Monitoring Program for Biodiversity of Terrestrial Vertebrates on Conservation Lands within the Cumberland Plateau Region of Alabama

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PROJECT OVERVIEW

A comprehensive monitoring program was developed on the J. D. Martin Skyline Wildlife Management Area and Walls of Jericho Forever Wild Tract (SWMA) to produce a defensible inventory of the distribution of most terrestrial vertebrates (e.g. amphibians, reptiles, birds and small mammals) that occur within the Cumberland Plateau region of Alabama. Quantified biological inventory efforts began in spring 2005 targeting the aforementioned vertebrate taxa groups with emphasis on detecting 21 species of Greatest Conservation Need (GCN; Priority 1–2) and 42 Watchlist species (Priority 3) as identified in Alabama's Comprehensive Wildlife Conservation Strategy (CWCS). Upon survey completion in fall 2006, a total of 138 vertebrate species (26 amphibians, 21 reptiles, 81 birds and 10 small mammals) were detected from all phases of the inventory. Of those, 7 GCN species (1 amphibian, 4 birds and 2 small mammals) and 18 Watchlist species (4 reptiles, 12 birds and 2 small mammals) were detected that together (n = 25) accounted for 40% of the target priority species (Priority 1–3) and 18% of all species detected. Survey design enabled for the performance of numerous analyses to model species occupancy (using various landform and habitat measurements) to develop predictive maps of probable occurrence over the entire study area for most detected species, including some GCN and Watchlist species. The results from this project are intended to assist state resource managers with making science-based decisions (e.g., involving stewardship and land acquisition) that will benefit GCN and Watchlist species and other wildlife on SWMA. This information may also help determine whether or not the public lands currently under conservation management in this region are large enough to sustain the associated terrestrial vertebrates, including GCN and Watchlist species, not only within the political boundaries of Alabama but also over a larger regional context.

This monitoring program was designed to be repeatable and cost-effective, yet adaptable enough for periodic sampling long-term to produce estimates of trends in species richness, distribution, and abundance for the Cumberland Plateau region. These estimates will enable state resource managers to predict the outcome of specific management actions and subsequently evaluate their efficacy over time, particularly those focused on benefiting GCN and Watchlist species. With continued monitoring, adjustments in management can then be applied (i.e., adaptive management) on SWMA, when necessary, to better achieve desired results and ultimately address the conservation objectives outlined in the CWCS for this ecoregion.

PROJECT COLLABORATORS

This project was performed as a collaborative effort between the United States Geological Survey's (USGS) Alabama Cooperative Fish and Wildlife Research Unit (ACFWRU) at Auburn University, the Department of Natural Resources and Environmental Sciences at Alabama Agricultural and Mechanical University (AL A&M) and the State Lands Division (SLD) of the Alabama Department of Conservation and Natural Resources (ADCNR). ACFWRU personnel developed and implemented avifaunal (birds) and small mammalian inventories, while AL A&M personnel developed and implemented inventories targeting herpetofauna (amphibians and reptiles). A supplemental objective was amended to this project in 2007 and performed by ACFWRU

personnel to ascertain landscape influences on the productivity (habitat effects on reproductive success) of a select group of songbirds in the study area. SLD personnel oversaw project coordination and assisted both collaborators with inventory and monitoring efforts. Following data collection, collaborators analyzed their respective datasets and submitted their findings and deliverables separately to SLD. Although ACFWRU and AL A&M split the responsibility for inventorying different vertebrate taxa groups and performed them independently, their respective findings were reconciled herein to provide a synopsis of the entire project. Therefore, this overview serves as a synthesized narrative summarizing the objectives, methods, findings, and recommendations derived from each collaborator's submitted final report (Hitch et al. 2008, Wang and Chang 2008). Links to both final reports are provided below.

PROJECT OBJECTIVES

Surveys were conducted for amphibians, reptiles, birds and small mammals to inventory the diversity of terrestrial vertebrates on SWMA, one of the largest state-owned Wildlife Management Areas in Alabama, in Jackson County in northeastern Alabama during 2005–2006. This area lies in the southwest Appalachians and covers the southern most extent of the Cumberland Plateau, Plateau escarpment and associated valleys. Objectives were to:

1. Establish a program for monitoring the distribution of associated birds, small mammals and herpetofauna on SWMA.

2. Estimate the landform and vegetative parameters that influence the detection and use of areas by the majority of vertebrates detected on surveys of both areas.

3. Determine relationships among species richness, community dynamics, landform, and vegetative characteristics of habitats.

4. Map the significant landform and vegetative characters related to vertebrate distribution using 2001 LANDSAT VII TM data at 30-m resolution.

5. Integrate the information on distribution of commonly-detected vertebrates with habitat maps to depict the probable current distribution of vertebrate populations that could be used to support decisions regarding the acquisition and management of conservation lands in the region.

6. Develop conservation and management recommendations for identified areas with high probability use by high priority species and areas of high biodiversity.

METHODS

Within SWMA, 176 survey locations were selected randomly from a 250-m grid stratified by land form and solar exposure to capture the full range of available habitats and environmental conditions. A Geographic Information System (ArcGIS) was used to

determine landscape characteristics, including Land-use and Land-cover (LULC). Forest structure characteristics were also sampled at each of the survey points.

ACFWRU: Six bird point counts (accounting for two separate survey point visits) were conducted at half of the sites in 2005 and remaining sites in 2006. At half of the selected sites each year, Sherman live traps and drift fence arrays with funnel and pitfall traps were used on five nights to survey small mammals, reptiles, and amphibians. To reduce the biases associated with imperfect detection on surveys, detection rates and the probability of use of each site was estimated for each species of bird, mammal, and amphibian encountered on at least five surveys using occupancy analysis. The best fitting models of detection and habitat use based on landscape characteristics were used to determine the most important landscape characteristics related to species' distributions. Forest structure characteristics were then added to determine whether structure could substantially improve the model fit of habitat use. The probabilistic distribution based on the weighted landscape characteristics models was estimated for each species detected on at least five surveys and exported for use in ArcGIS. For birds, the results were compiled to estimate expected species richness.

To calculate estimates of productivity, four highly detectable species of songbirds were chosen to assess differences in reproductive success related to habitat choice. Singing males were identified and monitored on three-to-five day intervals to identify the stage in the breeding cycle; reflected through 12 levels of reproduction ranging from territory establishment (lowest level) to fledging (highest). Breeding territories with young seen or heard (Level 8) were deemed successful. Associated habitats were identified using a General Land Cover map at the center-point of each monitored breeding territory to calculate the proportion of successful males of conspecific species in different habitat-types. Logistic regression (proportional odds model) was used to estimate differences in reproductive success among habitats.

AL A&M: Line transects, drift fence arrays with funnel and pitfall traps, pond visits, and targeted and opportunistic searches were techniques employed to survey amphibians and reptiles. Of these, line transects were the primary method of inventory and performed at half of the sites in spring and fall 2005 and remaining sites in spring and fall 2006. Eight 100-m transect surveys were conducted in a figure eight pattern (all at right angles) starting and finishing at the survey point. Perpendicular distances of encountered organisms were measured from transect lines (up to 10-m away) to estimate detection rates and abundance using Program DISTANCE. Models were selected based on model robustness, shape of detection curve, and estimator efficiency. Because sample size was limited for most encountered herpetofauna, species were pooled into ecological guilds for detection analyses. Canonical Correspondence Analysis (CCA) was used to evaluate the relationship between species and their association with habitat, landscape, and climatic variables. Species diversity indices and Cluster analyses over landform data were also performed. Predictive maps revealing estimated species presence (those with sufficient detections), species richness, and abundance were generated using ArcGIS. Supplemental survey techniques (i.e. funnel and pitfall traps along drift fence arrays, pond searches using dip nets and minnow traps, targeted and opportunistic searches) were

performed to target additional species unlikely to be encountered during line transects and to develop a more complete compilation of species.

PROJECT FINDINGS (Condensed)

A total of 13,441 detections (n = 138 species) were made during all phases of quantified surveys on SWMA. Of those, only 864 were detections of priority species (n = 25) accounting for 6% of all detections. Moreover, 537 (62%) of those detections were GCN species (n = 7), while the remaining 327 (38%) detections were Watchlist species (n = 18). See Table 1 for a summarized list of all GCN and Watchlist species detected during this project.

TABLE 1. Summary of 7 GCN and 18 Watchlist species detected on SWMA, 2005–2006.

Priority	Taxa Group	Species	Scientific Name	Number of Detections
1	Bird	Cerulean Warbler	*Dendroica cerulea*	16
2	Bird	Wood Thrush	*Hylocichla mustelina*	191
2	Bird	Worm-eating Warbler	*Helmitheros vermivorum*	241
2	Bird	Kentucky Warbler	*Oporornis formosus*	76
3	Bird	Broad-winged Hawk	*Buteo platypterus*	6
3	Bird	Great Horned Owl	*Bubo virginianus*	7
3	Bird	Whip-poor-will	*Caprimulgus vociferus*	11
3	Bird	Belted Kingfisher	*Megaceryle alcyon*	2
3	Bird	Red-headed Woodpecker	*Melanerpes erythrocephalus*	2
3	Bird	Downy Woodpecker	*Picoides pubescens*	56
3	Bird	Hairy Woodpecker	*Picoides villosus*	28
3	Bird	Brown-headed Nuthatch	*Sitta pusilla*	1
3	Bird	Blue-winged Warbler	*Vermivora pinus*	1
3	Bird	Northern Parula	*Parula americana*	38
3	Bird	Prairie Warbler	*Dendroica discolor*	138
3	Bird	Louisiana Waterthrush	*Seiurus motacilla*	15
2	Amphibian	Green Salamander	*Aneides aeneus*	5
3	Reptile	Eastern Six-lined Racerunner	*Aspidoscelis s. sexlineatus*	1
3	Reptile	Eastern Hog-nosed Snake	*Herterodon platyrhinos*	2
3	Reptile	Eastern Milksnake	*Lampropeltis t. triangulum*	1
3	Reptile	Cornsnake	*Pantherophis guttata*	2
2	Mammal	Alleghany Woodrat	*Neotoma magister*	2
2	Mammal	Pygmy Shrew	*Sorex hoyi*	6
3	Mammal	Southeastern Shrew	*Sorex longirostris*	5
3	Mammal	Southern Short-tailed Shrew	*Blarina carolinensis*	11

ACFWRU: During surveys 81 bird species were detected 10,128 times. Of these, 59 bird species were detected frequently enough to estimate and map occupancy, including four GCN and eight Watchlist species. This included Cerulean Warbler (GCN; Priority 1), which was the only species of highest conservation concern targeted in this project. Occupancy was also mapped for three species of high conservation concern (GCN; Priority 2), Wood Thrush, Worm-eating Warbler and Kentucky Warbler and eight Watchlist species (Priority 3), Broad-winged Hawk, Great Horned Owl, Whip-poor-will, Downy Woodpecker, Hairy Woodpecker, Northern Parula, Prairie Warbler and Louisiana Waterthrush. Four additional Watchlist species were encountered during point counts and included Belted Kingfisher, Red-headed Woodpecker, Brown-headed Nuthatch and Blue-winged Warbler, but each accounted for fewer than five detections. It is also worth

noting that Ruffed Grouse, another Watchlist species, was encountered incidentally when surveys were not being performed.

Accounts summarizing the relative importance of the detection models for each of the 59 bird species (including the 12 aforementioned GCN and Watchlist species) were described in the final report. Each species account entails brief descriptions of habitat requirements based on literature review, interpretation of the habitat relationships in the best fitting models, and correlations between landscape characteristics and model-averaged occupancy. Additional information regarding model selection results for birds, including estimates of specific model parameters and associated measures of uncertainty for each model and maps showing predicted occupancy for each species based on model averaging, are found in the final report's appendices (see link below).

For estimating occupancy rates for the majority of the bird species encountered, habitat use was best explained by the proportion of deciduous forest cover in relation to non-forested and pine habitats at the survey site. Use of sites by 15 species including Yellow-throated Vireo, Red-eyed Vireo, White-breasted Nuthatch and Worm-eating Warbler increased sharply as the proportion of deciduous forest cover increased. Only two species, Eastern Wood-Pewee and White-breasted Nuthatch, were positively related ($r^2 > 0.25$) to the proportion of calcareous forest. Dry oak forest was preferred by eight species including Kentucky Warbler, American Goldfinch and Cerulean Warbler. By contrast, mesophytic forest was selected by 12 species including Wood Thrush, Tufted Titmouse, Red-shouldered Hawk, and Kentucky Warbler. Habitat use by 18 species was positively correlated with the amount of anthropogenically disturbed habitats. These included Mourning Dove, Field Sparrow, Blue Grosbeak and Prairie Warbler; all of which responded positively to agricultural fields. Some of these species also demonstrated a strong positive response to developed areas and early successional habitat. For some species, use was positively related to the proportion of pine forest. For six species, Eastern Phoebe, Worm-eating Warbler, Scarlet Tanager, Carolina Chickadee, Yellow-throated Vireo and Yellow-shafted Flicker, use decreased as road influence increased.

During small mammal and herpetofaunal surveys, eight species of mammals and six species of amphibians and reptiles were detected. Of these, only six species were encountered frequently enough to estimate and map occupancy, including one Watchlist species; Southern Short-tailed Shrew (Priority 3). This species showed a positive relationship between forest habitats and disturbed areas with the exception of agricultural habitats. Additional priority small mammal species with five or less detections included Allegheny Woodrat (GCN; Priority 2), Pygmy Shrew (GCN; Priority 2) and Southeastern Shrew (Watchlist; Priority 3). Only two species of amphibians were captured frequently enough to estimate and map probability of occupancy, American Toad and Slimy Salamander. Additional priority herpetofaunal species with five or less detections included Green Salamander (GCN; Priority 2), Eastern Hog-nosed Snake (Watchlist; Priority 3) and Eastern Milksnake (Watchlist; Priority 3).

AL A&M: A total of 2,307 individuals accounting for 26 species of amphibians and 20 species of reptiles were detected during line transects. Of these, 84% of all individuals

detected were amphibians, with Slimy Salamander being the most abundant species overall (representing 75% of all amphibians encountered). Rounding out the top five species encountered included Eastern Zigzag Salamander, Eastern Worm Snake, Spotted Dusky Salamander and Red Salamander, respectively. Only four priority species were detected during surveys and included Green Salamander (GCN; Priority 2), Cornsnake (Watchlist; Priority 3), Eastern Six-lined Racerunner (Watchlist; Priority 3) and Eastern Hog-nosed Snake (Watchlist; Priority 3). Collectively, GCN and Watchlist species' encounters represented a very small proportion of all detections during line transects.

Species diversity indices revealed that herpetofaunal richness varied considerably between spring and fall seasons. The highest diversity areas appeared to be consistently associated with sideslopes (coves; >4º and <25º slope) during both seasons, while drier sites, including flats (<4º slope) with differing solar exposures, varied in diversity between seasons (i.e. low richness in fall, but higher in spring). Overall, the spring season had a higher average of species and individual detections for all strata types than the fall season and this was attributed primarily to life history patterns. Cluster analyses revealed species associations. CCA determined relationships between eight components of landscape and habitat variables and herpetofaunal guilds. This analysis revealed that soil, canopy, duff, and tree diameter at breast height (DBH) components were important variables that affect herpetofaunal community structure.

Detection probabilities determined from line transect data was highest for stream salamanders (30%) and lowest for terrestrial and spring-associated amphibians (20% each). Moreover, distance sampling provided estimates of approximately 38,245,000 amphibians (396/km^2) and 8,426,600 reptiles (87/km^2) over the entire study area. Soil pH was shown to be positively correlated with herpetofaunal species richness and abundance. Furthermore, canopy cover, soil condition, amount of disturbance, and distance to streams were all predictors that significantly influenced species richness and abundance. Lastly, land cover type analyses suggested that species richness and abundance increased with larger areas of deciduous forest, and decreased when influenced by agricultural and developed areas.

CONCLUSIONS AND RECOMMENDATIONS

ACFWRU: At the landscape level, GCN forest breeding birds on the study area, Worm-eating Warbler, Wood Thrush, Kentucky Warbler, Cerulean Warbler, were found most frequently in mesophytic (Worm-eating Warbler) and dry oak (Wood Thrush, Kentucky Warbler, Cerulean Warbler) forest types. Northern Parula (Priority 3) demonstrated a similar pattern of habitat use. These species would benefit most from increased availability of large contiguous patches of mesophytic and dry oak forest habitat. Use by all of these species was negatively correlated with the abundance of disturbed habitats, and an increase in disturbed habitats at the expense of mesophytic and dry oak forest types may lead to further declines in these forest breeding birds. If it is necessary to harvest timber or develop wildlife openings in forested habitats, doing so in calcareous forest areas may have less impact on this group of birds. Further, the negative relationship between edge conditions and use by these species also suggests that if it is

necessary to establish wildlife openings or other enhancements for wildlife within natural forest stands, small openings should have less impact on the distribution of these birds. This also supports the recommendations in the CWCS to use sites of previous disturbance or choose new sites that mimic natural disturbances to avoid unwanted impacts; minimize unnecessary, artificial, and/or unnatural structures and processes; and restore the biological integrity of habitats.

In contrast, the Watchlist (Priority 3) breeding bird species Broad-winged Hawk, Great Horned Owl, Whip-poor-will, Red-headed Woodpecker, Downy Woodpecker, Hairy Woodpecker, Prairie Warbler and Louisiana Waterthrush were positively correlated with the disturbed LULC classes including agricultural fields, developed, early successional, and pine forest areas. For these species, agricultural areas had the highest correlation with occupancy. These species were negatively correlated with forest habitats, and management actions that increase the proportion of forest habitats and decrease the proportion of disturbed areas may negatively affect their populations. Thus, agricultural habitats may be important to these species for breeding or foraging. However, in the larger context, these habitats are widely available on privately owned lands in this ecoregion, and to the extent that disturbed LULC classes on private lands can maintain acceptable populations of these species it may not be necessary to increase their availability or maintenance on state-owned lands.

Three game birds were detected frequently on this study; Wild Turkey, Northern Bobwhite and Mourning Dove. Use by these species was highly correlated with disturbed areas and in particular agricultural habitat. Abundant ground cover in agricultural and early successional areas serve as foraging habitat for all three species, and nesting habitat for Wild Turkey and Northern Bobwhite. These species were also highly correlated with large values of edge (i.e., large patches of non-forested habitat) although edge was not included in the best model for any of them. The maintenance of agricultural and other disturbed habitats are important to populations of these game species and may also benefit non-game species that use disturbed areas for breeding habitat. However, further conversion of forested lands to early successional and agricultural fields may increase game bird abundance at the expense of breeding habitat for GCN forest birds.

Results from this project could be used as an important baseline for non-game wildlife populations on SWMA. The initial estimates of occupied habitat should be valuable for determining how well current management is providing for priority species. The habitat relationships revealed in this study could be used to establish objectives and predict the outcome of specific management actions related to land acquisition and management in terms of the amount and suitability of habitat available for use by GCN, Watchlist and other wildlife species. A monitoring program involving repetition of all or part of these surveys at appropriate intervals to evaluate the accuracy of those predictions, and the efficacy of management actions for GCN and Watchlist species would serve as the basis for science-based, adaptive management on SWMA. Further elaboration and additional recommendations can be viewed in the final report (see link below).

AL A&M: By using different GIS applications to estimate animal population numbers, ADCNR and other organizations will be able to identify areas of high animal abundance and diversity for the management of state-owned lands and areas of possible land acquisition. While Slimy Salamander, Eastern Zigzag Salamander, Eastern Worm Snake, Spotted Dusky Salamander and Red Salamander accounted for 81% of the total detections, most species were rare during transect surveys. The secretive nature of these species could be the factor contributing to this pattern. Although this survey effort was very intensive, the distance sampling estimation suggested that the detection rate was below 50% even for the most abundant species and guilds. The species and sampling effort curve suggested that the number of species detected had leveled off or the number of new species that could be found by additional sampling effort was at a minimum. These patterns suggest that the sampling effort was sufficient, and the low detection rate of these species were mostly due low abundance and/or the secretive nature of the herpetofauna.

Species richness and abundance varied by season. Both species richness and abundance in spring were double compared to what was detected in fall. This pattern reflected the more active foraging and breeding activities of herpetofauna in spring. Most salamanders and frogs breed in spring and early summer, and only a few species such as Marbled Salamanders initiate breeding activities in fall. Mating and foraging activities may bring out a substantial number of animals that would normally be below ground or in their hibernation sites. Climate conditions may be contributing factors for the lower detections of species and abundance. In northern Alabama, precipitation has been below average for the past two years, which may have limited the activities of some herpetofauna that are sensitive to drier conditions.

Habitat and landscape components were significant in the prediction of herpetofaunal species abundance and diversity. Species and individuals were not distributed randomly across the landscape. There appeared to be a relationship between richness and abundance among strata. The sideslopes with medium solar exposure had the highest averages for species detected in both seasons and overall encounters. Sideslopes with high exposure had the highest averages for the number of individuals and species encountered overall detections. This pattern could be related to the vegetation structure and microclimate conditions associated with this stratum. On upperslopes, light and moisture conditions might impact amphibian distribution. On the sideslopes, the habitat conditions were probably more diverse with intermediate light and moisture conditions. The Tate Cove and Jack Gap area, which had high species diversity and abundance, also had moderate soil pH levels. Four other areas showed high abundance: Letson Point, north side of Jacob's Farm, southern end of the southwestern SWMA parcel, and Summers Top. These patterns were consistent with strata-related species and abundance variations. LULC composition in the sampling area affected herpetofaunal species richness and abundance. With increased deciduous forest cover, herpetofaunal species richness increased. This pattern was likely due to the decline of amphibian species richness and abundance associated with nonforested habitat.

The following recommendations are based on the findings from this study:

- Continuation of herpetofaunal monitoring on SWMA is recommended to better understand population dynamics, community structure, and to have a more complete inventory of species. In addition, herpetofaunal population and community structure may vary annually depending on climate conditions, and continuation of monitoring may help better address such variances in detection.

- Areas that had high species richness and abundance should continue to be monitored because these areas were not distributed evenly throughout SWMA.

- The Green Salamander (Priority 2), the only amphibian GCN species detected during surveys, was detected in mesophytic and mixed oak forests; the latter considered atypical for this species. Therefore, further examination of this species' population status and habitat preferences in SWMA is recommended.

- The low number of species detections during surveys resulted in pooling species into ecological guilds to bolster sample sizes to better predict distributions of species diversity and abundance using ArcGIS. As additional data is accumulated through ongoing monitoring efforts, it is recommended that this technique be continually used to better predict species' distributions and identify areas for focused management.

- Lastly, the amount of deciduous forests on SWMA was a significant positive predictor of herpetofaunal species richness and abundance. Given that more than 85% of the forested land in northern Alabama is currently in private ownership, and that many of these lands are constantly under pressure for development, the additional acquisition of forested lands by the state or other government agencies and conservation organizations be a high priority for the conservation of these prestigious natural resources, including the herpetofaunal community.

Links to Final Reports:

Hitch, A. T., J. B. Grand, S. L. Allen, and N. W. Sharp. 2008. Habitat use and distributions of birds, small mammals and herpetofauna on the J. D. Martin Skyline Wildlife Management Area, Jackson County, Alabama. Final Report. USGS, Alabama Cooperative Fish and Wildlife Research Unit, Auburn University, AL. 79 pp. + appendices.

Wang, Y. and F. Chan. 2008. An inventory of herpetofauna on state conservation lands in the Cumberland Plateau of northern Alabama. Final Report. Dept. of Natural Resources and Environmental Sciences, Alabama Agricultural and Mechanical University, Normal, AL. 115 pp.