USDA - Forest Service FS-4000-1 (8/76)

RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	1. Number FS-SRS-4111	2. Station SRS
	3. Unit Location Pineville, Louisiana	

4. Research Work Unit Title
Ecological Processes and Management of Pine Forests on the Gulf Coastal Plain

5. Project Leader (Name and address)
James P. Barnett, Alexandria Forestry Center, 2500 Shreveport Highway, Pineville, LA 71360

6. Area of Research Applicability	7. Estimated Duration
Southern United States and nationally for reforestation problems	5 years

8. Mission
Provide fundamental knowledge of the relationships among ecology, physiology, and management to enhance and sustain the productivity of southern pine ecosystems.

9. Justification and Problem Selection
The United States economy depends on the South for 57 percent of its pulpwood, 50 percent of its plywood, and 33 percent of its softwood lumber. Timber is the highest valued crop in the region, representing an annual economic value of $90 billion. In addition to being a valuable source of wood products, these forested lands support a vast recreation business, contribute to clean air for the region, supply abundant water for domestic, agricultural and industrial use, and provide diverse habitats for plants, mammals, fish, reptiles, and birds. The concept of sustainability offers a solution to the dichotomy between the South's immediate need for forest benefits and the emerging public realization that we must sustain the systems that support us. It is a concept that places value on forest health, diversity, and productivity--the components needed to meet the demands of present and future generations. These concepts are documented in the Strategic Framework for the Southern Research Station that was developed in 1997 after extended consultation with groups in the public, private, and university sectors. In the document, the Station's goals and accomplishments are driven by three research priorities: 1) measuring and monitoring forest resources, 2) understanding ecosystem structure, function, and processes, and 3) ensuring environmental quality and sustainable productivity.

Implementing this Strategic Science Plan requires that we integrate the biological, physical, and social sciences and that we collaborate with our partners on fundamental research and the development of useful products. Meeting human needs and achieving forest sustainability requires an approach that responds to multidisciplinary questions. Research Work Units

10. Approach to Problem Solution (Start at conclusion of item 9.)

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

specialize in related disciplines to provide subject matter experts and scientist mentors, but are decentralized to facilitate collaboration among units. To engage in complex, multidisciplinary research, the SRS has designated six cross-cutting themes (CCTs) that address the issues and needs identified during the strategic planning process. Four of the CCTs reflect predominant resource characteristics--Southern Appalachians, Interior Highlands, southern pine ecosystems, and wetland/bottomland/riparian areas. The remaining two, inventory-and-monitoring and large-scale assessment/modeling, support the sustainable management of all forest ecosystems and types. This Research Work Unit is an integral component of the Sustainability and Productivity of Southern Pine Ecosystems CCT that is aimed at providing ecologically sound, economically viable, and socially acceptable management alternatives for the vast southern pine and pine-hardwood complex.

During the assessment of research needs and priorities for the preparation of this Research Work Unit Description, high priority research areas were reviewed and compared to the skills and resources currently available in SRS-4111. The problem statements respond to these priorities and skills. High priority is given to maintaining and expanding reforestation research that not only supports the southern forestry community, but responds to national needs by providing technical expertise that results in improved tree seedling reestablishment success. Another high priority is developing a better understanding of the fundamental relationships among stand environment, tree physiology, and silviculture to allow science-based management decisions. The information and technology gained in these efforts will quantify the effects of site and management on forest structure, composition, and growth to allow sustainable management.

The first of three integrated problems deals with developing and applying knowledge of physiological processes and how they interact with site factors to determine reforestation success. With knowledge of desirable seedling attributes, including seed and seedling physiology, methods to produce seedlings with optimum characteristics can be developed. A major focus of this problem is longleaf pine ecosystem restoration with an emphasis on seedling establishment and development on a wide array of sites. Site-specific reforestation guidelines are needed by both public and private landowners. The loss of nursery and reforestation expertise in other regions of the U.S. has resulted in the need for SRS-4111 to address national reforestation issues. Currently, one scientist is assigned to the Unit with national responsibility for providing consultation to federal, state, and private organizations and landowners. This effort will be institutionalized and resources allocated to maintain and enhance both ongoing research and application of reforestation technology. On both regional and national scales, <u>forest managers need information concerning seed production and handling, nursery management, and establishment practices to reestablish sustainable conifer ecosystems</u> (Problem 1).

Forestry research has contributed much to ensuring the continued regeneration, growth, and sustainability of southern forests. Silvicultural studies have resulted in guides for harvesting, regenerating, and managing most of the major forest types in the South. However, if continued gains are to be made in sustainable forest systems, it is necessary to have a better basic understanding of how silviculture interacts with the availability of essential resources, vegetative competition, climate, and soil to affect physiological processes that control carbon fixation and allocation, water and mineral acquisition and stand productivity. As these processes for trees and stands become better understood, models can be developed to predict forest productivity in a changing environment and under varying management regimes. <u>We need to better understand the fundamental relationships among atmospheric and soil environments, physiology, and silviculture to allow science-based management decisions</u> (Problem 2).

We know that the silvicultural practices applied to a forest stand may have long-term effects on the soil that will affect the productivity of the next rotation of crop trees. Examples are soil compaction, removal of organic matter and nutrients during harvest, soil movement during intensive mechanical site preparation, loss of organic matter and nutrients during prescribed burning, and fertilization. We will apply the information from the studies in Problem 2 to refine management practices so that productivity is more sustainable. Information from these studies will be the basis for improving and developing new growth and yield prediction systems. Information from Problem 2 will also be used to develop physiologically-based individual tree growth models and integrate them with stand models in order to more accurately mimic the biological processes occurring within trees and stands of southern pines. Current models generally address problem-free sites. Thus, model development will incorporate the effects of insects, disease, and climate on plantation growth and yield. <u>We need to develop tools that predict the effects of site and management on forest structure, composition, and growth to allow for sustainable management</u> (Problem 3).

The solution of these problems is important to a wide array of land managers and forestry professionals across the southern region, and for reforestation issues, across the nation. Improvements in nursery production and seedling establishment are essential to the continued productivity of southern pine forests and especially to restoration of the longleaf pine ecosystem. The loss of reforestation expertise within the Forest Service has resulted in the need to provide reforestation technology on a national scale to both public and private organizations. The solution to, and application of, the issues included in <u>Problem 1</u> is important to nursery and reforestation managers, silviculturists, botanists, and related professionals who are concerned with reforestation, restoration, and management of conifer ecosystems, particularly that of longleaf pine. These managers will be provided tools to improve and monitor plantation establishment success that will permit managerial accountability at all stages of the reforestation process to a degree never before possible. Probability of success in this research is high (about 80 percent).

With solution of <u>Problem 2</u>, managers and researchers will be provided information to better understand the fundamental relationships among physiology, climate and edaphic factors that control stand dynamics and responses to silvicultural treatments. Such basic knowledge is necessary to continue to improve forest management in the southern region. With development of a better understanding of tree and stand responses to the environment, it will be possible to model growth responses to important variables such as climate change. The multidisciplinary nature of this effort presents a significant challenge to plant physiologists, silviculturists and soil scientists to combine, analyze and interpret a maze of interrelated data. Chances of success are estimated at 75 percent.

The solution of <u>Problem 3</u> is of special interest to National Forest System and forest industry managers because information and tools to sustain the productivity of southern pine forests has become a major concern. Application of the fundamental information developed in Problem 2 enhances our capability to increase forest productivity in an environmentally sensitive manner. Recommendations developed from an array of long-term studies will provide guides to managing silvicultural practices and predicting tree and stand growth that take in account physiologically based information and more accurately relate to biological responses. Probability of solution is about 75 percent, and the solution will be applicable to a wide range of sites across the South.

10. Approach to Problem Solution:

Problem 1. Forest managers need information concerning seed production and handling, nursery management, and establishment practices to reestablish sustainable conifer ecosystems.

The demand for longleaf pine seeds and seedlings continues to escalate at a rapid pace and the scale of production has created major problems in producing high quality seed and seedlings. Problems are associated with bareroot and container seedling production and with direct seeding. Continued effort must be put into developing and publishing guidelines to make reforestation and restoration of this species easier to accomplish. The loss of technical expertise within the Forest Service in areas of nurseries and reforestation is now recognized, and there is need to expand the role of reforestation research in this RWU to a national scale to help fill this need. This will not only strengthen the efforts with the over 1 billion southern pines produced annually, but will provide expertise that will be available nationally for consultation and assistance in developing administrative studies that can respond to problems at nursery and district levels or developing research studies for conifers in other regions. Although successful methods for establishing southern pines and conifers in other regions exist for many sites, some sites are difficult to regenerate. Thus, models need to be developed to help forest managers predict establishment success on specific sites with respect to stock quality and cultural treatments, as well as climate in the year of planting.

Accomplishments planned for the next 5 years:

1. Develop and publish guidelines for collecting, processing, and storing longleaf pine cones and seeds that will result in high seed quality.

2. Contribute information on the harvesting, storage, shipping, and planting of container conifer seedlings for Volume 7 of the Agricultural Handbook series entitled "Container Tree Nursery Manual."

3. Publish recommendations for reducing the seed and seedling pathogen problems that continue to be a significant problem in production of southern pine container stock.

4. Publish proceedings of the Longleaf Pine Container Production Workshop and work with Cooperative Forestry to initiate a biennial conference on container nursery production.

5. Develop and publish information on a repellent to protect seeds used for direct seeding from rodent depredation and revise and publish the guidelines for "Direct seeding pines in the South."

6. Using chemometric techniques, develop and publish methodology to separate viable from nonviable seeds that can be applied to the longleaf pine seed quality problem.

7. Produce a model that predicts survival and early growth resulting from different stock types, site preparation, site conditions, weather, and cultural treatments such as vegetation management. The model will provide input into standard growth and yield models.

8. Develop protocols for and demonstrate the value of cold hardiness testing to determine when to fall or winter lift conifers, and how far into the spring they can be lifted without loss of field performance.

9. Assist nursery and reforestation managers by consultation on and trouble shooting of urgent and important problems.

Problem 2. We need to better understand the fundamental relationships among atmospheric and soil environments, physiology, and silviculture to allow science-based management decisions.

Interaction among physiology, environment and edaphic factors is the basis of ecological processes that control stand dynamics. These ecophysiological relationships are complex, dynamic and vary both spatially and temporally. As a result, Unit resources are concentrated at a limited number of study sites where intensive research is conducted. As appropriate, simultaneous measurements of crown and root system environment, physiology and growth, soil chemical and physical properties, and stand growth and yield are conducted frequently and throughout the year with regard for crown and soil spatial variation. Data are being applied to expand our knowledge of tree and soil processes, and combined to build our understanding of the ecophysiological mechanisms that control tree growth and stand responses to silvicultural treatments. Modeling provides a way to link these important ecosystem processes into a system that describes the fundamental basis of productivity, and potentially to reflect the effects of management on productivity. Existing long-term studies provide an opportunity to investigate nutrient and carbon dynamics on Gulf Coastal Plain sites throughout stand development as influenced by site preparation practices that affect vegetative competition, soil fertility and soil compaction at planting. Furthermore, access to both long-term burning studies on the Palustris Experimental Forest, and National Forest stands managed with repeated prescribed fire afford an excellent setting to investigate growth, physiology and soil responses of loblolly and longleaf pine stands to repeated prescribed fire and identify the possible effects of this management tool on the sustainability of these systems.

Accomplishments planned for next 5 years:

1. Continue to study interactions among above-and below-ground physiology and growth and canopy and soil environments of plantation loblolly pine to gain basic knowledge of tree ecophysiology and understand the ecophysiological relationships that control stand productivity.

2. Publish several reports that describe above- and below-ground ecophysiological responses to silvicultural manipulation of light, water, soil fertility and structure, and the use of prescribed fire and describe the fate of carbon sequestration in the soil as well as the fate of course woody debris littering the forest sites.

3. Combine information on root growth, fascicle and root carbohydrate relations, branch phenology, nutrition, and soil environment to identify the physiological mechanisms of root system growth and development and propose how silvicultural control of stand density, light, leaf area and mineral nutrition manipulates root growth.

4. Define the relationship between fine root biomass and its distribution by soil depth and above-ground indicators of stand productivity such as volume, leaf area index, foliar

nutrition and canopy water flux density to determine the optimum fine root conditions for maximum stand growth.

5. Improve our existing models describing crown characteristics and incorporate them into the PTAEDA-MAESTRO hydrid model.

6. Do deep and intensive soil sampling and measure distribution of C, N, P, K, and other nutrients in the soil and the above-ground biomass to understand the long-term changes in soil and foliar chemistry and soil carbon sequestration as influenced by repeated controlled burning and intensive management practices applied during establishment of planted loblolly, longleaf, and slash pines.

7. Produce a process-oriented model for forest productivity, based upon available active rooting volume, and nutrient and water availability.

8. With a research direction, standard methods, treatments and families chosen by SRS-4111 and SRS-4154, establish an experiment to study loblolly pine ecophysiology at selected LTSP installations to express regional variation in ecological processes and validate site-specific conclusions.

9. Develop models that express fascicle transpiration and carbon fixation at the branch, crown and canopy level by studying branch, crown, and canopy water flux density relative to stand environment.

10. Determine the long-term changes in soil and foliar chemistry and soil carbon sequestration as influenced by prescribed burning and intensive management practices applied during establishment of planted loblolly, longleaf, and slash pines and publish results.

11. Validate contemporary physiological process models by applying current soil and ecophysiology data and develop modifications that improve predictions on the Gulf Coastal Plain.

12. Document rate of decay of coarse woody debris in four locations and the influence of forest insects in the decay process (Cooperative with SRS units 4502, 4501, and 4154).

<u>Problem 3. We need to develop tools that predict the effects of site and management on forest structure, composition, and growth to allow for sustainable management</u>.

Studies of successive rotations of intensively managed loblolly and slash pine continue to provide information on productivity decline in short-rotation stands. As part of the international Long-Term Soil Productivity program, our Unit is evaluating the effect of intensive site preparation and harvesting on soil productivity. Installations in Louisiana, Mississippi, and Texas are being used to measure the effects of compaction and organic matter removal on sustainability of forest sites. The concept has been extended to short rotations and high intensity cultural practices on industrial forest sites by a partnership with forest industry and universities in an effort to mitigate disturbance and enhance productivity. This mix of studies will allow us to evaluate the relationship of forest soils and silvicultural practices to ecosystem productivity and sustainability. Our long-term databases for forest growth and development must be revitalized by establishing new plots in young stands to determine the effects of newer silvicultural practices applied during establishment, and to ensure that the historical data is relevant to current practices. Additional relevency of our forest projection models will be obtained by integrating components that reflect ecological processes, and thus may better represent forest growth under a changing environment. Management of stand density throughout the rotation, by initial spacing and subsequent thinning, is critical for sustaining high levels of productivity. Stand density guides will be developed and tested. Restoration of the longleaf pine ecosystem continues to be a major concern of the National Forests in the South along with many other government and private institutions. Studies are underway to evaluate the effects of silvicultural practices, such as controlled burning, on the preservation and restoration of native plant communities. Besides this formal research, monitoring efforts on several Administrative Study Sites is a productive area of work being conducted cooperatively with the Kisatchie National Forest and SRS-4105.

Accomplishments planned for next 5 years:

1. Determine the long-term productivity and diversity of native plant communities of plantation southern pines restored or managed under several different management techniques.

2. Develop a longleaf pine G&Y model that includes early seedling development as influenced by vegetation and soil physical and chemical properties.

3. Continue soil monitoring of LTSP projects on National Forest lands and communicate results at a national meeting on Long-term Soil Productivity in the fall of 2000 and continue cooperation with the industry and university extension of LTSP that will result in development of management practices that will improve forest productivity.

4. Develop guidelines and practical validation or monitoring techniques for restoring native plant communities (primarily understory vegetation) on frequently burned landscapes.

5. Continue group selection projects with the Kisatchie National Forest to monitor longleaf seedling establishment and growth dynamics to restore old-growth attributes and sustain native plant communities.

6. Produce a system to predict timber-oriented productivity based upon soil, site, geographic, and climatic variables.

7. Produce and test a new type of stand density management diagram based on optimal stand management rather than upon arbitrarily-defined benchmarks of stand density.

11. Mission Problem: None

12. Environmental Considerations:

Based on the guidelines for categorical exclusion (FSH 1909.15.31), past experience, and environmental analysis, it is determined that the research identified in the above problems will not have significant effect on the human environment, individually or cumulatively, and is, therefore, categorically excluded from documentation in an environmental assessment (EA) or environmental impact statement (EIS). 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 for the individual study. In addition, if any use of toxicants is proposed, an environmental analysis will be conducted to determine if such use in research will have a significant impact on the human environment (FSM 1950 & FSH 1909.15).

13. Staff:

Research outlined above will require a minimum of 7 scientists per year (including the project leader) and an annual project-level budget of at least $1,750,000. Estimated scientist-years by problem that reflect projected increases in support are as follows:

SY's by time in the TAV period					
Problem	Year 1	Year 2	Year 3	Year 4	Year 5
1	2.0	3.0	3.0	3.0	3.0
2	2.0	2.0	3.0	3.0	3.0
3	2.0	2.0	2.0	2.0	2.0
Total	6.0	7.0	8.0	8.0	8.0

Annual project-level expenditures by problem that correspond to the SY's are as follows:

Funding by time in the TAV period (thousands of dollars)					
Problem	Year 1	Year 2	Year 3	Year 4	Year 5
1	500	750	750	750	750
2	500	500	750	750	750
3	500	500	500	500	500
Total	1,500	1,750	2,000	2,000	2,000

At present the research scientist staff includes two research foresters (silviculturists), one research soil scientist, one research plant physiologist, one forest biometrician, and one plant physiologist (with technology transfer responsibilites). To accomplish the outlined work, we will have to obtain additional funding, but with this potential additional funding a research plant physiologist will be added to the staff to expand the nursery and reforestation capability (problem 1). An additional position will be added to support the aboveground portion of the ecophysiological research (problem 2) or to the soils research program (problems 2 and 3). An excellent support staff is present to support the research program.