larger areas of bug or fire killed trees would be nice in a larger
landscape context.

[6]5000 acres of contiguous upland pine habitat is necessary for a viable population of Red-cockaded woodpeckers.

[7]1 yr= too high; 2 to 4 years = high frequency; interval of fire ranges between 1 and 4 years with an average between 2 and 3

[8]15 March through 30 September.

ARTICULATING POPULATION OBJECTIVES AND SPECIES-HABITAT RELATIONSHIPS

Population Objectives

Population objectives and progress towards them are critical to SHC. We started with continental population objectives identified by Partners-in-Flight for each of the priority species (Rich et al. 2004). We then determined the portion of the population expected to occur within

the boundary to scale the objective to the EGCP area. For birds that breed within the EGCP, we used the ratio of population density within the EGCP to the total population density to estimate the proportion of the population within the EGCP based on data from The North American Breeding Bird Survey (BBS). BBS estimates density as the mean number of birds expected on a typical 25-mi BBS route. This value is calculated for each species in each cell of an approximately 25km^2 grid covering North America. We summed the density across the cells intersecting the EGCP and divided by the total of the density estimates for the entire range of each species. This portion was multiplied by the continental objective for the species to obtain the population objective (Table 2). Population objectives for Henslow's sparrow were derived in a slightly different manner. This species does not breed in the EGCP so BBS would not be informative. Instead, we estimated the proportion of the Southeastern Coastal Plain Bird Conservation Region (BCR 27) covered by the EGCP. This proportion was applied to the BCR population objective to yield the EGCP population objective.

Table 2. Continental population estimates and objectives, proportion of breeding population with the East Gulf Coastal Plain planning boundary (EGCP), and the EGCP population objectives for umbrella species in open pine ecosystems.

Species	Continental estimate[1]	Continental Population Objective[2]	Percentage of BBS density within the EGCP	EGCP Population Objective
Bachman's sparrow	300,000	increase 100%	28%	168,000
Blue grosbeak	6,100,000		9.50%	maintain
Brown-headed nuthatch	1,500,000	increase 50%	16%	360,000
Chuck-will's-widow	15,000,000	maintain	10%	1,500,000
Henslow's sparrow	80,000	increase 100%		maintain
Northern bobwhite		58,857,000[3]	7.40%	4,355,418
Red-cockaded woodpecker				2150 groups[4]
SE American Kestrel	4,300,000		0.50%	maintain

[1] PIF database estimates (http://www.rmbo.org/pif_db/laped/default.aspx). Estimate is number of individuals.

[2] PIF plan (**Rich et al. 2004**).

[3]Continental population objective (NBCI 2000 – Dimmick et al. 2002)

[4] Species recovery plan (U.S. Fish and Wildlife Service 2003.).

In addition to well-documented assumptions of the BBS estimates of breeding bird density and trends (O'Connor et al. 2000, Link and Sauer 1994). Our methodology assumes EGCP-level analyses are an appropriate scale for subsetting BBS data, and perhaps more importantly that the **current distribution reflects the desired distribution of the population.** Furthermore,

our method for determining population objectives for Henslow's Sparrow assumes that the desired wintering distribution is a **uniform (constant) density across the BCR**.

Defining and Mapping Species-habitat Relationships

We used the habitat relationship models developed for the Southeast Regional Gap Analysis Project (SEGAP) to determine where potential habitat existed for each species (McKerrow et al. in prep). These models are based upon species-specific habitat requirements that were determined by literature review and expert opinion (Table 3). The habitat requirements were reduced to those that could be mapped at landscape scales, such as landcover, hydrology, distance to water, road density, elevation, and slope. Spatial queries of the resulting GIS were used to map the potential habitat within the known range of each species at 30m resolution for the entire southeastern United States. Appendix 1 describes each GAP species model in greater detail and lists the literature that was reviewed during model development.

The range maps used to limit species' distributions were derived from published sources and reviewed by regional experts. The landcover map developed by SEGAP is a classification of Landsat Thematic Mapper™ data and the classification scheme was developed using NatureServe's™ Ecological Systems®. The portion corresponding to nearly the entire ECGP was classified and assessed for accuracy by staff members at the Alabama Cooperative Fish and Wildlife Research Unit (Kleiner 2007; Kleiner et. al 2007). The remaining portion of the EGCP in Tennessee and Kentucky was classified by the Biological and Spatial Information Center (BASIC) at North Carolina State University and the portion of the JV's administrative boundary falling within the Piedmont was classified by Natural Resources Spatial Analysis Laboratory (NARSAL) at the University of Georgia. In the JV's administrative boundary there are 101 classes, 80 of which are Ecological Systems® and their modifications. Appendix 2 lists the map units of EGCP and Piedmont subsection and includes a crosswalk to the map units described below.

In addition to landcover, GAP models used the following inputs to model potential habitat: Landcover metrics (patch, edge, forest interior), Hydrography (stream type, stream flow, and salinity), road density/urban avoidance, elevation, and landform.

Table 3. Landcover units and ancillary variables used in the SEGAP habitat models for the EGCP priority species.

Species	Landcover[1]	Contiguous[2]	Elevation[3]	Urban avoid[4]	Buffer[5]
Bachman's sparrow	Successional, longleaf pine, prairie, pine flatwoods	3 ha			
Blue grosbeak	Pasture, successional, developed open space, hardwood forest		< 853 m		forest int > 250
Brown-headed nuthatch	All pine and mixed forest except plantation		< 762 m		
Chuck-will's-widow	Pasture, successional, developed open space, low intensity developed, hardwood, pine, mixed.		< 518 m		open < 500m forest

Table 3. Landcover units and ancillary variables used in the SEGAP habitat models for the EGCP priority species.

Species	Landcover[1]	Contiguous[2]	Elevation[3]	Urban avoid[4]	Buffer[5]
Henslow's sparrow[6]	Longleaf pine, successional, herbaceous, pine flatwoods				
Northern bobwhite	Pasture, successional, developed open space, all pine forest except plantation, prairie	8 ha	<975 m	medium	
Red-cockaded woodpecker	All pine except plantations	40 ha			
Southeastern American Kestrel	Pasture, successional, developed open space, low intensity developed, swamp, bottomland forest, montane forest, longleaf pine forest	13 ha			

[1]See Appendix 2 for a list of the Ecological Systems and a crosswalk to these landcover types.

[2]Contiguous is derived from landcover and is the minimum size (i.e., the territory size) of contiguous suitable landcover types required by the species.

[3]Mapped using National Elevation Data (USGS 2006) at 30m resolution and used to determine where potential habitat exists.

[4]Urban Avoid is a buffer of urban areas (including roads), with the levels corresponding to increasingly larger buffer distances. In the case of bobwhite, it was used to include herbaceous roadsides as potential habitat.

[5]Buffering was used as a modeling tool both for species utilizing edge and those requiring core areas. For blue grosbeak, only forested areas greater than 250 meters from an edge were included as habitat. For Chuck-will's widow, any open areas within 500 meters of forest habitat were included.

[6]Not a GAP model because this species does not breed within the range of longleaf in the EGCP. These landcover classes were identified as wintering habitat from the literature.

CONSERVATION DESIGN

Having defined the ecological context of the open pine systems, identified priority birds and described their habitats, and developed population objectives and the species-habitat relationships, we proceed with the elements of conservation design that culminate in the DST illustrating where we can achieve the desired landscape condition. The first step in doing so is to determine the habitat objectives for the priority birds in the EGCP. Having determined the habitat objective without regard to the arrangement of habitats on the landscape, it is necessary to describe the desired configuration of habitat to achieve the population objective as well as goals for sustainability of populations. The final step is then to determine where in the existing landscape we can achieve those objectives through implementation of the conservation design and the identification of focal areas, which if restored should provide sustainable populations of the priority species and their associated flora and fauna.

HABITAT REQUIRED TO MEET POPULATION OBJECTIVES

Sustainable Populations

In this element of conservation design, our objective was to determine the acreage of suitable habitat required to sustain populations of our priority species at or above the objective levels. Conservation theory tells us that to be sustainable a population must be persistent. For the purposes of this exercise we defined a population as a group of animals of the same species living in one relatively contiguous area block of suitable habitat. We defined contiguity as being within the estimated average dispersal distance of that animal. Populations of many species of concern are declining in abundance, therefore given a stable environment they will inevitably become extinct; stochastic environments make extinction less certain, but frequently more likely. Further, even for populations that are stable or increasing the possibility exists that some sequence of events leads to their demise; particularly if annual fluctuations in population size are large. Additionally, populations in stochastic environments have lower average annual growth rates, which contribute to the likelihood of their extinction. Theory also tells us that if populations become too small (defined as quasi-extinction) they may decline even more rapidly thus extinction becomes inevitable, due to Allee effects (Allee 1931). Populations that fall below this quasi-extinction threshold are for all practical purposes extinct. However, island biogeography and metapopulation theory suggests that if populations are not closed to the processes of emigration and immigration and local extinctions occur, a species may re-colonize suitable habitat (MacArthur and Wilson 1967; Hanski 1999). The probability of colonization is directly related to dispersal distance, but inversely related to the distance from source populations. The nature of this relationship depends upon species-specific behavior and dispersal capabilities, and could be irrelevant for [many migratory] species that do not demonstrate strong site fidelity or natal philopatry.

Table 4. Population trend (average percent annual change), standard error, and minimum viable population size (MVP) for priority species inhabiting open pine systems in the East Gulf Coastal Plain.

Species	Trend	SE	MVP estimate
Bachman's sparrow			
Blue grosbeak			
Brown-headed nuthatch			
Chuck-will's-widow			
Henslow's sparrow			
Northern bobwhite			
Red-cockaded woodpecker			
SE American Kestrel			

[1]Trend data from North American Breeding Bird Survey.

[2] MVP – minimum population size with >95% chance of remaining above 25 individuals (quasi-extinction) over a 50-year time period.

For our purposes, we define a sustainable population as one large enough to have a relatively low probability of quasiextinction over a relatively long time period in the absence of immigration and emigration. Using the concept of minimum viable population size (MVP) from conservation theory, we define a sustainable population as one large enough to have a 95% chance of remaining above 25 individuals (quasi-extinction) over a 50-year time period (**Table 4**).

Desired Patch Size and Number of Patches

We used the above-described maps of existing habitat to determine where putative self-sustaining or source populations already existed. These were expected to occur where patches of contiguous potential habitat were large enough to contain a sustainable population of a priority species. We estimated the size of these patches based on the product of either the mean territory size, or mean density of each species and the functional group size of the population for territorial breeding birds (e.g., Bachman's Sparrow) this was one pair, for Red-cockaded Woodpeckers this was mean group size, and for Northern Bobwhites this was breeding density (Table 5). Using Red-cockaded Woodpecker as an example [these are not the values used in our analysis], with a mean group size of 4.5 birds and an average territory of 500 ha, and if MVP is 250 birds then the desired minimum patch size is:

$$\text{Patch} = (250/4.5)*500 = 250{,}000\text{ha}.$$

This approach assumes that territory size and density are interchangeable and that an average density figure can be applied across the landscape to determine the total habitat objective even though density varies among habitats within that landscape.

Table 5. Density estimates for priority species used in species modeling.

Species	Density Estimate (ha/breeding pair)	Type of Estimate[1]	Literature Source
Bachman's sparrow	3	home range	Stober and Krementz, 2006
Blue grosbeak	17	allometric equation	Ingold 1993[2]
Brown-headed nuthatch	2.8	breeding territory	Withgott and Smith 1998
Chuck-will's-widow	217	allometric equation	Rohwer and Butler 1977[2]
Henslow's sparrow	0.3	home range	Bechtoldt and Stouffer, 2005
Northern bobwhite	20	breeding territory	Parnell et al. 2001
Red-cockaded woodpecker			
SE American Kestrel			

We determined the desired number of populations (patches) also based on extinction risk. We arbitrarily set acceptable extinction risk at 0.05 (1-0.95) over a 50-year period. In a similarly arbitrary way, we set the acceptable risk of species extinction at less than 1e-6 (one in one million). If we assume independence of extinction risk among the subpopulations (patches),

then at least 5 ($\ln(1e\text{-}6)/\ln(0.05)$) populations are required. Aside from using 0.05 as the accepted extinction risk for each subpopulation, the assumption that these populations function independently is an important one. The degree to which the environments that influence subpopulations are shared compromises their independence. For example, weather patterns and catastrophic events are more likely to compromise this independence for subpopulations as a function of the distance among them. Certainly for migratory birds breeding subpopulations that share wintering areas are not going to have unrelated population processes.

Assumptions

- All potential habitat can and will be restored to suitable habitat within a patch
- Not all suitable habitat will be longleaf
- Average density (territory-size) requirements apply within the potential habitats
- As it relates to extinction risk at the JV level, environmental factors affecting subpopulations are not correlated
- No connectivity among subpopulations.

WHERE CAN WE BEST SUPPORT BIRD POPULATION OBJECTIVES?

The goal of this section is to develop a spatially explicit model and map of ***conservation priority*** under the assumption that areas assigned the highest priority are likely to provide the greatest contribution to the conservation objectives and should be the target of conservation delivery. The above-described elements of biological planning and conservation design provide us with a list of priority bird species, population objectives, habitat requirements, patch size, and number of patches along with a list of verifiable assumptions associated with them. The next step in developing a DST is to provide a spatially explicit model of where we can expect to be most effective with conservation delivery. That is, how we can most efficiently meet the desired landscape conditions to ensure sustainable populations of priority birds at or above the desired levels set in the population objectives. This approach often assigns the highest priority to lands that already meet the conservation objectives. Our intent is to identify those areas and make their maintenance in desired conditions the highest priority for conservation delivery, and to use them as sources for building larger, more secure habitat base for the priority species.

Density – Integrating patch size with proximity [Still working on this section]

Once we described derived the spatial data that best described the criteria related to each of the desired landscape objectives, we were challenged with the best use of that information in modeling conservation priority. Reaching back to paradigms related to habitat fragmentation, connectivity, and MVP, it became apparent that if conservation delivery were focused in areas that offered or had the potential to offer large contiguous blocks of potential habitat and areas that were potential connected to suitable habitat we could minimize the area required to meet the population objectives.

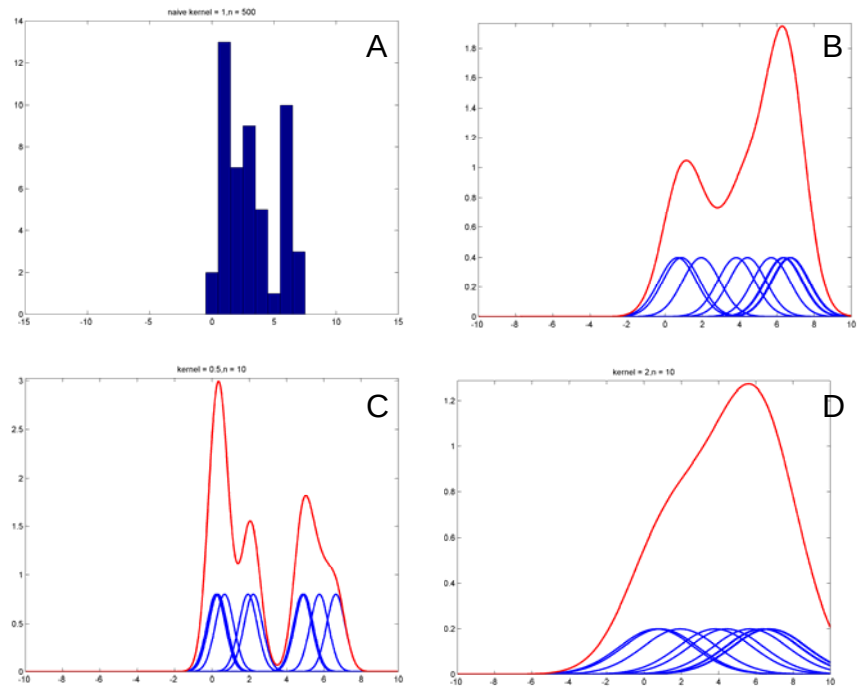

Figure 2. The effect of kernel size on density mapping of points following a bimodal distribution along a number line. A – naïve estimator (histogram), B – Density based on normal kernel, C – Density based on small normal kernel, and D – Density based on larger normal kernel.

For example, if we want to maintain and create large patches of longleaf pine, the highest priority should be given to maintaining the existing large patches and lower priority given to maintaining smaller patches. While patch size is an important criterion for prioritizing existing open pine sites for conservation or management purposes, it does not allow us to prioritize areas that are adjacent to existing open pine sites.

Proximity to existing open pine is a very useful criterion by which to rank sites that are not currently in open pine, but distance alone does not indicate the relative importance of the open pine itself. When selecting sites for restoration, we would like to assign the highest priority to sites that are nearest the largest patches of existing open pine, and that priority should be higher yet for sites that present the opportunity to connect existing patches.

It should be apparent that neither patch size nor proximity by themselves adequately that the size and proximity to existing open pine woodlands is and important criteria for prioritizing our conservation efforts, but a metric that incorporated patch size and proximity of existing open pine would provide a very good measure of conservation priority for conserving, creating, and managing large open pine forests. What we need is measure of the density of existing open pines sites.

The best way to illustrate this concept is to use an analogy to the distribution of points along a number line (Figure 2). A histogram representing the number of points in each segment along the line represents a simple estimate of density. Increasing the bin size for the histogram smoothes the results and the choice of bin size is completely arbitrary. Similarly a kernel density estimator based on a normal kernel places a normal distribution with a fixed "bin size" (bandwidth or kernel) at each point and sums the area under the overlapping curves to provide a smoothed estimate of density along the line (Silverman 1986). If we extend this to two dimensions (x and y or east and north) we can map the density of points meeting some criteria in 2-dimensional space. This measure of density represented by the red line in Figure 2 provides a single measure of both proximity and clustering of the data.

THE SIX QUESTIONS

1. Where is the existing open pine?

We framed this problem as a series of six questions that could be translated into characteristics of the desired landscape. Those questions may be better described as the objectives of the conservation design. Those questions included identifying 1) where open pine systems exist or 2) have recently been restored or planted, 3) determining where it would be appropriate and desirable to restore longleaf pine systems, 4) mapping where long-term conservation and 5) the use of fire as a management tool is likely to occur, and finally 6) where restoration efforts will contribute most to meeting our objectives related to sustainable bird populations. These layers are combined to develop a single map of conservation priority for each priority species that can be used to identify focal areas that meet the habitat objectives for strategic habitat conservation.

An important data layer in this analysis is the current distribution of longleaf pine (Figure 3). One potential source for this is the USDA Forest Service's Forest Inventory and Analysis (FIA) data. The FIA program is designed to generate reliable and regularly updated estimates of the standing stock of forest resources throughout the conterminous US (Gillespie 1999). This is accomplished by systematically collecting stand data at random locations and extrapolating this data up to larger areas. One of the many things FIA publishes is a species specific importance value extrapolated to a 25 km grid (Prasad and Iverson 2003). However, sampling points in FIA's scheme are not sufficiently dense to provide these estimates at small spatial scales with reasonable confidence (Alerich et al. 2005).

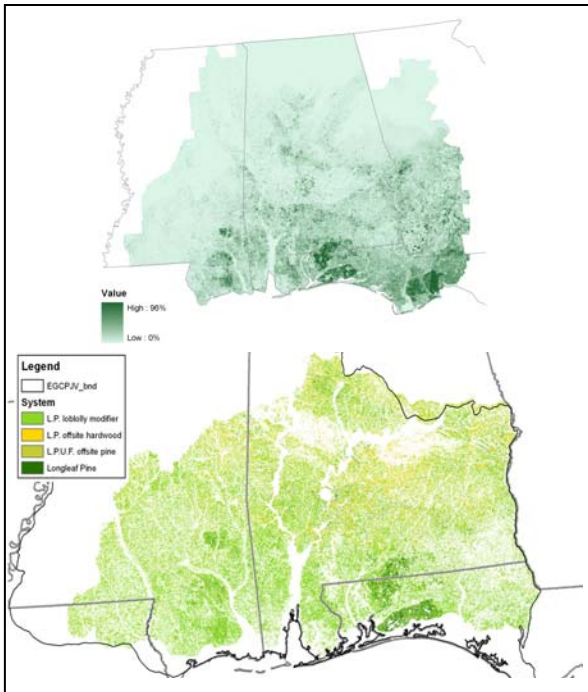

Figure 3. Map of probability of longleaf occurrence (Hogland 1995)(Top). Longleaf dominated systems, excluding coastal flatwoods, mapped by the Southeast Regional Gap Analysis Project.

Another map depicting the current distribution of longleaf pine was created by John Hogland, a graduate student at Auburn University. Hogland (2005) created a fine scale (30 meter) map, using Landsat ETM™ satellite imagery and an extensive field dataset. This dataset was collected as part of the AL-GAP project and contained approximately 1700 training sites. Data was collected exclusively on

national and state forests and military installations, as these are the only locations which are both accessible and reliably have longleaf. A polytomous logistic regression model was created predicting the probability of longleaf occurrence as a function of the spectral reflectance as recorded in the satellite image. This model was then applied to the entire satellite image to produce the probability map. Initial accuracy assessment indicates that this map is largely mapping open pine, not exclusively longleaf. Probabilities are also lower in Mississippi, relative to areas in Alabama and Florida, where a greater percentage of sample points were collected. We also think it likely that the concentration of training data on public lands has biased what is mapped on private land. The Alabama Cooperative Fish and Wildlife Research Unit is currently working to improve this longleaf classification.

The Hogland model of longleaf pine was not used directly in our modeling process. However, the longleaf pine model is included in the landcover map of the recent Southeast Gap Analysis Project's landcover map within the East Gulf Coastal Plain. The Hogland model was incorporated as follows: first, a post hoc maximum likelihood classification was created from the longleaf probability layer and other forest ecosystem probability layers created in Hogland's work. Then, pixels in the GAP landcover which were mapped as pine forest (excluding pine plantation) or grasslands were remapped to longleaf if longleaf was the maximum likelihood probability for that pixel. This final landcover map is the basis for the potential habitat models, an output of the gap analysis. The spatial maps of the species habitat models were the initial maps used for the umbrella species habitat and population modeling.

Additionally, the longleaf map could serve as a basis for an evaluation of the focal area models. The amount of longleaf habitat in each focal area could be measured and this could be a measure of the extent to which the focal area was meeting the objective of being near existing longleaf.

2. Where has longleaf recently been restored or planted?

The location of young stands of recently afforested longleaf pine are integral to a comprehensive understanding of where mature open pine habitats- assuming continued proper management- are anticipated to occur in the future. This information is particularly important for its influence on which areas of the landscape should be of high priority for conservation efforts. However, young longleaf pine trees ($\leq$ 15 years) are spectrally similar to shrub-scrub and other grassland habitats. This includes longleaf that has been planted as part of multiple restoration programs across the EGCP. Thus, remote sensing technologies cannot currently be used to obtain this information. Instead, the data must be obtained from the individual programs and partners who have either funded or facilitated on-the-ground restoration of longleaf in the past 15 years.

The accumulation of this information into a spatially-explicit database is an effort that could ultimately evolve into a tracking database to monitor where longleaf is restored on the EGCP landscape and beyond. This information will support the iterative refinement of the DST over time. Without a complete understanding of recent restoration efforts, this DST could mistakenly identify areas as high priority for conservation that have already been recently restored

3. Where is it ecologically appropriate to restore and plant longleaf?

In addressing this objective we were attempting to prioritize areas based on the density of sites that were within the historic range, potentially suitable for or could potentially be restored as functional longleaf or open pine systems. Thus, it was important to first identify areas that

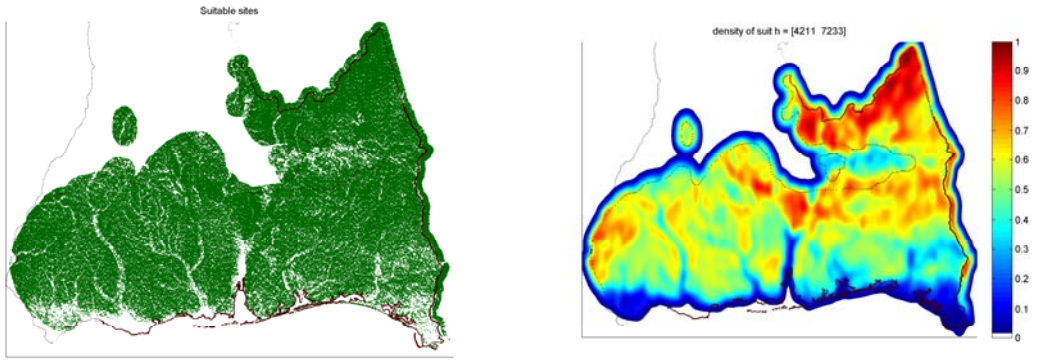

Figure 4. Suitable sites for longleaf management and conservation (left), and their density within the range of longleaf in the East Gulf Coastal Plain Joint Venture planning area.

historically would have been dominated by longleaf. This is important because we do not want to promote the establishment of longleaf in areas where it is less likely that it will grow well or be managed as a functional open pine ecosystem or displace other systems on appropriate sites.

At the coarsest level we limited the selection of suitable sites using the historic range limit of longleaf pine. Little's (1971) Atlas of United States Trees is the most widely used source for tree species range maps. Little generated these maps used Forest Inventory and Analysis (FIA) data, and it is important to realize that these lines are not absolute.

Within the range of longleaf, we eliminated sites based on landform, a digital elevation model (DEM) derivative that integrates slope and landscape position. Riparian corridors are identified from the landform categories and are designated 'not historically longleaf'. A drawback to this approach is that accurate landform identification is dependant upon some minimal amount of topographic relief on the landscape. But as one approaches the coast, the topography flattens out and there is a corresponding degradation in the quality of the landform model. For this reason we are also pursuing the inclusion of soils data into a historic longleaf model and will include that in the future.

In addition to landform and Little's historic range map, areas that were identified as either water or urban (other than open space urban) in the NLCD 2001 (USGS 2001) landcover map were excluded as these are highly unlikely to ever be restored back to longleaf pine.

The resulting map (Figure 4) illustrates **suitable** sites where longleaf might have occurred and where it could potentially be restored within the study area boundary based on longleaf range, and the elimination of bottoms, flooded sites, and developed areas. We mapped the density of these sites using a kernel density estimator with a kernel size calculated using the **normal scale rule**. The map thus reflects the density of suitable sites with relatively little smoothing. The suitability density layer is incorporated into the modeling process in the priority function. It is a limiting (multiplicative) factor in this function because the goal is to restrict longleaf restoration to sites that were historically longleaf and currently are of a landcover deemed suitable for restoration or other conservation actions.

4. WHERE CAN OPEN PINE SYSTEMS BE MANAGED (WITH FIRE)?

In this section, our objective was to prioritize areas where the use of fire as a management tool would not be limited. Historically, natural fires were a dominant factor shaping the structure and function of longleaf ecosystems. When fire is suppressed in these systems, hardwoods and shrubs become established which reduces herbaceous and grass diversity and eventually leads to hardwood stand replacement. Although grazing and herbicides can slow this succession, fire has proven to be the only management technique capable of fully maintaining ecosystem integrity. Thus, the ability to regularly manage with fire is a crucial component in deciding where open pine systems can be maintained and restored.

However, managing with fire can be problematic, primarily because of smoke. If it does not disperse sufficiently, smoke can be an annoyance, a health hazard, and a driving hazard. In many instances concern over human safety due to the smoke from fire has inhibited land managers from burning on a schedule which they would otherwise prefer. Although there is active research on modeling smoke dispersal, it is very site and condition specific. Therefore, we took a much simpler route based on the assumption that the density of urban areas was inversely related to the ability to use fire as a management tool.

We recognize that this is a very simplistic approach to identifying fire management potential. Two areas that will likely be pursued in future iterations are high priority areas and wind/topography. Hospitals, schools, bridges, airports, and other places where smoke is definitely prohibited can be identified and incorporated. Predominant wind direction in combination with large scale topography can also be included.

We mapped the density of urban areas using data extracted from the 2001 NLCD (USGS 2001) (Figure 5). We used a binary map of urban areas and estimated density using a kernel density estimator with a normal kernel and a bandwidth of 10,000. We subtracted the resulting estimates of density from 1.0 to produce the inverse of urban density. The result was a map that assigned highest values to areas with the greatest density of undeveloped sites.

Other factors which potentially could be added include attainment areas, urban growth, and local policies. Attainment areas are counties (?) that the EPA has identified as currently having relatively poor air quality. These are counties which typically include large urban areas. The

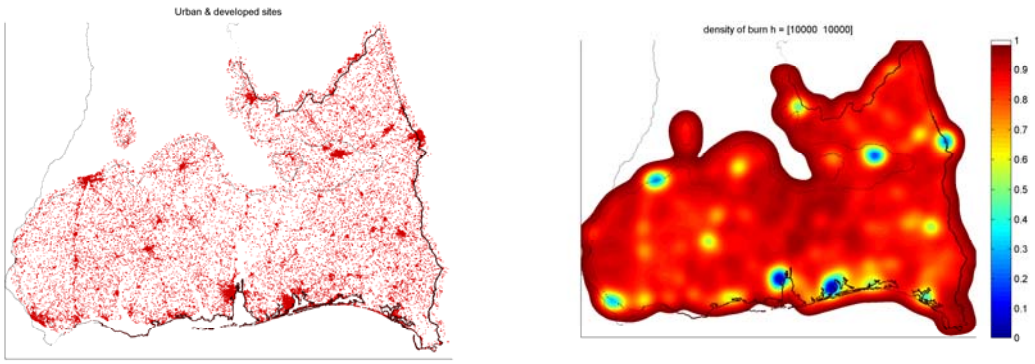

Figure 5. Urban sites based on NLCD 2001 (left) and the density of undeveloped areas (right) within the range of longleaf in the East Gulf Coastal Plain Joint Venture planning area.

county is required by the EPA to keep concentrations of pollutants below set levels and these counties are fined on days that minimum standards are not met (?). Urban growth is also a factor that could significantly impact the ability to manage with fire. A location that is easily burned today because it is rural may be more difficult to burn in the future when the surrounding area has urbanized. Finally, local policies and opinions can affect the ability to burn. When there is strong local opposition to any burning this reduces the likelihood of burning sufficiently in the long term.

The choice of both kernel size and kernel shape for fire management is perhaps the most interesting of all the data layers. Here motivation is primarily as follows: We want a large value for our kernel density estimate in relatively dense urban areas, and we want large density estimates along major roads and interstates, even in rural areas. There are two ways of dealing with this. First, we could more heavily weight large roads, in the input layer. A second approach would be to change the function or shape within the kernel so that a very large weight is given to pixels in the center of the kernel, there is a rapid decay, and then the weight levels off for a large distance (a function which asymptotes to both axes). The choice of kernel size should depend on how far from an urban area one must be before there is no effect on the

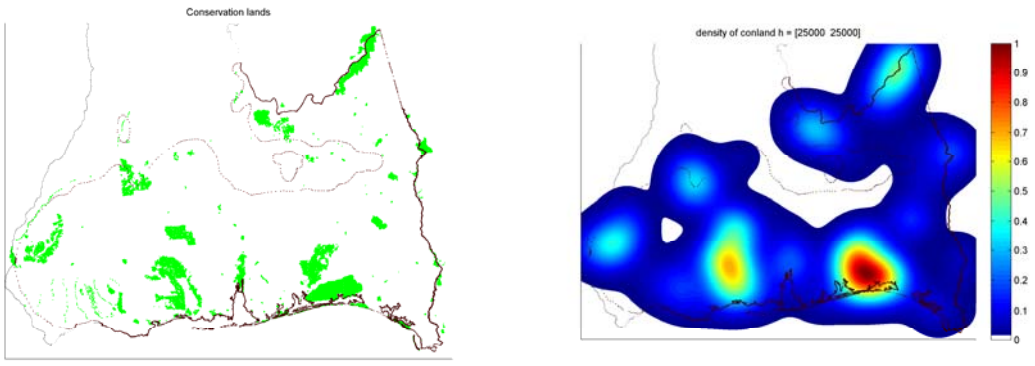

Figure 6. Conservation lands and their density within the range of longleaf in the East Gulf Coastal Plain Joint Venture planning area..

ability to burn.

5. WHERE CAN OPEN PINE SYSTEMS BE MAINTAINED FOR THE LONG-TERM?

Another objective of the DST was to prioritize areas in or near the largest tracts of land that could be managed for long-term conservation of bird populations. This objective is compatible with the goal of sustainable bird populations at or above the EGCP targets. Thus, we used the SEGAP stewardship data, the most recent database of conservation stewardship for the region. We extracted public conservation lands, nature preserves, permanent easements included in the SEGAP database that indicated a mandate for long-term conservation of any type. While this data is relatively current, it does not include many private conservation lands, including those in easements. In calculating the density of these sites, we subjectively chose a large normal kernel (25,000) because we wanted to assign higher priority to areas with the potential to improve connectivity of even widely separated areas that were in long-term conservation (Figure 6).

6. WHERE DOES POTENTIAL HABITAT FOR PRIORITY SPECIES EXIST?

This objective was included to ensure that conservation and restoration efforts would take place in proximity to larger tracts of habitat for the priority bird species. Under the assumption that the SEGAP animal distribution layers provide useful information with regard to the distribution of sites that are or could be suitable for the priority species, we used the density of sites classified as potential habitat for each species to prioritize areas for conservation and management of open pine systems. We mapped the density of these sites using a kernel density estimator with a kernel size calculated using the **normal scale rule** (Figure 7). The map thus reflects the density of suitable sites with relatively little smoothing. These densities were used in

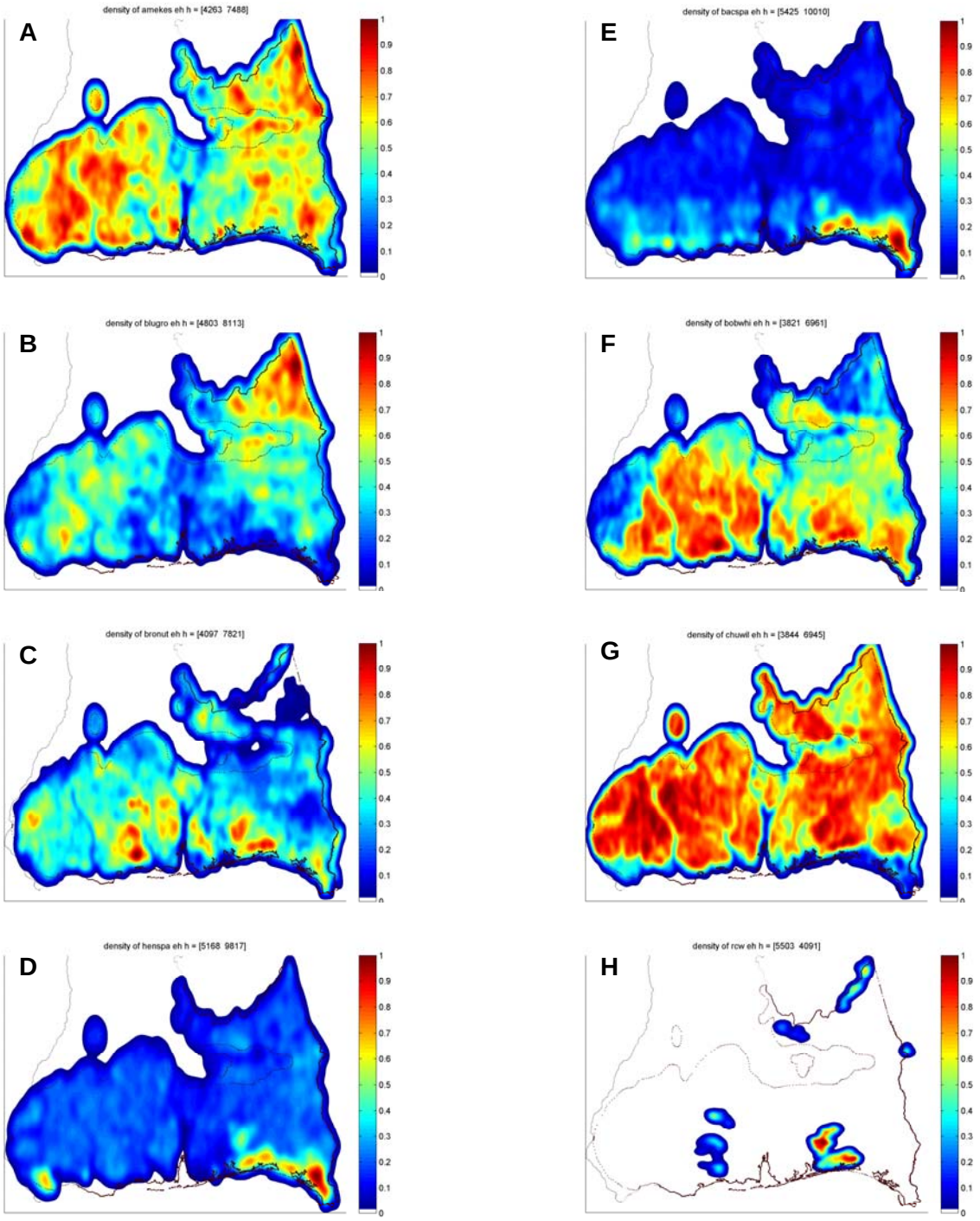

Figure 7. Density of potential habitat mapped by SEGAP with the range of longleaf pine for priority species inhabiting open pine systems in the East Gulf Coastal Plan Joint Venture Area. A – ameke-American kestrel, B – bacspa, Bachman's sparrow, C – bluegro-blue grosbeak, D – bobwhi, northern bobwhite, E – bronut-brown-headed nuthatch, F – chuwil, chuck will's widow, G – henspa, Henslow's sparrow, and H – rcw, Red-cockaded woodpecker.

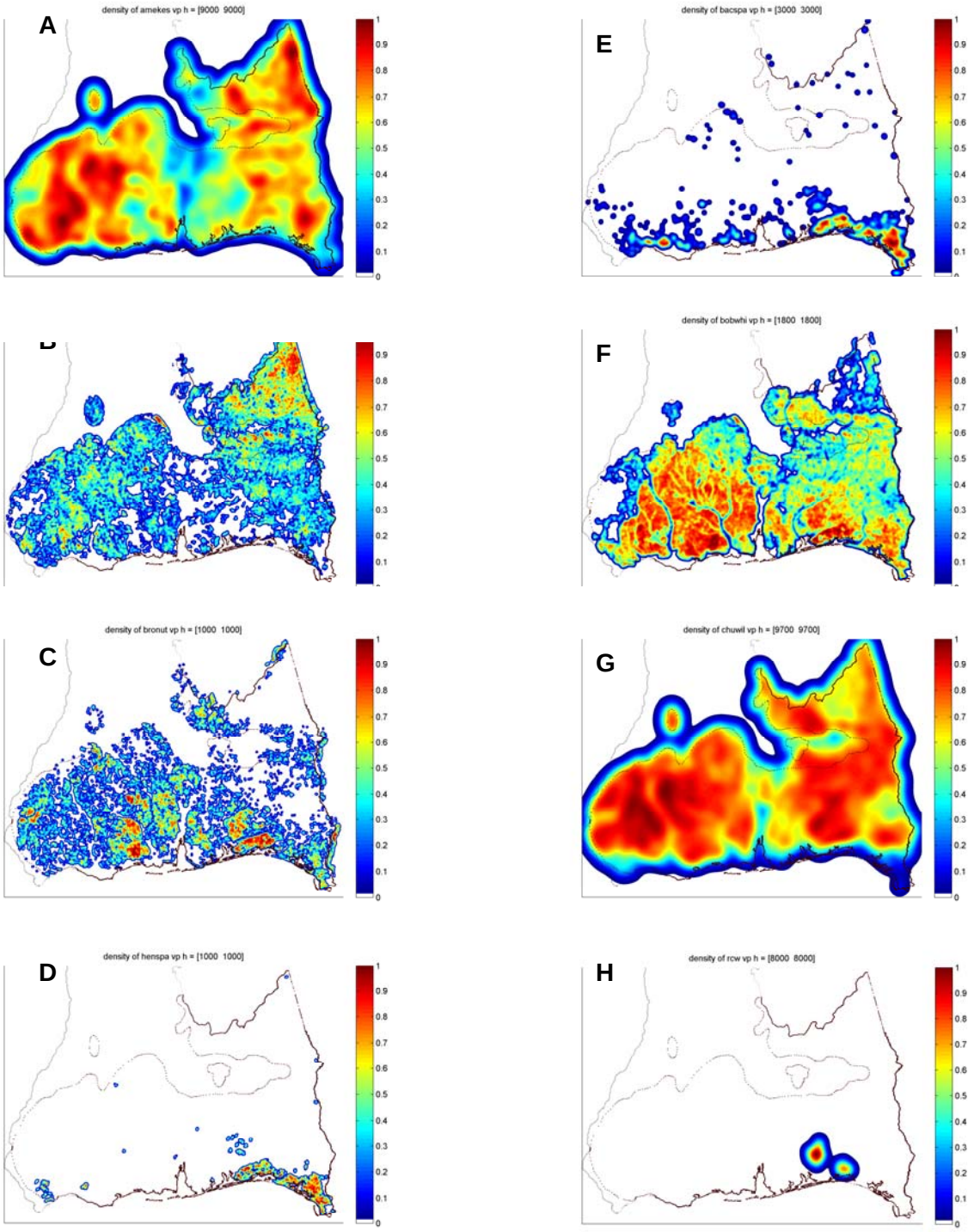

Figure 8. Density of putative source populations habitat with the range of longleaf pine for priority species inhabiting open pine systems in the East Gulf Coastal Plan Joint Venture Area. **A – amekeSAmerican kestrel, B – bacspa, Bachman's sparrow, C – bluegro-blue grosbeak, D – bobwhi, northern bobwhite, E – bronut-brown-headed nuthatch, F – chuwil, chuck will's widow, G – henspa, Henslow's sparrow, and H – rcw, Red-cockaded woodpecker.**

7. WHERE DO PUTATIVE SOURCE POPULATIONS FOR PRIORITY BIRDS EXIST?

The objective addressed in this layer is to prioritize areas near large patches of potential habitat that could hold source populations for the colonization of smaller patches of managed, conserved, or restored (potential) habitat. Previously, the patch size required for MVP was determined for each priority bird species. In this step we determined where patches of potential habitat existed that were large enough to provide for MVP.

Because we wanted to give higher priority to areas that would likely be colonized by priority bird species we used a normal kernel size based on the estimated dispersal distance for each respective species (Figure 8, Table 6). Dispersal distances were determined from the literature or estimated from the allometric equation

$$\text{Distance} = 36.4\, M^{0.62},$$

for carnivores and

$$\text{Distance} = 2.1\, M^{0.18}$$

for omnivores, where M is average body mass (kg).

Table 6. Dispersal distances used for open pine system umbrella species in the East Gulf Coastal Plain.

Species	Dispersal Distance (km)	Source	Body Mass	Source	Trophic Type	Source
Bachman's sparrow	3[1]	Dunning et. al 1995				
Blue grosbeak	1.11[1]		28.4 g	Ingold 1993	omnivore	Ingold 1993
Brown-headed nuthatch	0.92[1]		10.1 g	Norris 1958	omnivore	Norris 1958
Chuck-will's-widow	9.78[1]		120 g	Rohwer and Butler 1977	carnivore	Spunt and Chamberlain 1970
Henslow's sparrow	0.96[1]		12.8 g	Skipper 1998	omnivore	Hyde 1939
Northern bobwhite	1.8	Dimmick 1992				
Red-cockaded woodpecker	8	Eric Spadgenske, (Pers. comm.)				
SE American Kestrel	9	Miller and Smallwood 1997				

[1]Dispersal distance estimated via allometric equations (Sutherland et. al 2000).

MODELING CONSERVATION PRIORITY

This phase in mapping conservation priority integrates the maps addressing the objectives to determine where the highest densities of sites suitable for restoration; sites that can be conserved and managed for sustainable populations; sites that are most likely to be managed with fire; sites that are potential habitat for priority species; and sites that are likely to hold source populations. In performing this integration we invoke a relatively simple model borrowing from the concept of habitat evaluation procedures to create a priority surface for each species. We then select contiguous blocks of the highest priority areas for each species that were large enough to meet the objectives for population size and sustainability. We rescaled the density on each map to a maximum of value of 1.0

Let: $\boldsymbol{S}$ be the density of sites **suitable** for restoration,
$\boldsymbol{L}$ be the density of conservation **lands**,
$\boldsymbol{F}$ be the density of lands most likely to be managed with **fire**,
$\boldsymbol{H}$ be the density of sites that are potential **habitat** for priority species, and
$\boldsymbol{P}$ be the density of sites that are likely to hold source **populations**.

Then, we estimated conservation priority using the following equation:

$$\text{Priority} = S*F*(P+L+H).$$

After calculating the priority surface for each species, we again rescaled such that the maximum value was equal to 1.0 (Figure 9)

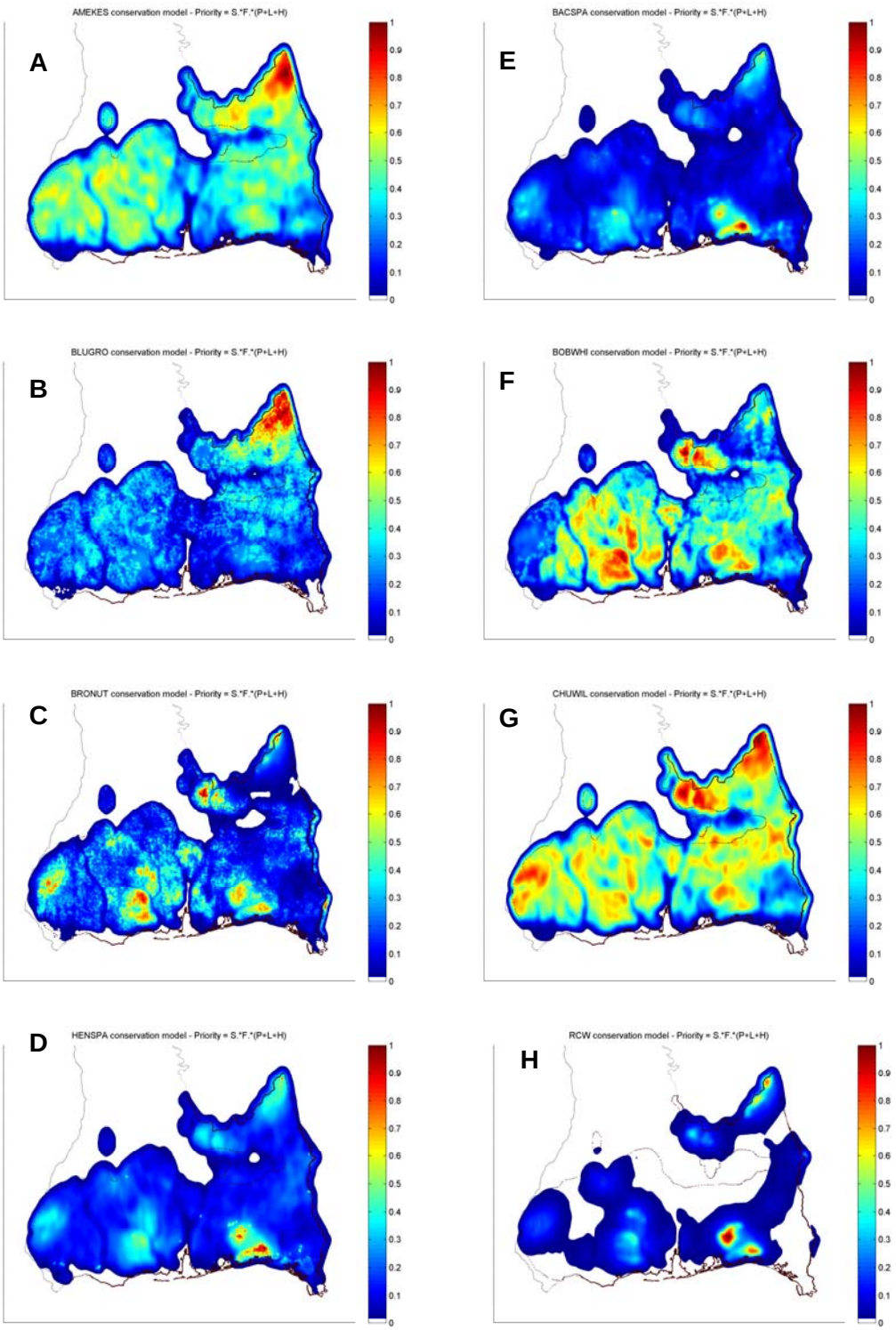

Figure 9 Map of conservation priorities Priority = $S*F*(P+L+H)$. within the range of longleaf pine for priority species inhabiting open pine systems in the East Gulf Coastal Plan Joint Venture Area. **A – ameke-American kestrel, B – bacspa, Bachman's sparrow, C – bluegro-blue grosbeak, D – bobwhi, northern bobwhite, E – bronut-brown-headed nuthatch, F – chuwil, chuck will's widow, G – henspa, Henslow's sparrow, and H – rcw, Red-cockaded woodpecker.**

Identification of Focal Areas

In this, the final step in DST development, we select patches of the highest priority areas that meet our criteria for the sustainability and persistence (MVP and number of patches) for each priority bird species. It should be noted that this is not a unique solution and our goal was to determine the highest conservation priority and smallest area in which we could meet the population objectives. We use the contour map of each species' conservation priorities scaled to a range of 0-1.0 selected progressively lower minimum threshold of conservation priorities until we had selected five areas (minimum number of patches) that were each large enough to provide habitat for the MVP for that species (Figure 10). This process was repeated for each species (Figure 11).

We used the union of the minimum conservation priority contours across species to set the boundaries of the focal area. We also summed and rescaled the priority scores across species to provide an overall conservation priority surface without focal area boundaries (Figure 12).

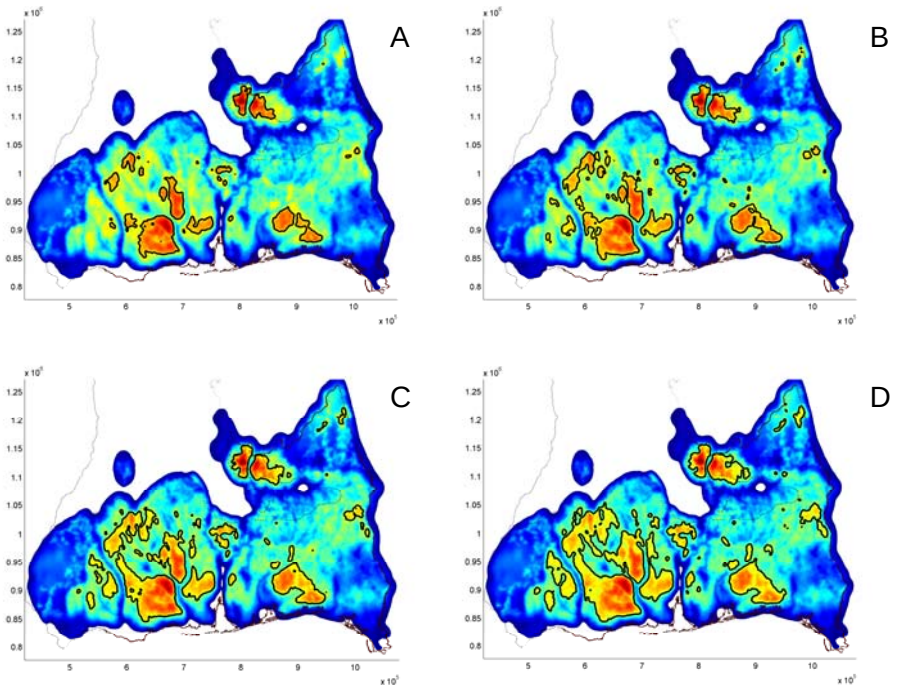

Figure 10. Map of conservation priority for northern bobwhite in open pine systems within the range of longleaf in the East Gulf Coastal Plain Joint Venture planning area. Dark red areas are highest priority; dark blue areas are lowest priority. The black line on each map represents a conservation priority level on a scale of 0-1.0 for consideration in meeting habitat objectives with 1.0 being the highest priority. Priority levels used in these figures are A – 0.95, B – 0.90, C – 0.85, and D – 0.80

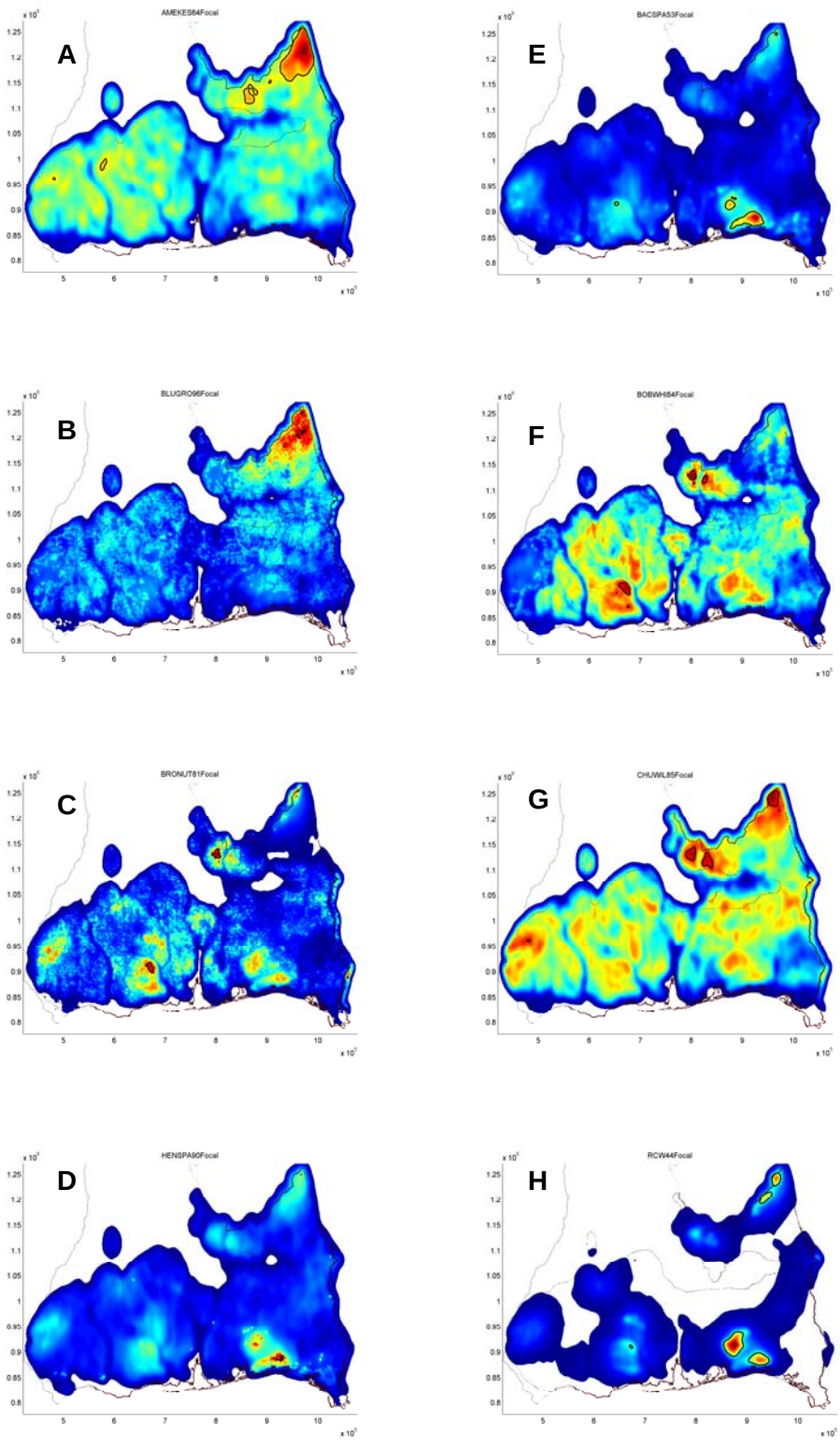

Figure 11. Map of conservation priorities and boundaries of species' focal areas based on highest conservation priority meeting criteria for number of areas, patch size required for a minimum viable population size, and ECGP habitat goals for priority species inhabiting open pine systems in the East Gulf Coastal Plan Joint Venture Area. **A – ameke-American kestrel, B – bacspa, Bachman's sparrow, C – bluegro-blue grosbeak, D – bobwhi, northern bobwhite, E – bronut-brown-headed nuthatch, F – chuwil, chuck will's widow, G – henspa, Henslow's sparrow, and H – rcw, Red-cockaded woodpecker.**

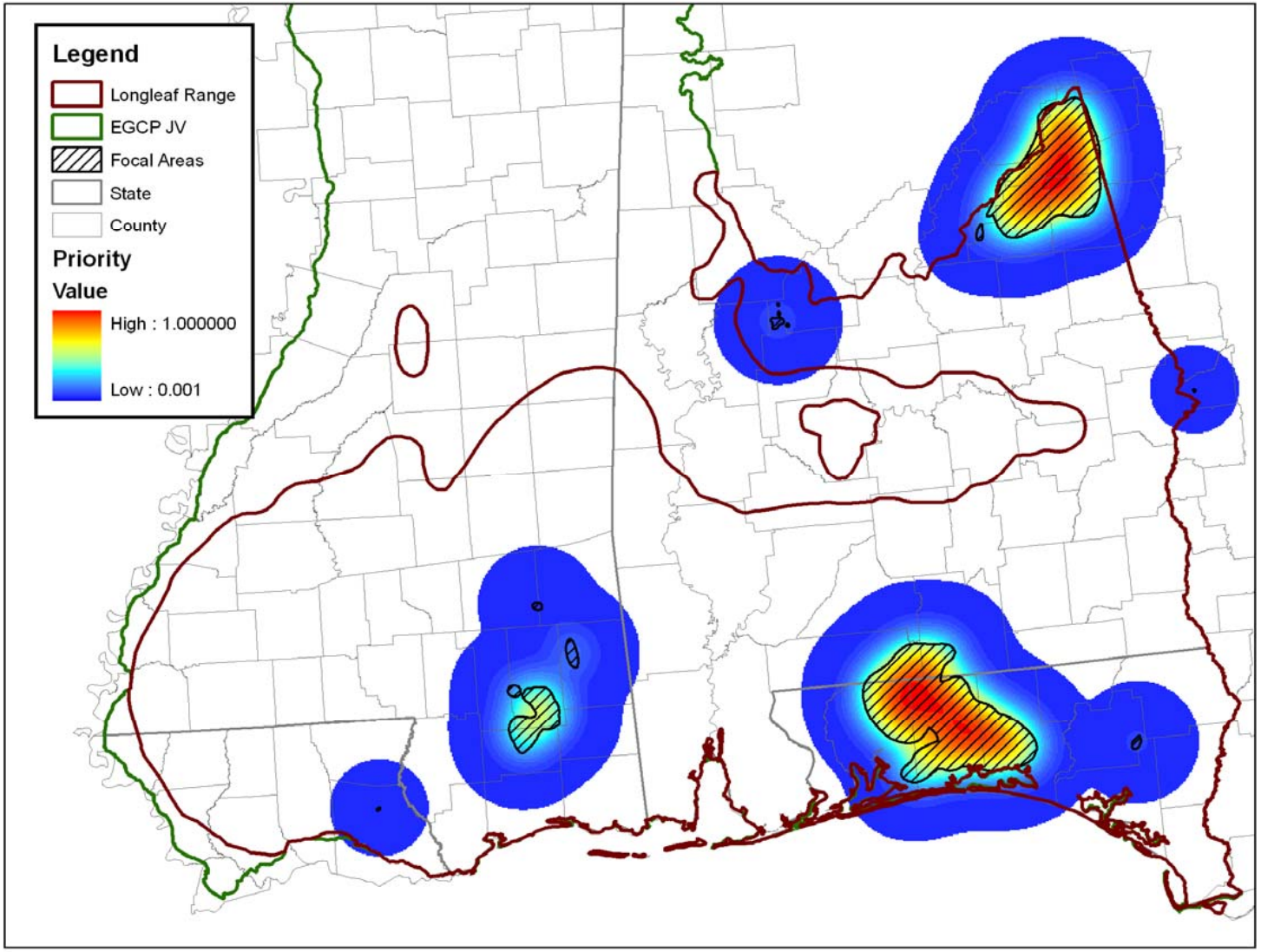

Figure 12. Combined conservation priorities and focal areas for all priority inhabiting open pine systems in the East Gulf Coastal Plan Joint Venture Area.

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APPENDIX 1
GAP SPECIES MODELS, HABITAT NOTES AND REFERENCES

AMERICAN KESTREL

Habitat Notes:

American Kestrels inhabit open areas with scattered trees or telephone poles, such as in pastures, fields, farmland, woodland margins, pine savannah (Hamel 1992, Simpson 1992), oak hammocks (Layne et al. 1977), and edges of river bottoms (Kale 1978). They also inhabit partly open habitats such as prairies, deserts, wooded streams, burned forest, open woodland, road margins, and sometimes cities (Smallwood 1987, Palmer 1988). Forages from high perches in these habitats (Hamel 1992, Kaufman 1996). During the summer, their preference was in the longleaf pine-turkey oak community. Within this community type the most occurrences occurred within the pastures and sandhill woodlands for both male and females (Bohall 1984). Along with elevated perches, and open terrain for hunting, available nesting sites are also required, such as tree cavities, earthen banks, occasionally birdhouses, and non-tree cavities or crevices (Johnsgard 1990). Kestrels commonly occur in urban and suburban areas, and have even nested in chimneys and drainpipes (Palmer 1988). Kestrels are uncommon in the mountains (Hamel 1992).

The size of the breeding territories ranged from 13.1-23.2 ha (Gard & Bird 1990). In Missouri, the average diameter of territories for breeding pairs was 0.75-2.42 km. In high quality habitat (sandhill woodlands), territory size was approximately 50 ha. In disturbed areas a pair may require 116-317 ha (Stys 1993). Average home range size was 350 acres (Schoener 1968).

Quoted directly from existing state habitat notes - K. Cook, 13Feb05

Modeling Notes:

MODEL: buffer open area and woodland (primary Map units) into forest, because does not use continuous forest

NON_primary MU HABITAT: cypress swamp, bottomland fors, montane & mountain forests fors types (hemlock-pine, cove hardwoods, birch, spruce-fir)

NOTES: Canopy cover or dense understory veg neg corr with foraging (Smallwod 1987). Extirpation from s Florida due to pine plantations with little structure (Hoffman and Callopy 1988).

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BACHMAN'S SPARROW

Habitat notes:

Breeds in pine woodland or open habitats with a dense ground layer of grasses and, forbs, and an open understory with few dense shrubs. Traditionally associated with mature pine stands where wiregrass or broomsedge dominates ground cover. Sparrow populations often especially high in areas maintained for RCWs. Also found in open grassy habitat patches where understory shrub intrusion is limited by poor soils, fire or disturbance. Such habitat includes limestone glades and dry grassy edges of seasonal ponds. With no mature pine, majority of sparrows found in open habitats such as roadcuts, utility rights-of-way and especially clearcuts. A few studies list breeding territories averaging approximately 2.5 ha (Dunning & Watts 1990, Dunning 1993, Dunning et al. 1995, LeGrand & Schneider 1992). NatureServe (not sure of their source) states minimum clearcut size used is usually 20 ha. M. Rubino, 10jan05.

Modeling Notes:

Select open areas (selected MUs) at least 20ha in size within 1500m of 3ha patches of the forested MUs; i.e. buffer 3ha patches of selected forest MUs and select only > 20ha patches of open if within 1500m of forested patches.

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BROWN-HEADED NUTHATCH

Habitat Notes:

Potter et al (1980) lists this nuthatch as a 'common permanent resident of open pine woods throughout the coastal plain and most of the piedmont.' Simpson (1992) states its status in the mountains as a 'rare and local permanent resident in pine forests below 2,500 ft.' It is absent on the barrier islands (Fussell 1994).They appear to prefer open pinewoods (Harison 1975, Potter et al 1980), often mixed with deciduous tree species (Ehrilch et al 1988, Kaufman 1996). Hamel (1992) asserts the Brown-headed nuthatch favors mature pine stands, and is not common in dense forests. The nest is usually excavated by both sexes in a dead pine tree, although occasionally a deciduous tree or fence post is used (Kaufman 1996). According to Potter et al (1980) nest height ranges from 'a few inches to about 90 feet' above the ground, generally though it is less than 15 feet. With regard to other cavities, Brown-headed nuthatches rarely use old woodpecker holes (Ehrlich et al 1988, Potter et al 1980). Oft times the pair will begin several cavities before completing one for use (Kaufman 1996, Ehrlich et al 1988).

Quoted form State habitat notes - K. Cook - 4-9-05

Modeling Notes:

Buffer out from open pine wood types into dense pine, since they tend to avoid dense pine but may use edge. I removed the "buffer in" and contiguous patch selection Kacy had used for this species. Her patch size was set to 0. The comments above would require using open pines as PMUs and dense pines as AMUs and

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BLUE GROSBEAK

Habitat Notes:

Inhabits old fields, forest edge, transmission-line corridors, open slashings (left after logging), hedgerows, stream edge, clear-cuts, etc…. Nests in low tree or bush, tangle of vegetation, usually about 1-3 m above ground, often at edge of open area. M. Rubino, 10jan05.

Modeling Notes:

Include forest edge of all forest types but include contiguous patches of all map units selected.

Model Cited Works:

CHUCK-WILL'S-WIDOW

Habitat Notes:

Chuck-will's widows are common to fairly common in coastal areas (Fussell 1994) and the eastern piedmont (Potter et al. 1980), but rare in the mountains (Simpson 1992). They breed throughout much of Georgia at moderate and lower elevations. They prefer woods and forests, primarily dry or mesic types, pines or hardwoods, favoring mixed woods. They feed mainly in adjacent fields and clearings (Hamel 1992). Generally inhabits all types of forests with an open understory (Nicholson 1997) and forage over open country with pastureland (Cleere 1998). Along the southern coast, found especially in upland deciduous areas; farther north, found in thickets along the edge of marshes (Fussell 1994). Deciduous forest and pine-oak association, live-oak groves, and edges of clearings are common breeding habitat (AOU 1983). Regularly breeding in coastal scrub (Fernald 1989). They are also reported to breed in open pine flatwoods, longleaf pine, xerophytic oak woodlands, hardwoods, and tropical hammocks (Stevenson and Anderson 1994).

These birds roosts on the ground, on logs and low branches. Forages by flying low over open fields and thickets, by hawking insects from a perch, and by chasing insects on the ground (Cleere 1998).Eggs are laid on leaf litter or pine needles on the ground in an open area (Cleere 1998).

Quoted directly from existing state habitat notes - K. Cook, 17Feb05

Additional information:

"In places where Chuck-will's-widow and Whip-poor-will co-occur, former is associated with more open habitat, latter with more forested habitat (Brewer et al. 1991). In n. Georgia, along a roadside-count route, Chuck-will's-widow was more common than Whip-poor-will in areas that were about 50% forested and 50% agriculture, whereas reverse was true in areas that were about 90% forested and 10% agricultural (Cooper 1982). The 2 species were about equally common in a predominantly suburban portion of route. Additionally, in Kansas and Ohio, Chuck-will's-widow used woodlands that were distinctly drier than those used by Whip-poor-will (Fitch 1958, Peterjohn and Rice 1991)." - quote from Birds of North America - Straight and Cooper (2000). K. Cook, 17Feb05

Modeling Notes:

Buffer forests and woodlands and accept open and wetland habitat classes within buffer.

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HENSLOW'S SPARROW

Habitat Notes:

Historically, populations along Atlantic Coast found to inhabit coastal marshes, swamps, dry fields, salt marshes, low wet meadows, upland weedy hayfields or pastures and in NC, clearcut pocosins. As native habitats declined, species moved into additional habitats, in particular cultivated hay fields. In general, habitat can be characterized as relatively large fields consisting of tall, dense grass, a well-developed litter layer, standing dead vegetation and sparse or no woody vegetation. M. Rubino, 12jan05.

Modeling Notes:

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NORTHERN BOBWHITE

Habitat Notes:

A habitat generalist (Nicholson 1997), the Northern Bobwhite breeds in a variety of early successional stage habitats, such as what exists in agricultural areas, open deciduous and mixed woodlands (Brennan 1999), overgrown fields, woodland edges (Fussell 1994), and gaps made in the forest by logging (Stupka 1963). They are commonly found in pine woodlands with well developed grass ground cover and little or no midstory, such as longleaf-slash, loblolly-shortleaf in the Coastal Plain and Piedmont and virginia pine, shortleaf pine in the Ridge and Valley, Highland Rim, Cumberland Plateau and Peidmont (Hunter 1990). In Tennessee, are most abundant in a mosaic of agricultural fields, wooded hedgerows, and fallow fields dominated by broom sedge (Nicholson 1997). Bobwhites nest May-September in the northern part of the range. Clutch size usually is 12-16; takes about 18-20 days to complete a clutch of 14 eggs. Incubation, by both sexes, lasts 23-24 days. Young follow and are are attended by both parents soon after hatching; at about weeks of age they join other adults and young and form coveys. Brood remains together until spring. Generally there is one brood/season in the north. Renests if clutch is lost. The nesting sites can be found in woodlands or fields (Harrison 1975), usually within 15-20 m of an opening such as a field or road . The nest is located on ground that is partially covered with standing vegetation <45 cm tall (Brennan 1999) and placed in a tuft of dead or live grass with surrounding herbaceous plants covering it and often woven into an arch above it (Harrison 1975).

Ecosystem Classifiers: Successional, open pine woodlands, & Praire- Woodland systems only.

Modeling Notes:

Nests usually within 15-20 m of an opening such as a field or road (Brennan 1999). Could not find citation for elevation parameter from GA-GAP Models. Included in low density Urban because of farms, rural roadsides, etc. NRCS Wildlife management leaflet #9 (1999) (http://policy.nrcs.usda.gov/scripts/lpsiis.dll/TN/TN_B_6_a.pdf), identify under optimal habitat covey activity occurs on tracts of land 20 to 40 acres & in less optimal 50 acres. Applied patch of 8 ha Amy Silvano 16may05

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RED-COCKADED WOODPECKER

Habitat Notes:

Caveat to the GAP model: Several mechanisms for population regulation have been reported as potential causes for decline in Red-cockated woodpecker populations, all of which relate indirectly to habitat suitability. However only some of the potential mechanisms relate directly to habitat availability. Competition with other species for nest cavities, forest age and fire regime, are important factors in modeling realized (available) habitat. Thus a map of potential habitat produced by the southeast regional GAP, may not be an effective representation of realized potential (available) habitat. Many of the direct habitat mechanisms for population regulation occur at much finer scales than those scales used to produce GAP landcover maps; forest age is a case in point. K. Cook - 4-27-05

The following habitat notes are quoted directly from the State habitat notes, but have been reorganized. K. Cook -4-27-05

Restricted to southern pine forests, the largest red-cockated woodpecker populations are found in longleaf pine, although loblolly pine, short leaf pine, pond pine, slash pine, and rarely Virginia pine and pitch pine are also used. Open, park like pine savanna with little hardwood understory is preferred (NATURESERVE). The red-cockaded woodpecker has a cooperative breeding system (Walters et al. 1989). Cooperative breeding systems are very rare among birds (Koenig and Pitelka 1981, Walters 1991), and an understanding of the general ecology of red-cockaded woodpeckers requires an understanding of this system, especially since the system appears to be molded by the pyrogenic nature of the habitat (Jackson 1971). Evidence suggests that a forest fire interval of 1-5 years may be a necessary component in breeding habitat (Jackson et al. 1986). Fire during the growing season is recognized as a key factor in sustaining habitat (SNN 1990). A strong preference for living pines as foraging substrate has been demonstrated. Their most striking habitat requirement is that of mature living pines for cavity excavation (NATURESERVE). Cavities are excavated almost exclusively in living pine trees that are generally at least 70-years old (Hooper et al. 1980, Hooper 1982, Patterson and Robertson 1983). The almost exclusive use of living trees may reflect an evolutionary response to a situation where frequent fires reduced the abundance of standing dead trees (Jackson 1971). No other woodpecker demonstrates such strict requirements for nest or roost sites (Ligon 1970, Lay 1973, Harlow 1983), and habitat conditions that are suitable in every other way may not be occupied owing to an absence of cavities (Walters 1991). It takes many months, and often longer than a year, to excavate a cavity (Hooper et al. 1980, Walters 1991). The difficulty of cavity excavation is offset by the persistence of the cavity (Lay and Russell 1970, Jackson 1978a). Trees infected with red heart fungus are often selected, presumably because excavation is easier if the heartwood is rotten, and these are usually the oldest trees in the forest. Longleaf cavity trees usually average around 100 yrs. Of age, but, in the NC Sandhills, where older trees exist , many cavity trees are more than 200 years old. Similar ages have been reported for shortleaf and pond pine, whereas cavity trees average about 20 yrs. Younger in the faster growing slash and loblolly pines. They have consistently shown a preference for the oldest trees available in both foraging and cavity excavation, but because old-growth pine is so uncommon in the south today, it has not been possible to determine the ideal age of trees or habitat.

In Kentucky, basal area of active colonies was 48% pine and 52% nonpine (chiefly oak); hardwood abundance (88% of total stems) was much higher than recorded in habitat elsewhere (Kalisz and Boettcher 1991). Encroachment of hardwood midstory negatively impacts habitat. In eastern Texas, loss of forest habitat and fragmentation negatively affected woodpecker group size in small populations that had relatively isolated clusters of cavity trees, apparently by causing an insufficiency of foraging habitat and dispersal-demographic problems (Conner and Rudolph 1991, which see for contrasting results from another study).

In eastern Texas, bark beetles (54%), wind snap (30%), and fire (7%) were the major causes of cavity tree mortality; in Angelina National Forest, cavity enlargement by pileated woodpeckers was a significant factor in cavity loss for red-cockaded woodpeckers (Conner et al. 1991). In Texas, woodpeckers preferentially selected the oldest trees for cavity excavation; the current average age of cavity trees (85-130 years) may not provide optimum conditions (optimum may be represented by older trees that are not yet available) (Rudolph and Conner 1991); older/larger trees allow placement of cavities at a greater height, which reduces predation, fire damage, and girdling damage by woodpeckers. A moderate population occurs in the Sandhills, and several small populations are found in the southern Coastal Plain. Only scattered, relict populations remain in the northern Coastal Plain and Piedmont. The four largest populations in NC (Sandhills, Camp Lejeune, Croatan National Forest, and Sunny Point Military Ocean Terminal) contained approx. 535 groups and 1300 adult birds in 1988. It is unlikely that there are more than 50 additional groups of woodpeckers (120 adults) elsewhere in

the state. Endemic to the southern US. Currently undergoing a range contraction due to loss of habitat. In the NC Sandhills there was apparently a significant decline in the mid-to-late 1970's. Many colonies in this region are now abandoned. There was a further decline of 16% in the number of groups between 1981 and 1983, and this was followed by a period of gradual decline of 3% / year through 1985.

Red-cockated woodpeckers forage on artjropods and some mast. A common foraging technique is to fip pine bark scales (often dislodging them) to prey on arthropods beneath the scales (Jackson 1992). They have beed reprted to forage in corn fields for corn earworms, also fruits of Prunus serotina, wax myrtle, magnolia grandiflora, Toxicodendron radicans, and swamp black gum, occasionaly forages on hardwood trunks (Stevenson and Anderson 1994).

Each member of a group usually has an exclusive roost cavity, although two nonbreeding birds sometimes briefly share a cavity (Hooper and Lennartz 1983b, Harris and Jerauld 1983, Jansen 1983). As many as 30 cavities may exist in a cluster of cavity trees (Hooper et al. 1980, Ligon et al. 1986), but the average number is usually less than six (Shapiro 1983, Hovis and Labisky 1985). Birds may roost under a limb or other protected site aswell (Jackson 1994).

Access to a cavity is important for roosting purposes, and it is critical to the nesting success of males (Ligon 1970, Hooper and Lennartz 1983). The nesting cavity is almost always the cavity of the single breeding male (Ligon 1970, Hooper and Lennartz 1983). The importance of attaining a cavity, contrasted with the extended time required to excavate a cavity, has led (in part) to different strategies among young birds for coping with the common situation wherein most suitable cavities are occupied by conspecifics (Walters 1990). One strategy is to disperse to an unoccupied area and begin excavating

a new cavity, but this strategy is very rarely followed (Walters 1990). In eight years of study, Walters (1990) reported no instance of this "pioneering" behavior, although it has been reported elsewhere (Hooper, pers. Comm., in James, in press). Another strategy is to disperse from a natal territory and attempt to find a cavity (or attain breeding status) with a new group. This strategy is employed by almost all young females and by most (about 73%) young males (Walters et al. 1988). Yet another strategy is to remain on the natal territory in hopes of inheriting the natal territory or another nearby territory. This strategy is employed by 27% of the young males and less than 1% of young females (Walters et al. 1988). ^Birds that remain in natal territories may do so for many years and assist (i.e., "help") the breeding pair raise and care for new birds (Walters et al. 1988). The reason that almost all helpers are males may relate to their slightly closer genetic relationship, on average, with siblings (Wade 1979), or to their apparent dominance over young females (Jackson 1983a). The retention of young birds within their natal group is believed to be the most common pathway to a cooperative breeding system (Koening and Pitelka 1981). ^Once a male attains breeding status in a group, it usually retains that position until death. Females may switch groups after attaining breeding status, particularly when an offspring male inherits a territory (Walters et al. 1989). This behavior may help to avoid close inbreeding (Walters et al. 1989). In short, because of the time and energy required to construct a cavity, established territories with cavities are heavily preferred over areas with appropriate habitat conditions yet lacking cavities (Walters 1990). The presence of suitable cavities can lead some birds to occupy and defend an area that has unsuitable habitat conditions. Males acquire breeding position through inheritance of a natal territory, by dispersing and joining another group and inheriting the new territory, by dispersing and displacing another male, or by locating an unoccupied cavity cluster and attracting a unmated female.

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APPENDIX 2.
LANDCOVER CLASSES AND CROSSWALK

Table 7. Landcover classes (map units) mapped by SEGAP in the East Gulf Coastal Plain Joint Venture planning area and crosswalk to Landcover Unit names in **Table 2.**

Landcover class mapped by SEGAP	Landcover name in Table 2
Open Water (Fresh)	*
Open Water (Brackish/Salt)	*
Open Water (Aquaculture)	*
Developed Open Space	developed open space
Low Intensity Developed	low intensity developed
Medium Intensity Developed	*
High Intensity Developed	*
Florida Panhandle Beach Vegetation	*
Bare Sand	*
Bare Soil	*
Quarry/Strip Mine/Gravel Pit	*
Central Interior Calcareous Cliff and Talus	*
Southern Piedmont Cliff	*
East Gulf Coastal Plain Dry Chalk Bluff	*
Southern Piedmont Granite Flatrock	*
Unconsolidated Shore (Lake/River/Pond)	*
Unconsolidated Shore (Beach/Dune)	*
Deciduous Plantations	*
Allegheny-Cumberland Dry Oak Forest and Woodland - Hardwood	hardwood forest
Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest	hardwood forest
Atlantic Coastal Plain Mesic Hardwood and Mixed Forest	hardwood forest
East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest - Hardwood Modifier	hardwood forest
East Gulf Coastal Plain Limestone Forest	hardwood forest
East Gulf Coastal Plain Northern Dry Upland Hardwood Forest	hardwood forest
East Gulf Coastal Plain Northern Loess Bluff Forest	hardwood forest
East Gulf Coastal Plain Northern Loess Plain Oak-Hickory Upland - Hardwood Modifier	hardwood forest
East Gulf Coastal Plain Northern Mesic Hardwood Forest	hardwood forest

Table 7. Landcover classes (map units) mapped by SEGAP in the East Gulf Coastal Plain Joint Venture planning area and crosswalk to Landcover Unit names in **Table 2.**

Landcover class mapped by SEGAP	Landcover name in Table 2
East Gulf Coastal Plain Southern Loess Bluff Forest	hardwood forest
East Gulf Coastal Plain Southern Mesic Slope Forest	hardwood forest
South-Central Interior Highlands Dry Oak Forest	hardwood forest
South-Central Interior Mesophytic Forest	hardwood forest
Southern Coastal Plain Dry Upland Hardwood Forest	hardwood forest
Southern Ridge and Valley Dry Calcareous Forest	hardwood forest
Atlantic Coastal Plain Fall-line Sandhills Longleaf Pine Woodland - Offsite Hardwood Modif	hardwood forest
East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Offsite Hardwood Modifier	hardwood forest
East Gulf Coastal Plain Jackson Plain Dry Flatwoods - Open Understory Modifier	hardwood forest
Southern Piedmont Dry Oak-(Pine) Forest - Hardwood Modifier	hardwood forest
Southern Piedmont Mesic Forest	hardwood forest
East Gulf Coastal Plain Black Belt Calcareous Prairie and Woodland - Woodland Modifier	*
1324 Northern Atlantic Coastal Plain Dry Hardwood Forest (CES203475)	hardwood forest
Evergreen Plantations or Managed Pine (can include dense successional regrowth)	plantation
East Gulf Coastal Plain Maritime Forest	evergreen forest
East Gulf Coastal Plain Northern Loess Plain Oak-Hickory Upland - Juniper Modifier	evergreen forest
Southern Appalachian Low Mountain Pine Forest	pine forest
Southern Piedmont Dry Oak-(Pine) Forest - Loblolly Pine Modifier	pine forest
Atlantic Coastal Plain Fall-Line Sandhills Longleaf Pine Woodland - Loblolly Modifier	pine forest
Atlantic Coastal Plain Fall-line Sandhills Longleaf Pine Woodland - Open Understory Modifi	pine forest
Atlantic Coastal Plain Longleaf Pine Woodland	pine forest
East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Loblolly Modifier	pine forest
East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Open Understory Modifier	longleaf pine
East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland - Scrub/Shrub Modifier	longleaf pine
Southern Coastal Plain Oak Dome and Hammock	hardwood forest

Table 7. Landcover classes (map units) mapped by SEGAP in the East Gulf Coastal Plain Joint Venture planning area and crosswalk to Landcover Unit names in **Table 2.**

Landcover class mapped by SEGAP	Landcover name in Table 2
Southern Piedmont Longleaf Pine Woodland	longleaf pine
East Gulf Coastal Plain Northern Dry Upland Hardwood Forest - Offsite Pine Modifier	pine forest
Allegheny-Cumberland Dry Oak Forest and Woodland - Pine Modifier	pine forest
Southern Ridge and Valley Dry Calcareous Forest	mixed forest
East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest - Mixed Modifier	mixed forest
Northeastern Interior Dry Oak Forest - Mixed Modifier	mixed forest
Ridge and Valley Calcareous Valley Bottom Glade and Woodland	*
Successional Shrub/Scrub (Clear Cut)	successional
Successional Shrub/Scrub (Utility Swath)	successional
Successional Shrub/Scrub (Other)	successional
East Gulf Coastal Plain Black Belt Calcareous Prairie and Woodland - Herbaceous Modifier	prairie
East Gulf Coastal Plain Jackson Prairie and Woodland	prairie
East Gulf Coastal Plain Dune and Coastal Grassland	prairie
Clearcut - Grassland/Herbaceous	herbaceous
Other - Herbaceous	herbaceous
Utility Swath - Herbaceous	herbaceous
Pasture/Hay	pasture
Row Crop	*
Atlantic Coastal Plain Small Brownwater River Floodplain Forest	*
East Gulf Coastal Plain Large River Floodplain Forest - Forest Modifier	*
East Gulf Coastal Plain Small Stream and River Floodplain Forest	bottomland hardwood
Mississippi River Low Floodplain (Bottomland) Forest	*
South-Central Interior Large Floodplain - Forest Modifier	*
South-Central Interior Small Stream and Riparian	bottomland hardwood
Southern Coastal Plain Blackwater River Floodplain Forest	*
Southern Piedmont Large Floodplain Forest - Forest Modifier	*
Southern Piedmont Small Floodplain and Riparian Forest	bottomland hardwood
Mississippi River Riparian Forest	*
Atlantic Coastal Plain Nonriverine Swamp and Wet Hardwood	*

Table 7. Landcover classes (map units) mapped by SEGAP in the East Gulf Coastal Plain Joint Venture planning area and crosswalk to Landcover Unit names in **Table 2.**

Landcover class mapped by SEGAP	Landcover name in Table 2
Forest - Oak Dominated Modifier	
Atlantic Coastal Plain Peatland Pocosin	*
Southern Coastal Plain Nonriverine Basin Swamp	swamp
Southern Coastal Plain Seepage Swamp and Baygall	swamp
East Gulf Coastal Plain Near-Coast Pine Flatwoods - Offsite Hardwood Modifier	pine flatwoods
East Gulf Coastal Plain Near-Coast Pine Flatwoods - Open Understory Modifier	pine flatwoods
East Gulf Coastal Plain Southern Loblolly-Hardwood Flatwoods	mixed forest
South-Central Interior/Upper Coastal Plain Wet Flatwoods	pine flatwoods
Southern Coastal Plain Hydric Hammock	swamp
Southern Coastal Plain Nonriverine Cypress Dome	swamp
Cumberland Riverscour	*
East Gulf Coastal Plain Tidal Wooded Swamp	*
Florida Big Bend Fresh-Oligohaline Tidal Marsh	*
Atlantic and Gulf Coastal Plain Interdunal Wetland	*
Floridian Highlands Freshwater Marsh	*
Southern Coastal Plain Herbaceous Seepage Bog	swamp
East Gulf Coastal Plain Treeless Savanna and Wet Prairie	prairie
East Gulf Coastal Plain Large River Floodplain Forest - Herbaceous Modifier	*
Atlantic Coastal Plain Central Salt and Brackish Tidal Marsh	*
Florida Big Bend Salt-Brackish Tidal Marsh	*
Mississippi Sound Salt and Brackish Tidal Marsh	*