West Gulf Coastal Plain and Ouachitas Forested Wetland Plan, Version 1.1

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Lower Mississippi Valley
JOINT VENTURE

West Gulf Coastal Plains/Ouachitas Forested Wetland Landbird Plan
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Introduction

The West Gulf Coastal Plain and Ouachitas (WGCPO) Bird Conservation Region encompasses 15 million ha of northwest Louisiana, southwest Arkansas, easternmost Texas, and the southeast corner of Oklahoma (Fig. 1). Although upland pines dominate the WGCPO, forested wetlands, including bottomland hardwood forest and riparian areas, occur along the Arkansas, Ouachita, Sabine, Neches, and Red Rivers as well as in other river flood plains. Forested wetland areas represent a unique and imperiled habitat in the WGCPO that supports area-sensitive breeding birds, such as Acadian Flycatcher (*Empidonax virescens*), Kentucky Warbler (*Geothlypis formosa*), Louisiana Waterthrush (*Parkesia motacilla*), Prothonotary Warbler (*Protonotaria citrea*) and Red-Shouldered Hawk (*Buteo lineatus*). Forested wetlands are not only important for high priority, area-sensitive breeding birds, but are also valuable to spring passage migrants. Radar images show large numbers of migrants descending into forested wetlands relatively close to the coast upon completing their Gulf of Mexico crossing (Barrow et al. 2005). Maintaining the structure and integrity of these forested wetlands may have conservation implications that extend well beyond the WGCPO.

Forested wetlands have been greatly reduced and fragmented for a multitude of reasons, primarily related to human land use (LMVJV 2013). Specifically, bottomland areas have frequently been converted to plantation (monotypic) stands, production of livestock, oil, or gas, conversion to cropland, or reservoir creation. Additionally, certain areas in the WGCPO are hotspots for emerging development (Texas Parks and Wildlife Department 2012), which places additional demands on water supplies.

This plan defines forested wetlands, lists priority bird species within this habitat, and identifies umbrella species representative of the needs of priority birds dependent on forested wetlands. We additionally (1) describe the habitat structure necessary for viable populations for each umbrella species, (2) detail how we set population and habitat goals based on stated assumptions for each umbrella species, and (3) describe a decision support tool intended to help guide management actions supporting conservation of existing forested wetland habitat.

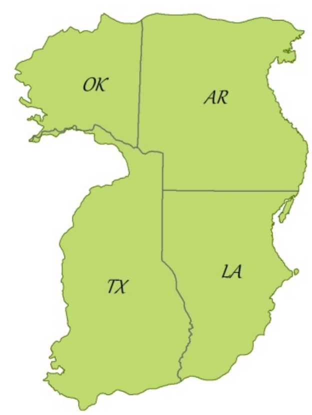


Figure 1. The West Gulf Coastal Plain and Ouachitas geography encompasses 15 million hectares over a four state region

Habitat Description

West Gulf Coastal Plain and Ouachitas Forested Wetlands

Forested wetlands include wetlands dominated by woody vegetation that is > 6 meters tall (Cowardin et-al. 1979). In the WGCPO, forested wetlands are dominated by woody broadleaf vegetation on soils that are periodically saturated or flooded with water. These include bottomland hardwood forests and cypress-tupelo swamps. The prevalent woody plant species have the ability to survive, achieve maturity and reproduce when soils within the root zone may become anaerobic during the growing season (Huffman and Forsythe 1981). Herein we define forested wetlands as occurring within floodplains of up to third order streams and terraces in the WGCPO.

Within WGCPO forested wetlands, a "narrow zone of habitats directly associated with streamsides or similar immediately adjacent habitat" (NatureServe 2014) represents an important ecological interface for a number of priority bird species. Specifically, a narrow width of stream borders where the vegetative composition is influenced by flooding and/or the moisture regime of the stream (Hodges and Krementz 1996; Partners in Flight 2003) provide key foraging habitat for Louisiana waterthrush (*Parkesia motacila*; Tirpak et al. 2009). It is important to note that in the WGCPO these dendritic stream corridors are ecotonal in nature, long and narrow in shape, have a very high edge-area ratio (Odum 1979), and represent a continuum within the forested wetland landscape. We assumed these riparian corridors may extend up to 300 meters from stream edges, although hydrological influences diminish with increased distance from stream.

Forested wetlands considered in this WGCPO bottomland hardwood and riparian plan include the following ecological systems (NatureServe 2014):

West Gulf Coastal Plain Large River Floodplain Forest (AR, LA, OK, TX)

This system represents broad bottomlands along large rivers such as the Sabine, Ouachita, Trinity, Neches and others. Several distinct plant communities are recognized within this system and are related to various geomorphic features (e.g., natural levees, point bars, meander scrolls, oxbows and sloughs) present within the floodplain. Vegetation generally includes forests dominated by bottomland hardwood trees and other vegetation that is tolerant of flooding. Tree species may include: bald cypress (*Taxodium distichum*) and water tupelo (*Nyssa aquatica*), red maple (*Acer rubrum*), river birch (*Betula nigra*), water hickory (*Carya aquatica*), sugarberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), American sycamore (*Platanus occidentalis*), water locust (*Gleditsia aquatica*), swamp blackgum (*N. biflora*), loblolly pine (*Pinus taeda*), eastern cottonwood (*Populus deltoides*), laurel oak (*Quercus laurifolia*), overcup oak (*Q. lyrata*), swamp chestnut oak (*Q. michauxii*), water oak (*Q. nigra*), cherrybark oak (*Q. pagoda*), willow oak (*Q. phellos*), bottomland post oak (*Q. similis*), Nuttall oak (*Q. texana*), black willow (*Salix nigra*), American elm (*Ulmus americana*), and cedar elm (*U. crassifolia) (*adapted from NatureServe 2014).

West Gulf Coastal Plain Red River Floodplain Forest (AR, LA, TX)

This system represents a geographic subset of Kuchler's (1964) Southern Floodplain Forest which is specifically restricted to the main stem of the Red River in southwestern Arkansas, and adjacent portions of Texas and Louisiana. Several distinct plant communities are recognized within this system and are related to various geomorphic features (e.g., natural levees, point bars, meander scrolls, oxbows and sloughs) present within the floodplain. Vegetation generally includes forests dominated by bottomland hardwood trees, such as bald cypress and water tupelo, and other vegetation tolerant of flooding. This system is similar in concept to West Gulf Coastal Plain Large River Floodplain Forest but is distinct from it because of the difference in magnitude between the typical large rivers (e.g., Ouachita, Saline) and the Red River bottoms. Native vegetation in the Red River bottoms differs from that of the West Gulf Coastal Plain Large River Floodplain Forest in having a larger area occupied by eastern cottonwood, black willow and other sandy riverfront forest species (adapted from NatureServe 2014).

West Gulf Coastal Plain Small Stream/River Forest (AR, LA, OK, TX)

This is a forested habitat associated with small rivers and creeks. In contrast to West Gulf Coastal Plain Large River Floodplain Forest, examples of this habitat have fewer major geomorphic floodplain features. Geomorphic features tend to be smaller and more closely intermixed with one another, resulting in less obvious vegetation zonation. Bottomland hardwood tree species are typically important and diagnostic, although mesic hardwood species are also present in areas with less inundation, such as upper terraces and possibly second bottoms. Flooding occurs annually, but the water table usually is well below the soil surface during the growing season. Areas impacted by beaver impoundments are also included in this system. Hardwood tree species include: sweetgum, water oak, sugarberry, green ash, river birch, laurel oak, American elm, cedar elm, winged elm (*U. alata*), slippery elm (*U. rubra*), swamp chestnut oak, Nuttal oak, cherrybark oak, southern red oak (*Q. falcata*), American sycamore, common persimmon (*Diospyros virginiana*), honeylocust (*G. triacanthos*), and red maple.Flood-tolerant species such as bald cypress, water tupelo, water locust, water hickory, overcup oak, planertree (*Planera aquatica*), and willow oak may dominate wetter sites (adapted from NatureServe 2014).

West Gulf Coastal Plain Seepage Swamp and Baygall (AR, LA, OK, TX)

This system consists of forested wetlands (often densely wooded) in acidic, seepage influenced wetland habitats. Forested seeps, also known as “baygalls”, are frequent along small streams dissecting sandy, acidic uplands of the Coastal Plain. These wetlands are influenced by groundwater seepage and are characterized by canopy species such as swamp blackgum (*N. biflora*), sweetbay magnolia (*Magnolia virginiana*), red maple, and in some occurrences, bald cypress. Ferns such as netted chain fern (*Woodwardia areolata*), cinnamon fern (*Osmunda cinnamomea*), and royal fern (*O. regalis*) are often conspicuous in the understory.Forested seeps may be linear, following a stream. Broader, more expansive forested seeps can occur where small headwater streams converge. Forested seeps can occur on lower topographic positions immediately adjacent to streams, and can also extend upward, “hanging” on steep slopes (adapted from NatureServe 2014).

Ozark-Ouachita Riparian (AR, OK)

This system is found along streams and small rivers. In contrast to larger floodplain systems, this system has little to no floodplain development and often contains cobble bars and steep banks. It is traditionally higher gradient than larger floodplains and experiences periodic flooding. It is often characterized by a cobble bar with adjacent forest and little to no marsh development. Typical tree species include: sweetgum, American sycamore, river birch, maples (*Acer* spp.), and oaks (*Quercus* spp.). The richness of the herbaceous layer can vary significantly, ranging from species-rich to species-poor. Likewise, the shrub layer can vary considerably, but typical species may include northern spicebush (*Lindera benzoin*), hazel alder (*Alnus serrulata*) and Ozark witchhazel (*Hamamelis vernalis*). Small seeps and fens can often be found within this system, especially at the headwaters and terraces of streams. These areas are typically dominated by primarily wetland obligate species of sedges (*Carex* spp.), ferns (*Osmunda* spp.), and other herbaceous species such as jewelweed (*Impatiens capensis*). Flooding and scouring strongly influence this system and prevent the floodplain development found on larger rivers (adapted from NatureServe 2014).

Birds of Forested Wetland Habitat in the WGCPO

Priority Species

Twelve species have been designated as warranting conservation concern or given priority status in forested wetland habitats of the WGCPO (Table 1). These species were selected from species included in the 2003 Draft Bird Conservation Plan for the West Gulf Coastal Plain Physiographic Area priority list for bottomland hardwood (Partners in Flight, unpubl. document). We also retained species designated as Birds of Conservation Concern by the U.S. Fish and Wildlife Service (2008, 2009) and species listed in at least one State Wildlife Action Plan (SWAP) from WGCPO states (Arkansas, Louisiana, Oklahoma and Texas). We also included Eastern Wild Turkey (*Meleagris gallopavo silvestris*) because of its high priority status for the general public, the potential for its management to provide a means to benefit other species in this habitat, and its value as a communication tool for private land managers that often focus on game animals.

Table 1. Priority bird species of forested wetland habitat in the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Priority Bird Species	Greatest Conservation Need (SWAP)[d]				Birds of Conservation Concern
	LA 2015	TX 2012	AR 2007	OK 2015	USFWS 2008
Acadian Flycatcher[a]					
Kentucky Warbler[b]	S4	S3	S4	S4	X
Louisiana Waterthrush[a]	S3	S3		S4	X
Northern Parula					
Prothonotary Warbler[ab]	S5	S3	S4	S4	X
Red-shouldered Hawk[a]		S4			
Rusty Blackbird *(winter)*[ac]	S3	S3	S5	S4	
Swainson's Warbler[a]	S4	S3	S3	S3,4	X
Eastern Wild Turkey[a]		S5			
Wood Thrush[ab]	S4	S4	S4	S4	X
Yellow-throated Vireo[a]	S4				
Yellow-throated Warbler[a]	S4	S4			

[a] Included in 2003 WGCPO Bottomland Hardwood and Riparian Draft Plan
[b] Yellow Watch List species (Partners in Flight 2016),
[c] Common Birds in Steep Decline (Partners in Flight 2016)
[d] S3 = rare and local throughout the state or found locally (even abundantly at some of its locations) in a restricted region of the state, or because of other factors making it vulnerable to extirpation; S4 = apparently secure with many occurrences; S5 = secure — common, widespread, and abundant in the nation or state/province.

Most of these priority species have decreasing population trends as identified from Breeding Bird Survey data (Table 2, Sauer et al. 2014). For some of these species, such as Louisiana Waterthrush, detections on Breeding Bird Surveys are spare, which may affect trend estimates (Sauer et al. 2003).

For our only priority wintering species, Rusty Blackbird, a 5.1% decline per year from 1965/66 to 2002/2003 has been observed on Christmas Bird Counts. This decline translates into an 85% population decline over this time period (Niven et al. 2004).

Table 2. Breeding Bird Survey trend, with credible interval (,) and relative abundance (RA) from 1966-2015 for priority species in the West Gulf Coastal Plain and Ouachitas Bird Conservation Region (BCR 25; Sauer et al. 2014).

Species	WGCPO[a]
Acadian Flycatcher	**-1.74 (-2.59, -0.92)** RA = 2.39
Kentucky Warbler	**-1.73 (-2.47,-0.98)** RA =4.76
Louisiana Waterthrush*	**-1.10 (-2.65, 0.58)** RA =0.25
Northern Parula	**-1.11 (-2.16, 0.03)** RA = 1.29
Prothonotary Warbler*	**-3.20 (-4.35, -2.00)** RA = 0.89
Red-shouldered Hawk	2.14 (1.28, 3.01) RA = 1.65
Swainson's Warbler*	1.11 (-1.14, 3.52) RA = 0.27
Wild Turkey*	6.96 (3.51, 10.52) RA = 0.08
Wood Thrush	**-2.42 (-3.07, -1.76)** RA = 3.18
Yellow-throated Vireo	1.18 (0.25, 2.14) RA = 1.55
Yellow-throated Warbler*	**-1.14 (-2.37, 0.12)** RA = 0.77

[a] Bold red indicates a significant declining trend where the interval does not overlap zero; bold black indicates a declining trend, but the interval overlaps zero; black indicates a positive trend either significant or non-significant
*Designates BBS data with a deficiency, primarily in this case due to low relative abundance (RA <1.0 birds/route)
Underline indicates umbrella species

Umbrella Species

We chose a subset of priority species as **umbrella species** for planning purposes. Umbrella species have measurable populations, are relatively well-studied, and represent the collective habitat requirements that we considered sufficient to meet the needs of all priority species in forested wetlands. Each umbrella species represented one or more potential limiting habitat factors (see *Habitat Management Recommendations*). We identified six umbrella species: Acadian Flycatcher; Kentucky Warbler; Louisiana Waterthrush[1]; Prothonotary Warbler; Red-shouldered Hawk; and Yellow-throated Warbler.

[1] Louisiana Waterthrush modeling is addressed in Appendix 3. The modeling for this species is still in progress and will be a part of version 2.0.

Acadian Flycatcher

Nearly 10% of the global Acadian Flycatcher population is estimated to breed in the WGCPO. Within the WGCPO, Regional Concern Score for Acadian Flycatcher is 17 (out of 25 maximum) making it a species of Regional Concern and Regional Stewardship (Panjabi et al. 2012). Acadian Flycatcher has moderate threats to their breeding area (Threats to Breeding-regional (TB-r) = 3), primarily due to forest loss and fragmentation, and moderate regional declines (Population Trend – regional (PT-r) = 4) within the WGCPO (Partners in Flight Science Committee 2012). This has resulted in recommendations for management or other conservation actions to reverse or stabilize significant long-term population declines. Forests large enough to support large and productive populations of this flycatcher should be adequate to support source populations of many other species that occur in mature forested wetlands (Hunter et al. 2001).

Kentucky Warbler

Nearly 25% of the global Kentucky Warbler population is estimated to breed in the WGCPO. Within the WGCPO, Regional Concern Score for Kentucky Warbler is 17 (out of 25 maximum) making it a species of Regional Concern and Regional Stewardship (Panjabi et al. 2012). Kentucky Warbler has moderate threats to their breeding area (TB-r = 3), primarily due to forest loss and fragmentation, and moderate regional declines (PT-r = 4) within the WGCPO (Partners in Flight Science Committee 2012). This has resulted in recommendations for management or other conservation actions to reverse or stabilize significant long-term population declines. Kentucky Warbler is designated as a Yellow Watch List species in the 2016 Partners in Flight Landbird Conservation Plan because continentally they have a steep population decline (25%) and experience moderate to high threats (Rosenberg et al. 2016).

Prothonotary Warbler

Within the WGCPO, Regional Concern Score for Prothonotary Warbler is 16 (out of 25 maximum; Panjabi et al. 2012). Moderate threats to their breeding area (TB-r = 3), primarily due to forest loss and fragmentation, and significant regional declines (PT-r = 5) within the WGCPO. These have resulted in recommendations for management attention to reverse or stabilize the long-term population decline (Partners in Flight Science Committee 2012). Prothonotary Warbler is designated as a Yellow Watch List species in the 2016 Partners in Flight Landbird Conservation Plan because continentally they have a steep population decline (34%) and experience moderate to high threats (Rosenberg et al. 2016).

Red-shouldered Hawk

Populations within the WGCPO have either stable or slightly increasing trends and conditions for breeding populations are projected to remain stable (Partners in Flight Science Committee 2012). Across its range, the species has historically (150 years) experienced moderate to substantial declines (Dykstra et al. 2008). Yet since 1966, Red-shouldered Hawks seem to be stable in the southern part of their range with an increasing regional Breeding Bird Survey trend and statewide trends increasing in Arkansas, Oklahoma, and Texas and stable in Louisiana (Sauer et al. 2014). Nevertheless, the Texas Wildlife Action Plan lists Red-shouldered Hawk as a low-priority, Species of Conservation Concern (Texas Parks and Wildlife Department 2012).

Yellow-throated Warbler

Yellow-throated Warblers breed throughout the south and mid-eastern United States. Although some individuals are resident from South Carolina to Florida, most of the population is migratory. Winters are spent in eastern Mexico through Nicaragua and in the Bahamas and Greater Antilles. Almost 8% of the global Yellow-throated Warbler population is estimated to breed in the WGCPO Bird Conservation Region. Within the WGCPO, the Yellow-throated Warbler is not a species of Regional Concern (score = 15; PIF Science Committee 2012).

Population and Habitat Goals

We do not have reliable estimates of population sizes for our umbrella species. The Partners in Flight estimates likely underestimate density of birds in the WGCPO (Twedt 2015). Therefore, we developed trend-based population goals. Because of the declining BBS trends in umbrella species, except Red-shouldered Hawk, our short-term goal is to ***stabilize BBS trends based on the trend from the last ten years and a three-year moving average*** (Appendix 1)**.** Essentially, this means that Breeding Bird Survey detections would need to be returned to detection levels seen in 2002 for each species. However, there are various ways that this objective could be accomplished. See Appendix 1 for examples. Thus, monitoring through BBS routes must occur to validate if this goal is being achieved over the next 5-10 years (see *Monitoring and Evaluation*).

Comparing available landcover datasets, it is unlikely that declining trends in forested wetland species are due to loss of forest quantity over the past decade. The difference in the NLCD woody wetland category (90) between 2001 and 2011 was a loss of 31,518 acres (0.59% decline; Table 3). Hence, ***our primary habitat objectives are focused on improving the protection and management of existing tracts of forested wetland that have the potential to support minimum viable populations*** (see *Habitat Management Recommendations*). In doing so, we assume a positive relationship between Breeding Bird Survey trends and the amount of **potential breeding habitat** available.

Table 3. Area of woody wetlands within the West Gulf Coastal Plain and Ouachitas Bird Conservation Region identified from National Land Cover data (class 90) from remotely sensed data obtained during 2001 (Homer et al. 2015) and 2011 (Homer et al. 2015).

Year	Acres	Hectares
2001	5,331,557	2,157,605
2011	5,300,039	2,144,850
Difference	-31,518	-12,755

Decision Support Model

Because our primary habitat objectives are focused on improving the protection and management of existing tracts of forested wetland that have the potential to support minimum viable populations, ***our Decision Support Model is intended to highlight those areas where conservation efforts (i.e., protection or management) directed at existing forested wetlands will have the greatest potential for positive impact on landbird populations.*** Our initial step was to characterize the landscape that was available to umbrella species for breeding. We then prioritized the potential breeding landscape through several habitat factors.

1) Methodology for Landscape Characterization

We began with Minimum Viable Populations (MVP) using the framework from the West Gulf Coastal Plain/Ouachitas Open Pine Landbird Plan (LMVJV 2011; B. Grand, unpublished data, Table 4). MVPs were based on the variability around simulated population trajectories from Breeding Bird Survey data (Appendix 1). A sustainable population was defined as a population large enough to have >95% chance of remaining above 25 individuals over a 50-year interval.

For each species, we reviewed the literature for (1) breeding area (i.e., territory) requirements per pair; and (2) natal dispersal distances. For some species we could not find information on natal dispersal distance in the literature. For these species we used an allometric equation to estimate dispersal distance (Sutherland et al. 2000).

We converted area requirements per pair to area requirements per MVP. We used metrics of area requirements and natal dispersal distances to calculate carrying capacity and available suitable habitat on the landscape.

Area Requirements

We initially calculated three area requirement estimates based on 25th percentile, median, and 75th percentile values of area requirements from our literature review (Appendix 2), but we present median values as representative of area requirements (Table 4).

Table 4. Estimated Minimum Viable Populations (MVP), natal dispersal distance, and suitable habitat area requirements for select species breeding in forested wetlands in the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Species	MVP (# pairs)	Dispersal distance (km)	Area (ha/pair)	MVP area requirement (ha/MVP)
ACFL	63	1.8[a]	1.6	101
KEWA	63	1.9[a]	5.5	347
PROW	134	4	2.5	335
RSHA	25	15	171	4,275
YTWA	48	1.6[a]	2.8	134

[a] Dispersal distances determined through via allometric equation.

For these species, we used woody wetland identified in the 2011 National Land Cover Database (NLCD; land cover class = 90; Homer et al. 2015) as the base layer to quantify the amount of potentially "suitable habitat" on the landscape. Additionally, we used the National Hydrography Dataset - High Resolution (NHD - HR; U.S. Geological Survey 2013) to define primary order streams. We combined these data with the National Hydrography Dataset Plus to define secondary and tertiary order along with primary order streams from NHD - HR.

We identified habitat patches through a clumping process in Erdas Imagine (2015; Leica Geosystems, Atlanta, GA, USA) and refined these data by removing those clumps of habitat that did not have enough suitable habitat in close enough proximity to support a minimum viable population, with habitat suitability and proximity as defined below for each species. The amount of suitable habitat was determined by neighborhood analysis in ArcGIS Pro version 1.4 (ESRI, Redlands, CA, USA) and was not restricted to contiguous patches, but patches needed to be within natal dispersal distance to allow for post-fledgling movements among patches.

Avicentric Landscape

To further characterize the landscape for all of our umbrella species, we defined a circular area that was within the natal dispersal distance of each species (Table 5). This area was assumed to be available for natal dispersal. We designated this circular area an "avicentric" landscape. These landscapes were species specific, based on presumed natal dispersal distance:

Equation 1. Avicentric Landscape (ha) = [π * (Dispersal Distance [m])^{2}]/10000.

The percent of suitable habitat required within each avicentric landscape to support the species MVP was (Table 5):

Equation 2. Area requirement for MVP (ha) ÷ Avicentric Landscape (ha)

Table 5. Metrics for the avicentric landscape and percent of suitable habitat required for umbrella species in the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

	ACFL	KEWA	PROW	RSHA	YTWA
Avicentric Landscape (ha)	1,018	1,134	5,026	70,686	804
% Suitable Habitat Required in Avicentric Landscape	9.9%	30.6%	6.7%	6.0%	16.7%

If the species specific avicentric landscape harbored at least the required percentage of suitable habitat (Table 5) then the landscape was characterized as suitable for the species. Alternatively, if the avicentric landscape harbored less than the required percentage of habitat, those landscapes were deem incapable of supporting a MVP of the species. For example, Acadian Flycatchers require ≥9.9% suitable habitat within a 1,018 ha avicentric landscape. Thus, ≥101 ha of suitable habitat is required with these landscapes to be deemed supportive of Acadian Flycatcher MVPs.

Final Landscape Characterization

Based on the landscape characterization from the area requirements analysis within avicentric landscapes, we developed a base layer of habitat presumed to be supportive of minimum viable population of each species. These maps identified areas with sufficient potential breeding habitat within natal dispersal proximities capable of supporting minimum viable populations of each species. Additional habitat factors were applied to these potential habitat layers to ultimately develop the decision support models.

2) Methodology for Habitat Factors

We applied habitat-specific parameters to each species in order to prioritize potential breeding habitat using a habitat suitability modeling approach (Tirpak et al. 2009). This approach closely examines the relationships of important features in the landscape to umbrella species, although Red-shouldered Hawk was not included in the Tirpak et al. (2009) assessment. Algorithmic relationships for species suitability with particular habitat features were applied using geospatial data that were either easily produced or readily available.

The habitat features used in our models included:

- **Distance to Water**
- **Percent Forest** in the landscape
- **Flood Tolerance** and **Flood Preference**
- **Bald-cypress - Tupelo Floodplain Forest**

Bald-cypress - Tupelo Floodplain Forest classification was used from the 2011 National Gap Analysis Program dataset (USGS 2011).

Not all habitat features were used in each species' model. However, these habitat factors were incorporated in the same manner for each of the species' model in which they were used.

Distance to Water

The suitability of distance to water varied among species modeled. For Acadian Flycatcher and Red-shouldered Hawk (Equation 3) and Yellow-throated Warbler (Equation 4), we produced separate Distance to Water rasters for each species based on algorithms provided by Tirpak et al. (2009). We created each of these Euclidean distance rasters based on a combination of National Hydrography Dataset (NHD) High Resolution and NHD Plus streams created for the WGCPO that also had lakes and large streams included.

Equation 3. Suitability Value = $1 - (1.049/ (1+ (1664.953 * e^{-0.021*\text{distance to water}}))$.

Equation 4. Suitability Value = $1 - (1.05/ (1+ (1661.322 * e^{-0.021*\text{distance to water}}))$.

For Prothonotary Warbler, however, we limited our Euclidean distance analysis to 200 m because this species is rarely found more than 200m from water during the breeding season (Tirpak et al. 1999). Thus any bottomland hardwood forest within 200 m from water was assigned a Habitat Suitability value of 1 whereas everywhere else was given a value of 0 (zero).

The relationship between distance to water and habitat suitability are provided for Acadian Flycatcher and Red-shouldered Hawk (Fig. 2) and for Yellow-throated Warbler (Fig. 3).

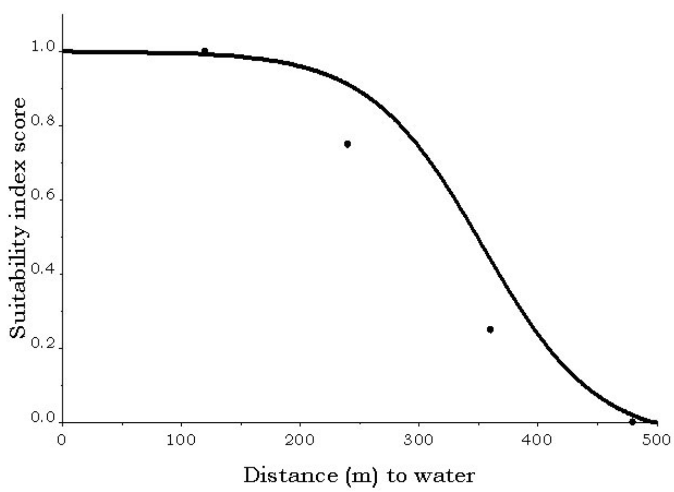


Figure 2. Relationship between distance to water (m) and suitability index scores for Acadian Flycatcher and Red-shouldered Hawk [from Tirpak et al. (2009)].

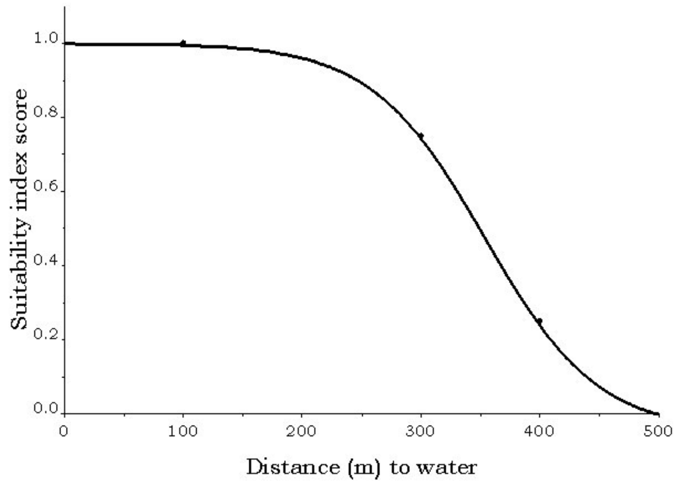


Figure 3. Relationship between distance to water (m) and suitability index scores for Yellow-throated Warbler [from Tirpak et al. (2009)].

Percent Forest

We conducted a neighborhood focal mean analysis (ArcGIS Pro version 1.4, ESRI, Redlands, CA, USA) on 1-km radius landscape windows for all forested classes in the National Land Cover data (NLCD 2011). We reclassified data inputs as binary (1=forest, 0=non-forest) such that the resultant focal mean provided the percentage of pixels that were forest with these 1-km landscapes. The relationship between suitability for the bird species we modeled and the forested landscape composition was provided by Tirpak et al. (2009) as:

Equation 5. Suitability Value = 1.005/ (1 + (221.816 * e $^{-0.108*\text{landscape composition}}$)).

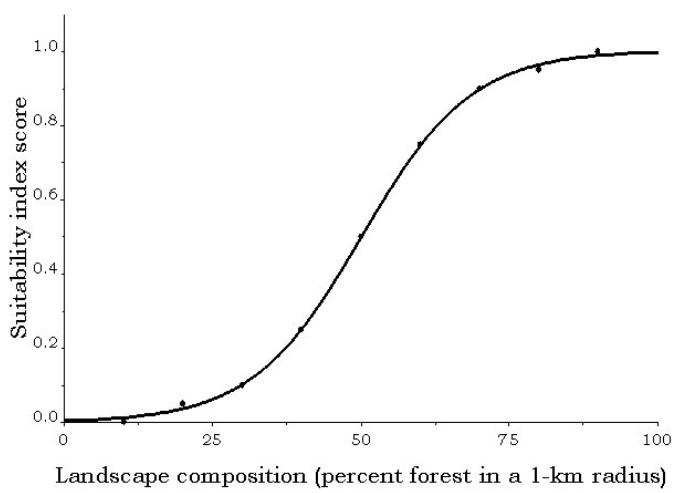


Figure 4. Relationship between landscape composition (percent forest in 1-km radius) and suitability index scores [from Tirpak et al. (2009)].

Flood Preference and Flood Tolerance

This relationship was developed specifically for Prothonotary Warbler as this species typically nests over or near large bodies of standing or slow-moving water, including seasonally flooded bottomland hardwood forest, bald cypress swamps, and large rivers or lakes (Walkinshaw 1953, Blem and Blem 1991). To create this dataset, Inundation Frequency Water Mosaic (IFWM) data from Gulf Coastal Plain & Ozarks Landscape Conservation Cooperative that provides a landscape comparison of floodplain inundation frequency was used and weighted according to the table below.

IFWM Flood frequency	Habitat suitability
0 – 25%	0
26 – 49%	0.5
50 – 75%	0.75
76 – 100%	1.0

Because Kentucky Warbler is not greatly tolerant of flooding and is more frequently found on relatively drier sites, we inverted the Flood Preference raster and produced a Flood Tolerance raster assigned less suitability to areas that were frequently flooded or had permanent water and increased suitability to area with less flood frequency. Again using IFWM data, these weights were:

IFWM Flood frequency	Habitat suitability
0 – 25%	1.0
26 – 49%	0.75
50 – 75%	0.5
76 – 100%	0

Bald-cypress - Tupelo Floodplain Forest

Yellow-throated Warblers exhibit strong preference for bald cypress and tupelo habitats (Gabbe et. al 2002); Prothonotary Warblers also favor bald-cypress - tupelo floodplain forest (Petit 1999). Therefore, we developed a GIS raster that depicted these habitat types. We extracted these data from the Gap Analysis Program (GAP) National Land Cover (U.S. Geological Survey 2011). These habitats were assigned a suitably value of 1 whereas other habitats were assigned a value of 0 (zero).

Final Models

Finally, the relevant rasters for each species were combined (i.e., added together in an Overlay Analysis approach) and then normalized to the number of inputs to produce a HSI raster for each species' potential breeding habitat, which was defined and characterized in an earlier step of the process (see *Methodology for Landscape Characterization*). Species-specific methodologies and outputs can be found in each species' discussion paragraphs below. Model output indicates priority level for protection and/or management (see Habitat Management and Recommendations, pp.24-27).

Acadian Flycatcher

We identified the relative suitability of potential breeding habitat for Acadian Flycatcher (Fig. 5) based on extant bottomland hardwood forest (woody wetland) patches capable of supporting at least one pair (≥1.6 ha), that were within landscapes of presumed natal dispersal distance (1,018 ha) that contained sufficient suitable habitat (10%) to support a minimum viable population of ≥63 pairs.

Because Acadian Flycatchers are presumed to be negatively impacted by forest fragmentation (Tirpak et. al 2009), we included **Percent Forest** in the landscape (Eq. 5) as a suitability factor. Also, as Acadian Flycatchers tend to be found near water (Whitehead and Taylor 2002), **Distance to Water** (Eq. 3; Fig. 2) was also included as a habitat suitability factor.

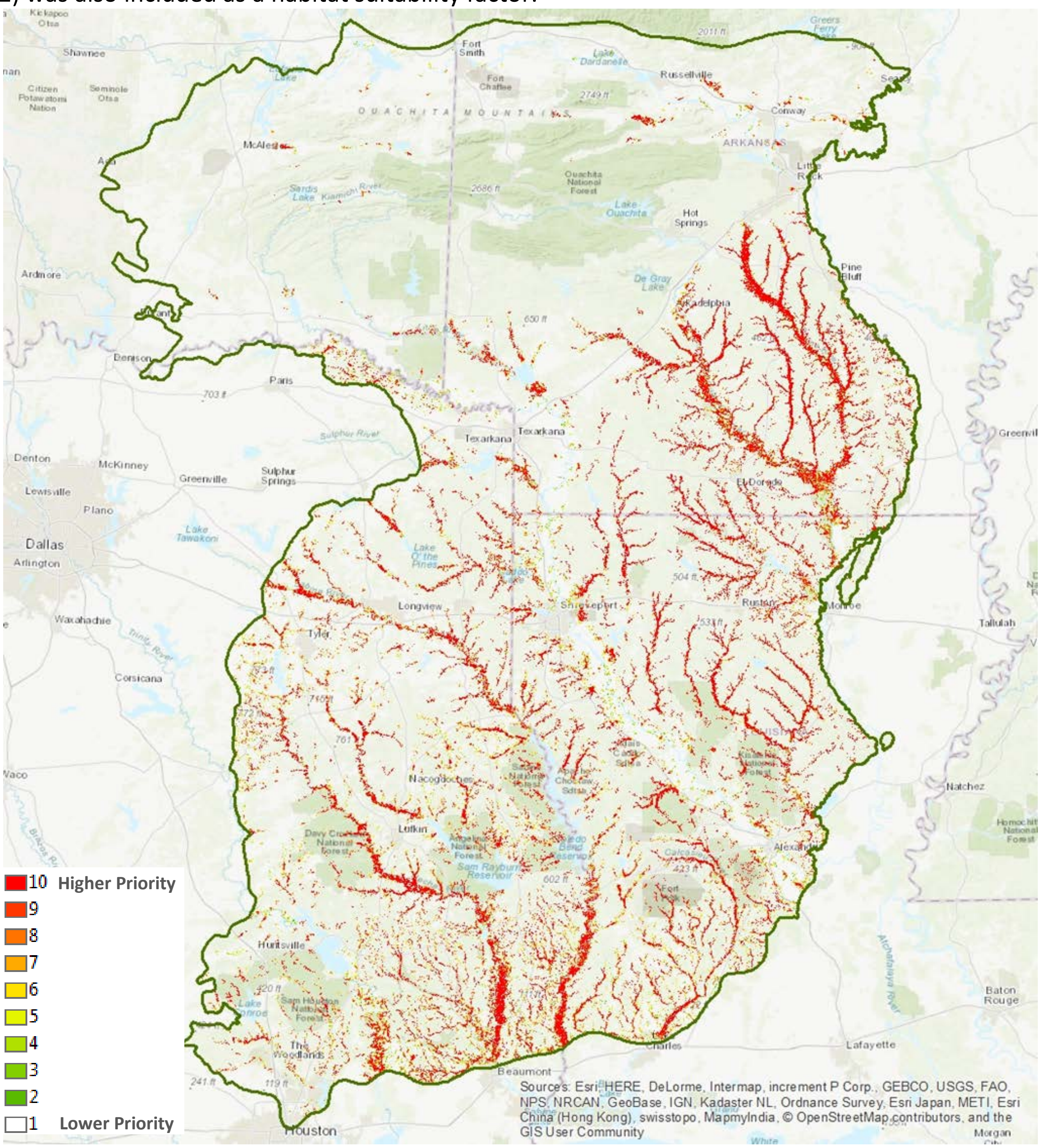


Figure 5. Acadian Flycatcher decision support model for the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Kentucky Warbler

We identified relative suitability of potential breeding habitat for Kentucky Warbler (Fig. 6) based on extant bottomland hardwood forest (woody wetland) patches capable of supporting at least one pair (≥5.5 ha), that were within landscapes of presumed natal dispersal distance (1,134 ha) that contained sufficient suitable habitat (31 %) to support a minimum viable population of ≥63 pairs.

Kentucky Warblers are forest-interior specialists (Morse and Robinson 1999) and are therefore likely positively influenced by increased forest within the landscape (Lynch and Whigham 1984). Although this warbler is a bottomland forest priority species in this geography, their propensity to nest on or near the ground makes them vulnerable to floods during the breeding season. To address these habitat factors, we included **Percent Forest** in the landscape (Eq. 5) as a positive factor and **Flood Avoidance** (Table 5) as a negative factor to model their habitat suitability.

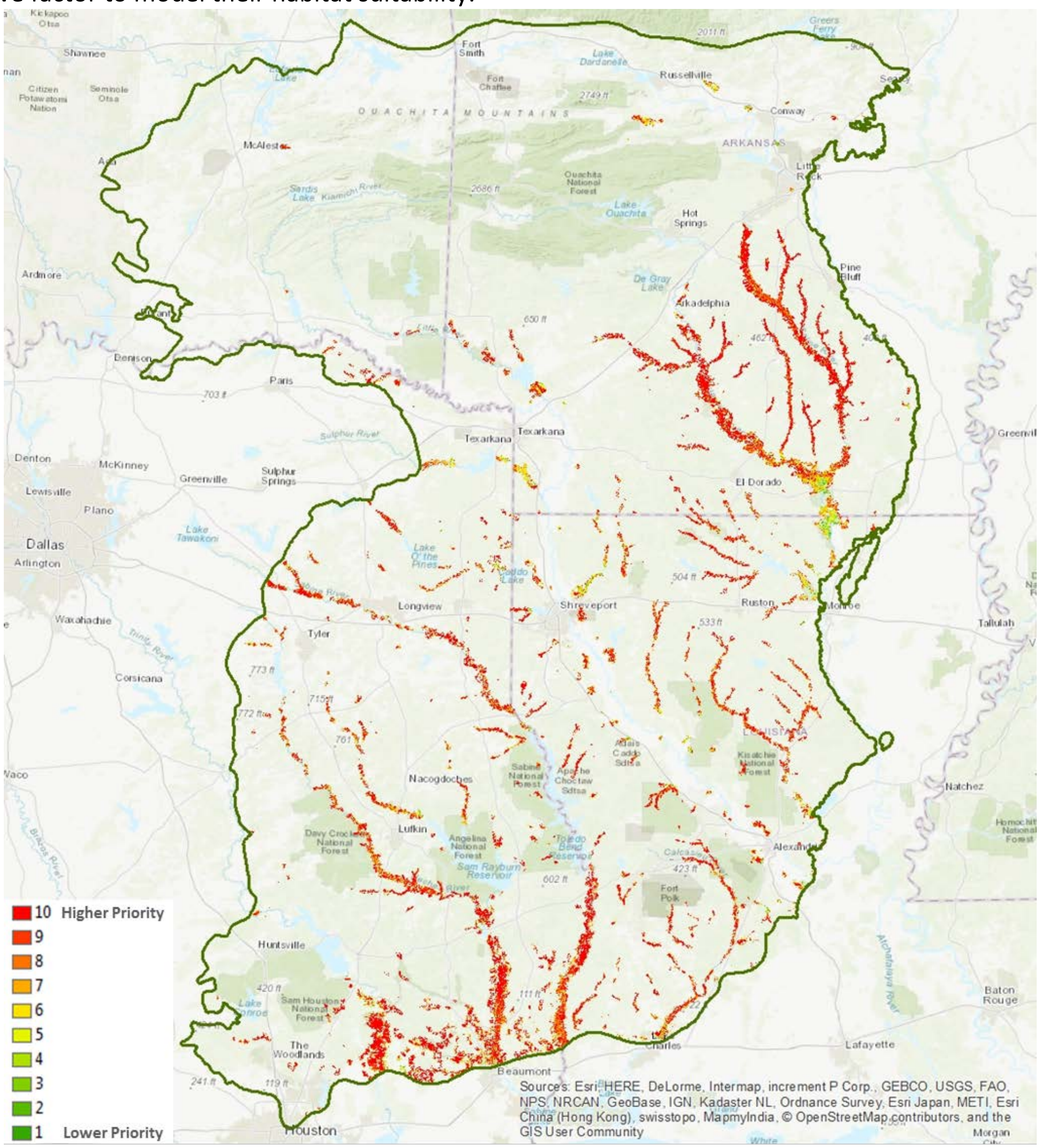


Figure 6. Kentucky Warbler decision support model for the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Prothonotary Warbler

We identified relative suitability of potential breeding habitat for Prothonotary Warbler (Fig. 8) based on extant bottomland hardwood forest (woody wetland) patches capable of supporting at least one pair (≥2.5 ha), that were within landscapes of presumed natal dispersal distance (5,026 ha) that contained sufficient suitable habitat (7 %) to support a minimum viable population of ≥134 pairs.

As Prothonotary Warblers almost universally breed near water, primarily in flooded bottomland forests, and have an affinity for cypress swamps (Petit 1999), we used **Distance to Water** (Eq. 3; Fig 2), **Percent Forest** in landscape (Eq. 5), **Flood Preference** (Table 5), and **Bald-cypress - Tupelo Floodplain Forest** as suitability factors for modelling habitat suitability for this species.

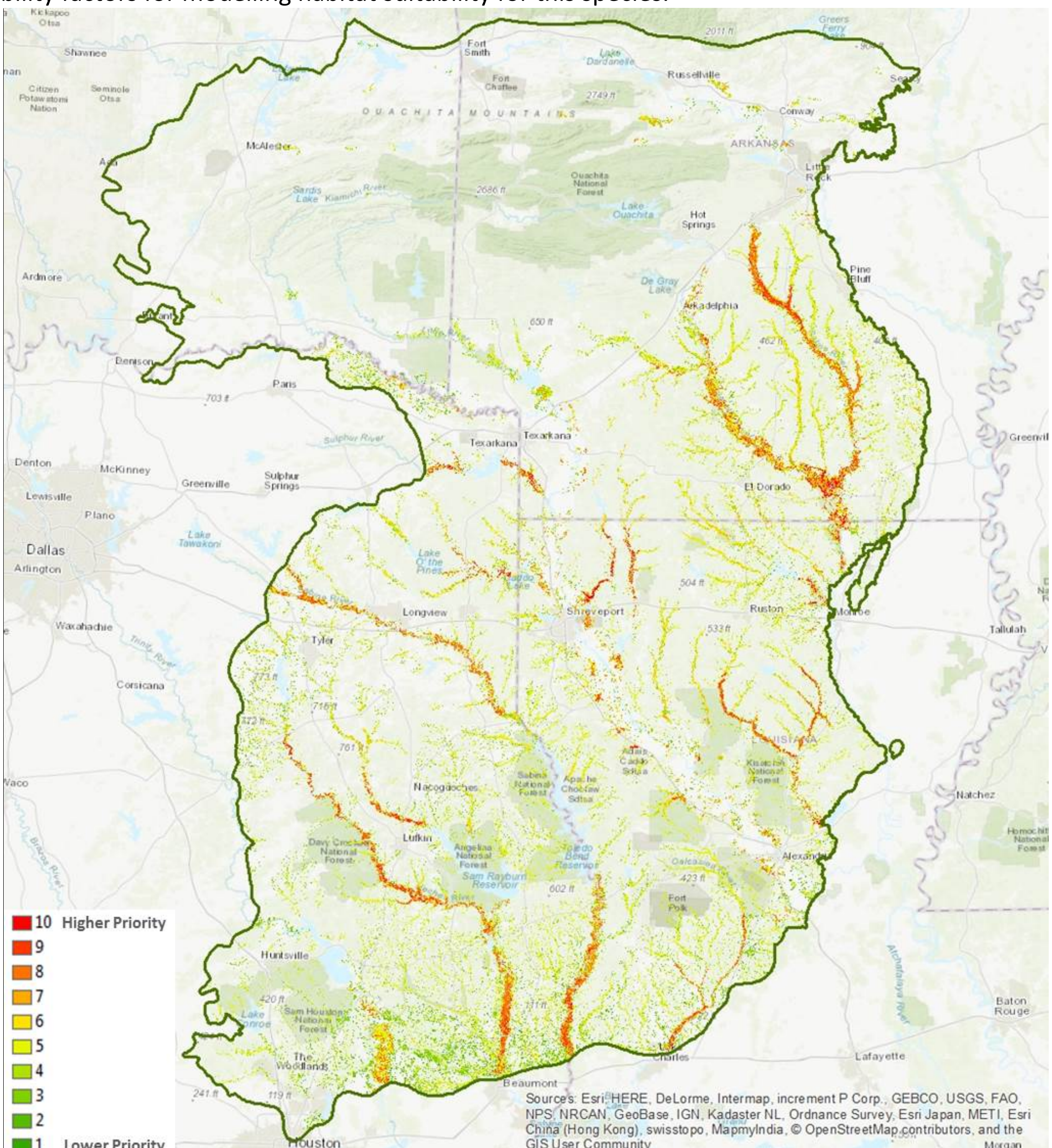


Figure 7. Prothonotary Warbler decision support model for West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Red-shouldered Hawk

We identified relative suitability of potential breeding habitat for Red-shouldered Hawk (Fig. 9) based on extant bottomland hardwood forest (woody wetland) patches capable of supporting at least one pair (≥171 ha), that were within landscapes of presumed natal dispersal distance (70,685 ha) that contained sufficient suitable habitat (6 %) to support a minimum viable population of ≥25 pairs.

Red-shouldered Hawks are found in large tracts of intact forest (Dykstra et al. 2008). Although they use small openings (Bednarz and Dinsmore 1981), Red-shouldered Hawks respond positively to the amount of forest in the landscape (Dykstra et al. 2008). They also tend to have a close association with water during nesting (Dykstra et al. 2001). Therefore, we used the **Percent Forest** in the landscape (Eq. 5) and **Distance to Water** (Eq. 3; Fig. 2) as suitability factors when modeling this species.

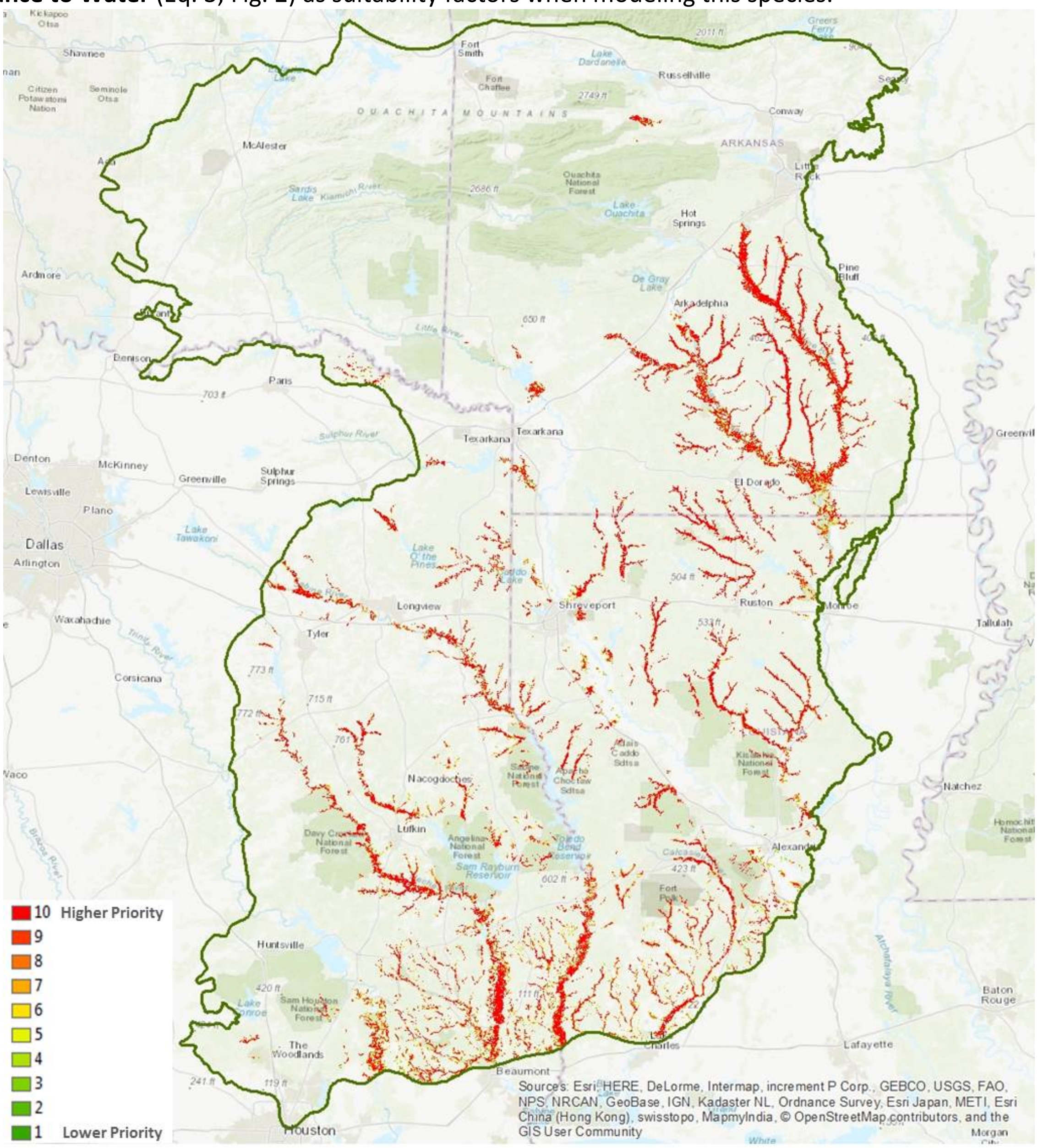


Figure 8. Red-shouldered Hawk decision support model for West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Yellow-throated Warbler

We identified relative suitability of potential breeding habitat for Yellow-throated Warbler (Fig. 10) based on extant bottomland hardwood forest (woody wetland) patches capable of supporting at least one pair (≥2.8 ha), that were within landscapes of presumed natal dispersal distance (804 ha) that contained sufficient suitable habitat (17 %) to support a minimum viable population of ≥48 pairs.

The Yellow-throated Warbler breeds in mature bottomland forest (Hall 1996) and typically nests near water (Hamel 1992). In addition, Yellow-throated Warblers exhibit a strong affinity for nesting in bald cypress and tupelo habitats (Gabbe et. al 2002). As such, we used **Distance to Water** (Eq. 4; Fig. 3), **Percent Forest** within the landscape (Eq. 5), and **Bald-cypress - Tupelo Floodplain Forest** as suitability factors when modelling this species.

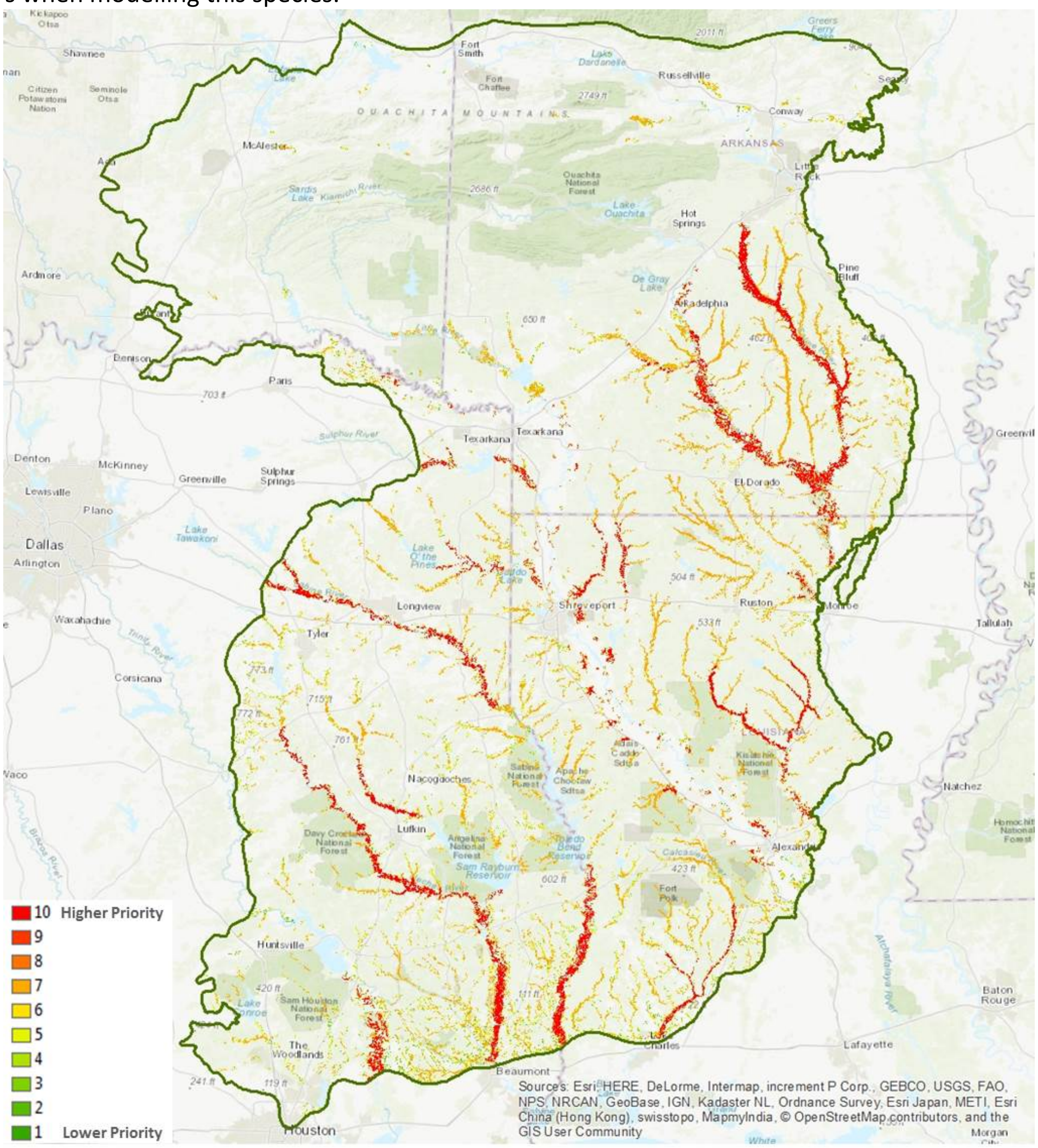


Figure 9. Yellow-throated Warbler decision support model for West Gulf Coastal Plains and Ouachitas Bird Conservation Region.

Composite HSI Forested Wetland Species Prioritization Modeling

We combined species-specific habitat suitability for the five forested wetlands umbrella species whose habitat suitability was defined above and normalized this value to account for the number of species. This composite depicts the relative suitability of habitat for species using woody wetlands and riparian areas and provides the geographic framework for *Management and Recommendation*s (see below).

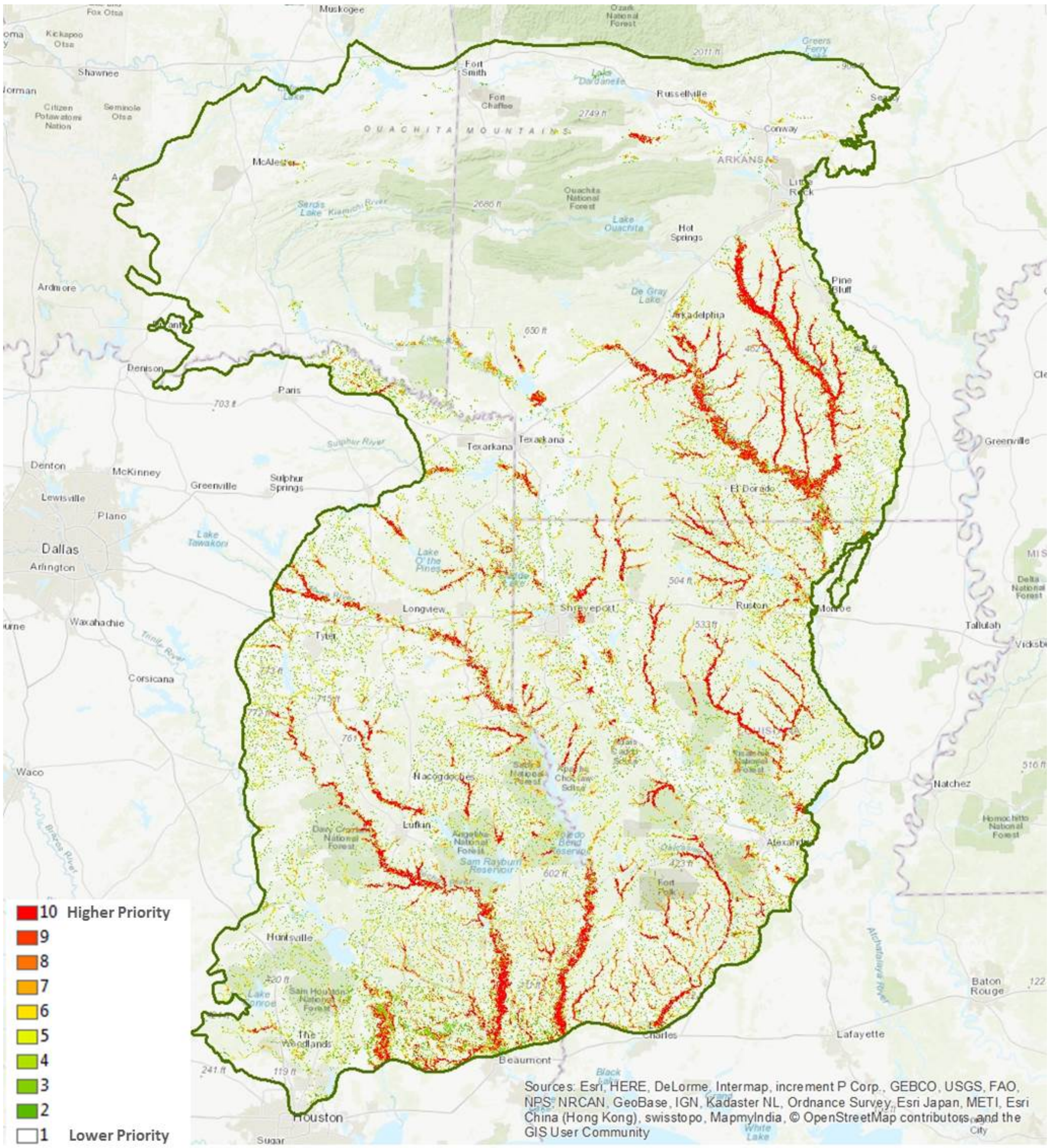


Figure 10. Composite priority map of West Gulf Coastal Plain and Ouachitas Bird Conservation Region forested wetlands for five umbrella bird species considered, including Acadian Flycatcher, Kentucky Warbler, Prothonotary Warbler, Red-shouldered Hawk, and Yellow-throated Warbler. Louisiana Waterthrush was not included in this final composite.

Habitat Management and Recommendations

Each of the umbrella species modeled above is associated with one or more additional suitability factors that influence their habitat suitability (Tirpak et al. 2009). However, some of these factors are difficult to accurately measure geospatially and, therefore, are listed below as qualitative descriptors. Even so, the 8 factors below (Table 6) should be considered when considering conservation actions on behalf of these species.

It is important to note that forest management results in a dynamic landscape. Thus managing desired stand structure as identified by the Lower Mississippi Valley Joint Venture Forest Resource Conservation Working Group (2007) likely results in a broad range of stand conditions that benefit a diverse suite of species. This diversity results, in part, from forest stand entering and exiting desired stand structure due to successional change over time after management has been undertaken.

Table 6 Habitat factors that influence habitat quality for six umbrella species in the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

Habitat Factors	ACFL	KEWA	PROW	RSHA	YTWA
Large tree diameter (>23 cm dbh)	x			x	x
Density of large trees (>40 trees >50dbh/ha)					x
Low tree density (250-300/ha)			x	x	x
Mid-story cover (open)	x			x	
Understory cover (open)	x				
Understory cover (dense)		x			
Moderate to well-developed canopy (60-70%)	x	x		x	
Small cavities (<10 inch diameter) or snag density of 5 snags/ha			x		

Acadian Flycatcher

Acadian Flycatchers breed throughout all mature forest habitats of WGCPO. However, as this species is usually found near water, especially along small and large streams (Mumford and Keller 1984, Brauning 1992), Acadian Flycatchers are predominately associated with mature deciduous (bottomland) hardwood and forested riparian areas. Acadian Flycatcher occupancy appears to be correlated with area of forest, as within other regions of the U.S. this species was reported only in forest patches >24 ha (Blake and Karr 1987) and was most abundant within large (>3,000 ha) forests (Robbins et al. 1989).

Acadian Flycatcher typically nests near water, such as rivers, streams, swamps, or marsh, usually within mature hardwood forests that have moderate or well-developed canopy and relatively open mid- and under-stories. Nests are typically in a fork near the end of small horizontal or slightly drooping branches of small trees or occasionally in understory shrubs. Nests are often located over open areas (e.g., water or trails), and positioned between the understory (top of shrub layer) and lower canopy (e.g., 3.0–9.0 m above ground). There appears to be selection for particular species of trees for nesting, such as sugarberry (*Celtis laevigata*), Nuttall oak (*Quercus nuttallii*), overcup oak (*Q. lyrata*), and possumhaw (*Ilex decidua*; Wilson and Cooper 1998) with nests in trees of mean dbh 23 cm (9 inches: range 4 - 107cm; R. Wilson and R. Cooper pers. comm.).

For Acadian Flycatcher populations, conservation and restoration of large forest tracts are necessary. Forest tracts must be of sufficient area to deter parasitism and depredation, thereby permitting reproductive output to exceed between-year mortality (Robinson et al. 1995). Ideally, forest area should have little internal disturbance (Thompson et al. 1996) and be in predominantly rural landscapes (Bakermans and Rodewald 2006). Forest structure and species composition within mature forests may be less critical than forest area, although forests with more open mid- and under-stories are desirable for nest sites and for foraging.

Kentucky Warbler

Kentucky Warblers breed throughout all mature forest habitats of WGCPO, but the species is predominately associated with mature deciduous (bottomland) hardwood and woods near streams with dense understory (McDonald 2013). Kentucky Warblers appear to be somewhat area-sensitive. Although Kentucky Warblers will occupy fragments as small as 2.4 ha, in Missouri this species had highest breeding success in patches >500 ha. Occupancy may be a poor indicator of habitat quality, as small fragments have been demonstrated to be population sinks for some species and many additional factors influence site occupancy (Johnson 2007).

Kentucky Warblers nest in mature deciduous forests with dense understory, but the degree to which closed canopy is preferred is debatable (McDonald 2013). Nests are built near the ground and the base may be 2-3 cm above ground. Nests are often anchored in an herbaceous plant or small shrub (McDonald 2013). Nests are almost always in dense understory and rarely on the edge between forest and clearing (McDonald 2013).

For Kentucky Warblers, forest management practices that maintain relatively mature trees with moderately high canopy cover, while encouraging a dense understory and well-developed ground cover are beneficial (Bushman and Therres 1988). Optimal Kentucky Warbler habitat results from management that creates canopy gaps via harvesting techniques such as group selection, small or narrow clear-cuts, thinning, and selection-cutting (Crawford et al. 1981). Clear-cutting temporarily removes habitat for Kentucky Warbler, but in Virginia the regenerating forest was occupied 6–7 years after harvest (Conner and Adkisson 1975, McDonald 2013). In Missouri, Kentucky Warblers had greater densities in landscapes composed of 10% regenerating habitat, 10% sapling habitat, and 80% pole-sawtimber habitat that is characteristic of landscapes subjected to clearcutting in the context of 100-year even-aged management rotation. In these landscapes Kentucky Warblers were more likely found in regenerating habitat, likely reflecting selection of high woody-stem density (Thompson et al. 1992).

Prothonotary Warbler

Prothonotary Warblers breeds in moist bottomland forests that are seasonally or permanently flooded. This species tends to be more common in functioning floodplain forests than in forests with altered flooding patterns (Cooper et al. 2009). Territories are often established in areas with standing water, such as oxbow ponds, sloughs, and slow-moving backwater (Gannon 2005). Increasing water depths appear to lower predation risk (Gannon 2005; Hoover 2006, 2009).

Prothonotary Warbler abundance tends to be positively associated with width of forest (Hodges and Krementz 1996). In eastern Texas, Brown (2001) found Prothonotary Warblers tends to favor forested wetlands with more open canopies that harbored a variety of hardwood species including planer tree (*Planera aquatica*), ashes (*Fraxinus* sp.), red maple (*Acer rubrum*), and oaks (*Quercus* sp.).

Prothonotary Warbler is the only warbler in the eastern U.S. that is an obligate cavity-nester - using natural cavities, woodpecker cavities, and nest boxes (Petit 1999). Cavity trees are typically >15 cm in diameter. Nests are placed approximately 2 meters above water and are typically lined with Spanish moss (*Tillandsia usnea*), liverwort, rootlets, bark, or other fine plant material (Petit 1999). Thus, management that promotes Spanish moss, within site limitations, is optimal.

Land management should include the promotion of forests with diverse hardwood species, seasonal flooding, and cavity trees (<25cm diameter; >10 visible holes/ha; LMVJV 2007). Leaving broad riparian zones along waterways is beneficial to this warbler. Altered waterways, especially through the construction of large dams, which can completely inundate forested wetlands, and channelization which reduces standing water, represent conservation threats to this species.

Red-shouldered Hawk

The Red-shouldered Hawk occurs throughout the WGCPO, particularly in extensive, mature bottomland hardwood and forested riparian areas. This species typically nests near water, such as rivers, streams, swamps, or marshes (Preston et al. 1989, Bosakowski et al. 1992, McLeod et al. 2000). Nesting habitat within bottomland hardwoods typically consists of mature forest with a well-developed overstory, open midstory, and variable understory (Kimmel and Federickson 1981, Titus and Mosher 1981, Bednarz and Dinsmore 1982, Szuba et al. 1991, Crocoll 1994). Non-breeding season habitat is similar but less restrictive than breeding season habitat. During the winter, some Red-shouldered Hawks can be seen in open agricultural landscapes (Bednarz, personal communication) and in general occur more frequently in open areas than during the breeding season (Bent 1937, Crocoll 1994).

Red-shouldered Hawk nests are usually built in the main fork of a large hardwood tree and are generally within forest interiors and further from forest edges than those of the Red-tailed Hawk (Moorman and Chapman 1996). At least 43 species of mainly deciduous trees have been used for nesting: so size and shape of nest trees seem more important than tree species (Bednarz 1979, Apfelbaum and Seelbach 1983, Titus and Mosher 1987, Palmer 1988). Nests are typically placed midway up the tree in the lower portion of the crown (Morris et al. 1983, Titus and Mosher 1987) at a height between 12- and 19 m. Nest trees typically have larger diameter boles and are taller than randomly selected trees within the same stand (McLeod et al. 2000).

Maintaining and encouraging mature (50- to 100-yr-old) forest stands with relatively large (20-60 cm dbh) trees at densities of 250–300 trees per ha appear to be desirable for Red-shouldered Hawks (Jacobs and Jacobs 2002), yet stands with tree densities of 370-990 trees per ha have also been viewed as desirable (Bednarz and Dinsmore 1981). Selective cuts which create small openings (<4 ha; comprising <15% of forest area) may provide benefits to Red-shouldered Hawks (Bednarz and Dinsmore 1981, 1982), but others suggest openings favor Red-tailed Hawks at the expense of Red-shouldered Hawks (Hands et al. 1989). Overall, there is disagreement on the benefits of small openings and the best structure of forests for Red-shouldered Hawks. Nevertheless, most agree that extensive areas (>250 ha) should be maintained in forest (>70% canopy) such that management via thinning and selective cutting is more beneficial than management via large area clearcut (Bryant 1986, Preston et al. 1989, Jacobs and Jacobs 2002). Open wetland inclusions are desirable (Bednarz and Dinsmore 1981, Howell and Chapman 1997).

Forest management plans should take into account the need for large areas of contiguous, mature forest. This species was once considered the most common woodland hawk throughout the eastern U.S., but its numbers have declined dramatically over the last two centuries, likely due to timber harvest that reduced and fragmented large contiguous tracts of bottomland hardwood and riparian forests (Martin 2004). The larger and more dominant Red-tailed Hawk (*Buteo jamaicensis*) and Great Horned Owl (*Bubo virginianus*) tend to favor these more open habitats and have displaced Red-shouldered Hawks in many areas following landscape modifications that fragment large contiguous, mature forests (Craighead and Craighead 1969; Bednarz and Dinsmore 1981, 1982; Bryant, 1986). These larger raptors prefer more open structure and may out-compete Red-shouldered Hawks for foraging habitat and nest sites following fragmentation of or reduction in tree density in their territories; more study is needed to fully understand this association. Red-shouldered Hawk populations have stabilized or increased in some areas since 1980 as regrowth of previously harvested forests provide more suitable habitat. Even so, indiscriminate timber management or conversion of forest lands could result in declines in their populations (Martin 2004).

Some Red-shouldered Hawk populations appear to be intolerant of human presence during the nesting season, with high nest failures reported associated with human disturbance near nests (Wiley 1975). Other populations, however, have been reported to be more tolerant of human activities near nests and suburban populations have been observed (Dykstra at al. 2000).

Yellow-throated Warbler

Yellow-throated Warblers breed in a variety of habitat types from cypress swamps to lowland hardwoods to upland pine forest (Lowery 1955, Harrison 1975, Stevenson and Anderson 1994, McKay and Hall 2012). In the Delmarva Peninsula, they are almost exclusively found in loblolly pine (*Pinus taeda*) forest (Ficken et al. 1968, Dunn and Garrett 1997). In wetland forests, these warblers are found in both baldcypress (*Taxodium distichum*) (Lowery 1955, Gooding 1998, McKay and Hall 2012) and sycamore (*Platanus occidentalis*) (Oberholser 1974, Hall 1983). Such a positive correlation between sycamore trees and Yellow-throated Warblers exist that the subspecies, *S. dominica albilora*, once held the name Sycamore Warbler (Imhof 1962, Butler 1928). It has been suggested that in the east, the birds prefer pine forests and in the west, sycamores; however, this may be a product of tree species availability (McKay and Hall 2012).

In the Cache River wetlands of southern Illinois, Gabbe et al. (2002) found that Yellow-throated Warblers have a strong preference for baldcypress and tupelo gum as foraging substrate, avoiding ashes, oaks, hickories and maples. They spend most of their time in the mid to upper canopy gleaning from leaves, Spanish moss, and twigs (Hamel 1992, Gooding 1998). They are often observed foraging along large limbs (Imhof 1962, Hamel 1992), creeping like a Black and White Warbler (Stevenson and Anderson 1994). Robins et al. (1989) found Yellow-throated Warblers were associated with large diameter trees.

Yellow-throated Warblers build cup-shaped nests inside clumps of Spanish moss when available (Lowery 1955, Harrison 1975, Oberholser 1974, Potter et al. 1980, Dunn and Garrett 1997, Gooding 1998, McKay and Hall 2012). Yellow-throated Warblers also place their nests in clumps of pine needles (Imhof 1962, Potter et al. 1980) or build an open cup nest away from the trunk of the tree (Harrison 1975, Dunn and Garrettt 1997). In upland areas, they often nest in mature pine and mixed pine/oak forests with open understory conditions (McKay and Hall 2012). Yellow-throated Warblers may choose open forests with relatively low tree density (Hamel 1992, Gooding 1998, McKay and Hall 2012). Nests average 9-18 m above ground but can be as high as 37 meters (Harrison 1975).

Monitoring and Evaluation

Our objectives and decision support model are based on numerous assumptions regarding life history parameters and bird-habitat relationships. These assumptions, as stated herein, should be evaluated. Ultimately, measuring the conservation community's success in achieving the biological objectives for birds of forested wetland will be possible only through monitoring bird populations and their response to management actions.

Assessment of population goals for umbrella species relies on continued bird monitoring via the North American Breeding Bird Survey (Sauer et al. 2014) within the WGCPO Bird Conservation Region. We advocate continuance and potentially expansion of this monitoring program. Assessment of trends from Breeding Bird Survey data will provide a useful measure of progress toward population goals. Conservation managers are encouraged to work with state coordinators (Table 7) to ensure that all Breeding Bird Survey routes within the WGCPO Bird Conservation Region are annually monitored.

In addition, habitat conservation activities through the LMVJV's Conservation Delivery Networks (CDNs) focused on addressing priority needs of bottomland hardwood breeding birds, coupled with effects monitoring, provide opportunities to test some of our assumptions. For example, a recent pilot effort to conduct breeding bird surveys in within the Northeast Texas CDN utilizing a waterborne approach along major stream segments may prove useful in this regard (Holdermann et al. 2017, unpubl. data), as BBS routes in northeastern Texas sample only a small proportion of bottomland hardwood and riparian habitats. We encourage CDNs to consider possibilities for monitoring and research efforts that strengthen our understanding of the critical biological underpinnings of this plan.

Table 7. Breeding Bird Survey coordinators for states within the within the West Gulf Coastal Plain and Ouachitas Bird Conservation Region.

State	BBS Coordinator & Contact Information
Arkansas	Dick Baxter; 870-866-2806; dickbaxter100@gmail.com
Oklahoma	Dan Reinking; 918-336-7778; dan@suttoncenter.org
Louisiana	Michael Seymour; 225-763-3554; mseymour@wlf.la.gov
Texas	Brent Ortego; 361-827-4691; brentortego@hotmail.com

References

Apfelbaum, S.I., and P. Seelbach. 1983. Nest tree, habitat selection and productivity of seven North American raptor species based on the Cornell University Nest Record Card Program. Journal of Raptor Research 17:97-113.

Bakermans, M.H. and A.D. Rodewald. 2006. Scale-Dependent Habitat Use of Acadian Flycatcher (*Empidonax virescens*) in Central Ohio. Auk 123:368-382.

Bednarz, J. C., and J. J. Dinsmore. 1981. Status, habitat use and management of Red-shouldered Hawks in Iowa. Journal of Wildlife Management 45:236-241.

Bednarz, J. C., and J. J. Dinsmore. 1982. Nest-sites and habitat of red-shouldered and red-tailed hawks in Iowa. Wilson Bulletin 94:31-45.

Bent, A.C. 1963. Life histories of North American wood warblers, part two. Dover Publishing, Inc., New York, NY. 734pp.

Blake, J. G. and J. R. Karr. 1987. Breeding birds of isolated woodlots: area and habitat relationships. Ecology 68:1724-1734.

Blem, C.R. and L.B. Blem. 1991. Nest box selection by Prothonotary Warblers. Journal of Field Ornithology 62:299-307.

Bosakowski, T., D. G. Smith, and R. Speiser. 1992. Status, nesting density, and macrohabitat selection of Red-shouldered Hawks in northern New Jersey. Wilson Bulletin 104:434–446.

Brauning, D. W. 1992. Acadian Flycatcher (Empidonax virescens***)***. Pages 200-201 *in* Atlas of breeding birds in Pennsylvania. (Brauning, D. W., Ed.) Univ. of Pittsburgh Press, Pittsburgh, PA.

Brown, R.E. 2001. Breeding biology, habitat, nest site, and nest box selection by Prothonotary Warblers and other species in eastern Texas. Unpublished M.S. thesis, Stephen F. Austin State University, Nacogdoches, TX. 200 pp.

Bryant, A.A. 1986. Influence of selective logging on Red-shouldered Hawks, *Buteo lineatus*, in Waterloo region, Ontario, 1953-1978. Canadian Field-Naturalist 100:520-525.

Bushman, E. S. and G. D. Therres. 1988. Habitat management guidelines for forest interior breeding birds of coastal Maryland. Wildlife Technical Publication 88-1. Maryland Department of Natural Resources.

Butler, A.W. 1928. Nesting of the sycamore warbler. Auk 45:224-225.

Conner, R. N. and C. S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. Journal of Forestry 73:781-785.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of Interior, Fish and Wildlife Service, Publication FWS/OBS-79/31, Washington, D.C. 103 pp.

Craighead, J. J., and F. C. Craighead, Jr. 1956. Hawks, Owls and Wildlife. The Stackpole Company, Harrisburg, Pennsylvania, and the Wildlife Management Institute, Washington, D.C.

Crawford, H. S., R. G. Hooper, and R. W. Titterington. 1981. Songbird population response to silvicultural practices in central Appalachian hardwoods. Journal of Wildlife Management 45:680-692.

Crocoll, S. 1994. Red-shouldered hawk (*Buteo lineatus*). Pp. 1-20 in A Poole, F Gill, eds. The Birds of North America, Vol. 107. Washington, DC: The American Ornithologist's Union.

Dunn, J. and K. Garrett. 1997. A Field Guide to Warblers of North America. Houghton Mifflin Co. Boston. 656 pp.

Dykstra, C. R., F. B. Daniel, J. L. Hays and M. M. Simon. 2001a. Correlation of Red-shouldered Hawk abundance and macrohabitat characteristics in southern Ohio. Condor 103:652-656.

Dykstra, CR., J. L. Hays, and S.T. Crocoll. 2008. Red-shouldered Hawk (Buteo lineatus), The Birds of North America (P. G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/reshaw

Eaton, S.W. 1958. A life history study of the Louisiana Waterthrush. Wilson Bulletin 70:210-235.

LMVJV Forest Resource Conservation Working Group. 2007. Restoration, Management, and Monitoring of Forest Resources in the Mississippi Alluvial Valley: Recommendations for Enhancing Wildlife Habitat. Edited by R. Wilson, K. Ribbeck, S. King, and D. Twedt.

Ficken, R.W., M.S. Ficken, and D.H. Morse. 1968. Competition and character displacement in two sympatric pine-dwelling warblers (*Dendroica, Parulidae*). Evolution 22: 307-314.

Gabbe, A.P., S.K. Robinson, and J. D. Brawn. 2002. Tree-species preferences of foraging insectivorous birds: implications for floodplain forest restoration. Conservation Biology 16: 462-470.

Gooding, G. 1998. Nesting ecology and foraging behavior of yellow-throated warblers and northern parulas on Caddo Lake in Texas. M.S. Thesis, Louisiana State University, Baton Rouge, LA, 71 pp.

Graber, J.W., R.R. Graber, and E.L. Kirk. 1983. Illinois birds: wood warblers. Illinois Natural History Survey Biological Notes 118.

Griscom, L. and A. Sprunt. 1978. The warblers of America: a popular account of the wood warblers as they occur in the Western Hemisphere. Doubleday and Company, Inc., Garden City, NY. 302pp.

Hall, G.A. 1983. West Virginia birds. Carnegie Mus. Nat. Hist. Spec. Publ. 7.

Hall, G.A. 1996. Yellow-throated warbler (Dendroica dominica). Number 223. In: Poole, A.; Gill, F., eds. The birds of North America. Philadelphia, PA: The Academy of Natural Sciences and Washington, DC: The American Ornithologists' Union.

Hamel, P.B. 1992. Land manager's guide to the birds of the South. Chapel Hill, NC: The Nature Conservancy, Southeastern Region. 437 p.

Hands, H.M., R.D. Drobney, and M.R. Ryan. 1989. Status of the Red-shouldered Hawk in the northcentral United States. Missouri Coop. Fish Wildl. Res. Unit Rep. 21 pp.

Harrison, H.H. 1975. A field guide to birds' nests. Houghton Mifflin Co., Boston, MA, 257 pp.

Hodges, M.F, Jr., and D.G. Krementz. 1996. Neotropical migratory breeding bird communities in riparian forests of different widths along the Altamaha River, Georgia. Wilson Bulletin 108:496-506.

Holdermann, D., J. Estrella, and K. McKnight. 2017. Preliminary summary of development of a waterborne survey protocol for bottomland hardwood forest breeding birds in northeastern Texas. Unpublished manuscript.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354

Howell, D. L. and Chapman, B. R. 1997. Home range and habitat use of Red-shouldered Hawks in Georgia. Wilson Bulletin, 109**,** 131-144.

Huffman, R.T., and S.W. Forsythe. 1981. Bottomland hardwood forest communities and their relation to anaerobic soil conditions. Pages 187-196 in Clark, J.R. and J. Benforado (editors). Wetlands of bottomland hardwood forests. Elsevier Scientific Publishing Co., Amsterdam, the Netherlands.

Hunter, W. C., D. A. Buehler, R. A. Canterbury, J. L. Confer, and P. B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin, 29(2):440-455.

Imhof, T. 1962. Alabama birds. Univ. of Alabama Press, University, AL 59 pp.

Jacobs, J. and Jacobs, E. 2002. Conservation assessment for Red-shouldered Hawks (*Buteo lineatus*) National forests of North Central States. USDA Forest Service Eastern Region.

Johnson, M.D. 2007. Measuring habitat quality: a review. Condor 109:489-504.

Kimmel, V.L., and L.H. Fredrickson. 1981. Nesting ecology of the Red-shouldered Hawk in southeastern Missouri. Transactions of the Missouri Academy of Science 15:21-27.

Lower Mississippi Valley Joint Venture Management Board. 2013. Lower Mississippi Valley Joint Venture Operational Plan. Vicksburg, Mississippi. 39 pp.

Lowery, G.H., Jr. 1955. Louisiana Birds. Louisiana State Univ. Press, Baton Rouge, LA, 567 pp.

Lynch, J.F. and D.F. Whigham. 1984. Effects of forest fragmentation on breeding bird communities in Maryland, U.S.A. Biological Conservation 38:287-324.

Martin, E. M. 2004. Decreases in a population of Red-shouldered Hawks nesting in central Maryland. Journal of Raptor Research 38:312-319.

McKay, B. and G.A. Hall. 2012. Yellow-throated Warbler (*Setophaga dominica*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/223

McLeod, M.A., A. Belleman, D.E. Andersen and G.W. Oehlert. 2000. Red-shouldered Hawk nest site selection in North-central Minnesota. Wilson Bulletin 112:203-213.

Mengel, R.M. 1965. The birds of Kentucky. Ornithological Monograph 3.

Moorman, C. E. and B. R. Chapman. 1996. Nest-site selection of Red-shouldered and Red-tailed Hawks in a managed forest. Wilson Bulletin 108:357–368.

Mumford, R. E. and C. E. Keller. 1984. The birds of Indiana. Indiana Univ. Press, Bloomington.

Mattsson, B. J. and R. J. Cooper. 2009. Multiscale analysis of the effects of rainfall extremes on reproduction by an obligate riparian bird in urban and rural landscapes. Auk 126:64-76.

Mattsson, B.J., T. L. Master, R.S. Mulvihill and W.D. Robinson. 2009. Louisiana Waterthrush (Parkesia motacilla), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology http://bna.birds.cornell.edu/bna/species/151

McKay, B. and G.A. Hall. 2012. Yellow-throated Warbler (*Setophaga dominica*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/223

McDonald, Mary Victoria. 2013. Kentucky Warbler (*Geothlypis formosa*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/324

Morse, S.F. and S.K. Robinson. 1999. Nesting success of a neotropical migrant in a multiple-use, forested landscape. Conservation Biology 13:327-337.

NatureServe. 2014. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: March 9, 2015).

NatureServe. 2017. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://explorer.natureserve.org. (Accessed: April 17, 2017).

Niven, D.K., J.R. Sauer, G.S. Butcher, and W.A. Link. 2004. Christmas Bird Count provides insights into population change in land birds that breed in the boreal forest. Pages 10-20 *in* The 104th Christmas Bird Count, American Birds 58. National Audubon Society

Oberholser, H.C. 1974. The bird life of Texas. Vol. 2, Univ. of Texas Press, Austin, 1057 pp.

O'Connell, T. J., R. P. Brooks, S. E. Laubscher, R. S. Mulvihill, and T. L. Master. 2003.Using bioindicators to develop a calibrated index of regional ecological integrity for forested headwater ecosystems. Final Report to U.S. Environmental Protection Agency, STAR Grants Program. Penn State Cooperative Wetlands Center, Pennsylvania State University, University Park, PA.

Odum, E.P. 1979. Ecological importance of the riparian zone. Pages 2-4 in Johnson, R.R. and J.F. McCormick (technical coordinators). Strategies for protection and management of floodplain wetlands and other riparian ecosystems. U.S. Department of Agriculture, Forest Service, General Technical Report WO 12, Washington, D.C. 410 pp.

Palmer, R. S. 1988. Red-shouldered Hawk, *Asturina lineata*. Pages 413-29 in R. S. Palmer (editor). Handbook of North American Birds. Vol. 4: Diurnal Raptors (Part 1). Yale University Press, New Haven, Connecticut. 433 pp.

Panjabi, A. O., P. J. Blancher, R. Dettmers, and K. V. Rosenberg, Version 2012. Partners in Flight Technical Series No. 3. Rocky Mountain Bird Observatory website: http://www.rmbo.org/pubs/downloads/Handbook2012.pdf

Partners in Flight. 2003. West Gulf Coastal Plain Bird Conservation Region Bird Conservation Plan (draft). May 1, 2003. 53 pp.

Partners in Flight Science Committee 2012. Species Assessment Database, version 2012. Available at: http://rmbo.org/pifassessment. Accessed on 16 March 2014.

Petit, L.J. 1999.Prothonotary Warbler (Protonotaria citrea), The Birds of North America (P.G. Rodewald, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America: https://birdsna.org/Species-Account/bna/species/prowar

Potter, E.F., J.F. Parnell, and R.P. Teulings. 1980. Birds of the Carolinas. Univ. of N. Carolina Press, Chapel Hill, NC, 408 pp.

Preston, C. R., C. S. Harger, and H. E. Harger. 1989. Habitat use and nest-site selection by Red-shouldered Hawks in Arkansas. Southwestern Naturalist 34:72-78.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proc. Natl. Acad. Sci. 86:6758-7662.

Robinson, S. K., F. R. Thompson III, T. M. Donovan, D. R. Whitehead, and J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987-1990.

Robinson, W.D. 1990. Louisiana Waterthrush foraging behavior and microhabitat selection in southern Illinois. Master’s thesis, Southern Illinois University, Carbondale.

Rosenberg, K.V., J. A. Kennedy, R. Dettmers, R. P. Ford, D. Reynolds, J.D. Alexander, C. J. Beardmore, P. J. Blancher, R. E. Bogart, G. S. Butcher, A. F. Camfield, A. Couturier, D. W. Demarest, W. E. Easton, J.J. Giocomo, R.H. Keller, A. E. Mini, A. O. Panjabi, D. N. Pashley, T. D. Rich, J. M. Ruth, H. Stabins, J. Stanton, T. Will. 2016. Partners in Flight Landbird Conservation Plan: 2016 Revision for Canada and Continental United States. Partners in Flight Science Committee. 119 pp.

Sauer, J. R., J. E. Fallon, and R. Johnson. 2003. Use of North American Breeding Bird Survey data to estimate population change for bird conservation regions. Journal of Wildlife Management 67:372–389.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2014. The North American Breeding Bird Survey, Results and Analysis 1966 - 2012. Version 02.19.2014 USGS Patuxent Wildlife Research Center, Laurel, MD. Accessed online at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html <6 March 2014>

Stevenson, H.M. and B.H. Anderson. 1994. The birdlife of Florida. Univ. Presses of Florida, Tallahassee, FL, 892 pp.

Sutherland, G. D., A. S. Harestad, K. Price, and K. Lertzman. 2000. Scaling of natal dispersal distances in terrestrial birds and mammals. Conservation Ecology 4:16. [online] URL: http://www.consecol.org/Journal/vol4/iss1/art16

Szuba, K.J., B.J. Naylor and J.A. Baker. 1991. Nesting habitat of Red-shouldered Hawks in the Great Lakes – St. Lawrence forest region of central and southeastern Ontario. Ontario Ministry of Natural Resources, COFTDU Tech. Rpt. No. 14.

Texas Parks and Wildlife Department. 2012. Texas Conservation Action Plan 2012 – 2016: Western Gulf Coastal Plain Handbook. Editor, Wendy Connally, Texas Conservation Action Plan Coordinator. Austin, Texas.

Thomspon, F.R., III, J.R. Probst, and M.G. Raphael. 1992. Silvicultural options for neotropical migratory birds. Pages 353-362 in Finch, Deborah M.; Stangel, Peter W., eds. 1993. Status and Management of Neotropical Migratory Birds; 1992 September 21-25; Estes Park, CO. Gen. Tech. Rep. RM-229. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 422 p.

Thompson, F. R., III, S. K. Robinson, D. R. Whitehead, and J. D. Brawn. 1996. Management of central hardwood landscapes for the conservation of migratory birds. Pages 117-143 in Thompson, F. R., III, ed. Management of Midwestern landscapes for the conservation of neotropical migratory birds. General Technical Report NC-187. USDA Forest Service, North Central Forest Experiment Station. 207 p.

Titus, K., and J. A. Mosher. 1981. Nest site habitat selection by woodland hawks in the central Appalachians. Auk 98:270-281.

Tirpak, J. M., D. T. Jones-Farrand, F. R. Thompson, III, D. J. Twedt, M. D. Nelson, and W. B. Uihlein, III. 2009. Predicting bird habitat quality from a geospatial analysis of FIA data. Pages 171-179 In R.

E. McRoberts, G. A. Reams, P. C. Van Duesen, and W. H. McWilliams, editors. Proceedings of the Eighth Annual Forest Inventory and Analysis Symposium. October 16-19, 2006. Monterey, CA. U. S. Forest Service General Technical Report WO-79, Washington D.C., USA. http://nrs.fs.fed.us/pubs/gtr/gtr_wo079/gtr_wo079.pdf

Twedt, D. J. 2015. Estimating regional landbird populations from enhanced North American Breeding Bird Surveys. Journal of Field Ornithology 86:352-368. [online] URL: https://www.researchgate.net/profile/Daniel_Twedt/publication/283956364_Estimating_regional_landbird_populations_from_enhanced_North_American_Breeding_Bird_Surveys/links/5654903208ae4988a7b044a5.pdf

U.S. Geological Survey. 2013. National Hydrography Geodatabase: The National Map viewer available on the World Wide Web (http://viewer.nationalmap.gov/viewer/nhd.html?p=nhd). <Accessed 10 March 2016>

U.S. Geological Survey. 2011. Gap Analysis Program (GAP). National Land Cover, Version 2.

Walkinshaw, L.H. 1953. Life-history of the Prothonotary Warbler. Wilson Bulletin 65:152-168.

Whitehead, Donald R. and Terry Taylor. 2002. Acadian Flycatcher (Empidonax virescens), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/614

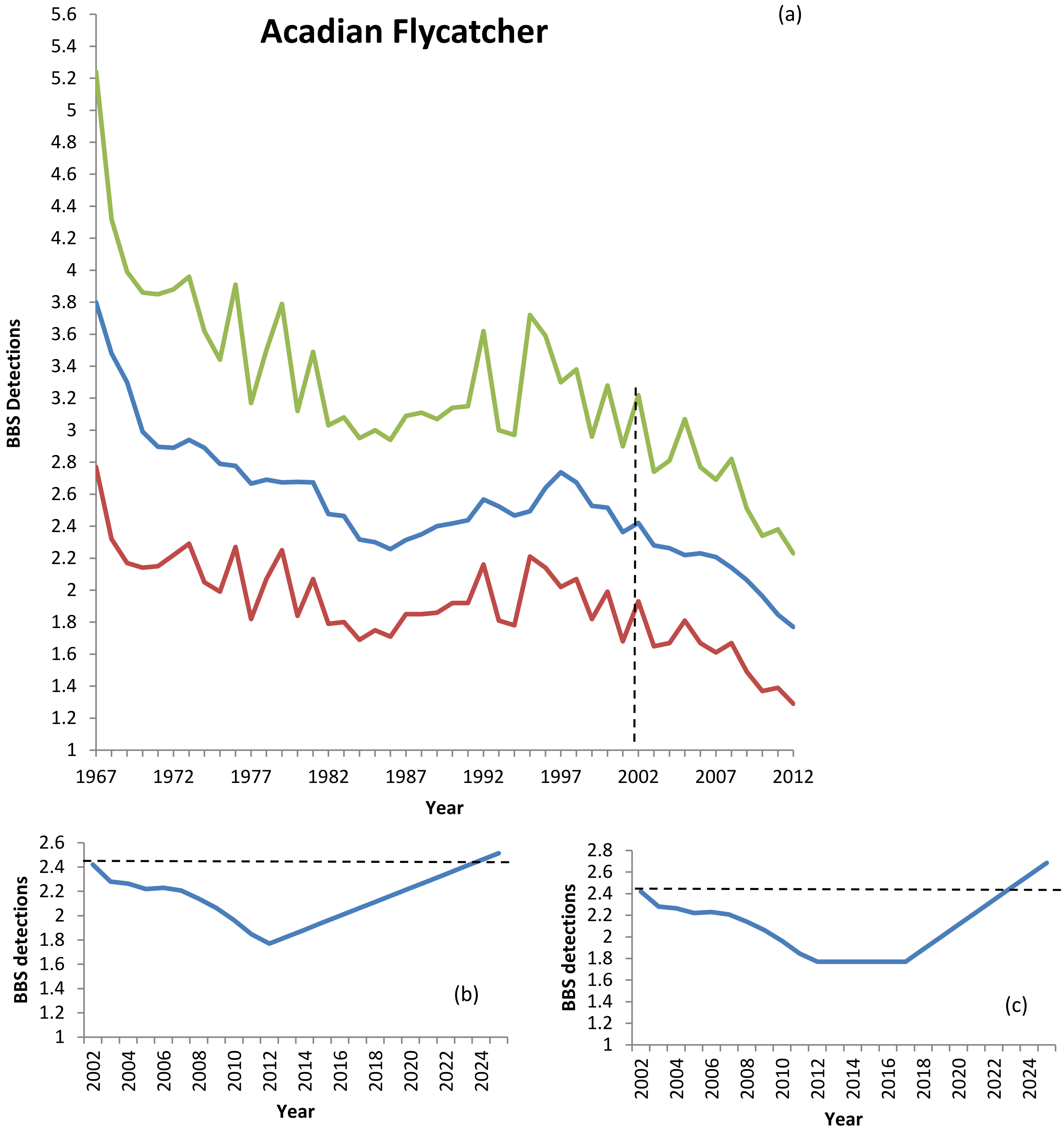
Wiley, J. W. 1975. The nesting and reproductive success of red-tailed hawks and Red-shouldered Hawks in Orange County, California, 1973. Condor 77:133-139.

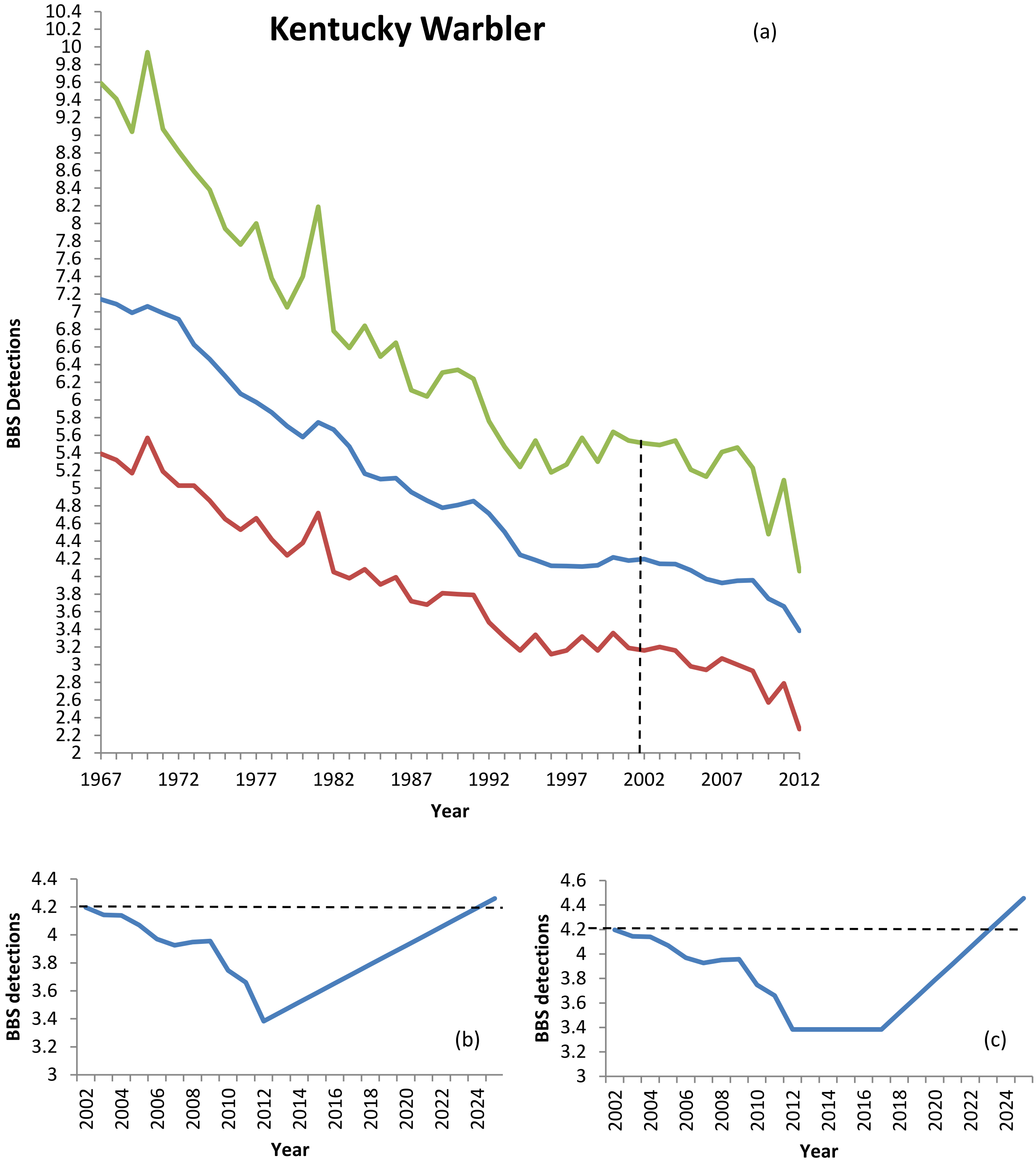
Wilson, R. R. and R. J. Cooper. 1998. Breeding biology of Acadian Flycatchers in a bottomland hardwood forest. Wilson Bull. 110:226-232.

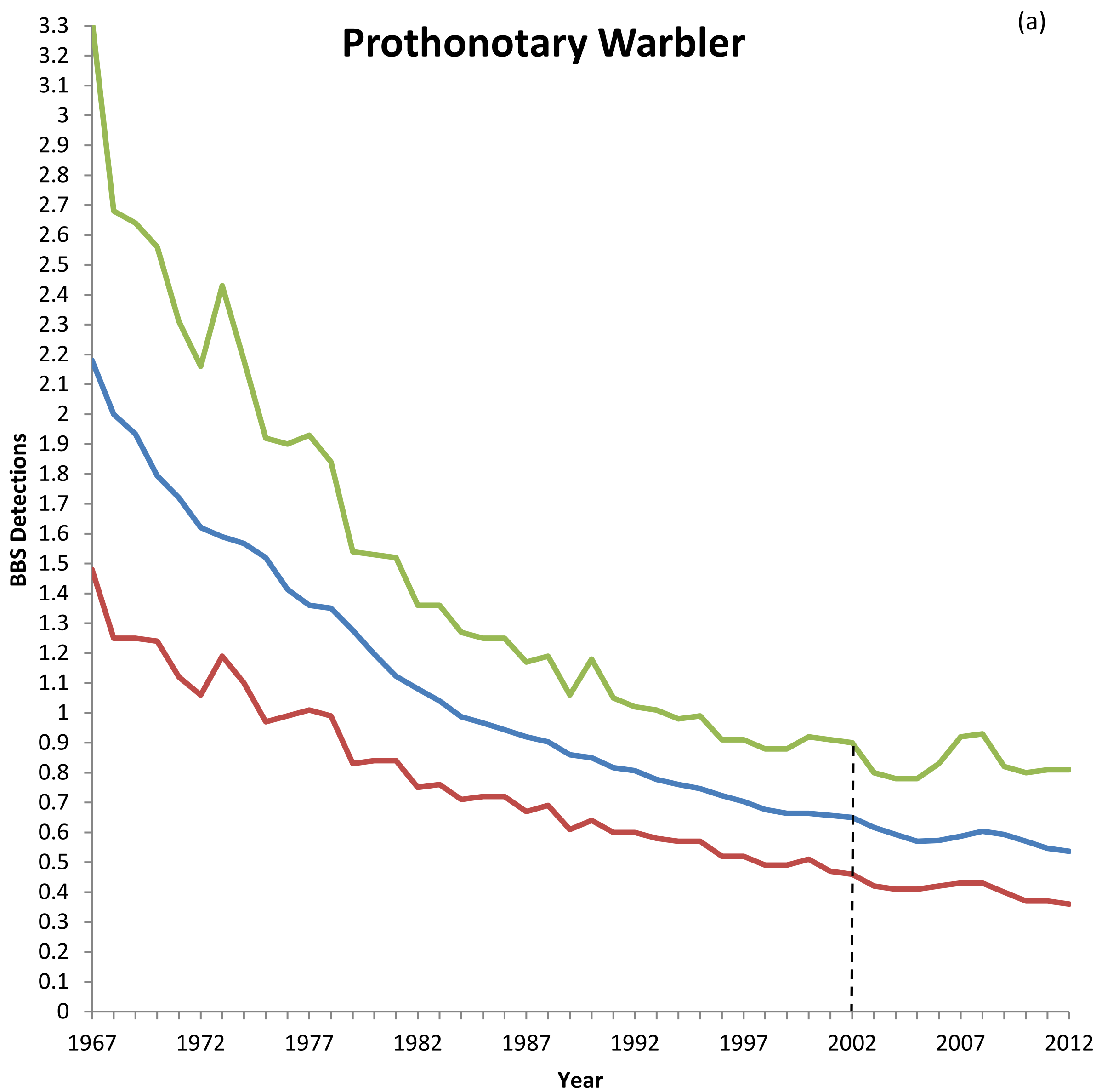
Wunderle, Jr., J. M. and R. B. Waide. 1994. Future prospects for nearctic migrants wintering in Caribbean forests. Bird Conservation International 4:191-207.

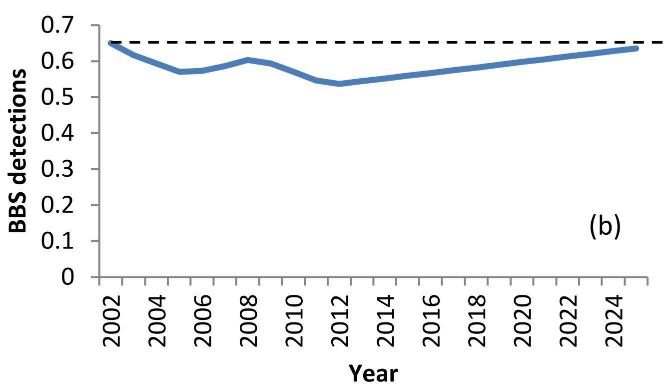
Appendices

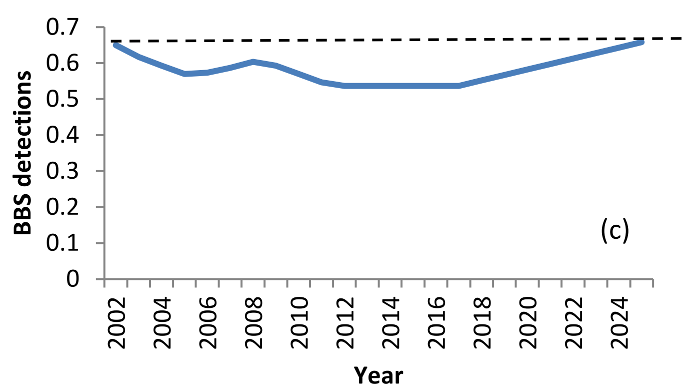
Appendix 1. Breeding Bird Survey (BBS) trends for umbrella species with declining trends, calculated as 3-year moving averages. Dashed line indicates BBS detections at the beginning of the 10-year period. Figures (a) represent the overall BBS trend; Figures (b) represent the last 10 years of BBS data (negative trend) and projected needed trend increase (based on similar postitive trend) if an immediate increase begins; Figures (c) represent the last 10 years of BBS data (negative trend) and projected needed trend increase (based on similar postitive trend) if trends are stablized for 5 years.

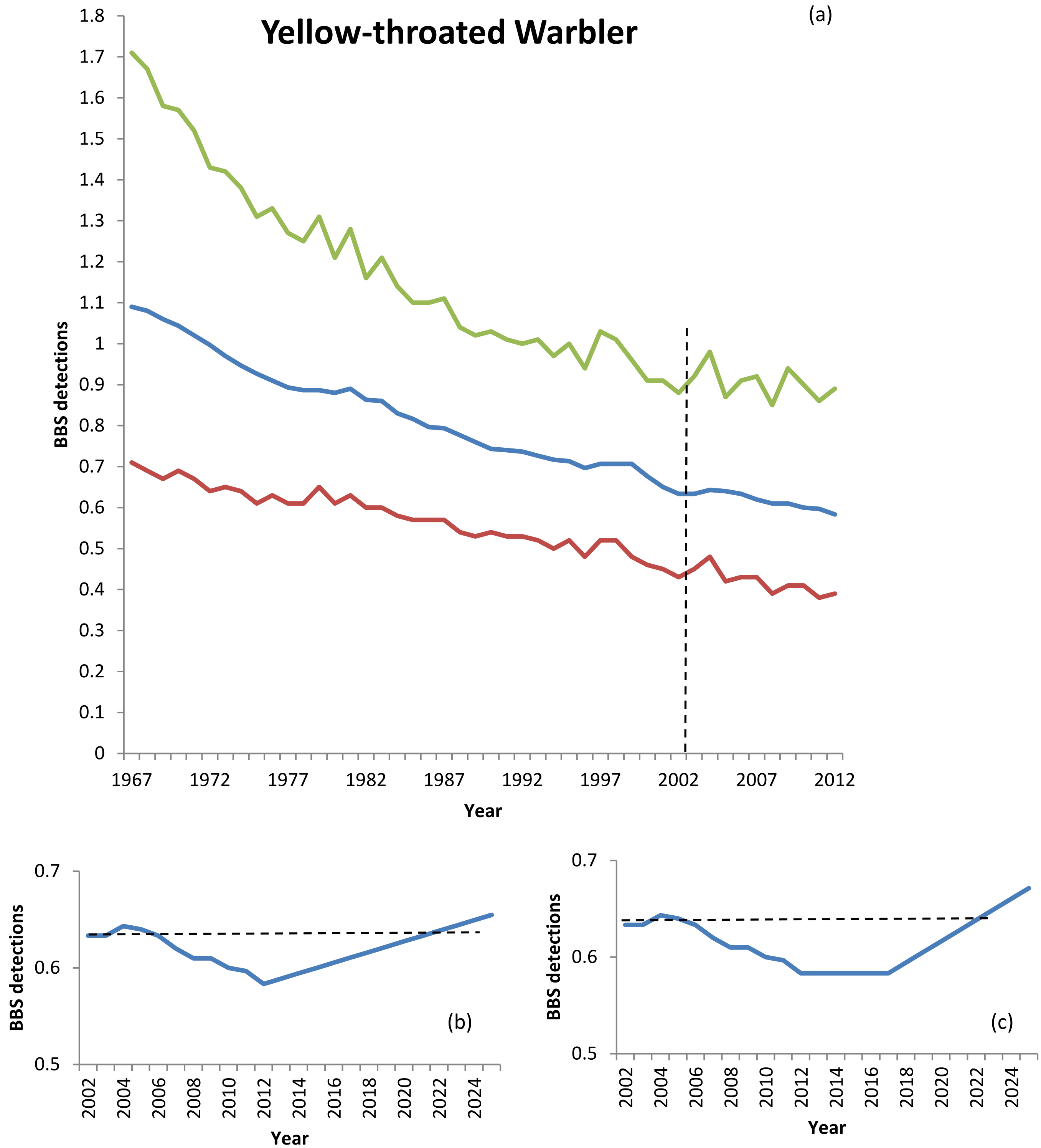



Kentucky Warbler
(a)
BBS Detections
Year
(b)
BBS detections
Year
(c)
BBS detections
Year


Prothonotary Warbler
(a)
BBS Detections
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1967
1972
1977
1982
1987
1992
1997
2002
2007
2012
Year


BBS detections
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
(b)
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Year


BBS detections
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
(c)
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Year


Yellow-throated Warbler
(a)
BBS detections
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1967
1972
1977
1982
1987
1992
1997
2002
2007
2012
Year
(b)
BBS detections
0.7
0.6
0.5
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Year
(c)
BBS detections
0.7
0.6
0.5
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
Year

Appendix 2. Area Requirements for Umbrella Species based on 25th percentile, median, and 75th percentile.

Bold indicates the MVP area requirement that partners agreed upon after review. For some species, such as Prothonotary Warbler, these values greatly influenced the minimum area requirements. For others, such as Acadian Flycatcher, the values did not have much variance.

Species	MVP (# pairs)	Dispersal Distance (km)	Area (ha/pair)	MVP Area Requirement (ha/MVP)
ACFL	63	1.8*	1.1	69
			1.6	**101**
			1.7	107
KEWA	63	1.9*	4.5	284
			5.5	**347**
			8.3	523
PROW	134	4	1.5	201
			2.5	**335**
			7.8	1,045
RSHA	25	15	109	2,725
			171	**4,275**
			339	8,475
YTWA	48	1.6*	2.1	101
			2.8	**134**
			3.9	187

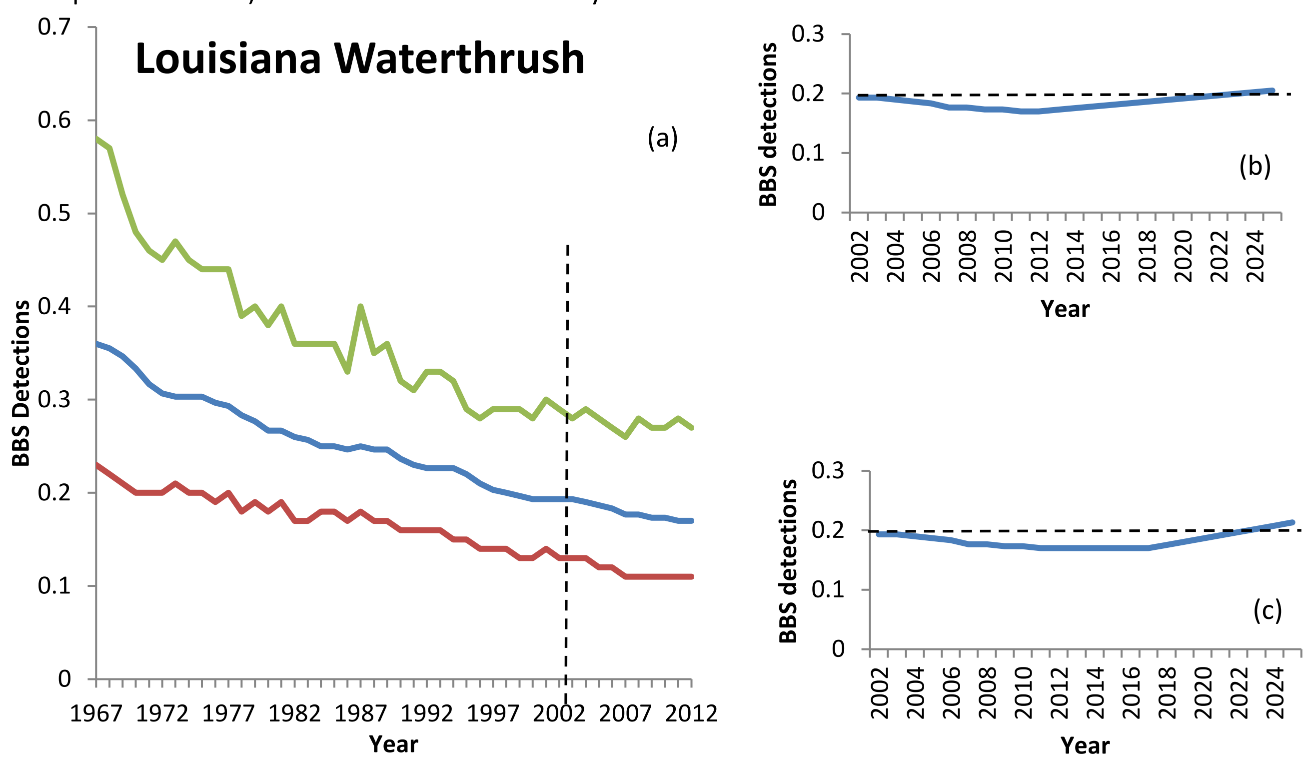
Appendix 3. Louisiana Waterthrush Model

Approximately 5% of the global Louisiana Waterthrush population is estimated to breed in the West Gulf Coastal Plain /Ouachitas Bird Conservation Region (WGCPO). Within the WGCPO, Regional Concern Score for Louisiana Waterthrush is 16 (out of 25 maximum) making it a species of Regional Concern (Panjabi et al. 2012). Moderate threats to their breeding area (TB-r = 3), primarily due to forest loss and fragmentation, and moderate regional declines (PT-r = 4) within the WGCPO (Partners in Flight Science Committee 2012)have resulted in recommendations for management or other conservation actions to reverse or stabilize significant long-term population declines.

Population and Habitat Goals

We do not have reliable estimates of population sizes for Louisiana Waterthrush. The Partners in Flight estimates likely underestimate density of birds in the WGCPO (Twedt 2015). Therefore, we developed trend-based population goals. Because of the declining BBS trend in Louisiana Waterthrush, our short-term goal is to ***stabilize BBS trend based on the trend from the last ten years and a three-year moving average***. Essentially, this means that Breeding Bird Survey detections would need to be returned to detection levels seen in 2002. However, there are various ways that this objective could be accomplished. Thus, monitoring through BBS routes must occur to validate if this goal is being achieved over the next 5-10 years (see *Monitoring and Evaluation*).

Breeding Bird Survey (BBS) trends for Louisiana Waterthrush, calculated as 3-year moving averages. Dashed line indicates BBS detections at the beginning of the 10-year period. Figure (a) represents the overall BBS trend; Figure (b) represents the last 10 years of BBS data (negative trend) and projected needed trend increase(based on similar postitive trend) if an immediate increase begins; Figure (c) represents the last 10 years of BBS data (negative trend) and projected needed trend increase(based on similar postitive trend) if trends are stablized for 5 years.



Decision Support Model

Methodology for Landscape Characterization

We began with Minimum Viable Population (MVP) using the framework from the West Gulf Coastal Plain/Ouachitas Open Pine Landbird Plan (LMVJV 2011; B. Grand, unpublished data, Table 4). MVP was based on the variability around simulated population trajectories from Breeding Bird Survey data (Appendix 1). A sustainable population was defined as a population large enough to have >95% chance of remaining above 25 individuals over a 50-year interval.

We reviewed the literature for (1) breeding area (i.e., territory) requirements per pair; and (2) natal dispersal distances. Dispersal distances for Louisiana Waterthrush were averaged from the Birds of North America account (Mattsson et al. 2009).

We converted area requirements per pair to area requirements per MVP. We used metrics of area requirements and natal dispersal distances to calculate carrying capacity and available suitable habitat on the landscape.

Area Requirements

We initially calculated three area requirement estimates based on 25th percentile, median, and 75th percentile values of area requirements from our literature review (Appendix 2), but we present median values as representative of area requirements.

Estimated Minimum Viable Populations (MVP), natal dispersal distance, and suitable habitat area requirements for select species breeding in forested wetlands in the West Gulf Coastal Plain / Ouachitas Bird Conservation Area.

Species	MVP (# pairs)	Dispersal Distance (km)	Linear km per pair	Linear km per MVP	MVP Area Requirement (ha/MVP)
LOWA	48	4.5	0.38	18.2	550

Louisiana Waterthrush breeds on territories along streamsides that average 380 m in length (Mattson et al. 2009). Therefore, rather that restrict their occurrence to woody wetlands, we converted linear stream segment territories into estimated area requirements that included all forested habitat. We did this by multiplying the average linear stream size for Louisiana Waterthrush MVP (18.2 km) by the 300 m buffer assumed in our wetland forest definition.

We used the National Hydrography Dataset - High Resolution (NHD - HR; U.S. Geological Survey 2013) to define primary order streams. We combined these data with the National Hydrography Dataset Plus to define secondary and tertiary order along with primary order streams from NHD - HR. We considered **all forest land classes** (not solely woody wetlands) of the 2011 National Land Cover Database (NLCD; Homer et al. 2015) **within 300 meters of each stream segment** to define the base layer to quantify the amount of available Louisiana Waterthrush habitat on the landscape.

We identified habitat patches through a clumping process in Erdas Imagine (2015; Leica Geosystems, Atlanta, GA, USA) and refined these data by removing those clumps of habitat that did not have enough suitable habitat in close enough proximity to support a minimum viable population, with habitat suitability and proximity as defined below. The amount of suitable habitat was determined by neighborhood analysis in ArcGIS Pro version 1.4 (ESRI, Redlands, CA, USA) and was not restricted to contiguous patches, but patches needed to be within natal dispersal distance to allow for post-fledgling movements among patches.

Avicentric Landscape

To further characterize the landscape, we defined a circular area that was within the natal dispersal distance for Louisiana Waterthrush. This area was assumed to be available for natal dispersal. We designated this circular area an "avicentric" landscape:

Equation 4. Avicentric Landscape (ha) = $[\pi * (\text{Dispersal Distance [m]})^2]/10000$.

The percent of suitable habitat required within each avicentric landscape to support the species MVP was:

Equation 5. Area requirement for MVP (ha) ÷ Avicentric Landscape (ha)

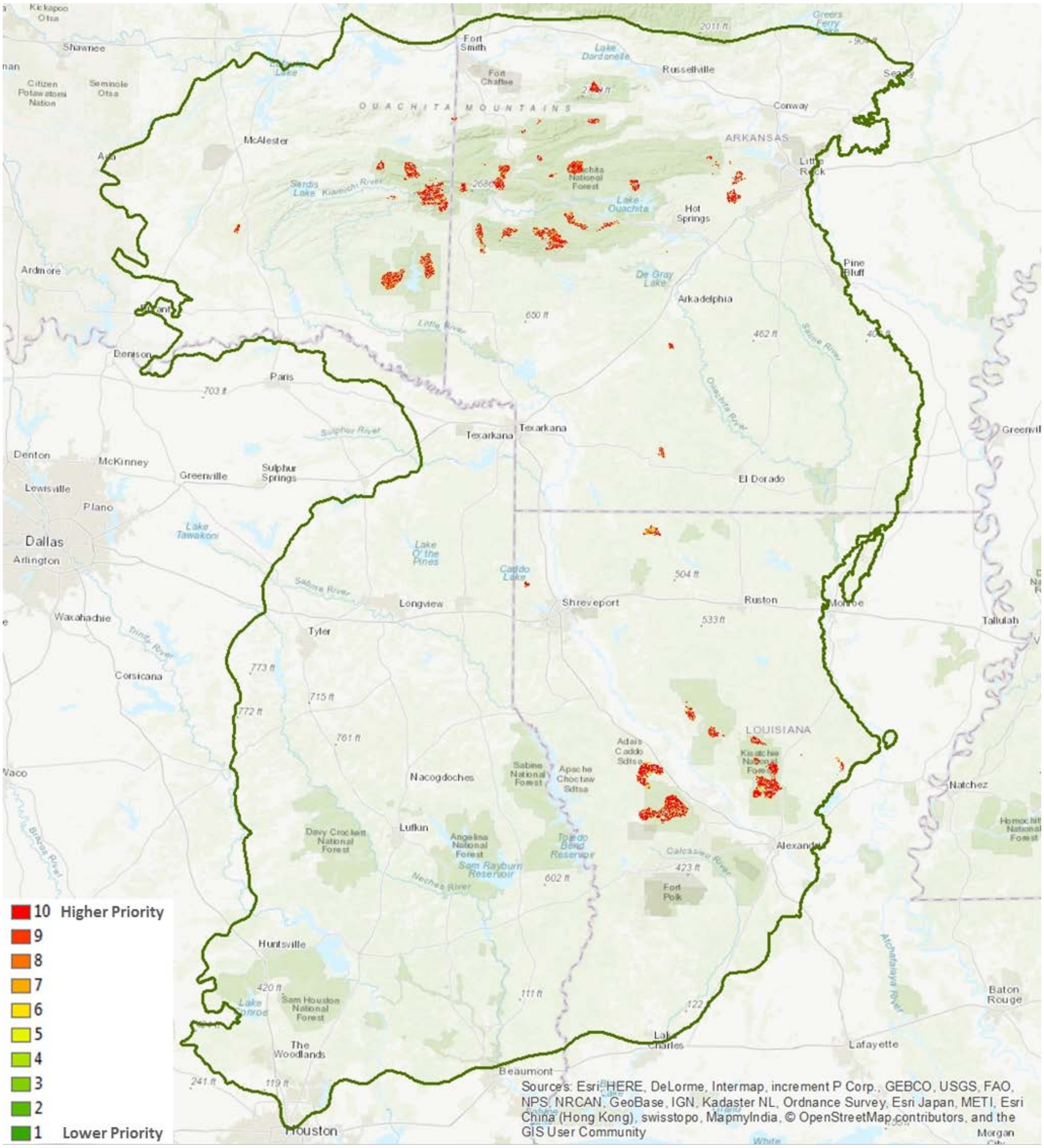
Metrics for the avicentric landscape and percent of suitable habitat required for Louisiana Waterthrush.

	LOWA
Avicentric Landscape (ha)	816
% Suitable Habitat Required in Avicentric Landscape	66.9%

Final Model

We defined the base layer of potential breeding habitat based on stream segments that would support at least one pair (0.38 km), and areas (550 ha) that contained enough suitable habitat (66.9%) to support at least one MVP (48 pairs).

Louisiana Waterthrushes are closely associated with streams (Mattson et al. 2009), so we used **Distance to Water** in the analysis. Additionally, Louisiana Waterthrushes are associated with forested landscapes (Tirpak et al. 2009) so we used the **Percent Forest** raster.



Draft Louisiana Waterthrush decision support model for WGCPO

Habitat Management and Recommendations

Louisiana Waterthrush favors deciduous or mixed forests with rocky streams, often with rocks projecting from the water; it less commonly occurs along sluggish streams and rivers and in swamps (Hamel 1992). Louisiana Waterthrushes prefer areas with rapidly running water and woodland swamps with running streams or ditches (Griscom and Sprunt 1978), as well as bottomlands and the borders of streams and swamps in areas also occupied by Prothonotary Warblers (Bent 1963). The species often breeds near streams with gravel bottoms in hilly, deciduous forests (Mengel 1965, Graber et al. 1983) and in cypress swamps and bottomlands adjacent to mud-bottomed streams, but in lower densities than in mesic woodlands (Graber et al. 1983). In upland forests, nests are usually placed along stream banks, in small hollows or cavities within the root mass of upturned trees, or under fallen logs (Bent 1963, Eaton 1958, Robinson 1990).

Louisiana Waterthrushes forage on the ground, always in or near a stream, where insects are gleaned from rocks, mud, or water (Hamel 1992). The major prey of the Louisiana Waterthrush is aquatic insects and invertebrates, and small to medium-sized flying insects (Robinson 1990).

Appropriate management actions include protection of forest tracts and water systems inhabited during the breeding season (Wunderle and Waide 1994). Louisiana Waterthrushes are thought to be sensitive to water quality and the amount of forest canopy (60-70%; O'Connel et al. 2003; Mattsson and Cooper 2009).

Habitat factors that influence habitat quality for Louisiana Waterthrush in the West Gulf Coastal Plain/Ouachitas Bird Conservation Region.

Habitat Factors	LOWA
Large tree diameter (>23 cm dbh)	
Density of large trees (>40 trees >50dbh/ha)	
Low tree density (250-300/ha)	
Mid-story cover (open)	
Understory cover (open)	
Understory cover (dense)	
Moderate to well-developed canopy (60-70%)	X
Small cavities (<10 inch diameter) or snag density of 5 snags/ha	