USDA-Forest Service
RESEARCH WORK UNIT DESCRIPTION

1. Number :
   SRS-4106

2. Station:
   Southern

3. Unit Location:
   Monticello, Arkansas

4. Research Work Unit Title:
   Managing Upland Forest Ecosystems in the Midsouth

5. Project Leader (Name and address):
   James M. Guldin, Forestry Sciences Laboratory, P.O. Box 3516,
   Monticello, AR 71656-3516

6. Area of Research Applicability
   Midsouth states including AL, AR, LA, MS, OK, and TX

7. Estimated Duration
   5 Years

8. Mission

Provide scientific information to understand, manage, and sustain the ecological processes, structures, and benefits of loblolly pine, shortleaf pine, mixed pine-hardwood, and hardwood forests in the uplands of the Midsouth.

9. Justification and Problem Selection

This document outlines the future direction of forestry research conducted by Research Work Unit (RWU) SRS-4106 of the Southern Research Station, USDA Forest Service. The unit is located on the campus of the University of Arkansas at Monticello in association with the School of Forest Resources. Subunits are located at Fayetteville and Hot Springs, AR; support personnel are located at the Crossett and Koen Experimental Forests.

During the last 18 years, this unit has focused its research efforts on the development of silvicultural alternatives to clearcutting and planting in upland forests of the Midsouth. These alternatives emphasize partial cutting, depend on natural regeneration, and require control of competing vegetation. Because of the relatively low cost and aesthetic appeal of these silvicultural systems, the unit has directed its program essentially to the needs of non-industrial private land- owners, who control two-thirds of the South's forest land. However, over the last decade, the National Forests have become increasingly interested in silvicultural systems based on partial cutting methods, because clearcutting and planting have become very controversial. They view these alternative methods as potentially more effective in protecting the aesthetic resource, initiating a variety of successional stages, and achieving multiple-resource management goals. As a result, this RWU is now directing attention to the National Forests, other public agencies, and forest industries as well as non-industrial private forest landowners.

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

During the next 5 years, this RWU will continue its research to develop silvicultural alternatives for managing loblolly pine, shortleaf pine, mixed pine- hardwood, and upland hardwood forests in the Midsouth. However, the scope of the research will be expanded from studies of individual trees and forest stands to include landscape-scale considerations. At this larger scale, research will be able to address silvicultural interactions and impacts on vegetation patterns, wildlife movement and habitat use, effects of natural and human disturbances, and riparian management.

This RWU will investigate ecosystem processes and management interactions at the tree or microsite, forest stand, and landscape scales. The research conforms to the research themes "Understanding Ecosystem, Structure, Function, and Processes" and "Managing our Resources to Sustain and Enhance Productivity" that are found in the Southern Research Station's draft strategic plan. To facilitate this research, three problem areas will be investigated.

<u>Problem 1. A better understanding of environmental factors and ecological processes influencing establishment and growth of forest reproduction is needed to fully develop silvicultural alternatives for upland forests in the Midsouth.</u>

Natural reproduction cutting methods can provide a low-cost means for obtaining acceptable regeneration. However, successful application requires a basic understanding of natural regeneration processes, which are complex and are not as controllable as artificial regeneration techniques associated with plantation culture. Most natural reproduction cutting methods retain overstory trees, which produce shade and compete with regeneration for light, moisture, and nutrients. Also, pines and hardwoods react differently to environmental conditions and have different strategies for regeneration. For example, most pine seedlings develop from seeds dispersed after the reproduction cut; whereas the hardwoods (especially the oaks) develop mainly from existing advance reproduction or from sprouts. Factors determining the density, stocking, and species composition of natural regeneration include seed supply, seedbed conditions, competing vegetation, and limiting resources. These are the factors that need additional investigation.

A better understanding of processes affecting natural regeneration also facilitates the development of integrated vegetation management techniques that recognize the importance of suppressing vegetation but only to the extent that such vegetation interferes with beneficial plants or other land uses. Integrated vegetation management allows flexibility in using a variety of techniques--such as biological, fire, mechanical, and chemical--to manipulate competing vegetation. Vegetation management programs must also be integrated with other cultural activities so that the whole gamut of forest benefits is considered.

Silvicultural systems involved in vegetation manipulation cannot be universally adapted to all sites. There is a need for site-specific information regarding various roles and outcomes of silvicultural systems. Most assessments of vegetation control techniques have been concerned only with their biological efficacy. Consequently, there is a need for long-term economic and multi-resource evaluations when comparing vegetation management alternatives. Fire, herbicides, and mechanical treatments have inherent advantages and disadvantages. In the future, there will likely be an increased demand for biological control agents to replace or enhance the vegetation management techniques that are in use today. The need for vegetation management in any forest environment is usually based on subjective evaluations rather than quantitative assessments. There is a need to develop vegetation assessment techniques that will give quantitative credence to these evaluation efforts.

<u>Problem 2. Development of silvicultural alternatives for regenerating and managing upland forests in the Midsouth requires a better understanding of forest stand dynamics, including the role of disturbance.</u>

Stand dynamics refers to changes in structure, size, and composition of a stand with time. It encompasses the interaction of various vegetative components of the forest, i.e., overstory and understory, with each other and with their environment through time. Stand dynamics also includes how these components respond to site factors and exogenous events--such as natural disturbance, logging, etc. This concept is more inclusive than the former concept of only looking at the merchant- able portion of the stand. It is an especially useful framework for studying more complex stand structures and processes and is closely related to plant population ecology.

There is also a need to look at more than just vegetation. Silvicultural practices have a pronounced impact on most forest resources and values besides timber. Society's demands for such non-timber forest resources as wildlife, aesthetics, recreation, water quality, etc., are projected to increase dramatically in the future. The increased recognition of non-timber resources presents forest managers with new challenges to integrate all resources within a single management framework. New questions are being posed about the interaction between silvicultural practices and different resources, which emphasize the need to collect additional information concerning the tradeoffs among different forest values. Such information will enable forest managers to make wise choices among various silvicultural systems and practices to provide the desired mix of resources.

<u>Problem 3. A better understanding of the effects of silvicultural treatments on forest stands and interactions between stands is needed to make landscape-level decisions.</u>

A large part of the forested area in the Ouachita-Ozark Highlands is under National Forest management, but significant areas are held by forest industry and non-industrial private owners. Both within and among these various ownerships, differences in management policies and objectives result in different levels of management intensities across the landscapes which often lead to misunderstandings and conflicts. Implicit in ecosystem management is the need to better understand the ecological, managerial, and policy ramifications associated with these debates. Large-scale ecosystem-based research offers the opportunity to frame these debates scientifically by evaluating the interactions among different parts of the system and by quantifying ecosystem capacity to produce benefits. These studies have significance both theoretically, and in specific application to the region.

The linkage between stand-level treatments and landscape-level management is more than just the sum of their components. Landscape-level management starts with an array of alternatives, but each stand/treatment combination must be located in space and time so as to sustain and enhance landscape ecosystem attributes. Natural resources that are affected by and influence management decisions include water quality, aquatic ecology, wildlife habitat/populations, and the composition/ distribution of vegetation. Human and social concerns also have greater meaning in the context of landscape-level management.

Yet we have little information to apply to management decisions either in theory or in application to the landscapes commonly found in the Interior Highlands of Arkansas and Oklahoma. For example, existing research in water quality in the Interior Highlands has been limited to headwater-catchment hydrology, but has not yet attempted to integrate water quality and quantity within nested watersheds of

increasing size. Similarly, studies of aquatic ecology have been limited and conducted with little physical linkage to the hydrological regime. Existing studies of wildlife populations such as songbirds and herpetofauna in the region have been limited to the stand level. Patterns of vegetation distribution that exceed 40 acres have not been integrated through classification over space and time.

Finally, our lack of knowledge about these factors is compounded when different ownerships impose markedly different management strategies across landscapes. Some watersheds are almost entirely under intensive industry management, others share industry and Federal management in the same watershed, and still others on Federal lands have been largely untouched for over three decades. To reduce concerns from society about cumulative effects of managing landscapes such as these, research is needed to establish a theoretical framework within which landscape-level management decisions can be made in an interdisciplinary context.

10. Approach to Research Problem Solution

Problem 1. A better understanding of environmental factors and ecological processes influencing establishment and growth of forest reproduction is needed to fully develop silvicultural alternatives for upland forests in the Midsouth.

Natural reproduction cutting methods for pines and upland hardwoods have been widely used throughout the South, and naturally regenerated stands still provide more than two-thirds of the timber that is being harvested in the southeastern U.S. Consequently, resource managers have a general understanding of silvicultural techniques needed to establish, manage, and sustain natural stands.

Although basic silvicultural techniques provide useful standards in forest management, silvicultural prescriptions must often be tailored to specific stand and site conditions. Consequently, there is a need to develop stand- or site-specific prescriptions for natural reproduction requirements and processes, such as: (1) seedbed conditions, (2) reproduction physiology, (3) variability of natural seed- crops, (4) fate of seed before and after dispersal, (5) environmental stress physiology, and (6) development of advance reproduction. There is also a need to better understand the contribution of stump sprouts to both stand composition and vegetative competition in these systems. In addition, integrated vegetation management research is lacking on techniques to control exotic plants, like kudzu and Japanese honeysuckle, that occur in localized areas and provide severe competition to desirable tree species in natural stands.

Given the emphasis on tree planting during the past 30 years, there has been relatively little effort in developing a comprehensive understanding of pine and hardwood regeneration processes that will complement natural stand management. Thus, there is a need for long-term evaluations of silvicultural systems that: (1) rely on natural reproduction cutting methods, (2) often retain, or attempt to regenerate mixtures of both shade-intolerant and shade-tolerant species, and (3) often provide for many non-timber resources or values. Active studies in this problem area (a list is provided in the Appendix) were initiated to test the effects of various reproduction cutting methods in combination with competition control techniques on the establishment, survival, and development of pine, pine- hardwood, and hardwood reproduction over time. Therefore, many of these active studies will continue over the next 5 years to capture definitive trends in early stand establishment and development and to improve our understanding of some of the basic regeneration requirements and processes previously listed. These studies will also provide information on stand dynamics, ecosystem sustainability, and a multitude of non-timber resources and values. Additional studies may be initiated to investigate some of the specific requirements and processes related to the establishment and development of pine and hardwood reproduction.

Planned accomplishments by topic areas for the next 5 years (assuming current staffing and funding levels) include:

1.0 ESTABLISHMENT AND DEVELOPMENT OF REPRODUCTION IN EVEN-AGED STANDS

1.1 Publish 5-year results on the establishment and development of pine and hard- wood regeneration following shelterwood cutting in pine-hardwood stands in the Ouachita National Forest (study 69).

1.2 Publish 10-year results of shelterwood cutting and competition control on the establishment, survival, and growth of oak, ash, and cherry reproduction and derive stocking guides for these species in the Interior Highlands (studies 74 and 76) [Also related to 3 -- Competition Control, below]

1.3 Develop guidelines for evaluating regeneration potential in upland mixed- species hardwood stands in the Interior Highlands (studies 74 and 76).

1.4 Publish results on effects of seedling characteristics, overstory density, and competition control on survival and growth of underplanted northern red oak on productive mountain sites in the Interior Highlands (study 75) [Also related to 3 -- Competition Control, below]

1.5 Publish on short-term effects of aspect, residual stand density, overstory structure, and intensity of competition control on reproduction establishment, survival, and growth in upland oak-hickory forests in the Interior Highlands (study 78) [Also related to 1.3 -- Competition Control, below]

1.6 Publish 3-year results on the establishment and development of pine and hard- wood regeneration following group selection cutting in pine-hardwood stands in the Crossett Experimental Forest (study 83).

2.0 ESTABLISHMENT AND DEVELOPMENT OF REPRODUCTION IN UNEVEN-AGED STANDS

2.1 Publish 10-year results on the establishment and development of pine regeneration in stands under single-tree selection in southern Arkansas and northern Louisiana (study 36).

2.2 Publish 6-year results on the establishment and development of pine and hard- wood regeneration following the implementation of single-tree selection in pine-hardwood stands in the Ouachita National Forest (study 63).

2.3 Publish 3-year results on the establishment and development of pine and hardwood regeneration following the implementation of single-tree selection in pine-hardwood stands in the Homochitto National Forest (study 65).

2.4 Publish 3-year assessment of shortleaf pine regeneration on the Upper Coastal Plain of Arkansas using uneven-aged management and controlling hardwoods with and without herbicides (closed study 79) [Also related to 3.0 -- Competition Control, below].

<u>3.0 COMPETITION CONTROL IN PINE, PINE-HARDWOOD, AND HARDWOOD STANDS</u>

3.1 Publish 9-year results on efficacy of operational hardwood control treatments for growth enhancement of natural pine regeneration in uneven-aged stands (study 29).

3.2 Publish long-term results on the effects of intensive competition control in natural even-aged pine stands (study 37).

3.3 Publish 5-year results on growth and development of seeded shortleaf pine regeneration and hardwood regrowth following manual control and herbicide control of the hardwood component (closed study 77).

3.4 Publish cost comparison from three release treatments and quantify growth and development of natural loblolly and shortleaf pine saplings and hardwood regrowth following release (study 85).

3.5 See items 1.2, 1.4 and 1.5 above.

<u>4.0 INTEGRATED FOREST RESOURCE MANAGEMENT</u>

4.1 Conduct a symposium summarizing 5-year results of the Phase II Ecosystem Management Research project; a proceedings will be published to include over 30 papers dealing with the effects of even-aged and uneven-aged reproduction cutting methods (with and without retention of overstory hardwoods) on the following parameters (study 81):

a. seedbed condition, soil disturbance and logging damage
b. seed production as affected by environmental factors
c. plant communities (diversity and dynamics)
d. animal communities (populations and habitat)
e. arthropod/microbial communities (diversity, damaging/beneficial effects) and forest health
f. water, soil, and cultural resources
g. scenic quality and recreational opportunities
h. logging and management economics

4.2 Publish 6-year results on effects of even-aged and uneven-aged management of pine and pine-hardwood mixtures in the Ouachita National Forest on wildlife habitat, aesthetics, plant diversity, timber, and water resources (study 63a)

4.3 Publish 3-year results of single-tree selection cutting, with and without overstory hardwood retention, in the Homochitto National Forest on wildlife habitat (study 65a)

4.4 Publish effects of site preparation treatments in group-selection openings on the Kisatchie National Forest on wildlife habitat (study 80a)

4.5 Publish effects of overstory thinning and nitrogen fertilization on diversity of understory plants and forage production in upland hardwood forests (study 72).

4.6 Publish on the effects of uneven-aged cutting methods on small mammals, snag and cavity utilization by wildlife, and neotropical birds in upland oak- hickory forests in the Interior Highlands (study 78).

5.0 MISCELLANEOUS

5.1 Publish 10-year results on survival and growth differences between loblolly pine seedlings established by natural regeneration versus planted container seedlings from a genetically improved seed source (study 56).

5.2 Publish a method for forecasting shortleaf pine seed crops to improve the success of natural regeneration on poor sites in the Ouachita and Ozark National Forests (study 86).

5.3 Publish results of field storing loblolly and shortleaf pine seeds through two growing seasons (closed study 87).

Problem 2. Development of silvicultural alternatives for regenerating and managing upland forests in the Midsouth requires a better understanding of forest stand dynamics, including the role of disturbance.

Stand dynamics for single-species even-aged stands has been studied at length and is well understood except for some species such as shortleaf pine. However, our understanding of forest stand dynamics in mixed species and uneven-aged forests is still rudimentary. There is also an increasing interest in older stands as public agencies have begun creating such stands for non-timber goals, but we have little information regarding the dynamics of these stands. We also have some knowledge of the role that stand dynamics plays in providing wildlife habitat for game species like deer and turkey in even-aged systems, but its importance for non-game species is not well understood for any silvicultural system.

Based upon this current state of knowledge, we have identified the following as critical gaps in our knowledge regarding the effects of forest stand dynamics on timber and non-timber resources in: (1) natural even-aged and uneven-aged pine and pine-hardwood stands in the Upper Coastal Plain, (2) natural even-aged and uneven- aged pine,

pine-hardwood, and hardwood stands in the Interior Highlands, and (3) old-growth stands.

In most cases, our understanding of the dynamics of these forests and how they are to be managed can be gained only through long-term plot or stand-level studies. The RWU has installed a series of studies that address most of the three critical knowledge gaps listed above. Study installations are on National Forests, state lands, forest industry lands, and the Crossett Experimental Forest, and are being maintained in cooperation with these organizations. A listing of active studies in this problem area is given in the Appendix. Most of the information sought can be derived from these studies; however, old-growth information for the Interior Highlands will depend upon a new investigation contingent upon future funding and staffing. The ultimate goal of this problem area is to develop quantitative and qualitative models that describe and/or predict dynamics under a variety of stand and site conditions.

Planned accomplishments by topic area for the next 5 years (assuming current staffing and funding levels) include:

<u>1.0 LOBLOLLY AND SHORTLEAF PINE STANDS IN THE UPPER COASTAL PLAIN AND INTERIOR HIGHLANDS</u>

1.1 Publish guidelines for thinning dense, even-aged natural stands of loblolly- shortleaf pine regeneration (study 5).

1.2 Publish 10-year results on diameter-limit cutting in loblolly-shortleaf pine stands in the West Gulf Coastal Plain (study 30).

1.3 Develop individual-tree growth and yield model and software for natural even- aged shortleaf pine stands in the Interior Highlands (studies 48, 58).

1.4 Develop individual-tree growth and yield model and software for uneven-aged shortleaf pine stands in the Interior Highlands (cooperative study with Oklahoma State University).

1.5 Develop individual-tree survival and height models for uneven-aged loblolly pine in the West Gulf Coastal Plain (study 36).

1.6 Publish 45-year results of thinning even-aged loblolly-shortleaf pine stands in the West Gulf Coastal Plain (study 8, closed study).

<u>2.0 PINE-HARDWOOD STANDS IN THE UPPER COASTAL PLAIN AND INTERIOR HIGHLANDS</u>

2.1 Publish results reporting fine litter production in stands following partial cutting on National Forest Lands (Studies 63, 65, and 69).

2.2 Publish 5-year results of growth of pine-hardwood stands after thinning (study 64).

2.3 Publish on the role of hardwoods in the management of poorly stocked pine stands in southern Arkansas and northern Louisiana (studies 46 and 47).

2.4 See accomplishment #16 for Problem Area 1.

3.0 UPLAND HARDWOOD STANDS IN THE INTERIOR HIGHLANDS

3.1 Publish 10-year growth response of red and white oak crop trees to varying levels of crown release (study 70).

3.2 Report on preharvest and postharvest stand structure and species composition resulting from application of uneven-aged cutting methods in mature even-aged upland hardwood forests (study 78).

3.3 Report on effects of opening size and crown border on initial stand development in group-selection openings (study 76).

3.4 Develop individual-tree model describing stand development following intermediate thinning in upland hardwood forests (study 71).

4.0 OLD-GROWTH STANDS

4.1 Publish 5-year results on stand dynamics in the R.R. Reynolds Research Natural Area (study 66).

Problem 3. A better understanding of the effects of silvicultural treatments on forest stands and interactions between stands is needed to make landscape-level decisions.

The practice of silviculture will see two major advances in the next five years-- expanded proficiency with alternatives to clearcutting and planting, and enhanced understanding of how to combine stand-level treatments across a landscape for ecosystem sustainability. Problems 1 and 2 will focus on microsite and stand- level issues, while Problem 3 will focus on landscape-level issues.

A dual approach will be used to structure landscape-level research in Problem 3. The first is to understand the ecological dynamics of the large forested land- scape, and how those dynamics are rooted in individual stands. The second element is to study the effects of various stand-level silvicultural methods and practices upon the forested landscape. Emphases will be upon (1) vegetation patterns and processes, (2) wildlife use patterns, (3) the interaction of hydrology and aquatic ecology with terrestrial components, and (4) the effect of direct and indirect human interactions. Thus, to address these issues the Phase III research team was structured around five research groups--aquatic ecology, hydrology, social science, vegetation, and wildlife.

To implement this problem, four core watersheds (3200-6500 ac) that support different intensities of management across the watershed have been identified. Vegetation and wildlife research will emphasize plot measurements, linked to TM-LANDSAT imagery, to produce classifications of vegetation and wildlife that reflect differences in forest pattern and intensity of management. The hydrology research will relate stage and water quality variables within and between watersheds to these vegetation patterns; aquatic ecology research will relate fish and benthic communities to hydrological and vegetation regimes. The social science research will link humans to the landscape through studies of stakeholder preference, decision-making styles and processes, and existing social infrastructure using census data linked to GIS platforms.

This problem area became affiliated with this unit during FY96 with the closure of RWU-SO-4351 (the Forest Hydrology research unit in Oxford, MS), where this problem was previously located. The transfer of the Phase III problem area and team leader from Oxford to Monticello resulted in the Monticello unit having administrative responsibility for all three phases of the Ouachita Mountains Ecosystem Management Project.

Planned accomplishments for the next 5 years (assuming current staffing and funding levels) include:

1. Conduct a symposium to summarize 5-year results of the Phase III Ecosystem Management Research Project. A proceedings will be published.

2. Develop database and assessment techniques for trophic ecology of fishes in Ouachita ecosystems (research directed by SRS cooperators from other RWUs).

3. Develop methods to evaluate the effect of ecosystem-based management on affected human populations (research directed by University cooperators).

4. Develop models that relate neotropical migrant bird populations and amphibian/ herpetofaunal populations to forest type, structure, and pattern based on extensive georeferenced sampling in the four core watersheds. (research directed by SRS cooperators from other RWUs).

5. Develop models that relate forest vegetation to forest structure and pattern, using the same georeferenced sampling network in the four core watersheds (research directed by State cooperators).

6. Develop and implement treatments from current condition more toward the desired future condition of each watershed, and monitor the results of this management in light of five-year baseline monitoring results.

11. Estimated Annual Staffing and Costs

Currently there are 6 Research Scientists, 1 Forester, 1 Supervisory Support Specialist, 1 Office Automation Clerk, 1 Computer Assistant, 1 Forestry Aid (term), and 5 Forestry Technicians (2 term and 3 permanent) in RWU-4106. These staff are located at Monticello, Crossett, Fayetteville, Hot Springs, and Jasper (all in Arkansas).

Problem Number and Title	(FTE's)	Funding (Thousands dollars)
1. Regeneration processes	2.3	485
2. Forest ecosystem dynamics, stand level	3.2	734
3. Forest ecosystem dynamics, landscape level	0.5 *	400
Total	6.0	1,619

* The majority of this research is being conducted through cooperative efforts of other RWUs, universities, and other cooperators.

APPENDIX

LIST OF CURRENT STUDIES BY NUMBER, TITLE, AND PROBLEM AREA

Studies are assigned to only one problem area for reporting purposes. However, many studies involve two problems and are so indicated in parenthesis.

PROBLEM AREA 1 -- ESTABLISHMENT AND GROWTH OF FOREST REPRODUCTION

20. Effect of burning cycles on natural regeneration in uneven-aged loblolly- shortleaf pine stands (problems 1 and 2).

29. Prelogging hardwood control for establishing natural loblolly-shortleaf pine regeneration (problems 1 and 2).

37. Competition impacts on natural loblolly and shortleaf pine regeneration in south Arkansas (problems 1 and 2).

56. Comparison of naturally-seeded to genetically-improved container-grown loblolly pine seedlings established on a cutover pine site in southern Arkansas (problems 1 and 2).

72. Effects of cutting and fertilization on understory development in Ozark Highland and Boston Mountain poletimber oak stands (problem 1).

73. Effects of overstory density on establishment and growth of advance oak reproduction in Boston Mountain poletimber stands (problems 1 and 2).

74. Effects of intermediate cutting and understory control on development of oak advance reproduction in the Boston Mountains of Arkansas (problems 1 and 2).

75. Methods of planting northern red oak on the Ozark National Forest (problem 1).

76. The effect of opening size and competition control on advance regeneration of oaks and other desirable species in upland stands on the Ozark National Forest (problem 1).

77. An assessment of shortleaf pine regeneration on the Ozark National Forest using uneven-aged management and controlling hardwoods with and without herbicides [Closed study] (problem 1).

79. An assessment of shortleaf pine regeneration on the Upper Coastal Plain of Arkansas using uneven-aged management and controlling hardwoods with and without herbicides [Closed study] (problem 1).

80. Implementing uneven-aged management using group selection in pine-hardwood stands of the Kisatchie National Forest: Effects of opening size and competition control on regeneration (problems 1 and 2).
80a. Uneven-aged management of pine-hardwood stands using group selection in the Kisatchie National Forest: Effects of site preparation treatment on wildlife habitat [Supplement to study 80] (problems 1 and 2).

81. New Perspectives (Ecosystem Management) research and forest management activities on the Ouachita National Forest (problems 1 and 2).

83. Uneven-aged management of pine-hardwood stands using group selection: Effects of opening size on regeneration (problems 1 and 2).

85. Growth response of natural loblolly-shortleaf pine regeneration following release by manual techniques, fire, and herbicides on a cutover site (problems 1 and 2).

86. Field testing a forecasting system for loblolly and shortleaf pine seed crops (problem 1).

87. Viability of loblolly and shortleaf pine seeds after field storage [Closed study] (problem 1).

88. Effects of the forest floor on the early establishment of pine-hardwood regeneration (problem 1).

PROBLEM AREA 2 -- STAND DYNAMICS

5. Precommercial thinning and management of natural loblolly pine stands for rapid sawlog production (problem 2).

8. Even-aged loblolly pine thinning study. [Closed study] (problem 2).

16. Objective regulation of uneven-aged loblolly-shortleaf pine stands in Arkansas (problem 2).

30. The effects of diameter-limit cutting on loblolly-shortleaf pine stands (problem 2).

36. Effects of density, site quality and maximum diameter on growth and yield of uneven-aged loblolly pine stands (problem 2).

46. Management of poorly stocked pine stands as mixed pine-hardwood stands [Supplement to closed study 46] (problem 2).

47. Management of poorly stocked, cutover pine stands as mixed pine-hardwood stands [Supplement to closed study 47] (problem 2).

48. Growth and yield of thinned natural shortleaf pine stands on the Ouachita and Ozark National Forests. (problem 2).

58. Growth relationships for even-aged stands of shortleaf pine (problem 2).
63. Uneven-aged management of shortleaf pine in the Ouachita National Forest: Effects of maintaining a hardwood component during conversion from even-aged management (problem 2).

63a. Even-aged and uneven-aged management of pine and pine-hardwood mixtures: Effects on wildlife habitat, aesthetics, biodiversity, timber, and water resources [Supplement to studies 63 and 69] (problems 1 and 2).

64. The effects of hardwoods on the growth of natural even-aged loblolly pine stands (problems 1 and 2).

65. Uneven-aged management of loblolly pine in the Homochitto National Forest: Effects of maintaining a hardwood component during conversion from even-aged management (problems 1 and 2).

65a. Uneven-aged management of loblolly pine in the Homochitto National Forest: Effects of single-tree selection, with and without overstory hardwood retention on wildlife habitat. [A supplement to study 65] (problems 1 and 2).
66. Successional development of a cutover virgin pine stand in Southeastern Arkansas -- The R.R. Reynolds Research Natural Area (problem 2).

69. Establishing mixed shortleaf pine-hardwood stands in the Ouachita Highlands using the shelterwood method (problems 1 and 2).

70. Effects of fertilization and release on diameter growth of overstocked poletimber oak stands (problem 2).

71. Effects of intermediate cutting and fertilization on growth of Boston Mountain and Ozark Highland oak poletimber stands (problem 2).

78. Alternative silvicultural systems--A test of implementing uneven-aged management utilizing group selection cutting in oak-hickory stands in the Ozark National Forest (problems 1 and 2).

PROBLEM AREA 3 -- LANDSCAPE-LEVEL FOREST RESOURCE MANAGEMENT

89. Ouachita Mountains Ecosystem Management Research Project, Phase III--Large scale research, umbrella study plan (problem 3).