RESEARCH WORK UNIT DESCRIPTION Ref: FSM 4070	1. Number SRS-4801	2. Station Southern
	3. Unit Location Asheville, NC and Starkville, MS	

4. Research Work Unit Title
Forest Inventory and Analysis for Southern States

5. Project Leader (Name and address)
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6. Area of Research Applicability	7. Estimated Duration
13 Southern States and Puerto Rico	5 Years

8. Mission

To conduct a program of research to improve the understanding of Southern forest ecosystems through inventories and analyses of the status and trends in resource conditions, use, productivity, and sustainability; and to conduct research to provide improved technology for timely and accurate resource inventories.

9. Justification and Problem Selection

This document outlines the future direction of forestry research conducted by Research Work Unit (RWU) SRS-4801 of the Southern Research Station, USDA Forest Service. The unit has two principal locations: (1) Station headquarters in Asheville, North Carolina; and (2) the Forestry Sciences Lab in Starkville, Mississippi. During FY 1997, the Forest Inventory and Analysis units in the former Experiment Stations comprising the recently formed Southern Research Station were merged. This is the first research work unit description involving the newly merged unit.

Forest ecosystems occupy 40 percent of the region's 535 million acres of total land area. These 213 million acres of forest provide important economic, social, and esthetic values to the region and nation. Benefits provided include recreational opportunities, watershed protection, wildlife habitat, and economic benefits from timber products. In 1992, the latest year for which comparable nationwide data are available, the South supported over 34 percent of the softwood growing stock and over 64 percent of the hardwood growing stock in the United States. This inventory accounted for 45 percent of the net annual growth for both softwoods and hardwoods nationwide. In 1991, the latest year data are available nationwide, removals of softwoods in the South accounted for 53 percent of the Nation's total; removals of hardwood in the South represented 59 percent of the total.

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

Signature		Title	Date
Recommended:	/s/ John F. Kelly	Assistant Director for Research	09/14/98
	/s/ W. Brad Smith	Assistant to Staff Director	08/31/98
	/s/ Richard W. Guldin	Staff Director	08/31/98
Approved:	/s/ Peter J. Roussopoulos	Station Director	09/16/98

Concurred:	/s/ Robert Lewis, Jr.	Deputy Chief for Research	09/24/98

The Forest Inventory and Analysis (FIA) program is authorized by the Forest and Rangeland Renewable Resource Planning Act of 1974, the Forest and Rangeland Renewable Resources Research Planning Act of 1978, the National Forest Management Act of 1976, and the Forest Ecosystems and Atmospheric Pollution Research Act of 1988. The FIA program is the only entity that conducts comprehensive forest resource inventories on both public and private lands in the Southern United States. FIA provides continuous evaluation and analyses of the resources for the region, individual states, and special study areas as well as contributing valuable support to national analyses, using national standards. FIA has developed the only nationwide forest resource data, based on permanent sample plots in every state in the region. A modernized delivery system is being used to provide access to FIA information, and allowing flexible user-specified tables to be generated over an Internet site.

In 1997, the second Blue Ribbon Panel on FIA was convened; this second panel followed the first, which issued a report in 1992. Both panels were composed of forestry experts from industry, academia, the Forest Service, and environmental organizations. The report from the second panel was issued in 1998 and listed the following key findings:

1. Elevate the priority of the FIA program
2. Initiate annual inventories and supporting analyses
3. Fulfill the mandate of reporting on all forest lands
4. Concentrate on core ecological and timber data
5. Develop a strategic plan for FIA

The second panel also developed a number of evaluations related to the program. These programmatic evaluations involved the following topics:

1. Organizational structure (program control, authority, and accountability)
2. Funding
3. Merger of FIA and the Forest Health Monitoring program
4. Improved data management and analysis
5. State reports
6. Core program and schedule
7. Coordination and cooperation with partners
8. Remote sensing and new technology
9. Relationship to sustainable forestry criteria and indicators
10. Monitoring progress and providing feedback

In addition to these key findings and evaluations, the second panel also evaluated progress in reaching the goals set by the first Blue Ribbon Panel. These and other FIA customer recommendations point out the need for the four problems addressed by this research work unit description.

Timely inventory information is a high priority for Southern forest ecosystems. This need has led to establishment of a collaborative effort that has become known as the Southern Annual Forest Inventory System (SAFIS). SAFIS is a partnership of the USDA Forest Service (the Southern Research Station and Region 8), Southern State Foresters, industry, universities, and

others. FIA is the focus of developing the annual inventory system for the South; other partners have contributed substantial resources to developing and implementing annual inventories.

The supply and demand situation for forest resources is constantly evolving in each state due to both natural and anthropogenic impacts. These impacts are especially important for the South, given the extremely high, and increasing levels of timber product harvests in the region. Most of the land in the South is owned by nonindustrial private owners, many of them with small acreages. This character of ownership is one element that heightens the need for accurate, timely resource inventories. The timeliness issue is paramount for FIA in the South; customers, clients, and collaborators have clearly stated that an annual forest inventory system needs to be implemented as soon as possible. Thus, because of the rapid changes fostered by the dynamic nature of human-resource interactions there is a continuing, high-priority need to conduct periodic inventories, while implementing annual inventories as practical and appropriate (problem 1).

Because the factors affecting forest ecosystems in the South foster rapid change, timeliness of inventories is of utmost importance. Because of the developments affecting the South, combined with the inherent resource dynamics, resource demands are unprecedented. The historical system of periodic inventories has entailed a lengthy period of time, 8 to 12 years, between remeasurements for individual States. Combining this length of time between inventories and the dynamics affecting the resource, periodic State inventories provide clients and customers with data that are reliable for only short periods of time, perhaps 3 to 4 years. Thus, there are long periods of time between remeasurements of plots where low confidence is placed in the latest data that are available. Furthermore, the state-to-state operations characteristic of historical inventories leads to inventory data that are disjoint in time across state boundaries. Given the rapid changes and high economic demands on the forest ecosystems of the South, there is a need for reliable information available on an annual basis. It is critical that catastrophic events such as hurricanes, changes in use such as the wildland/urban interface and balance of growth to harvest be monitored. Timeliness of inventory data continues to be a first priority among FIA collaborators, clients, and customers in the South. Therefore, the development and implementation of all components for a Southern annual forest inventory system is urgently needed (Problem 2).

The need to monitor health of forest ecosystems is expressed through several mechanisms, including the Forest Ecosystems and Atmospheric Pollution Research Act of 1988. This legislation requires the Secretary of Agriculture to increase the frequency of forest inventories in matters that relate to atmospheric pollution and conduct such surveys as are necessary to monitor long-term trends in the health and productivity of domestic forest ecosystems. The Forest Service has instituted the Forest Health Monitoring program to provide annual information regarding the health status and trends of these resources.

Through the Forest Health Monitoring (FHM) program, the Forest Service has developed a comprehensive scheme to assess forest health. This scheme includes the categories of detection monitoring, evaluation monitoring, and intensive site ecosystem monitoring. Detection monitoring involves annual examination of various indicators and includes a series of

measurements and observations across a grid of plots. Indicators observed on these plots include variables related to mensuration, lichens, soils, damage, tree crown conditions, and vegetative structure. These variables are important in assessing the condition of forest ecosystems for a wide range of values. State Foresters have been collaborating with the FHM program since its inception in the South.

The FHM detection monitoring plots are co-located with FIA plots (plots in the original FHM States are in the process of being moved so as to achieve co-location with FIA).

The advent of annual inventories and the demonstrated interest of State Foresters to participate with both the Southern annual forest inventory system and the FHM program provides a distinct opportunity in the South to integrate the FIA and the FHM detection monitoring programs (problem 3).

The forest products industry is extremely important to local economies in all 13 Southern States and also to the national economy. Nationally, the South accounts for 54 percent of all the roundwood products produced. Several Southern states rank in the top producers nationally of lumber, pulp, paper, and other wood-based products. The trend in recent years has been toward an increasing amount of timber products being produced in the South.

Timber product studies conducted by FIA and cooperators provide a vital measure of overall forest industry activity. Results have been used extensively by researchers and planners. Such studies are increasingly important, given the escalating need for information about the region's resources. Timber product studies are an important adjunct to the development and implementation of the Southern annual forest inventory system. In addition to the economic value of timber products to the South and the Nation, this use provides significant impact to the forest resources. To adequately analyze the impacts on the resource and the economy, reliable information is continually needed on resource use and timber product output (problem 4).

The research proposed for all four problem areas will fulfill critical needs for information on forest ecosystems to the public in general, resource managers, scientists, policy makers, economists, and a wide range of other specialists. There is a good likelihood for success, due to the nature of the proposed research. The outputs will provide FIA clients and customers with critical information via means of easy access (publications and computer access), and will provide improved techniques for application to a range of resource inventory and monitoring needs.

10. Approach to Problem Solution

Problem 1--Conduct periodic inventories, while implementing annual inventories as practical and appropriate.

Comprehensive inventories will be planned and conducted on all forest lands, including all ownerships and conditions, to provide information on the amount, condition, and use of the forest resources. The focus will be on efficient data collection and compilation of resource data to address business requirements for national needs and needs of collaborators. Data elements

will include land and site conditions, tree cover, land ownership, landscape patterns, resource treatment opportunities and related items. Permanent sample plots will be remeasured to provide information on: land-use changes; forest treatment and management; timber growth, removals, and mortality; and other ecosystem parameters. Data will be compiled for use in statistical and analytical reports, and made available in user-accessible computer formats and over the Internet.

To facilitate a systematic research approach, the problem will be divided into two elements.

Element A--Resource inventory sampling, and data compilation--This element is focused on efficiently collecting and compiling forest ecosystem data for periodic national, regional, state, and ecosystem level assessments. Multi-resource inventories are planned and conducted to provide current information on the kind, amount, condition, ownership, use of, and trends in forest resources. All owners and classes of forest land will be sampled.

The resource inventory sampling will consist of two phases. Both phases shall be accomplished according to national standards. The first phase will entail a determination of forest area, using either aerial photos or satellite imagery analysis. The aerial photo interpretations and remote sensing analysis shall be verified using field observations.

The second phase will consist of measurement of permanently located ground plots. Variables relating to the plot, forest condition, tree, and other resources shall be collected. The national FIA sample design will be used for data collection, with the previous point sample used to estimate change variables. The old point sample design will be closed out as the new national design is installed in each state. The national sample design entails mapping various forest conditions occurring on each plot; it is the same design as used in the Forest Health Monitoring program.

Quality assurance and quality control is a primary concern in the FIA inventories for the collection of field data. A quality assurance plan will be developed and used for all data collection activities, including those being done collaboratively. The quality assurance plan will be built on a three part program of prevention, assessment and appraisal, and correction.

During the next five-year period covered by this description, state-of-the-art computer software will be developed to (1) capture the field data so as to assure the best quality data possible; (2) compile the data; and (3) provide access to end users in an effective manner. This software will allow thorough editing procedures, facilitate quality assurance of field data collection, and provide efficient data compilation procedures. Data will be provided to end users over the Internet and alternative methods as appropriate, possibly using compact disk and other technologies.

Historically, FIA has conducted periodic inventories of individual states. The overwhelming need for more frequent resource information has brought forth the implementation of the Southern annual forest inventory system (SAFIS). The need for annual information has been so great that several Southern states have made resources available to collaborate on FIA data

collection. Therefore, a transition to annual inventories for Southern states is urgently needed. Several periodic inventories will be conducted as annual inventories are implemented in other states over the next five-year period.

Planned accomplishments for the next five years include work in the following states (collaborating states are indicated in the comments):

Periodic inventories

State	Years	Comments
North Carolina	1998-2000	Field work began in 1998; annual inventory scheduled to begin in 2000 (contingent on funding)
Texas	2000-2001	Grid will be extended to central and western portions of the State; annual inventory to begin as soon as practical (contingent on funding)
Oklahoma	2000-2001	Grid will be extended to central and western portions of the State; annual inventory to begin as soon as practical (contingent on funding)

Annual inventories

State	Year to start	Comments
Georgia	1998	Periodic inventory completed in 1998; State crews have begun annual inventory
Alabama	1997	In cooperation with the State; State crews will begin annual inventory after completion of current complete remeasurement in 1999
Tennessee	1999	State crews are being trained during completion of current periodic inventory
Virginia	1997	In cooperation with the State
Louisiana	1998	In cooperation with the State; complete remeasurement initially being done
South Carolina	1998	In cooperation with the State
Kentucky	1999	Planned in cooperation with the State;

		complete remeasurement to be done initially to complete systematic grid
Arkansas	1999	Planned in cooperation with the State
Florida	2000	Planned in cooperation with the State
Mississippi	2000	Contingent on funding
Puerto Rico	2001	Contingent on funding
American Virgin Islands	2001	Contingent on funding

Given the large amount of collaborative assistance being provided by Southern State Foresters, work is planned that otherwise would not be accomplished with only Federal resources. Over the five-year period covered by this research work unit description, available resources (as of the date of this description) will entail inventory of approximately 80 million acres according to periodic procedures (some of these are being completed at the request of the State Foresters, prior to initiation of annual inventories); and approximately 82 million acres inventoried on an annual basis. The total area covered by these inventories (periodic and annual) results in a plot remeasurement rate of about 6.5 years. Using only the available Federal funds available for the first year of this description (and continuing throughout the duration), an approximate 8-year cycle would be possible. Perhaps more significantly, the resources provided by the State Foresters are facilitating the transition to an annual forest inventory system; the rate of remeasurement could not be maintained while simultaneously dealing with the complex logistics of transitioning to an annual system if not for the assistance provided to the FIA unit by the State Foresters. Therefore, participation by the State Foresters in a number of states do provide significant additional resources. It appears that at least eight states, and most likely more, will collaborate with the Southern Research Station to conduct annual inventories during the next five years; it is entirely likely that more resources will made available throughout the period covered by this description. It is also possible, though certainly not anticipated, that some collaborating states will need to change plans for cooperative work.

In states where cooperative assistance is available for inventory work, the respective roles of the States and the Southern Research Station are identified in individual cooperative agreements. These roles are generally as follows:

States:

1. Provide a full time project coordinator and the appropriate number of full time crew leaders.
2. Provide field assistants each of the crew leaders and a backup crew leader.
3. Provide field equipment and vehicles; all field equipment must meet Forest Service specifications.
4. Measure all forested plots and conduct timber volume and felled tree studies in the manner prescribed by the inventory design and data collection protocols. This includes plots across the entire (sub) sampled FIA grid for all owners and all forest conditions.
5. Observe and evaluate non-forest samples for changes in land use.
6. Fulfill all requirements of the quality assurance plan set forth by the Forest Service.
7. Provide for use of data recorders as specified by the Forest Service.

8. Observe and follow confidentiality requirements pertaining to landowners where plots are located; names of landowners are not to be released.

USDA Forest Service:

1. Provide the inventory design, variable, and data collection protocols.
2. Provide aerial photography, plot records, location of plots on photography.
3. Provide training for the State Agency crew leaders and project coordinator.
4. Provide training for and ensure that timber volume and felled tree studies are conducted as appropriate.
5. Provide data recorder software for standard Forest Service data recorders.
6. Process, summarize, and analyze survey data.
7. Provide a quality assurance plan and ensure its implementation
8. Determine forest area for the State.
9. Research critical issues.

Environmental considerations: The work planned is categorically excluded from documentation of environmental analysis (FSM 1950).

Element B--Regional and state analyses and analyses of specific resource issues and concerns--This work will emphasize research and analyses of trends in renewable forest resources as they relate to the South's overall economic, social, and resource concerns. Resource reports and analyses will discuss the value and importance of timber, note the interactions among management activities, and identify opportunities for altering prospective trends.

Non-commodity uses of the South's forests are rising rapidly and the extent and condition of forest resources on which these uses depend should be thoroughly documented. The primary goal of multiresource assessments is to quantify and describe forest ecosystems as to their site, origin, vegetative character, and seral stage. The inventory merges information on trees with nontimber attributes (wildlife habitat, fragmentation, recreation use, range suitability, water presence, and erosion hazard).

The interaction of the forest ecosystems and socio-economic forces in the South results in an ever-changing array of resource issues and questions that range from local to national in scope. Legislators and resource planners and managers at all levels rely on state, regional, and national assessments and analyses for input in making critical decisions affecting the economic and environmental well-being of all citizens of the region. Due to the long-term nature of forestry investments and commitments, it is imperative that information for these decisions be timely and accurate.

Planned accomplishments during the next five-year period include the following:

1. Produce statistical reports and state analytical reports as appropriate for all periodic inventories.

2. Produce statistical reports and/or on-line data access for states inventoried on an annual basis; data for these states will be compiled and released as appropriate according to national policy.

3. For states involved in the annual inventories, analytical reports will be published every five years; Virginia will likely be the only state for which data will be collected for this length of time.

4. Prepare data for the 1998 RPA data base.

5. Refine methods to evaluate noncommodity resource attributes; develop analytical methods to aid in evaluating habitat conditions and extent; develop closer alliance with a diverse group of multiresource data users.

6. Conduct studies of timber availability and trends throughout the South; results should provide data users with quantitative relationships between levels of timber removals and various stand descriptive items often used in determining timber resource availability.

7. Continue to monitor and analyze pine regeneration trends and their adequacy.

8. Evaluate hardwood resource trends in the South, focusing on availability, tree grade distributions, and trends in tree size.

9. Assess the dynamics of the urban/wildland interface and the resulting impacts on forest resources.

10. Work cooperatively with social scientists in the Southern Research Station in the development of regional resource evaluations focusing on socio-economic factors, land management activities, recreational use, and prospective resource trends and influences.

11. Conduct analyses of landscape diversity for various Southern ecosystems.

12. Refine customer service mechanisms to provide user-friendly access to all FIA products.

<u>Problem 2--The development of all components for a Southern annual forest inventory system is urgently needed.</u>

The need for a Southern annual forest inventory system has been well expressed by customers, clients, and collaborators. While the initial implementation of an annual system in the South is using traditional procedures combined with a rotating panel sampling scheme, there are potentially many advantages to using an annual system. This problem addresses those potential improvements.

A valuable aspect of annual forest inventory systems is the time-invariant nature of the resulting information. Over a region, the same level of information is available each year, and confidence interval widths will therefore remain relatively constant, given the same intensity of plot measurement over time. The specific plot remeasurement cycle will depend on the proportion of plots that are measured each year. Discussions with customers, clients, and collaborators in the South have indicated the need for a plot cycle of five years.

While there are several potential sampling schemes for annual forest inventory systems, the rotating panel design has been viewed as having several advantages for the South. First, it is relatively simple to administer. This is true since each plot has a fixed remeasurement cycle that depends on resources available. For example, a five year cycle would indicate that 20 percent of the plots within a given state would be measured each year. A key necessity of the rotating panel is that plots measured in a given year be systematically distributed across the state. A second advantage of the rotating panel design for the South is the high degree of disturbance across the resource. This disturbance is primarily due to the high level of timber harvests, but also includes the frequency of storm damage affecting the landscape (hurricanes, ice storms, etc.). This means that individual plots have roughly a similar probability of disturbance that may be relatively higher than in other regions of the Nation.

This problem is focused primarily on three elements--remote sensing analysis, statistical estimation, and development of updating procedures.

Element A--Remote sensing analysis--Historically, the Phase I area estimates of forest and nonforest have been based on a process of interpreting a large number of sample points on aerial photographs and subsampling a proportion of the points on the ground. The traditional photo-based system of area estimation by strata is well suited to periodic inventories that occur, say on a 10-year cycle. Often, these periodic inventories take two or three years to complete for an individual state. An annual inventory system places greater demand for rapid generation of land cover estimates than periodic inventories.

The cost of satellite imagery has now reached the level where it may be feasible to routinely apply these data to forest cover estimation needs. Several types of satellite data are available, including Advanced Very High Resolution Radiometer (AVHRR), SPOT, and Landsat Thematic Mapper (TM). All these types of satellite data have advantages and disadvantages. For example, although AVHRR data are very inexpensive, the lack of spatial resolution limits their use for forest cover distribution and forest type classification. Landsat TM data have higher spatial resolution and are better for forest type separations in many cases than the coarser resolution AVHRR. SPOT data also have high spatial resolution. Some of the more spatially detailed data may have higher cost and processing needs, however.

In addition to the normal estimates of forest cover that is needed for the Phase I portion of the annual inventories, the routine development of forest cover maps, including forest type distributions need to be explored. Such products have never been a routine output for FIA, but would have great utility.

In addition to satellite imagery that are currently available, there are new satellites that have the potential to address important FIA needs. Therefore, continuing research regarding the capabilities of newly available data is needed.

Many of the alternatives currently available have had research conducted to determine the possibilities to address FIA needs. However, the most efficient methods will depend on the specific outputs and resources available at a given time, including cooperative data purchasing opportunities. The alternatives that are available need to be researched to determine the best operating procedures to deliver the products needed. Such research must be coordinated with other FIA and Forest Service units across the nation.

The research for this element will be accomplished by the following.

1. Development of procedures to routinely estimate forest area for phase I using the most efficient and effective satellite data available.

2. Development of procedures using georeferenced FIA ground plot locations as ground truth for both accuracy assessments of the satellite imagery classifications and for supervised classifications. There remains some work yet to refine the collection of ground reference data, including global positioning system (GPS) coordinates, and descriptions of forest cover that are most useful for application to satellite imagery analysis.

3. Develop schemes to update area estimates as efficiently and timely as possible. While annual estimates may be desirable, five-year updates may be almost as reliable but less costly. Alternatively, there may be options that do allow cost efficient estimates every two or three years.

4. Continue remote sensing research on areas such as west Texas and west Oklahoma and South Florida to meet FIA and FHM needs.

5. Continued research on imagery from newly available satellites, and their potential application to FIA needs.

Element B--Statistical estimation--While many of the needs relating to statistical estimation pertain to the entire inventory process, the pertinent study topic of this element deals solely with the application to annual inventories. Items to be addressed here involve the incorporation of new area estimates, likely from remote sensing analysis, into the annual inventory process; development of current-year and multi-year (e.g., five-year) estimates; and incorporation of updated (modelled) plots with remeasured plots.

While the development of area estimates is the subject of another element, the results from those procedures relate to the specific expansion factor for each plot. Often, the expansion factors may have greater influence than the per acre estimates derived from ground measurements. The frequency of new area estimates and how they are applied will impact the statistical estimates. For example, if new estimates of area are developed once every five years, they are usually

developed over some period of time, and involve input from ground checks that may be done over the entire period. Should the results of ground checks (as they affect area estimates) be applied in the year the data are collected, or should they be applied only after all data for the entire area updating procedure have been completed?

At the present time, there are no reliable growth or forest change models that apply across the entire spectrum of forest conditions in the South. Until such models or procedures are developed (note element C of this problem), only measured plots will be incorporated into inventory estimates. There are, however, several options as to how this may be accomplished.

The easiest option would be to perform the analysis each year using only the data collected in that year. This would provide annual unbiased estimates, but would entail a small sample and could involve a large variance. The next level of analysis could be to use a running average that would incorporate current and past annual estimates. A variation of the running average would be to use weights, with the most recent data being more heavily weighted than older data. Finally, there is the option of updating unmeasured plots and basing the estimates on a combination of measured and updated plots, providing such updating procedures are available.

The accomplishments for this element will include the following outputs over the next five year period:

1. Development of a mechanism to effectively incorporate area estimates into annual inventories.

2. Development of a series of options, with known parameters, for utilizing only measured plots. This will involve analysis of the current-year data; the current-year and previous year data (unweighted) incorporated into a running average; and the use of weighted running averages.

3. As models or updating mechanisms are developed, procedures to effectively incorporate them into annual estimates are needed.

4. Development of a user-friendly data base to accommodate statistical estimation procedures.

Element C--Development of plot and tree updating procedures--The options for updating unmeasured plots range from rather simple procedures to the use of complex models. This range would include simple imputation of values for unmeasured plots all the way to sophisticated models that are modified and improved with each remeasurement, predicting change given specific conditions.

Imputation is a general term for providing missing data. Application of imputation to estimate change on unmeasured plots could entail simply using a look up table and match plot characteristics with plots where recent measurements have been taken. In this fashion, assignments could be made for all the pertinent variables. An added complexity, which would have distinct advantages, would be to use multiple imputation. This procedure would usually

involve repeated application of a single imputation. This latter, more complex procedure would have the major advantage of being able to reflect a range of reasonable values for the variables being predicted and leads to realistic variance estimates. Multiple imputation will entail more efforts to establish a user-friendly, easily understood data base.

Statistical models, using linear regressions and other procedures would have great utility in applying known relationships to specific circumstances to estimate change. Explanatory variables would involve all pertinent stand conditions, site, and related vegetation conditions. These approaches have traditionally been used for growth and yield modelling, and have dealt with a narrow range of variables, most often related to timber objectives. Existing models may not address much of the annual inventory needs because of their rather limited application to specific stand conditions (such as fully stocked plantations) and a limited number of variables (such as basal area, numbers of trees, volume, etc.). However, they could possibly be designed so that a wide range of stand conditions and most pertinent variables are represented. Furthermore, statistical models may be developed so that parameters are continually changing and improving as additional data are collected on newly-remeasured plots. A distinct downside to the use of statistical models is that some variables may be very difficult to design predictive models for. An example of this difficulty would be the establishment and growth of forest reproduction.

Another type model would be individual tree growth models based on historical rates of change. Such models have been used to some extent in Southern FIA work to estimate diameters of cut and mortality trees. These models could be adapted to specific circumstances, and have been successfully applied for many situations.

There are several approaches that could provide satisfactory models to apply to unmeasured plots in a Southern annual forest inventory system. One requirement, at least for the long term, is that the models be applicable to individual trees. This requirement is evident since the unmeasured plots will need to be matched with measured plots in a compatible data base. However, there may be some short-term compromises that would yield valuable results.

The research outputs to be produced from this element include the following:

1. A survey of the model types, their potential application to FIA and their advantages and disadvantages.

2. Development of single imputation and multiple imputation procedures to apply to inventory data.

3. Development of statistical change models to apply to important inventory variables such as basal area, height, diameter, etc., across a wide range of stand conditions for the entire South.

4. Development of procedures to predict mortality and cut for individual trees.

5. Development of data base procedures to handle applications of the change estimation procedures being considered.

Problem 3--Integrate the FIA and FHM detection monitoring programs

While the FIA and FHM programs have somewhat different focus, there are many elements that are complementary. In fact, some elements could potentially be the same, especially in the context of FIA conducting annual inventories. The policy of colocating plots is already in place, but additional integration needs to be accomplished. For example, it is possible to use common mensurational protocols for both programs; this could foster joint field visits to collect data. In fact, several Southern State Foresters are already voicing the need to use the same field crew to collect both sets of data.

In addition to the use of the same mensurational data and joint field visits, there are other potential advantages to program integration. Much of the FIA data complements the health indicators used by FHM. Many of the current analyses of forest health draw heavily on the use of FIA data. It is also possible that distinct advantages could be obtained by using the FHM data protocols to complement the FIA process. For example, many variables that are desirable for a complete inventory of forest ecosystems are expensive to collect. Given the different sampling frame used by FHM, collection of these variables would perhaps be cost efficient in the FHM program. Integration would thus strengthen both programs, improving the information available to forest managers and policy makers.

It should be noted that this research augments that done by the FHM program. This is an integration of components from both programs, not a complete merger of the programs. All work proposed here will be done consistent to national direction.

Planned accomplishments for the next five years include the following:

1. Develop procedures to utilize the same crew for collection of both FIA and FHM data; this is to be coordinated nationally so as to achieve consistency.

2. Develop analytical procedures to incorporate results from both programs into common forest ecosystem analyses.

3. Develop procedures to link appropriate FHM variables to FIA results. The linkage of FHM and FIA variables will naturally occur with the colocation of plots.

4. Link FIA and FHM data as appropriate in a user-accessible data base to increase the scope of resource information available to end users.

Problem 4--Continue development of reliable information on resource use and timber product output

Studies of timber products output are conducted in cooperation with State forestry agencies, forest industries, and professional and trade associations. FIA scientists combine data from these

studies with data from the extensive inventories to conduct research on timber use and its relation to inventory volume. Such research is a critical adjunct to implementation of the annual forest inventory system in the South.

Principle results of this research include estimates of biomass potential, logging residues, and removals associated with cultural practices and changes in land use. This research must be kept up to date to monitor changes in logging technology and silvicultural practices in the region.

Planned accomplishments expected during the next five years include:

1. Establish links between resource use estimates and removals of timber from forest land in an annual forest inventory system context.

2. Analyze change between successive inventories, examining gross growth, mortality and removals.

3. Estimate and analyze change in timber utilization.

4. Conduct studies of total roundwood removals from all forest lands.

5. Prepare annual regional analyses of pulpwood production.

6. Conduct studies and report on veneer logs and specialty products.

7. Conduct studies and report on fuelwood use.

8. Work with State forestry agencies to cooperatively conduct timber product output surveys.

9. Evaluate the level of removals and mortality of trees in urban/rural land uses and develop trend data by species and land use classes.

10. Develop and maintain the data on timber products and resource use in a user-friendly data base.

STAFFING

The research unit has approximately 102 full time employees which includes the Project Leader, 12 research scientists, foresters, computer specialists, technical specialists, and various scientific support personnel. An additional three scientists will be needed by the end of the period covered by the research work unit description, along with additional support personnel.

The research outlined in this description would require a budget of $7.447 million for the first year of the description, with needs for years 2-5 averaging approximately $8 million, and considerably more if the Forest Service funds the entire effort to accomplish implementation of

annual inventories, measuring 20 percent of all plots in all Southern States. A portion of the current budget, approximately $1.17 million, is used to cost share data collection with State Foresters.

Scientist staffing requirements for this research throughout the duration of this period is as follows (this includes only personnel under the research grade evaluation guide):

Problem area	Element	Scientist years per year of the RWUD 1	2	3	4	5
1	A	1.0	1.0	1.0	1.0	1.0
	B	2.5	4.0	5.0	5.0	5.0
2	A	3.5	3.5	3.5	3.5	3.5
	B	1.0	.5	.5	.5	.5
	C	2.0	2.5	2.5	2.5	2.5
3		1.0	1.5	1.5	1.5	1.5
4		1.0	1.0	1.0	1.0	1.0
Total sci. years		12.0	14.0	15.0	15.0	15.0

Due to the nature of this research, a large number of professional and scientific support personnel are needed; most of these personnel work in Problem 1, for data collection, data compilation and analysis. The following table shows the approximate number of all other personnel not listed in the above table. It should be noted that this level of personnel does not account for the complete job of implementing annual inventories with a 5-year remeasurement cycle in the South; those requirements are being developed for the National FIA strategic plan.

Problem area	Element	Staff years per year of the RWUD 1	2	3	4	5
1	A	54.0	55.0	55.0	55.0	55.0
	B	23.0	24.0	24.0	24.0	24.0
2	A	3.0	3.0	4.0	4.0	4.0
	B	1.0	.5	.5	.5	.5
	C	1.0	1.0	1.0	1.0	1.0
3		2.0	2.5	2.5	2.5	2.5

4	6.0	6.0	6.0	6.0	6.0
Total staff years	90.0	92.0	93.0	93.0	93.0