RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	1. Number FS-SRS-4201	2. Station Southern Research Station
	3. Unit Location Clemson, SC	

4. Research Work Unit Title
Endangered, Threatened, and Sensitive Wildlife and Plants in southern Forests

5. Project Leader (Name and address)
Susan C. Loeb, USDA Forest Service, Dept. of Forest Resources, Clemson University, Clemson, SC 29634

6. Area of Research Applicability	7. Estimated Duration
Pine, pine-hardwood and cove hardwood forests in southern United States	**5 years**

8. Mission
To understand population and community processes that affect vulnerable wildlife and plant species in southern forests and to develop strategies for their conservation.

9. Justification and Problem Selection

Over the past several centuries, species and habitats have been lost at rates that are unprecedented in evolutionary time. Since the 1960's, biologists, politicians, and the public have become increasingly concerned over the loss of biological diversity and its implications for overall ecosystem health. In the 1970's, numerous pieces of legislation such as the Endangered Species Act and National Forest Management Act were enacted which mandated species conservation. Although these acts have resulted in the conservation and recovery of several species, numerous additional species are declining and need protection. Thus, conservation of biological diversity at the national and global scales continues to be a major issue. For example, the concept of sustainable resource management is one of the hallmarks of the land management strategies of most public agencies in the U.S. Global efforts are also being made to conserve biological diversity and achieve sustainability. The Santiago Declaration is a recently implemented international agreement that calls for all signatories to manage forests and grasslands to: 1) conserve biological diversity, 2) maintain and enhance production capacity of forests and rangelands, 3) maintain and enhance forest and rangeland health, 4) conserve and maintain soil, water, and air resources, 5) maintain forest and rangeland contributions to carbon cycles, 6) maintain and enhance long-term multiple socio-economic benefits, and 7) inventory and monitor forest resources.

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

Although many national land management strategies and the Santiago Declaration call for conservation of biological diversity and practices that ensure the longterm sustainability of forest products, the knowledge to achieve these goals and objectives is lacking, particularly in the areas of conservation of threatened, endangered, and sensitive (TES) species and habitat restoration. Thus, research on TES species and the management strategies to ensure their long-term viability in the face of various human activities continues to be of paramount importance.

Over the past decade, southern forests have been under increasing and often conflicting pressures. As demands for southern forest products have grown, so have concerns about the effects of forest management practices on wildlife, plants, and water quality. Further, rapid human population growth and development in the region are creating additional threats to forest conservation and health. The research needed to find solutions to these complex issues cannot be done by individual researchers or research units. Thus, the Southern Research Station supports a cross-disciplinary approach to solving these problems. To guide this effort, the SRS has identified two physiographic regions (Southern Appalachians and Ouachita/Ozark Interior Highlands), two broad habitat types (southern pines and forested wetlands, bottomland hardwoods, riparian areas) and two strategic areas of research (inventory and monitoring and landscape and regional assessment and modeling) that are areas of greatest concern in the region. Conservation of biological diversity is a concern in both physiographic regions and both broad habitat types, and requires inventory and monitoring as well as landscape and regional modeling to address important issues. This unit will concentrate its efforts on the Southern Appalachian region and pine ecosystems, although work in bottomland hardwoods may gain increasing prominence over the course of the next five years.

Problem Selection:

For the past 25 years, much of the TES species research and management in southern forests was conducted on the endangered red-cockaded woodpecker, *Picoides borealis*. Early research, much of which was conducted by this RWU, focused on the bird's basic biology and habitat requirements and included studies on cavity tree selection, social structure, demographics, and foraging behavior. Although the results of these studies provided a great deal of information and were the basis for early management guidelines and recovery strategies, many populations continued to decline. Consequently, the scope of research was broadened to address questions about the bird's ecological relationships. Research focused on foraging habitat requirements, the arthropod prey base, interspecific competition for cavities, population genetics and viability, and development of new technologies to accelerate population expansion such as translocation protocols and artificial cavities. Further, the impacts of Hurricane Hugo on the red-cockaded woodpecker population inhabiting the Francis Marion National Forest in 1989 raised the issues of catastrophic events and the need for regional management of red-cockaded woodpeckers.

Although the red-cockaded woodpecker has not reached its recovery goals, many woodpecker populations that were declining are now stable or increasing, and a whole suite of science-based management guidelines and plans are available to managers. Thus, intensive research focusing on red-cockaded woodpecker conservation and management is no longer warranted. However, results of completed ecological studies on foraging habitat, arthropod prey, interspecific competition, and translocation must be analyzed, published, and synthesized to provide managers with the information they need to further develop and adapt their management strategies. Thus, it is necessary to **complete studies on red-cockaded woodpecker foraging relationships, interspecific interactions, response to catastrophic events, and translocation technologies (Mission Problem).**

Traditionally, much of the research on the effects of forest management on wildlife has focused on game species, birds, and terrestrial small mammals. We have learned much about forest/wildlife relationships from these studies and have been able to use this information to develop effective conservation and management strategies for these groups. However, many other groups of wildlife have been virtually ignored and consequently, are suffering alarming declines in their numbers and distributions. One such group is the bats. For example, in 1960 it was estimated that there were 808,000 Indiana bats, *Myotis sodalis*, but by 1980, estimates of the Indiana bat population had dropped to 589,000. Based on the most recent surveys conducted in 1995-1997, the numbers of Indiana bats have dropped to approximately 353,000, despite protection of many of their important hibernacula. At this rate of decline, the species will go extinct within the next 20 years. Three additional species of bats in the South are also listed as endangered and four species are considered to be species of special concern. Thus, of the 18 species of bats that commonly inhabit the forests of the South, almost half are TES species. Further, many of the supposedly "common" bats may also be experiencing considerable declines in population numbers and distributions.

Bats are one of the most diverse and specialized groups of mammals and they play many significant roles in forested ecosystems including nutrient cycling, insect population control, transmission of diseases, and accumulation of pesticides. Thus, management guidelines to conserve their numbers and diversity are greatly needed. However, little information is available on the status of many species and little is known about their ecological relationships. Thus, information is needed on the **status, distribution, and habitat relationships of forest bats in the southeast (Problem 1).**

Although the Endangered Species Act only protects individual taxa, many conservation biologists recognize that entire ecosystems may also be endangered. The longleaf pine (*Pinus palustris*) ecosystem of the southern Coastal Plains is considered to be one such critically endangered system. Since European settlement, the longleaf pine ecosystem has been reduced to about 2% of its original 37 million hectares. In addition to the loss of area, fire suppression and intensive management practices have contributed to declines in habitat quality for many species. Consequently, as of 1995, 27 plant species of the longleaf ecosystem were listed as endangered or threatened. Most of these species are found on Federal lands, the only places where recovery is mandated under the Endangered Species Act. More than 70 additional plant species associated with longleaf pine are recognized as sensitive on southern national forests (1996 list).

Ideally, management strategies for rare plants would be based on a thorough understanding of life history and habitat requirements. But little is known about the basic species biology and the habitat factors that ensure the persistence of rare plants in managed longleaf pine landscapes. Specific to the longleaf pine ecosystem is the need to understand the role of fire in maintaining rare plant species. We do not understand how fire functions to maintain plant community diversity at multiple scales, nor do we know enough about the biology of individual species to reliably predict the impacts of management through decades.

Given the extensive losses and degradation of longleaf pine lands, habitat restoration and species reintroductions are essential components of rare plant recovery. While there is much information available about how to establish longleaf pines, there is scant information applicable to establishing the many herbaceous species of the system. To successfully recover rare species in longleaf ecosystems, land **managers need information on the basic biology of TES plants found in longleaf pine forests and on methods to recover populations and restore habitats (Problem 2).**

10. APPROACH TO PROBLEM SOLUTION:

<u>Mission Problem</u>: Complete studies on red-cockaded woodpecker foraging relationships, interspecific interactions, response to catastrophic events, and translocation technologies.

Scientists in this unit have been involved in research on the red-cockaded woodpecker for more than 20 years. This research has finished or is drawing to an end. Studies described under this mission problem have important objectives that will improve our knowledge of the red-cockaded woodpecker and its recovery, and are in various stages of completion. Most are awaiting final analyses and manuscript preparation. These will be completed as expeditiously as practical.

Anticipated Accomplishments:

1. Determine the relationship of recent fire history to the reproductive success and group size of red-cockaded woodpeckers in the Francis Marion National Forest. (Publish).
2. Compare the diets of red-cockaded woodpeckers in home ranges with and without recent prescribed burns. (Publish)
3. Complete assessment of the red-cockaded woodpecker population and recovery efforts 10 years post-Hugo. (Publish)
4. Develop and evaluate a GIS model relating red-cockaded woodpecker population growth and forest stand dynamics at the Savannah River Site. (Publish).
5. Publish study on the long-term efficacy of three types of artificial cavities used by red- cockaded woodpeckers for nesting and roosting.
6. Publish a study on comparison of spatial and foraging needs of red-cockaded woodpeckers before and after catastrophic reduction of foraging habitat.
7. Publish study on red-cockaded woodpecker demographics and viability in the Piedmont Region.
8. Determine whether the use of a mobile aviary increases translocation success of red-cockaded woodpeckers.
9. Publish results of red-cockaded woodpecker home range analysis and foraging use at the Savannah River Site.
10. Describe seasonal and annual population dynamics of southern flying squirrels in the Piedmont Region and relate to biotic and abiotic factors such as climate and mast production (publish).
11. Determine the nesting patterns of southern flying squirrels in the Piedmont Region (publish).
12. Test the relationship between hardwoods and southern flying squirrel habitat use at the micro-habitat scale (publish).
13. Determine the landscape factors contributing to southern flying squirrel use of red-cockaded woodpecker clusters and develop a model to predict level of cluster use by southern flying squirrels.
14. Develop a complete description of southern flying squirrel habitat use and selection.

Anticipated outcomes:

1. Foraging guidelines used by Federal agencies to manage public lands for recovery of the red-cockaded woodpecker will be improved, better meeting the needs of the birds.
2. Land managers responsible for the recovery of the red-cockaded woodpecker will have a better understanding of the long-term effects of hurricanes on red-cockaded woodpecker populations.
3. By using the GIS-based model being developed for the red-cockaded woodpecker at the Savannah River Site, managers will be able to predict the population growth and outcome when considering different timber harvest strategies for the site. Alternatively the model can be used

to set a desired red-cockaded woodpecker population growth rate and then estimate the extent of timber harvesting that can be allowed so that the desired red-cockaded woodpecker population is attained.

4. Information produced will influence recovery guidelines for the red-cockaded woodpecker on federal lands.
5. Results of home range and foraging studies of the red-cockaded woodpecker at the Savannah River Site will be incorporated into a revised management plan for the site.
6. If the mobile aviary is found to increase translocation success, provide technology transfer of use of the aviary to other interested federal and non-federal managers.
7. Information on southern flying squirrel habitat use and selection will be used by managers to develop management strategies that discourage habitat use by southern flying squirrel.
8. A model predicting the level of use of red-cockaded woodpecker clusters by southern flying squirrels will allow managers to evaluate potential recruitment sites based on their likelihood of experiencing southern flying squirrel interference. This model will also allow managers to determine which existing clusters are the most likely to experience squirrel problems and thus may need greater short-term management (e.g., squirrel excluder devices, removal, etc.).

Environmental consideration: Most of the studies in this problem area are expected to have little or no potential for soil movement, water quality degradation, or impact on sensitive resource values and are therefore covered under FSH 1909.15, Chapter 30, "Categorical Exclusion from Documentation in an EIS or EA". For those studies that have the potential to affect species that are federally listed as a endangered species, the unit will consult with the U.S. Fish and Wildlife Service as per Section 7 of the Endangered Species Act of 1973, as amended.

Problem 1. Status, distribution, and habitat relationships of forest bats in the southeast.

This problem area will have three focus areas or elements: 1) endangered species, 2) sensitive species, and 3) the effects of forest management on bat communities.

Element 1: Endangered bats of southern forests.

Research in this area will concentrate on the endangered Indiana bat. This species is the most widespread of the endangered species and it is the only endangered bat that uses trees for its maternity colonies. Thus, the effects of forest management may be having the greatest impact on this species. Further, our lack of knowledge about this species and the resulting legal problems associated with that lack of knowledge are impacting the ways in which the national forests in the eastern U.S. are being managed. Thus, information is urgently needed to determine the summer habitat requirements of Indiana bats to develop effective habitat management and conservation plans.

Planned studies and expected accomplishments:

1. Determine tree, stand, and landscape factors that affect maternity site selection in the southern portion of the range of the Indiana bat (North Carolina and Tennessee).
2. Determine use and selection of summer foraging habitat by Indiana bats in North Carolina.
3. Conduct a range-wide assessment of available Indiana bat roosting habitat over the past 20-30 years.

Element 2: Sensitive species.

Four species of bats in the South are considered to be species of special concern: Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), the southeastern bat (*Myotis austroriparius*), the small-footed bat (*M. leibii*), and the Florida mastiff bat (*Eumops glaucinus*). The status of Rafinesque's big-eared bat is the most controversial and in need of the quickest resolution. Big-eared bats in the Coastal Plain appear to rely on large hollow trees and old buildings for roosting. Both of these resources are declining and thus, biologists who work with these bats in the Coastal Plain are concerned about their longterm viability. In other areas of their range, big-eared bats often use caves and other structures for roosting and there is less concern about their status. However, big-eared bats are moth specialists and thus, control programs for gypsy moth in these areas may have an impact on their food supply. Data on population distribution, trends, and habitat requirements are needed to resolve the species' current status and potential for longterm viability.

Planned studies and expected accomplishments:

1. Determine the distribution of *C. rafinesquii* across South Carolina and initiate longterm monitoring studies on target populations in various habitats types and physiographic regions.
2. Determine the effects of gypsy moth control on non-target Lepidoptera and *C. rafinesquii* food habits in the upper Piedmont of South Carolina.

Element 3: The effects of forest management on bat communities.

Ultimately, bat conservation needs to entail management guidelines that protect the entire bat community across the landscape. However, the requirements and habitat associations of most bats, particularly the tree-roosting bats, are unknown. Further, there is little information on the effects of forest management practices on bat populations and bat community structure. To help managers determine the effects of forest management practices on bat abundance and community structure, information is needed on: 1) the relationships between bat habitat use and forest structure and composition, and 2) how forest management practices alter forest structure and composition and thus, habitat suitability for bats. Both experimental and observational/correlational studies will be used to obtain this information and results will be used to model bat/forest habitat relations. Further, many techniques to obtain information on the ecology of forest bats are relatively new and thus, research is needed to refine and modify these techniques.

Planned studies and expected accomplishments:

1. Determine the effective sampling area of Anabat ultrasonic detectors. The results of this study will be used to establish sampling protocols for future studies.
2. Determine factors associated with use of various forest habitat types and structures by bats in the Cumberland Plateau.
3. Test the effects of thinning and burning on use of upland pine stands by bats in the upper Piedmont of South Carolina.
4. In cooperation with researchers at the University of Kentucky, determine the effects of silvicultural practices on bat habitat use in the Southern Appalachians and the Cumberland Plateau.

Expected outcomes from research in Problem 1 include:

1. Models will be developed of Indiana bat summer roosting habitat in the Southern Appalachians. These models will help managers of national forests and other public lands maintain and protect existing Indiana bat maternity roost sites. These models will be applied across the landscape to predict potentially suitable sites for additional colonies.
2. Data on Rafinesque's big-eared bat distribution and population trends will be used by the USFWS and other agencies to clarify the status of this species. Further, data on habitat associations will be used to develop management strategies for this species.
3. Models of forest bat habitat associations will be developed that will allow managers to determine the effects of their management activities on bat populations and use various silvicultural techniques to improve bat habitat, if necessary.

Environmental consideration: Most of the studies in this problem area are expected to have little or no potential for soil movement, water quality degradation, or impact on sensitive resource values and are therefore covered under FSH 1909.15, Chapter 30, "Categorical Exclusion from Documentation in an EIS or EA". For those studies that have the potential to affect species that are federally listed as a endangered species, the unit will consult with the U.S. Fish and Wildlife Service as per Section 7 of the Endangered Species Act of 1973, as amended.

Problem 2: Managers need information on the basic biology of TES plants found in longleaf pine forests and on methods to recover populations and restore habitats.

The approach to research related to TES plants found in longleaf pine forests will fall under three general elements: 1) factors that facilitate rare species persistence in fire-maintained landscapes, 2) habitat requirements and population dynamics of an extinction-prone species, and 3) protocols for habitat restoration and species reintroductions in longleaf pine sandhills sites.

Element 1. Factors affecting rare species persistence in fire-maintained landscapes.

Two lines of autecological research will be used to identify factors that affect rare species persistence. First, the population processes of *Macbridea alba*, a species that typifies a number of rare species in fire-maintained systems, will be described. Secondly, key characteristics of a suite of co-occurring rare species will be described and compared.
Macbridea alba is a Federally threatened mint, and it is representative of a group of rare longleaf pine associates that share the following attributes: perennial herbs, flower morphologies that suggest a dependence on insect pollinators, no obvious adaptations for long-distance dispersal, and distributed on the landscape as discrete populations separated by inhospitable habitats while apparently suitable habitat remains unoccupied. Preliminary analyses of demographic data indicate that site quality influences population behavior, but also that inter-population gene flow may be important to individual plant fitness and species persistence at a landscape level. Because managers use fire at a landscape scale, it is critical to determine how rare species persistence is affected at that same scale.

Less intensive studies to describe population dynamics and fire responses of other rare species that occur with *Macbridea* will be initiated. This phase of the work will be done later in the research cycle, so that the results of *Macbridea* population and sensitivity analyses can be used to select key characteristics for inter-species comparisons. Likely variables for study include survivorship following fire, flowering and fruiting success, seed viability, and pollinator requirements.

Expected accomplishments include:

1. Model population dynamics of *Macbridea alba* across range of habitats and time since fire and complete a population viability analysis. (Publish)
2. Describe the breeding system and pollinator requirements in *Macbridea alba*. (Publish)
3. Describe genetic diversity in *Macbridea alba* in order to partition diversity within and among populations; compare findings with genetic diversity in *Macbridea caroliniana*, which is more widely distributed than *M. alba* and is the only other species in the genus. (Publish)
4. Evaluate the consequences of outbreeding and inbreeding on F1 and F2 progeny of *Macbridea alba* specifically describing effects on seed viability, seedling establishment and early growth. (Data collection completed.)
5. Establish a sampling protocol to describe the reproductive, mortality, and growth responses of a suite of co-occurring rare and common flatwoods and savannas species to variations in fire seasonality, frequency, and intensity.

Element 2. Habitat requirements and population responses to management of an extinction-prone herb of longleaf pine savannas.

Harperocallis flava is a federally endangered species restricted to the Apalachicola National Forest. The extremely narrow distribution and limited population sizes of *Harperocallis* make it necessary to couple non-destructive field studies with experimental studies on captive populations. Initial research will focus on establishing plots with marked individuals that can be located and measured annually. Annual censuses of marked natural populations provide the basic data to model population dynamics and assess viability under current management. Preliminary observations suggest that site hydrology is critical to species success, but the relationship of *Harperocallis* to fire is uncertain. Greenhouse and garden experiments to evaluate the effects of water and nutrient status, and fire intensity and seasonality on reproductive success will be initiated.

Expected accomplishments include:

6. Describe habitat requirements and effects of fire on mortality, longevity, flowering and fruiting, and recruitment into natural populations of *Harperocallis flava.* (Report to Fish and Wildlife Service and to Apalachicola National Forest.)

Element 3. Understanding consequences of fire exclusion and selected silvicultural treatments on herb communities in upland longleaf forests, and developing protocols for restoring herbaceous layers in longleaf pine communities.

The structure and composition of longleaf pine communities and rates of change following fire exclusion vary predictably across a site moisture gradient (also correlated with site fertility). Although restoration protocols must at some level be site specific, several lines of evidence suggest that such a gradient in site quality may serve as an organizing variable for developing generalizable restoration protocols. Previous research in this problem area was focused on understanding the effects of fire and silvicultural treatments on locally rare species in relatively simple, xeric sandhill communities. Similar work will be conducted in more mesic sites in order to understand how widely current knowledge can be applied.

Community level research will involve quantitative field descriptions of plant communities, and stand level experiments to determine effects of fire and silviculture treatments (specifically drum-

chopping) on herbaceous layers. Investigations of the direct and indirect roles of fire in germination and establishment of common and locally rare species of the sandhills will be conducted.

Expected accomplishments include:

7. Describe patterns of species loss with known historical disturbances, fire exclusion and plantation establishment in xeric and mesic sandhills communities. (Publish)
8. Determine the germination and establishment requirements of selected common and rare species in upland sandhills communities, including the species' relationships to fire for germination and for creating suitable germination and establishment sites. (Publish)
9. Describe the heterogeneity in fire intensity and behavior in the range of longleaf pine communities that harbor rare herbs. (Complete data collection)

Expected outcomes from research in Problem 2 include:

1. The National Forests in Florida will use research results and reports to refine management guidelines for *Harperocallis flava* and *Macbridea alba*, thereby facilitating agency responsibilities for species recovery.
2. Findings on the importance of gene flow in fire maintained habitats will be considered in the development of landscape level prescribed fire planning.
3. Findings on sandhills plant communities and sandhills species will be used to guide longleaf pine restoration projects in the North and South Carolina sandhills regions, and perhaps in other parts of the longleaf pine range.
4. Although there is wide agreement that fire is important in longleaf pine communities, there is remarkably little known about how fire functions to structure these diverse communities. Findings of proposed research will contribute to understanding of the role of fire in structuring complex communities. Additionally, there are no models that explain how fire acts to maintain rare species in fire-adapted landscapes. Specifically, no one has determined if metapopulation models are appropriate for predicting species viability for any rare species in fire-maintained landscapes. Proposed research will contribute to resolving these basic research issues.

Environmental consideration: Most of the studies in this problem area are expected to have little or no potential for soil movement, water quality degradation, or impact on sensitive resource values and are therefore covered under FSH 1909.15, Chapter 30, "Categorical Exclusion from Documentation in an EIS or EA". For those studies that have the potential to affect species that are federally listed as a endangered species, the unit will consult with the U.S. Fish and Wildlife Service as per Section 7 of the Endangered Species Act of 1973, as amended.

Staffing:

Allocation of scientist time by problem area

Problem	Scientist Years per Years of RWUD				
	1	2	3	4	5
1	0.8	0.8	0.9	1.0	1.0
2	1.0	1.0	1.0	1.0	1.0
Mission	0.2	0.2	0.1	0	0

The unit consists of two Research Ecologists (GS-13) including the Project Leader, one Ecologist (GS-11) who serves in a professional research support role, a permanent full-time Biological Science Technician (GS-9), a permanent full-time forestry technician/computer specialist (GS-7), a temporary full-time Biological Science Technician (GS-6), a permanent full-time Support Services Specialist. Several seasonal technicians are employed as needed.

The annual cost of the research program in FY2000 was approximately $545,000. This cost is projected to rise to approximately $600,000 in FY2005 due to cost of living increases alone (2.5% per year). The FY2000 allocation to the RWU was approximately $519,000. The remainder of the funds to support the research program were obtained from outside agencies and other programs within the Station. Without increases in appropriated funds, an increasing portion of the RWU's funding will have to come from outside sources. Due to the high cost of field work in both Problems Areas, decreased funding will seriously limit the ability of scientists to conduct research and achieve the anticipated outcomes.