RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	1. Number FS-SRS-4251	2. Station Southern Research Station
	3. Unit Location Nacogdoches, Texas	

4. Research Work Unit Title
Integrated management of wildlife habitat and timber resources.

5. Project Leader (Name and address)
Ronald E. Thill, Wildlife Habitat and Silviculture Laboratory, P.O. Box 7600, SFA, Nacogdoches, TX 75962

6. Area of Research Applicability	7. Estimated Duration
Loblolly shortleaf pine-hardwood forests, longleaf pine forests, and associated streamside zones; Southern Appalachian hardwood forests	5 years

8. Mission

To quantify relationships between wildlife habitat values and forest management strategies and to incorporate findings into the management planning processes.

9. Justification and Problem Selection

Under the Mission Problem (Problem 1), we will complete a number of manuscripts involving wildlife and streamside zone relationships and several other miscellaneous topics. These projects are outlined under Section 10.

Cavity nesting species are a major wildlife component of forest ecosystems. About 85 species of cavity nesting birds inhabit North America and contribute significantly to biodiversity of North American avifauna. Cavity nesters comprise more than 15 of the southern avian community. Eight species of woodpeckers are indigenous to forests of the southeastern United States. Woodpeckers serve as keystone species within the ecosystem by excavating cavities that are used by a wide variety of other vertebrates (birds, mammals, amphibians, and reptiles) and invertebrates. Woodpeckers and many cavity nesting birds are primarily insectivorous during most of the year. Populations of these species prey heavily on insect pests at endemic population levels and are known to significantly impact populations of some insects. Thus, woodpeckers are important species within the forest ecosystem and essential for maintenance of forest biodiversity. Typically, cavity nesting wildlife require mature or near mature trees for nesting and foraging. Because of cavity nester requirements for older trees and snags for nesting and foraging, the provision of their habitat often conflicts with optimization of timber production. Management of forests primarily for wood fiber can reduce the availability of nesting and foraging habitat by emphasizing short timber rotations and other silvicultural practices that are detrimental to cavity nesters. Ecosystem management cannot be achieved without knowledge of the special habitat features required by woodpeckers and other cavity nesting wildlife.

Signature	Title	Date
Recommended:	Assistant Director for Research	
	Assistant to Staff Director	
	Staff Director	
Approved:	Station Director	
Concurred:	Deputy Chief for Research	

Research on threatened, endangered, and sensitive species is necessary to provide information for management to maintain biodiversity. The endangered red-cockaded woodpecker (Picoides borealis) is a valuable species within the southern fire-climax pine ecosystem because it is the only species that regularly makes cavities in living southern pines. By doing so, it provides cavities for hosts of other cavity-using species of vertebrates and invertebrates in an otherwise cavity barren environment. They are cavity pathfinders for the entire cavity nesting guild. In living pines, red-cockaded woodpecker cavities provide sites for pileated woodpeckers (Dryocopus pileatus) to enlarge, eventually providing cavities for the larger cavity-using wildlife. Thus, red-cockaded woodpeckers are a keystone species within the southern pine ecosystem and crucial for the maintenance of biodiversity. Red-cockadeds are also indicators of an old growth pine-savannah community that is rapidly vanishing throughout the South. Biological diversity would be enhanced if knowledge can be developed to permit the restoration and conservation of this species, its ecosystem, and other pivotal species through ecosystem management. Society will benefit from research on the endangered red-cockaded woodpecker. Knowledge gained by studying this species may save the red-cockaded woodpecker and eventually other cavity-using wildlife from extinction, provide future generations with enjoyment, and prevent the occurrence of expensive and prolonged litigation (such as the current and past litigation in Texas).

Recent information indicates that many red-cockaded woodpecker populations, particularly on the western end of the woodpecker's range, are experiencing high cavity tree losses as a result of southern pine beetle (Dendroctonus frontalis) infestation of single cavity trees. In some instances, annual loss rates have been as high as 43% of the active cavity trees. These severe losses have occurred coincidental to intensification of cluster area management, which includes hardwood midstory removal, thinning of overstory pines, and mechanical removal of understory vegetation. These losses are currently being offset by the use of artificial cavities. However, in some cavity tree clusters the number of pines suitable for cavity inserts is critically low. Ecological factors associated with southern pine beetle infestation of single cavity trees need to be determined in order to develop management options that will permit necessary red-cockaded woodpecker cluster area management while minimizing losses of cavity trees to southern pine beetles.

The red-cockaded woodpecker is still experiencing population declines in some areas of the southern United States; most sensitive to problems are the small populations. Relationships between population demographics and habitat fragmentation and isolation of woodpecker groups, particularly mate replacement, is still not completely understood. Thresholds of permissible habitat alteration need to be determined so that habitat removal during harvest operations does not impair successful dispersal of woodpeckers for mate replacement.

Our understanding of how stand age, tree species, abundance of hardwood vegetation, and site conditions affect arthropod communities on the boles of pines is limited. Red-cockaded woodpeckers may not need the amount of foraging habitat currently specified in the recovery plan on all forest sites. We need to measure arthropod communities on pines under a variety of conditions throughout the West Gulf Coastal Plain to determine what management options enhance food resources for red-cockaded woodpeckers in managed forests.

Knowledge of specific types of nesting and foraging trees/snags required by many cavity nesters in the South is still sketchy. How fungal decay is associated with the quality of nesting and foraging habitat remains relatively uninvestigated for many woodpecker species in the South. Natural processes and anthropogenic factors that cause tree mortality will affect the fungi and arthropod communities associated with snags. Relationships among fungi, arthropod abundance, and snag

quality as foraging and nesting resources for woodpeckers are not fully understood. Such information would permit the development of management options that could produce the specialized habitat required by woodpeckers and enhance our ability to accomplish ecosystem management. Because some cavity nesting species are vulnerable to loss of mature trees, efforts to define their ecological needs and develop option with younger trees should yield good returns on resources invested. Once species reach minimal densities (threatened or endangered), efforts to reverse population declines often require enormous resource investments that are sometimes ineffective.

A major problem is what are the effects of forest habitat management on red-cockaded woodpeckers, other cavity nesters, and associated vertebrate and forest arthropod communities? (Problem 2).

Clearcutting has been the primary method of pine regeneration on southern national forests for over 30 years. Forest industry, which manages 42 million acres of southern forests, also generally uses even-aged management, but typically employs shorter rotations. Owners of nonindustrial private forests, who control 67% of the total commercial timberlands in the South, generally practice less intensive forest management, often with the goal of improving wildlife, recreation, or aesthetic amenities rather than maximizing timber production.

Although young pine plantations afford excellent habitat for many wildlife species, even-aged management (especially under short rotations) is generally considered detrimental to species that require an abundance of large snags, cavity and den trees, hardwoods, hard mast, large down wood, and other mature-forest features. Consequently, the Forest Service has been under increasing pressure to consider alternatives to even-aged management (especially clearcutting), such as single-tree and group-selection management, along with expanded management for mixed pine-hardwood stands. In 1992, the Forest Service began adopting a more socially acceptable, environmentally sensitive management approach (termed ecosystem management) to achieve multiple-use objectives. Under this new approach, clearcutting will only be used where other silvicultural approaches are impractical for accomplishing specific objectives. Thus, the Forest Service will rely much more on seed-tree and shelterwood even-aged regeneration and upon single-tree and group selection uneven-aged management, and greater emphasis will be given to maintaining more hardwoods within pine stands on appropriate sites. In Region 8, about 650,000 ac are scheduled for uneven-aged management.

Much is known about the effects of even-aged forest management on wildlife, but the effects of uneven-aged forest management on wildlife in pine and pine-hardwood communities are virtually unknown. How will wildlife abundance and diversity compare in frequently thinned, multi-aged stands with that found in different seral stages of even-aged management? What patch cut sizes are required by early-succession Neotropical migratory birds under group-selection management? To what extent will early-succession wildlife species utilize uneven-aged stands and what are the reproductive consequences of doing so? How will forest interior and edge species respond to uneven-aged management. Answers to these and other questions are urgently needed by the National Forest System and other federal land management agencies for environmental assessments of alternative forest management systems. This research is also needed by wildlife and forest extension personnel, state foresters, and private consultants who deal with nonindustrial private landowners who, for economic or environmental reasons, chose uneven-aged management. Thus, a major problem is what are the effects of alternative forest management practices (especially uneven-aged management) on habitat and wildlife communities? (Problem 3)

Pine communities and associated riparian communities of the southeastern United States are a major repository of biodiversity for North America. Changes in land use patterns due to agriculture and urbanization have greatly altered or eliminated many elements of this biodiversity from the landscape. Consequently, many species that once contributed to this high biodiversity are now threatened or endangered throughout the region. The managed pine forests and associated riparian communities of this region are the primary refuge of the high biodiversity once present throughout the southeastern United States.

These forested communities have been, and continue to be, impacted by silvicultural practices, habitat fragmentation, and changes in the fire regime. Silvicultural practices, including short rotations, site preparation, and species conversion have greatly altered forest structure and patterns of biodiversity. Intensification of silvicultural practices, primarily fertilization and control of competition using herbicides, will increase impacts in the future. Fragmentation, already substantial, may increase with increased demand from alternative land uses. The altered fire regimes have already resulted in massive changes in forest structure, with implications for regional biodiversity. Socio-economic factors threaten additional changes in fire regimes, or even complete elimination of prescribed burning on increasing portions of the landscape. Ecosystem management cannot be implemented in the absence of knowledge of the interactions of these factors, and the response of individual species and plant and animal communities to these impacts.

In the southeastern United States high diversity and abundance are characteristic of both amphibians and reptiles. Approximately 50 species of snakes occur in the region, and many are abundant. They serve as potential predators on a wide diversity of small vertebrates and large invertebrates and as prey for other predators. Human land use practices have the potential to impact snake faunas in many ways. As a result of such impacts, many species are currently included on TES species lists. Management and recovery of these species requires knowledge of their basic biology and factors determining population trends. Ecosystem management, in turn, requires attention to the conservation and management of snakes and other herpetofaunal species due to their abundance and contribution to biodiversity and ecosystem processes in the southeastern United States.

Research on two West Gulf Coastal Plain TES species has provided a more complete understanding of the impacts of silvicultural and other land use practices on their populations. Timber rattlesnakes (*Crotalus horridus*) are characteristic of forested ecosystems supporting tree squirrel (*Sciurus* spp.) populations. Increasing road density fragments forested habitats and snake populations and results in increased snake mortality that may lead to population extirpation. Consequently, silvicultural practices can impact populations directly. Louisiana pine snakes (*Pituophis ruthveni*) are possibly one of the rarest vertebrates in the United States, and the probability of listing under the Endangered Species Act is high. They are restricted to sandy, well drained soils, generally in longleaf pine habitat. Populations and distribution, based on the limited data available, are declining and fragmented. Louisiana pine snakes are closely associated with pocket gophers, which serve as their primary prey and provide burrows that are their primary sites of hibernation and shelter. Alteration of the fire regime (e.g., by lengthening the interval between burns) can lead to declines in herbaceous vegetation that supports pocket gopher populations, which in turn lead to population declines of Louisiana pine snakes.

Vehicular traffic on roads kill large numbers of snakes and other amphibian and reptile species. Habitats are becoming increasingly fragmented by developing road networks. The population consequences of this mortality are essentially unknown. In eastern Texas, preliminary data suggest that highways and Forest Service system roads can significantly impact snake populations up to

several hundred meters from roads. Data suggest that mortality on roadways is substantial both for Louisiana pine snakes and timber rattlesnakes. The population consequences of this mortality are not well understood for these and other herpetofaunal species.

Off-road vehicle use of forested ecosystems is increasing in the southeastern United States, including national forest lands. This is becoming a significant management issue on public and private holdings. While off-road vehicle use results in herpetofaunal mortality, including Louisiana pine snakes and timber rattlesnakes, the impact of this mortality on populations is essentially unknown. Management of off-road vehicle use of forested habitats requires knowledge of population impacts and possible mitigation measures.

The biology and status of the alligator snapping turtle (*Macroclemys temminckii*), a TES species, is poorly known. Potential and known impacts include land use changes, alteration of aquatic systems, and harvesting for human consumption. Data from the eastern portions of the range suggest that significant population declines have occurred. Effective management of this species requires additional data on habitat use and current status.

The construction of wildlife ponds on national forest land to provide water sources for game species is a common practice. Amphibians, including TES species, use these ponds in Texas. However, the extent of use and population consequences of this use is unknown. There is also a lack of data relating to successional patterns following pond construction, habitat relations within ponds, and other basic attributes of these ponds as they relate to amphibian use.

A major problem is what are the effects of forest management, habitat fragmentation, and road systems on snakes and other herpetofaunal and TES species? (Problem 4).

Neotropical migratory bird species are susceptible to habitat loss and fragmentation. Long-term surveys of breeding birds in the United States indicate that many of these species are experiencing population declines. Fragmentation and attendant isolation and overall loss of available breeding habitat in the U.S. and reductions in availability of wintering habitat through deforestation in the Caribbean, Mexico, Central America, and South America, are thought to be largely responsible for population losses. However, there is considerable confusion regarding which species are declining, the significance of those declines, and whether declines are occurring throughout a species' range. Given the massive, landscape-level changes in forest cover over much of eastern North America that have occurred during the last two centuries, it is not surprising that bird populations have shifted and fluctuated accordingly. From a conservation perspective, potential conflicts exist between local concerns for declining species and the long-term responsibility for conserving entire species throughout their ranges. The habitat requirements, responses to habitat alterations, effects of forest fragmentation, and the factors necessary to maintain populations of neotropical migratory birds are poorly understood. To reverse these trends it is necessary to more clearly define the factors responsible for the declines and to chart and implement a course of corrective actions. Therefore, a major problem is what are the effects of habitat modifications in the southern Appalachians on neotropical migratory birds? (Problem 5).

10. APPROACH TO PROBLEM SOLUTION

Problem 1--Mission Problem

Accomplishments planned for the next 5 years:
Complete existing studies and publish manuscripts on the following topics:

a. Natural history of the red-bellied woodpecker (species accounts for The Birds of North America).
b. Nest box use and habitat selection by prothonotary warblers.
c. Furbearer use of streamside management zones and adjacent forest stands in eastern Texas.
d. Bird communities of Arkansas streamside management zones.
e. Small mammal communities of Arkansas streamside management zones.
f. Breeding phenology of anurans in forested habitats of eastern Texas.

Problem 2--What are the effects of forest habitat management on red-cockaded woodpeckers, other cavity nesters, and associated vertebrate and forest arthropod communities?

Seasonality and process of southern pine beetle (SPB) infestation of single red-cockaded woodpecker cavity trees is virtually unstudied. The effects of pine volatiles at woodpecker resin wells, vegetation structure, and natural and management-induced site disturbances on SPB infestation of single woodpecker cavity trees is unknown. The effects of forest fragmentation and cluster isolation on the status of red-cockaded woodpecker clusters has received minimal research attention. Arthropod communities on the boles of pines serve as food for red-cockaded woodpeckers, but information on seasonal abundance relative to pine diameter, age, species, and presence or absence of hardwood midstory is lacking. Cavity tree selection as affected by presence of fungal decay, ability to produce pine resin, wood structure, and tree age has only recently received initial exploration. The effects of intensive red-cockaded woodpecker habitat management (such as mechanical removal of hardwood midstory and prescribed fire) on other sensitive wildlife species has been minimally examined.

In order to better understand the special habitat requirements of cavity nesting wildlife, cavity trees and foraging sites must be examined. The forest structure and processes that create suitable cavity sites must be understood to ensure sustained availability of these critical habitat features. The relationships among decay, tree size and height, and presence of arthropod prey need to be quantified. Factors affecting snag population dynamics (tree death and natural falling rates) of different tree species of varying sizes also need to be examined.

Eight basic areas of research will be pursued:
1. Ecological factors affecting southern pine beetle infestation of red-cockaded woodpecker cavity trees will be explored. Comparisons of ambient SPB populations to infestation rates of single cavity trees will be examined. The effects of hardwood midstory control and site disturbance on SPB activity within woodpecker cluster areas will be studied as well as possible attraction of SPB to the resin wick created by woodpecker excavation of pine resin wells.
2. Relationships between woodpecker cluster status and habitat fragmentation, cluster isolation, forest type and condition, and land use patterns will be examined. High altitude aerial photographs of national forests throughout the South will be examined. Forest type and condition, proximity of active and inactive clusters, and land use patterns will be compared to quantify landscape relationships. Forest habitat loss, composition, fragmentation, and existing isolation patterns of woodpecker clusters will be examined. Land use patterns associated with cluster inactivation will be studied if detected. Spatial analyses using fractal geometry and Taylor's index of patchiness will be used to examine woodpecker habitat and use patterns in Texas.
3. Relationships between arthropod communities and pine species, age, hardwood vegetation, height on bole, and season will be studied. Sampling of arthropod communities will include

use of tangle-trap® and scraping. We will focus on arthropods on the boles of pines because this area appears to the area of primary importance for foraging female red-cockaded woodpeckers.

4. Examination of the effects of red-cockaded woodpecker management on other sensitive vertebrate species will be concluded. Cluster areas where intensive management has removed hardwood vegetation and thinned pines to low basal areas will be compared with areas that have had relatively little disturbance. Selected sensitive species, and the avian community in general, will be studied to evaluate the impact of intensive woodpecker management on other species.
5. We will determine the characteristics of cavity trees and forest habitat used by pileated woodpeckers and other woodpecker species for nesting and foraging. Annual searches for nest trees of woodpeckers in eastern Texas will be made. Characteristics of trees/snags used for nesting and roosting and surrounding habitat will be quantified.
6. Population dynamics of snags of a variety of tree species and site conditions will be examined. Plots will be delineated and existing snags tagged and mapped. Annual inventories of the standing snag population will be made to determine numbers of snags falling and recruitment of new snags through natural tree mortality.
7. We will examine characteristics of trees and snags to determine relationships between the quality of woodpecker foraging sites, arthropod availability, and frequency of use by woodpeckers. Factors determining snag foraging quality (e.g., characteristics of bark, amount of decay, specific gravity, wood hardness, snag height, diameter, and arthropod abundance) will be examined.

The likelihood of problem resolution is 80%.

<u>Accomplishments planned for next 5 years include:</u>

1. Evaluate factors associated with southern pine beetle infestation of individual red-cockaded woodpecker cavity trees
2. Examine the relationships between red-cockaded woodpecker cluster status and land use patterns, forest type and condition, cluster isolation, and fragmentation of mature forest habitat.
3. Determine basic relationships between arthropod communities on pines as affected by pine species, tree age, and presence of hardwood foliage.
4. Conclude studies to evaluate the effects of intensive red-cockaded woodpecker habitat management on other wildlife species, particularly sensitive species such as American kestrels and Bachman's sparrows.
5. Evaluate population status of red-cockaded woodpeckers in eastern Texas to determine effectiveness of implemented management.
6. Complete book on the ecology of the red-cockaded woodpecker.
7. Continue long-term research to develop snag population dynamics models for a variety of tree species and site conditions.
8. Determine basic relationships between woodpecker foraging sites, arthropod abundance, and woodpecker use.
9. Complete manuscript addressing foraging biology of red-cockadedwoodpeckers including niche separation by social class, habitat selection, and impact of habitat on weight and growth.
10. Complete manuscript on mixed species foraging flocks associated with red-cockaded woodpeckers.

Problem 3 - What are the effects of alternative forest management practices (especially uneven-aged management) on habitat and wildlife communities?

Within the Western Gulf Coastal Plain, stands managed under a regulated, sustained-yield system of single-tree selection are rare, and those that are available generally have few, if any, hardwoods. Group selection cuts have only recently been initiated on national forests within Region 8 and none are available on other ownerships. Thus, with the exception of the few extant selectively cut private stands, much of this research will involve stands in transition from an even- to an uneven-aged structure and group-selection stands that have had only one, possibly two, initial harvesting entries. Consequently, research under this problem area will be long-term and initial findings will characterize stands in transition from an even- to uneven-aged structure. Nevertheless, data describing wildlife responses under these transitional conditions will be valuable because nearly all the stands that are being brought under uneven-aged management are initially even aged.

Studies that have already been initiated involve comparisons of habitat and measures of relative abundance, species richness, and diversity of bird, small mammal, and (in some cases) herpetofaunal communities under even- and uneven-aged management. Birds (especially Neotropical migrants) and amphibians are of major interest due to recent evidence of declining populations of many species. In addition to serving as a primary prey base for many avian and mammalian predators, small mammals are of interest because of their potential impact on pine regeneration (a key consideration for silvicultural systems that rely on natural regeneration) and the dispersal of mycorrhizae by mycophagous species. The uneven-aged stands that are currently available are too small to evaluate impacts of uneven-aged management on large, mobile game species. Therefore, inferences for these species will be based on stand-level habitat measurements coupled with known habitat relationships.

Given the limited availability of uneven-aged stands, most of the research under this problem area (with the exception explained below) was conducted in the Interior Highlands of the Ouachita National Forest in Arkansas and eastern Oklahoma and the southern-most district of the Ozark National Forest. This research was begun in 1992, when a long-term, multi-disciplinary, replicated, stand-level study was initiated as an Ecosystem Management research and demonstration project to compare 12 even- and uneven-aged silvicultural systems. Breeding bird, small mammal, and habitat responses to four of these treatments (conventional clearcutting, shelterwood, single-tree selection, and group selection--plus untreated late rotation "controls") is one component of this study. Two years (1992 and 1993) of pretreatment data were collected prior to implementation of treatments during the summer of 1993. Post-treatment data currently are being collected in alternate years and will be summarized and presented at a symposium scheduled for fall 1999. Current plans call for a second harvest entry in 2003 for the single-tree and group-selection treatments; a portion of the seed trees also may be removed in the shelterwood stands. Breeding bird and small mammal surveys (and associated habitat measurements) should be continued at least every 5 years (preferably more frequently) until such time as well-structured uneven-aged stands are obtained.

In addition to the stand-level (Phase II) component of the Ouachita Mountains Ecosystem Management Project, we have surveyed avian and herpetofaunal communities across four 3,200 to 6,500 ac watersheds to establish base line, pre-treatment conditions and to develop models to predict presence/absence of individual species as a function of both stand- and landscape-level attributes. Over four years, birds were surveyed at >2,000 point-count plots and amphibians and reptiles were censused at >1,000 of these points. Each of these sampling points was GPS referenced and Landsat imagery is being used to define habitat types and to characterize landscape attributes surrounding each point. We are now developing habitat relationship models to predict

community structure (e.g., presence/absence, species richness, species diversity, and relative abundance) as a function of these stand and landscape parameters. Once these models are developed, we plan to collect additional data to validate and refine these models.

The boundaries of these five watersheds have been re-drawn and management prescription are now being developed to achieve seven "desired future conditions" (DFCs) using different silvicultural systems and management intensities. Treatments will range from essentially unmanaged late rotation pine-hardwood stands to intensive forest industry even-aged management. Three watersheds are scheduled for uneven-aged management treatments: single tree selection, group selection with group opening $\leq$2 ac in size, and modified group selection with openings 5 to 10 ac in size. Using thinning and frequent prescribed burning, one watershed will be managed to restore shortleaf pine-bluestem habitat. We will continue to sample bird and herpetofaunal responses to at least several of these watershed treatments. These data will be used to model wildlife habitat relationships under these new ecosystem management alternatives.

The National Forest System is increasing its use of group-selection uneven-aged management. Many Neotropical migrants are dependent upon early-succession habitat like that created by clearcutting and similar disturbances. Our preliminary data from the Ouachita Mountains suggests that some of these species are absent or occur less frequently in conventional size ($\leq$2 ac) group openings. Furthermore, there is growing evidence elsewhere suggesting that reproductive success may be low in small habitat patches due to increased predation and/or nest parasitism. Consequently, evaluations of nesting success is imperative to ensure that group-selection management is not creating reproductive sinks. We propose to evaluate the effects of opening size and a host of other stand- and landscape-level habitat parameters on bird presence/absence and compare reproductive success of a subset of bird species within openings of three size classes: 1.2 to 2.0 ac, 8.0 to 10.0 ac, and 40 to 50 ac.

There is growing concern over the status of forest dwelling bats throughout the southeastern U.S. Availability of suitable roosting sites may limit the numbers and distribution of certain species of bats. Little is known about selection of natural roosts in forested landscapes, especially in areas like the Ouachita Mountains that have few available caves. Of the 11 bat species that occur in the Ouachita Mountain, 10 are known to utilize tree foliage, loose bark on tree trunks, or hollow trees as roosting sites, and four of these species roost almost entirely in trees. Research is needed to determine the effects of different silvicultural systems on the availability of suitable roosting sites for "tree bats."

To meet ecosystem management objectives (including re-establishment of viable red-cockaded woodpecker populations), the Ouachita National Forest is in the process of restoring about 120,000 ac to shortleaf pine-bluestem habitat. Restoration is accomplished through commercial thinning of the overstory, removal of much of the midstory pines and hardwoods, and application of prescribed burns about every three years. The initial impacts of this management on forest birds and small mammals has been documented. Given the growing concern of amphibians and pollinators, research is needed on the effects of this management on at least these groups. We propose to evaluate the effects of this restoration on amphibians, reptiles, butterflies, and their nectar-producing plants. Rather than use the Phase III watershed that will be restored, we will utilize sites that have already largely been restored through repeated prescribed burning.

In addition to the research in Arkansas, habitat and wildlife (breeding birds, amphibians, reptiles, and small mammals) were also studied on privately owned, selectively cut stands and in even-aged

stands of different seral stages in eastern Texas. This study has been completed, one manuscript is in progress, and several others await analyzes.

In summary, in addition to completing several pending manuscripts, five basic areas of research will be pursued:

1. Surveys quantifying breeding bird, small mammal, and habitat responses to the five Phase II silvicultural treatments will continue. Initial post-treatment responses will be summarized and presented at the Phase II/III symposium scheduled for fall 1999.
2. Models for predicting bird, amphibian, and reptile communities as a function of stand and landscape habitat parameters will be developed, validated, and refined. Bird and herpetofaunal surveys will be continued after new watershed treatments are implemented to quantify wildlife habitat relationships under the new Phase III treatments.
3. Research will be initiated (1) to determine how bird use of group selection openings is affected by stand- and landscape-level habitat parameters, and (2) to compare nesting productivity and success of a subset of bird species within openings of three size classes.
4. Research will be initiated to determine the effect of shortleaf pine-bluestem restoration on amphibians, reptiles, butterflies, and their nectar plants in the Ouachita Mountains.
5. Research will be initiated to characterize roosting habitat of tree bats under a number of the Phase III ecosystem management prescriptions.

The likelihood of problem resolution is 80%.

Accomplishments planned for next 5 years:

1. Publish pending manuscripts on the following subjects:
   a. Avian responses to even- and uneven-aged management of upland pine forests of eastern Texas
   b. Herpetofaunal responses to even- and uneven-aged management of upland forests of eastern Texas
   c. Small mammal responses to even- and uneven-aged management of upland forest of eastern Texas
   d. Herpetofauna of early- and late-rotation even-aged stands and uneven-aged stands in the Ouachita Mountains.
   e. Abundance, diversity and reproductive success of Neotropical migrants in even- and uneven-aged stands in the Ouachita Mountains, Arkansas
2. Publish initial post-treatment data on bird, small mammal, and habitat responses to Phase II treatments.
3. Develop and validate habitat relationship models for bird and herpetofauna communities in the Ouachita Mountains. Sample additional sites and silvicultural systems/practices to expand and refine these models. Manuscripts on initial pretreatment, base line herpetofaunal and avifauna habitat relationships will be published.
4. Determine how bird use of group selection openings is affected by stand- and landscape-level habitat parameters, and compare nesting productivity and success of a subset of bird species within openings of three size classes.
5. Determine responses of herpetofauna, butterflies, and their nectar plants to shortleaf pine-bluestem ecosystem restoration in the Ouachita Mountains.
6. Characterize roosting sites of tree bats under alternative landscape management prescriptions in the Ouachita Mountains of Arkansas.

Problem 4 - What are the effects of forest management, habitat fragmentation, and road systems on snakes and other herpetofaunal and TES species?

The biology of the Louisiana pine snake is less known than that of any other species of large snake in the United States. While recent radio-telemetry studies have done much to increase our knowledge, several critical aspects remain unresolved, including reproductive biology, range-wide status, impact of habitat fragmentation, and impacts of roads and vehicular traffic. In addition, the hypothesized relationship between fire regimes and populations of pocket gophers remains untested.

Existing data support the extirpation of timber rattlesnake populations by dense road networks that increase vehicle mortality and direct mortality by humans. However, the interaction between habitat quality and reproductive potential, and mortality associated with roads is unknown. Without additional knowledge of reproductive biology, habitat quality as a function of prey base, and movement patterns as affected by reproductive and predatory behavior, effective management of this species will remain difficult.

Knowledge of the impact of roads and associated vehicular traffic, and off-road vehicle use is critical to the effective management of overall biodiversity. Snakes and other amphibian and reptile species are, perhaps, most significantly impacted. The management of roads and vehicular traffic requires an understanding of the impacts on diverse assemblages of amphibians and reptiles.

Eight basic areas of research will be pursued:

1. Determine the range-wide status of the Louisiana pine snake. Trap success indices will be compared to habitat quality to assess the potential of marginal habitat to support populations of Louisiana pine snakes. Current status estimates are based primarily on data from the best remaining habitat.
2. Relationships between pocket gopher populations and herbaceous vegetation as influenced by the fire regime will be examined. Pocket gopher densities (as indexed by mound density) will be related to herbaceous vegetation cover and fire regimes to elucidate this relationship. Substantial data are currently available on pine snake use of these areas for refining the basic hypothesis.
3. Determine the prey composition of timber rattlesnakes by fecal analysis. Radio-instrumented snakes are currently being monitored. This monitoring provides ready access to snakes that have recently fed, and the ingested prey can be identified. Dead snakes will also be autopsied to provide additional data. These data will be evaluated in relation to snake size, sex, and habitat.
4. The basic reproductive cycle of timber rattlesnakes will be investigated. Radio-instrumented snakes will be monitored to determine birth interval, litter size, and other aspects of reproductive biology. Habitat requirements of neonate timber rattlesnakes will be investigated using externally attached transmitters.
5. The impact of roads on large snake species will be determined in a variety of forested habitats. A large trapping array will be utilized to provide an index of snake population density and structure at varying distances from roads.
6. The impact of off-road vehicle traffic on amphibian and reptile density, diversity, and community structure will be examined. Trapping arrays utilizing a variety of methods will be used to provide basic indices of abundance at appropriate distances from vehicle corridors.
7. The current distribution and status of the alligator snapping turtle in Texas will be determined. Trapping will be conducted throughout the historic range of the species to verify presence and habitat will be quantified at each trapping locality.

8. Amphibian use of NFS constructed wildlife ponds will be studied and related to forest type and seral stage and pond age.

The likelihood of problem resolution is 80%.

Accomplishments planned for the next 5 years include:

1. Determine the status of the Louisiana pine snake in Texas and Louisiana.
2. Determine interrelationships between fire, pocket gophers, and Louisiana pine snakes.
3. Determine food habitats of timber rattlesnakes.
4. Determine the reproductive cycle of timber rattlesnakes.
5. Evaluate the impact of roads and associated vehicular traffic on large snake species.
6. Evaluate the impact of off-road vehicle use on amphibian and reptile populations.
7. Determine the current distribution and status of the alligator snapping turtle in Texas.
8. Initiate research to determine use and succession of amphibians in constructed wildlife ponds on national forests in Texas.
9. Evaluate the faunal composition, abundance, and habitat use of lepidoptera in eastern Texas and western Arkansas; and examine these factors in relation to forest disturbance, especially fire.
10. Evaluate the effects of fire on Catahoula Barrens plant communities, especially the endangered Navasota Ladies' Tresses.

Problem 5: What are the effects of habitat modifications in the southern Appalachians on neotropical migratory birds?

Recent work examined the status of neotropical migratory birds in 13 physiographic regions in the southern Appalachians and northeastern forests using Breeding Bird Survey data. No significant differences were found in the distribution of species among breeding habitat or migratory status groups across the 13 physiographic regions. On average, 26.6% of forest species in each area were showing declines, whereas an average of 46 to 70% of grassland and successional-scrub species in each area were declining.

In general, a lower percentage of resident species than either neotropical or temperate migrants were declining in each area. Of the areas undergoing the highest percentage of declining neotropical migrants, the Blue Ridge Mountains had the highest rate of decline (53.5%). Clearly additional work is needed to understand the processes related to these declines so that decisions can be made as to how best to manage the avian resource. The goal of this research is to provide information that is necessary to properly manage these species to preclude the need to designate them as endangered or threatened. One issue of concern is whether early successional species deserve high priority status in these regions, especially if managing for these habitats is at odds with maintaining habitats for forest-breeding species. Moreover, particular species of forest birds in the southern Appalachians show consistent and troubling declines in all or part of their ranges.

Ongoing research projects being undertaken by the US Forest Service, US Fish and Wildlife Service, US Geological Survey (Biological Resources Division) and university scientists in the southern Appalachians are investigating numerous issues related to the conservation of neotropical migratory birds. These studies include work on avian distribution, densities, diversity, and habitat characteristics such as vegetation, composition, and structure in National Forests and adjacent National Park lands. In addition, the work has been expanded to include avian productivity studies on several species and development and validation of bird-habitat relationship models in the

southern Appalachians. With the recent establishment of the Southern Appalachian Mountains Cooperative Ecosystems Studies Unit under the auspices of the University of Tennessee, this work on the neotropical migratory birds will be further expanded. One of the objectives of the new unit is to facilitate research by federal, State, and local governments, as well as the academic community and conservation organizations. Work underway by the unit on neotropical migratory birds will be expanded, in keeping with the goals of this effort.

In addition to completing manuscripts currently in preparation, four basic areas of research will be pursued:

1. We will be assess the effects on neotropical migrants of harvesting cove hardwood forests in the southern Appalachians. Habitat characteristics associated with avian species utilizing regenerating cove hardwood forests will be defined. The data have been collected as part of a cooperative effort with the National Forests in North Carolina and Fish and Wildlife Cooperative Research Unit at North Carolina State University. This involved establishing 12 study plots in which spot-map surveys were conducted for three years. Ages of the plots ranged from 7 years to over 80 years of age. The data are in the process of being analyzed.

2. We will examine the effects of shelterwood cutting on neotropical migratory birds. With the assistance of the National Forests in North Carolina, we collected point count data on approximately 150 points from eight ranger districts in North Carolina and Tennessee. The avian data are in the process of being analyzed. The study will be expanded to include data collection in other shelterwood harvested sites as they become available. In a collaborative study with Drs. David Buehler and Randy Dettmers (University of Tennessee), these data are being used to test and refine bird habitat suitability models for species in the southern Appalachians derived from avian habitat relationships given in Paul Hamel's Land Managers' Guide to the Birds of the South. Models are being refined and will be validated. The model testing is being funded by the unit and by the National Forests in North Carolina. A study will be initiated to compare the most currect Breeding Bird Survey data available for early successional species and mature forest species in the Blue Ridge Physiographic province. Models that have been developed and refined by Dettmers, Buehler, and Franzreb will be used to predict population trends and then compared to actual Breeding Bird Survey trends. Landscape information, specifically the amount, type, and distribution of forests available based on Southern Appalachian Assessment data, will be factored into the predictions of the models.

3. In FY-96 a five-year cooperative landscape-scale study was begun with Dr. Ted Simons (US Geological Survey, Fish and Wildlife Cooperative Research Unit, North Carolina State University) to assess of the role of core areas, buffer zones, and forest management practices on avian communities in the southern Appalachians. The data collection process involves obtaining point count data during the breeding season on Forest Service lands in the southern Appalachians and within Great Smoky Mountains National Park. In addition, we plan to begin a new cooperative effort designed to assess the effects of forest fragmentation on neotropical migrants, permanent residents, and short-distance migrants within different physiographic provinces of the South relative to different silvicultural practices and forest types.

4. Landscape level investigations of occurrence and abundance of species will furnish information that is essential to land managers. We wish to explore the usefulness of the Region's ongoing landbird monitoring program in terms of providing data that will make it feasible to address some of the issues associated with forest fragmentation. This research may

eventually involve other Station scientists at Nacogdoches, Stoneville, Asheville (Bent Creek), and Charleston.

Accomplishments planned for the next 5 years include:

1. Complete manuscripts in preparation:
   a. The influence of stand characteristics on avian populations in cove hardwood forests in the southern Appalachians.
   b. The effects of harvesting core hardwood forests on neotropical migratory bird species diversity, abundance, and use.
   c. Effects of landscape composition on songbird habitat use in managed southern Appalachian forests.
2. Evaluate how birds respond to shelterwood harvesting in the southern Appalachians.
3. Complete manuscript in preparation: Effects of landscape composition on songbird habitat use in managed southern Appalachian forest.
4. Evaluate and predict how large-scale habitat changes may affect the breeding bird community.
5. Determine the importance of Great Smoky Mountains National Park and US Forest Service lands on regional population sources for declining bird species.
6. Publish manuscript on: The large-scale influence of habitat fragmentation on the status of breeding forest birds in the south.

The likelihood of problem resolution is 80%.

ENVIRONMENTAL EFFECTS The research outlined here will have no significant effect on the human environment, individually or cumulatively, and is, therefore, categorically excluded from documentation in an environmental assessment or environmental impact statement. As individual study plans are developed, or if research plans materially change, the proposed research will be examined to determine if a new environmental analysis is needed. In addition, if any use of toxicants are proposed an environmental analysis will be conducted to determine if such use in research will have a significant impact on the human environment. (FSM 1951 & FSH 1909.15).

11. **SCIENTIFIC STAFF**: With Kay Franzreb's transfer to Knoxville, Tennessee, and assignment to RWU-4251, the Unit currently has four scientists including the Project Leader. We also have a GS-9 professional support wildlife biologist (Dan Saenz) who has completed course work for his Ph.D. under the GETA program and is now initiating his dissertation research. We intend to convert this individual to a scientist in 2001 to fill a vacant position that resulted from Jim Dickson's retirement. Dan will complete several RCW manuscripts and will initiate research under Problem 4 to determine the effects of forest management practices on amphibians.

12. **BUDGET NEEDS:** The following table assumes staffing of four scientists in year 1 (2000) and five scientists thereafter each funded at $225,000 per year. Dan Saenz's research is shown under Problem 4 beginning in year 2 (2001). This budget is based on gross Station appropriations and does not include congressionally appropriated ecosystem management funds that we receive from RWU-SRS-4106 for Problem 3 research in the Ouachita Mountains.

    Budget by problem area and year:

Problem	YEAR				
	1	2	3	4	5
1	40,000	40,000	0	0	0
2	280,000	280,000	280,000	280,000	280,000
3	120,000	120,000	160,000	160,000	160,000
4	280,000	530,000	530,000	530,000	530,000
5	280,000	280,000	280,000	280,000	280,000
TOTAL	1,000,000	1,250,000	1,250,000	1,250,000	1,250,000

Scientist years by problem area and year:

Problem	YEAR				
	1	2	3	4	5
1	0.2	0.3	0	0	0
2	1.0	1.0	1.0	1.0	1.0
3	0.8	0.7	1.0	1.0	1.0
4	1.0	2.0	2.0	2.0	2.0
5	1.0	1.0	1.0	1.0	1.0
TOTAL	4.0	5.0	5.0	5.0	5.0