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| RESEARCH WORK UNIT DESCRIPTION<br>Ref: FSM 4070 | 1. Number<br>FS-SRS-4101 | 2. Station<br>Southern Research Station |
| | 3. Unit Location<br>Asheville, North Carolina | |

4. Research Work Unit Title
Ecology and Management of Southern Appalachian Forests

5. Project Leader (Name and address)
David L. Loftis, Bent Creek Experimental Forest, 1577 Brevard Rd, Asheville, NC 28806

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| 6. Area of Research Applicability<br>Western North Carolina, NW South Carolina, Kentucky, Northern Georgia, Tennessee, Western Virginia | 7. Estimated Duration<br>5 years |

8. Mission

To develop and disseminate the scientific knowledge and silvicultural techniques needed to provide a full range of benefits in Southern Appalachian forests.

9. Justification and Problem Selection

As in other parts of the country, managers of Southern Appalachian forested ecosystems are being challenged by an increasingly complex set of benefits expected from these ecosystems, whether in public or private ownership. To the list of historically important outputs such as timber, game species, clean water and recreational opportunities have been added benefits that reflect shifting values of the American public and a heightened awareness of the role that forests play in the local, regional, and global environment and economy. Developing management strategies to meet these challenges, while continuing to provide historically important values, requires a level of knowledge, based on both long- and short-term research, and an integration of knowledge, that currently does not exist.

An ecological approach to management of land resources requires classification of the forested landscape into relatively homogenous units of sites and plant species that respond in a predicable manner to disturbance. However, traditional methods of site classification (e.g., site index, forest type, soils classification) have proven to be inadequate or inapplicable for a large part of the Southern Appalachians. Widely varying site factors of climate, geology, soils, and topography produce environments suitable for occupation by many overstory, understory, and herbaceous species, but we have a poor understanding of how these factors affect distribution and productivity of vegetation. <u>Current capabilities in prediction of species composition and productivity in relation to environmental gradients across the southern Appalachian landscape limit our ability to manage land resources with an ecological approach</u> (Problem 1). Ideally, combinations of environmental factors should delineate site units that are repeating, mappable

| Signature | Title | Date |
|---|---|---|
| Recommended: /s/ Nancy G. Herbert | Assistant Director for Research | 4/2/99 |
| /s/ L. Whitmore | Assistant to Staff Director | 4/6/99 |
| /s/ W.T. Sommers | Staff Director | 4/6/99 |
| Approved: /s/ Peter J. Roussopoulos | Station Director | 4/10/99 |
| Concurred: /s/ Robert Lewis | Deputy Chief for Research | 4/20/99 |

segments of the landscape with identifying characteristics that are easily recognized and measured. The site units should be designed to have maximum utility at the local level where site-specific plans are made and treatments executed. A classification of these site units should, however, be compatible with regional and national needs.

Growth and volume yield and value are clearly a function of forest composition and structure. But it can also be argued that virtually all forest benefits are linked to the structure and composition of forest stands and landscapes. Our understanding of the temporal dynamics of Southern Appalachian forests is limited, and existing models are limited in both scope--metrics used--and extent—types of ecosystems represented. Specifically, our knowledge of seedling population dynamics under various stand conditions is limited to a few species. We have little quantitative information on the development of young stands past the stem exclusion stage (~ 10 yr.), and we know little about how a broad range of trees of various species and competitive status, and other vascular plant species, respond to disturbance. In short, <u>our predictive understanding of structural and compositional dynamics of Southern Appalachian vegetation in response to changes in forest structure caused by natural and/or managed disturbances within stands and on the landscape is inadequate for the current demands of forest management</u> (Problem 2).

Designing silvicultural systems that consider ecological processes and effects requires an understanding of how habitat structure and composition influence vertebrate communities. It is instructive to compare structural features (such as down and standing coarse woody debris (CWD), canopy cover, vertical vegetative strata, ground cover, stand size and the surrounding landscape matrix) and the response of selected vertebrate communities, among undisturbed, silviculturally disturbed, and naturally disturbed sites. Stand composition is especially important to vertebrates in relation to the available quantity and species of plant foods such as fleshy fruit, hard mast, grains and foliage. Both physical features and plant species composition are temporally and spatially dynamic. The role and relative importance of these attributes may differ among forest types and among animal species or communities. In addition, fleshy fruit and hard mast production may vary from year to year due to environmental and intrinsic factors not related to stand age. However, <u>inadequate understanding of how vertebrate populations and communities respond to changes in forest structure and composition caused by natural and/or managed disturbances within stands and on the landscape limits our ability to manage them as metapopulations at a landscape level</u> (Problem 3).

Ecosystem management means taking an ecological approach to forest management. It is the skillful, integrated use of ecological knowledge at various spatial scales to produce desired resource values, products, services and conditions in ways that also sustain the diversity and productivity of ecosystems. Practicing ecosystem management presumes three things (1) that we understand the ecological relationships and ecological responses in the systems we are managing; (2) that we know what we are managing for (i.e., have clearly articulated goals); and (3) that we can use this understanding to accomplish our goals.

Ecosystem management has been adopted as the philosophical paradigm guiding management on many federal forests in the United States. The strategic goal of ecosystem management is to find a sensible middle ground between ensuring long-term protection of the environment while allowing an increasing population to use its natural resources for maintaining and improving human life. This has been an elusive goal. Ecosystem management represents a shift from simple to complex definitions of the ecosystems we manage. It will require the development of effective, multi-objective decision support systems (DSS) to improve the quality, reproducibility, and explainability of the decision process. No adequate full-service decision support systems exist to assist managers and researchers take an ecological approach to forest management (Problem 4). Effective ecosystem management processes and support tools are urgently needed to allow forest land managers to better accommodate the continuing rapid change in societal perspectives and goals.

## 10. Approach to Problem Solution

**Problem 1**. Current capabilities in prediction of species composition and productivity in relation to environmental gradients across the Southern Appalachian landscape limit our ability to manage land resources with an ecological approach.

The diverse climate, geology, physiography, and soils of the Southern Appalachians interact to produce a broad array of landscape units with widely varying ecological characteristics and vegetatively rich overstory, understory, and herbaceous associations. The objective of this research is to gain understanding of the relationships among temperature, moisture, and fertility with the biological requirements of vascular plants and then formulate models to predict their occurrence in relation to environmental gradients. Application of these models will allow land managers to determine the suite of plant species that have a high probability of occurring on sites of specified characteristics, evaluate variability in vegetation dynamics and structure, develop management strategies that favor desired composition (Problem 2), assess resource availability and habitat requirements for selected vertebrate communities (Problem 3). This problem area is of particular importance in Problem 4, where our increased understanding of ecological relationships will provide the basis for formulating management options to achieve goals and desired future conditions included in decision support systems and a wider scientific audience for predicting biological effects resulting from changing climatic regimes.

Our methods will be to quantify occurrence and site productivity of selected vascular vegetative species across the range of climatic, geologic, physiographic, and edaphic gradients occurring in the Southern Appalachian mountains and Interior Uplands. Highest priority for work will be geographic areas in which national forests are present, locations where projects are planned with cooperators, or areas that fill a void in the matrix of conditions upon which our understanding and models are based, such as temperature and fertility gradients. Data collection strategy will emphasize methods for efficient development and integration of models applicable in the field and by geographic information system over areas of landscape to regional extent. Attention will be given to increasing objectivity and sampling efficiency for vegetation, an essential component of ecological classifications. Emphasis will be placed on techniques to validate and refine maps of ecological units at a range of scales, from local to regional.

Data will be obtained from an extensive network of existing plots established by the Research Work Unit to study vegetation dynamics (Problem 2) and vertebrate communities (Problem 3). Also available for analysis will be data sets from cooperators and collaborators that include vegetative composition and precise geographic coordinates of field plot locations. University and industry cooperators will continue to be involved in this problem where mutual interests and objectives are accomplished. Data and models will be available to other problem areas in the RWU, particularly Problems 2 and 4, and to cooperators and other groups with scientific interests.

Participation in crosscutting themes with other Research Work Units of the Southern Research Station will likely be part of our approach.

**Planned activities for the next 5 years include:**

1. Refine current formulations for important arborescent species and expand to other species models to predict occurrence of overstory, understory, and herbaceous vegetation particularly in relation to temperature and fertility gradients.

2. Evaluate variables to replace conventional methods of accounting for site quality (site index) in individual tree increment models, which are compatible with the Forest Vegetation Simulator.

3. Develop methods for testing uniqueness of ecological units delineated on ecoregion maps of various scales.

4. Increase understanding of climatic, topographic, and edaphic factors that influence the spatial and temporal variation of soil moisture at landscape scales.

5. Investigate methods for quantifying macroscale topographic relief using digital elevation data sets.

6. Develop techniques for replacing conventional classification and ordination of vegetative species when developing ecological-based site classifications.

7. Investigate the relationship between vegetation and characteristics of geologic formations as a possible indicator of site fertility.

**Anticipated Outcomes:**

1. Land managers responsible for resource planning, assessment, and monitoring can apply ecological-based classification models to stratify the forested landscape into areas of similar habitats, productive capacity and response to natural disturbance and management activities at site, stand, landscape, and regional scales (Problem 2). These products will be useful to the scientific community to provide a basis for hypothesis testing and applicable areas of research findings. The models will be useful in decision support systems for organizing available knowledge and identifying areas where it is lacking (Problem 4).

2. Management of nontimber forest products can be facilitated by using prediction models to make maps showing probable locations in unsurveyed areas. Biologists responsible for monitoring threatened and endangered species can stratify the landscape into areas where occurrence of a particular species is more likely, thereby increasing efficiency of field surveys (Problem 3).

3. Federal and state agencies responsible for assessing effects of climatic change on forest resources can apply models developed in this problem to predict spatial and temporal variation in soil moisture at landscape scales resulting from changes of precipitation amounts and distribution.

4. Managers dealing with controlling spread and mitigating effects of exotic species in native forests will have access to information that can be used to establish treatment priorities and predict probable outcomes on various parts of the landscape resulting from natural and planned disturbances (Problem 2).

5. Scientific communities and conservation organizations can utilize new methods of quantifying micro, meso, and macro-scale landforms as continuous variables to improve accuracy of ecological modeling and ensure objective application of the models in the field.

Environmental considerations: The studies in this problem area are expected to have little or no potential for soil movement, water quality degradation, or impact on sensitive resource values and are therefore covered under FSH 1909.15, Chapter 30, "Categorical Exclusion from Documentation in an EIS or EA." Where environmental concerns exist regarding particular studies, these will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by cooperating District or Forest staffs.

**Problem 2.** Our predictive understanding of structural and compositional dynamics of Southern Appalachian vegetation in response to changes in forest structure caused by natural and/or managed disturbances within stands and on the landscape is inadequate for the current demands of forest management.

This problem goes beyond past research efforts by this RWU by identifying regeneration, growth, and mortality information needs for *all* forest plants, as well as the effects of *natural* (in addition to managed) disturbances on forest structure. This large and complex problem is not solvable in its entirety within the time frame of a single RWU research planning cycle, but this research cycle will address the following areas.

Regeneration of forest vegetation in the Southern Appalachian region is mostly dependent on natural regeneration sources. Artificial regeneration technology is very limited in scope. Most tree species have an advance-growth-dependent strategy; that is, they persist through a disturbance as vegetative structures that existed before the disturbance. A very few species regenerate as new seedlings that become established after disturbance. However, three major technological goals remain. One is the development of models that predict at the time of stand closure the composition and structure of the developing overstory that occurs as a result of a stand density reducing disturbance. The model development goal of predicting composition and structure at the time of stand closure will rely on both new studies and analyses of available data from established long-term studies installed and maintained by this RWU. The second goal is to gain an understanding of the population dynamics of advance-growth-dependent species under various degrees of disturbance. The third goal is to develop the silvicultural dimensions (as opposed to the nursery dimensions) of artificial regeneration establishment and subsequent growth and survival of hardwood species.

One of the best ways to capture and make available developmental information for all vegetation on forested lands and the response of these plant communities to disturbances (natural or man-caused) is through the development of a comprehensive forest vegetation simulator. Such a simulator includes regeneration and growth-predicting modules for both understory and arborescent species. The large tree model component will be driven by relative tree size and crown condition, rather than by tree age. Because of the age-independence of this approach, the traditional age-driven phytogenic-based site index productivity tool will be replaced with an ecological-based site productivity metric. This apparent constraint actually creates the need and opportunity to integrate RWU problems 1 and 2. This comprehensive vegetation growth simulator will be incorporated into the Forest Vegetation Simulator (FVS) software system by taking advantage of the software maintained support provided by the Growth and Yield unit of the Fort Collins Management Center of the USDA Forest Service. The research goal is to develop a Southern Appalachian simulator that regenerates and grows arborescent and non-arborescent species, grows young trees during the crown closure phase and large trees during the self-thinning phase, and predicts the structure and quantities of course woody debris.

The effects of disturbances will be simulated through the density manipulation feature of the large-tree component of a forest growth simulator developed for Southern Appalachian vegetation. Natural disturbances themselves will be investigated from two perspectives. One perspective will investigate the regenerative responses of vegetation that occur in naturally caused gaps. The other perspective of disturbance will be spatial in context. It will classify the causes of these natural disturbances, and the spatial and temporal distribution they have over the Southern Appalachian landscape. The landscape approach will have to be collaborative with other government agencies and universities because the relevant databases are expensive and are not routinely developed by the USDA Forest Service. The goal will be to develop a probabilistic-based model of spatial distribution, intensity, and cause. It is anticipated that the results from the RWU's ecological classification research problem will be used in the development of such a spatial model.

**Planned activities for the next 5 years include:**

1. Test and refine the multi-species regeneration prediction model, including methods to generate tree lists (that is, predict tree size and species) at crown closure. Reformulate all regeneration models based on ecological units rather than site index.

2. Develop a prototype for a stochastic regeneration model.

3. Develop a small tree model for the FVS system that links to the predicted output of tree lists at crown closure for the regeneration module.

4. Refine an FVS-compatible large tree growth projection model for the Southern Appalachians.

5. Test the accuracy and range of applicability of the Southern Appalachian variant of the FVS.

6. Spatially and temporally characterize natural disturbance patterns and their impacts on vegetative structure.

7. Test the performance of FVS in predicting the volume of coarse woody debris.

**Anticipated outcomes:**

1. The National Forest silviculturalists will be able to predict regeneration responses to the effects of man-caused and natural disturbances.

2. Silviculturalists and forest planners will have a uniform model of forest vegetative growth across Southern Appalachian National Forests.

3. In combination with the imputation research in Problem 4, forest planners will be able to use FIA inventory data and the FVS system to spatially simulate the effects of silviculture.

4. Land managers and forest planners will be able to simulate the no-management alternative by modeling the effects of natural disturbances on forest composition and structure.

5. The coarse woody debris and forest structure predictions will assist wildlife and fire management on National Forests.

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

**Problem 3:** Inadequate understanding of how vertebrate populations and communities respond to changes in forest structure and composition caused by natural and/or managed disturbances within stands and on the landscape limits our ability to manage them as metapopulations at a landscape level.

The Southern Appalachian mountains include a wide range of soil, moisture, topographic and other ecological conditions that produce a great diversity of woody and herbaceous plant associations (Problem 1). This array of compositional diversity is confounded with a variety of natural (wind, ice storms and fire) and silvicultural disturbance types, intensities and patterns (Problem 2). Forest composition, along with numerous edaphic and environmental factors, affects the quantity and type, as well as the spatial and temporal availability of fruit (hard mast and fleshy fruit) food resources to animals. Both compositional and structural features of habitats additionally influence what vertebrate species will be present, and how many. Understanding the response of individual vertebrate species and whole communities to changes in forest features is necessary for predicting impacts of forest management options (Problem 4). Our objective is to study the influence of forest structure, composition and fruit resource availability on selected vertebrate species and communities, with particular emphasis placed on comparing naturally versus silviculturally disturbed sites. By focusing on the community level of several vertebrate classes we will gain a multi-faceted view of forest management that focuses on the trade-offs of forest management. That is, while silvicultural or naturally induced changes in forest structure may adversely affect some species or classes of vertebrates, it may benefit others. Special emphasis will be given to to white footed mice, whose populations may fluctuate asynchronously with hard mast production and which, in turn influence populations of their gypsy moth prey (by eating pupae), and Lyme disease. Slimy salamanders populations also will be studied specifically as potential indicators of how forest structure influences terrestrial salamanders.

Our approach to this problem area is to compare forest composition, structure, and vertebrate communities across a range of habitats and disturbance types in the Southern Appalachians. Currently, we are intensively studying large forest gaps created by natural wind disturbance (Hurricane Opal, October 1995). Several gaps are intact, and others have been salvage-logged. Within these and undisturbed sites, we have/are: characterizing changes in forest composition and structure (creation of pit and mound topography; soil disturbance; coarse woody debris (CWD); direction of treefalls); comparing and monitoring the generation and decay rates of CWD; studying plant recovery; and comparing small mammal, bird, and reptile and amphibian communities.
We also are evaluating spatial and temporal patterns of hard mast and fleshy fruit production, and the factors that influence it. Specifically, for eight years (and ongoing) we have been measuring acorn production of five oak species in the Southern Appalachians at a landscape scale with the

goal of developing a model to predict acorn production. We also have developed experiments to determine scarlet oak versus white oak acorn removal rates by vertebrates in relation to annual mast production levels. In the South Carolina Piedmont (Savannah River Site), we are comparing hard mast and fleshy fruit production in five habitat types (loblolly pine plantation; longleaf pine plantation; bottomland hardwoods; upland hardwoods and clearcuts). We also are conducting a series of experimental studies to determine the importance of fleshy fruit to birds (consumption), and seed dispersal at a landscape level.

**Planned activities for the next 5 years include:**

1. Develop manipulative experimental studies to determine the levels and sizes of CWD required to mitigate the effects of tree harvest on selected vertebrate communities in the Southern Appalachians.

2. Compare the effect of tree harvesting methods (shelterwood and group selection) on selected vertebrate communities of $\geq 2$ forest types in the Southern Appalachians.

3. Continue the long-term study of hard mast production by five southern Appalachian oak species and factors that affect it.

4. Quantify fleshy fruit and hard mast production among shelterwood, group selection harvests, and uncut forest of $\geq 2$ forest types in the Southern Appalachians.

5. Study the effects of past land use and surrounding landscape matrix (agricultural versus forested) on vertebrate response to specific tree harvesting methods.

**Anticipated Outcomes:**

1. An improved understanding of vertebrate community and individual species response to changes in forest structure such as CWD and live tree basal area will allow National Forest managers and other land managers to better predict the impacts of various forest management options, and compare them to impacts by natural disturbance. This can be useful in the development of landscape level ecosystem management and forest planning.

2. Estimation and prediction of hard mast and fleshy fruit yield based on stand or forest composition and structure will be an important contribution to forest planning efforts. The research results can be used to develop habitat association models, and in making resource decisions.

3. Results can be used by forest managers to mitigate the effects of forest management practices on vertebrate communities and individual species.

4. Results of studies on how habitat structure affects herpetofaunal, mammalian and avian communities, as well as and fruit resource production can be used in decision support models to predict impacts of forest management options (Problem 4).

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

**Problem 4.** No adequate full-service decision support systems exist to assist managers and researchers take an ecological approach to forest management.

We propose to focus our future work on three aspects of this problem:

1. Research on knowledge management theory and development of supporting methodology.

2. The design, production and distribution/marketing of a wide range of DSS functional service modules.

3. The design, production and distribution/marketing of NED, a full service DSS for ecosystem management.

Although work over the last 10 years in the fields of Artificial Intelligence applications and decision analysis theory can point to substantial progress, key theoretical elements and methodology are still missing or incomplete. Research on knowledge management theory and development of supporting methodology is needed before adequate full-service DSS, such as NED, can become a mature technology.

DSS functional service modules perform narrow, well-defined tasks in the overall decision support process. GIS is one example of a DSS functional service module that is used to provide spatial analysis and display capabilities in many full service DSS. Vegetation dynamic simulators, such as FVS, soil nitrogen impact analysis modules, such as the Coweeta Nitrogen Dynamics module, and hypertext knowledge management modules, such as the Oak Regeneration Hyperdocument, are other examples.

A full service DSS, such as NED, is a computer-based system that (1) integrates data sources with various kinds of functional service modules, facilitates the development, analysis, and ranking of alternative courses of action, assists in the management of uncertainty, and enhances comprehension of the problem. NED has been developed jointly by scientists from the NEFES, SRS, and the NCFES. NED-1, the first complete implementation, has been finished and is undergoing testing. NED-1 should be viewed as having completed the proof-of-concept stage of development. NED-1 will be used as both a synthesis and integration tool for researchers and as a decision support tool for forest managers. Specifically, NED-1 is useful for: (1) storing and retrieving organized & synthesized knowledge, information, and data; (2) identifying knowledge gaps; (3) delivering scientific knowledge in a usable, accessible form; (4) aiding managers and the public by supporting the evaluation of the consequences of proposed management alternatives; (4) enhancing the consistency, repeatability, and quality control of decisions; (5) aiding environmental education; and (6) providing a framework for monitoring.

**Planned activities for the next 5 years include:**

1. Develop, implement and test a generic, interoperable software framework to support between module control and communications both for legacy and newly developed functional service modules.

2.  Develop, implement, and test ways to implement uncertainty assessment in DSS in order to place qualitative or quantitative confidence intervals on technical analyses and recommendations and to explore the extent to which uncertainty affects management decisions.

3.  Study the structure of issues-goals-desired future conditions in the rich knowledge domains of ecosystem management in order to help users formulate and operationalize a set of goals that has a high probability of simultaneous satisfaction in the context of a decision.

4.  Develop, implement and test data imputation methods so that managers can field a fully populated data set of their ownership at an affordable price.

5.  Develop and test the ability (read procedures) to rapidly (≤ 6 months) produce resource capability models (RCM) using rapid prototyping tools like STELLA, MATHCAD, DSSTools.

6.  Identify goals, desired future conditions, and measurement variables for the Southern Appalachian variant of NED-SA.

7.  Identify and test the operational environment for NED in the National Forest System project planning system.

**Anticipated Outcomes:**

1.  The community of DSS developers will have a standardized, well-tested interoperable communications methodology available to use to link the various software modules that make up a DSS together.

2.  National forest and other forest-land managers will have a practical, comprehensive decision analysis process at their desposal to help them make their decisions defensible, understandable, and ecologically sound.

3.  National forest and other forest-land managers will have a full-service, goal-driven DSS called NED that can be used as a decision aiding and analysis tool for understanding the complexity of the ecosystem mangement process.

<u>Environmental considerations</u>: The studies in this problem area will have no potential for soil movement, water quality degradation, or impact on sensitive resource values and are therefore covered under FSH 1909.15, Chapter 30, "Categorical Exclusion from Documentation in an EIS or EA."  If environmental concerns arise, they will be evaluated within individual study plans, or by Environmental Assessments or Environmental Impact Statements prepared with and approved by cooperating District or Forest staffs.

## 11. Staffing and Budget

| Problem Number | Scientist Years/Year |
|---|---|
| 1 | 1 |
| 2 | 2.25 |
| 3 | 1 |
| 4 | 0.75 |

There are currently five scientists in the unit and one professional technical support assigned to technology transfer. Three permanent forestry technicians provide technical support. The project secretary/administrative assistant provides clerical, business and network management support. Assistance is also provided by the Senior Community Service Employment Program and by temporary hires. The unit cooperates with the National Forests in the Southern Region, several colleges and universities, the Hardwood Research Council, North Carolina State Hardwood Cooperative, and the State forestry organizations in Virginia, North Carolina, Tennessee, Georgia, South Carolina, Kentucky, and Alabama.

Full implementation of this Research Work Unit Description would require the following budget:

| FY 2000 | FY 2001 | FY 2002 | FY 2003 | FY 2004 |
|---|---|---|---|---|
| 1,181,000 | 1,234,000 | 1,290,000 | 1,348,000 | 1,408,000 |

With FY1999 levels of funding ($1,115,000), we adjusted the budget for proposed salary (4.4% for FY2000 and 3% thereafter) and inflation (1.5% per year based on current figures) increases. In addition to these figures, outside funding is expected from several sponsors for data collection at the Savannah River Site and for technology transfer programs.

## 12. Technology Transfer

This Research Work Unit maintains a very active program of technology transfer. The information presented varies from general knowledge about forest management to highly technical aspects of ecology and silviculture. We will continue to place substantial emphasis on our technical audience and will enhance our formal training activities. We currently have a highly successful training program that introduces foresters to Southern Appalachian forest management. We introduced a more advanced course in 1998 that focuses on the quantitative tools that result from our research. This activity is helping us focus our research efforts more keenly and improving product development for our customers.