United States
Department of
Agriculture

Forest Service

Southeastern Forest
Experiment Station

General Technical
Report SE-34

Technology Transfer in Integrated Forest Pest Management In the South

TECHNOLOGY TRANSFER IN INTEGRATED FOREST PEST MANAGEMENT IN THE SOUTH

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December 1985
Southeastern Forest Experiment Station
Asheville, North Carolina

Hertel, Gerard D.; Branham, Susan J.; Swain, Kenneth M., Sr. eds. Technology transfer in integrated forest pest management in the South. Gen. Tech. Rep. SE-34. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station; 1985. 82 p.

A synopsis of the technology transfer activities of the Forest Service's Integrated Pest Management Research, Development and Applications Program for Bark Beetles of Southern Pines, and the Southern Region, 1980-85, with emphasis on State demonstration projects and user involvement.

KEYWORDS: Research and development; technical information; information management; research applications; technology transfer; information systems; multimedia packaging; demonstration projects.

PREFACE

A large number of State and Federal experiment stations, universities, and Federal, State, and private resource management organizations have participated in the USDA Forest Service's Integrated Pest Management Research, Development and Applications Program for Bark Beetles of Southern Pines (IPM Program) and in Southern Region-sponsored State demonstration projects since 1980. The objectives of both of these accelerated efforts have been to more fully utilize available knowledge and to develop or improve and demonstrate methods for detecting, evaluating, predicting, preventing, and suppressing losses due to the five bark beetle species and three tree-killing pathogens affecting southern pines.

Nearing the completion of the IPM Program, we thought it appropriate to review and synthesize the results of the transfer efforts of the IPM Program and the Southern Region. Activities during the past 5 years have concentrated on planning, executing, packaging, and disseminating a substantial amount of new or improved technology. This involved individual and collective efforts of many Federal and State pest management and forestry specialists as well as those of representatives of Federal, State, industry, and university organizations who developed the technology or provided advice on its use.

The information presented here is for the benefit of those interested not only in the approach that was used in technology transfer but also in the results from a variety of transfer activities across the South. The IPM Program and Southern Region Forest Pest Management staffs are indebted to this publication's editors and the chapter authors for their contributions.

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I. INTRODUCTION TO TECHNOLOGY TRANSFER IN INTEGRATED FOREST PEST MANAGEMENT

BACKGROUND AND APPROACH

Gerard D. Hertel, Garland N. Mason, Robert C. Thatcher, and Susan J. Branham[1]

Occasionally, regional or national problems arise that require and benefit from accelerated research and development efforts. Such programs are usually undertaken in response to the need for more adequate technology to deal with a specific issue. Large numbers of individuals in many disciplines and organizations are brought together to address the topic of concern. Within the established time frame, research, development, and applications activities are completed and the new technology incorporated into operational programs as rapidly as possible.

This report describes how one such accelerated effort provided more effective ways of dealing with a regional problem involving five bark beetle species and three tree-killing diseases affecting southern pine forests, and how this information was delivered to its ultimate users through an aggressive technology transfer effort.

BACKGROUND

In the early 1970's, the southern pine beetle (SPB) was in epidemic status across the South. Resource managers and landowners expressed a need for new or improved means for dealing with this pest. Robert Long, then Assistant Secretary of Agriculture, asked the U.S. Department of Agriculture's Cooperative State Research Service and the Forest Service to pool their resources to plan and undertake an aggressive research and development program. Congress appropriated funds for this purpose in fiscal year 1975, and the 5-year Expanded Southern Pine Beetle Research and Applications Program (ESPBRAP) was initiated in February of that year.

The next 5-1/2 years of the ESPBRAP significantly advanced our understanding of SPB populations and the forests in which they occur. Federal, State, university, and industry specialists worked together to provide new or improved methods for dealing with this major regional pest problem.

Continuing interest and support led to approval of a second 5-year accelerated program in fiscal year 1981. The Integrated Pest Management (IPM) Research, Development and Applications Program for Bark Beetles of Southern Pines was charged with completing and transferring the technology resulting from ESPBRAP and developing new or improved methods for dealing with a complex of bark beetles and tree-killing diseases affecting southern pines. This complex comprises southern pine beetle, three species of *Ips* engraver beetles, black turpentine beetle, fusiform rust, annosus root rot, and littleleaf disease. (For scientific names, see appendix I.)

IPM PROGRAM GOALS AND OUTPUTS

The Southern Region of the Association of State College and University Forestry Research Organizations (now known as the National Association of Professional Forestry Schools and Colleges) and the Forest Service organized a planning team in 1978 to identify current and future forest pest research and application needs in the South. Their report was further reviewed and commented upon by State, Forest Service, consulting, and industrial representatives. A technical committee was subsequently appointed to develop a 5-year plan that would guide the conduct of research, development, and applications efforts. That document was, in turn, reviewed by researchers, specialists, foresters, and administrators representing the southern forest research and applications community.

The resulting plan was structured around six target areas. Program management later described 17 measurable outputs (see appendix II, item 1) and one or more research or application final products for each output. The outputs were further defined for each funded project. An assessment was made as to how these project outputs contributed to the completion of specific Program final products and to whom (specific user groups) the completed technology should ultimately be directed.

AUDIENCE IDENTIFICATION

The users of technology developed through the IPM Program were defined primarily as owners and managers of pine timberlands. Program management recognized early that it was neither possible nor desirable for the Program to deal directly with this entire group. It was clear that many forestry organizations already had effective means for communicating with their clients. The Program, therefore, targeted as its direct audience the State and Private Forestry Organization of

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the Forest Service's Southern Region. Secondary organizations included National Forest and other Federal agency regional offices, State forestry organizations, the Cooperative Extension Service, and major timber companies with pest management specialists. Their communication network capabilities permitted the Program to direct new technology to a fairly limited number of organizations who, in turn, passed it on in original or revised form to a large number of landowners and managers in the South with whom they already had professional contacts. This distribution system is illustrated below:

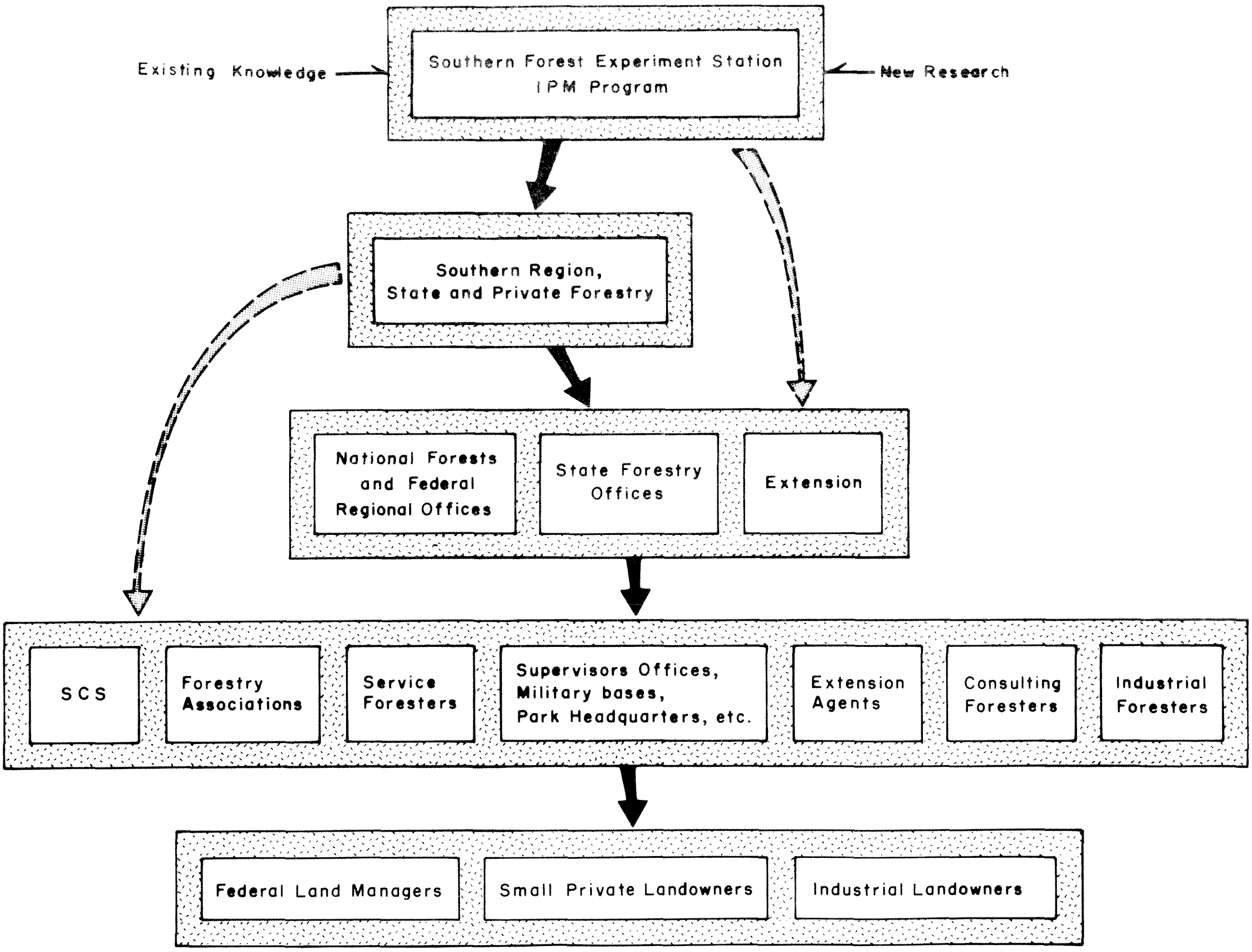

Figure 1—Flow of new technology from the IPM Program to various users in the South.

TECHNOLOGY TRANSFER APPROACHES

Several approaches were employed to provide research and development results to transfer agents and, on occasion, directly to forestry users. An abbreviated but very effective means of keeping a large audience informed on a very timely basis was through the Program newsletters—the Southern Pine Beetle News (ESPBRAP) and Pest Management News (IPM). On the average, 4 to 6 newsletters were mailed out to 2,000-plus readers each year. Other approaches included direct user involvement in the planning and execution of R&D projects; the preparation of technology transfer plans as a part of R&D proposals; involvement of R&D investigators in the technology transfer process (e.g., involvement in technology transfer teams, field and pilot studies); preparation, packaging, and delivery of written and visual materials to specialists and organizations; participation in training and professional society activities; and "hands-on" experience with computerized information management and decision support systems as well as involvement in the organization and conduct of demonstration projects.

Technology Transfer Plans

Funded investigators submitted an applications plan as a part of their original plan of work and budget (see example in appendix III). In these plans, investigators interacted with potential users and learned to recognize that the effective transfer of knowledge from research to use involves six steps: 1) Defining the message (what do we want to say?); 2) defining the audience (with whom do we wish to communicate?); 3) defining the objective(s) (why do we want to reach the

Figure 2—Planning for the transfer of knowledge from research to application.

audience and when?); 4) defining the working team (who will be most effective in communicating the message?); 5) defining the media (what methods of communication will be used?); and 6) defining the evaluation criteria (was the transfer successfully completed?).

User Involvement

As part of the technology transfer plan, investigators were encouraged to identify the users or user groups to whom research products would be directed and to involve them in the planning and execution of the research. This involvement ensured that the final product would be "user compatible." It also greatly accelerated the technology transfer process because little modification was required for immediate application and users had confidence in the technology through their own involvement in its development.

Encouraging user involvement also resulted in closer working relationships among researchers who were themselves often users of research products. It also allowed close collaboration with Federal and State pest management specialists in plot selection, data collection, and interpretation of results, and it facilitated commitments of additional industrial, State, and Federal manpower and other resources to accomplish larger tasks that would otherwise be impossible with limited resources.

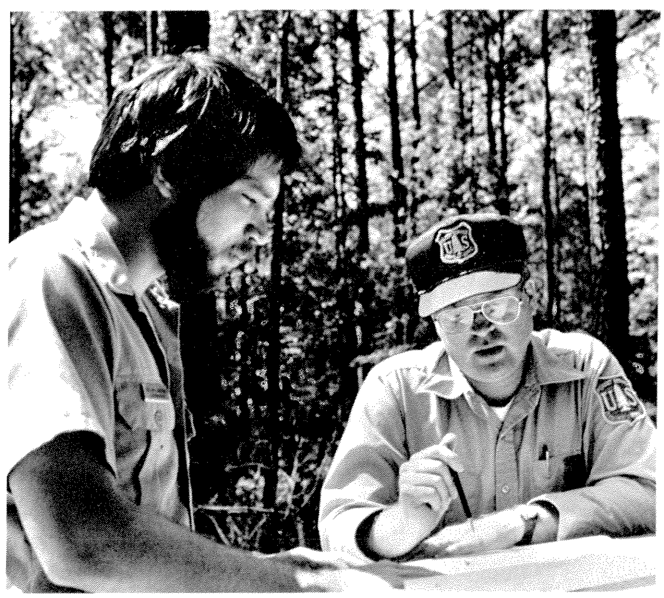

Figure 3—Collaboration between Federal foresters in plot selection and data collection.

Investigator Research and Development Activities

In addition to involving users directly in planning research and development activities, investigators were encouraged to participate in local professional society activities, to chair or participate in working group or technology transfer team activities, or to develop user-oriented audio-visual programs, publications, management guidelines, or other training aids in order to accelerate the packaging and/or distribution of results from each project.

Technology Transfer Teams

Experience in ESPBRAP revealed that technology transfer teams can be effectively used to facilitate the exchange of ideas, identify research results ready for transfer, devise innovative approaches for developing and disseminating information, and identify individuals most capable of carrying out these responsibilities. To a lesser extent, this idea was used in the IPM Program. Technology transfer teams active during ESPBRAP and the IPM Program are listed in appendix II, item 2.

Preparation and Packaging of Materials

Often good information fails to reach an intended audience because it is not properly packaged. Program management in ESPBRAP and IPM used many approaches to package or otherwise display and make available the results from research and development activities. These are tabulated in appendix II, item 3.

A complete listing of USDA Forest Service publications and visual aids developed with ESPBRAP, IPM, and S&PF support is presented in appendix II, item 4. The availability of these materials has been widely publicized in the professional forestry media. The Southern Region took responsibility for distributing all Agriculture Handbooks and southern pine beetle fact sheets; the ESPBRAP and IPM Programs distributed Technical Bulletins, General Technical Reports, and Program newsletters.

Some of the more applied Agriculture Handbooks have been assembled in a three-ring, indexed binder titled the "Forester's Handbook for Reducing Bark Beetle and Disease-Caused Losses in Southern Pines." This notebook has been distributed to State, industrial, and Federal foresters, and Federal and State pest management specialists. It has proven very useful, and its widespread popularity has led to further reproduction and distribution under the auspices of the National Association of State Foresters through the Texas Forest Service.

The IPM Program has given special emphasis to using popular journals to reach southern foresters. A partial listing of professional journals in which articles have appeared includes the *Southern Lumberman, Southern Journal of Applied Forestry, Forest Farmer, The Consultant,* and *Forests and People*. (See specific references in appendix II, item 4.)

Figure 4—Handbooks, newsletters, technical bulletins, and fact sheets transfer results to the user community.

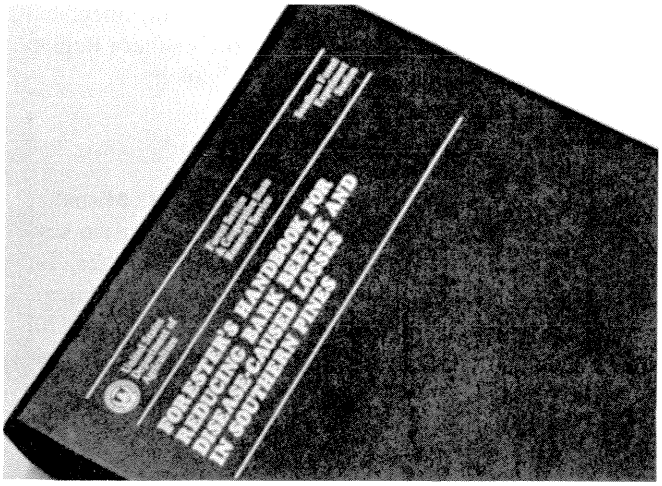

Figure 5—"The Forester's Handbook for Reducing Bark Beetle and Disease-Caused Losses in Southern Pines."

Training of Specialists

As the end of the IPM Program approached, it became apparent that there was a need to make State, Federal, and Extension specialists aware of the computer- and noncomputer-based models and procedures developed by researchers over an 8-year span of the two accelerated programs. A listing of what were considered the most useful models by categories was prepared (appendix II, item 5). The physiographic regions in which the models could be used were then identified. A 3-ring administrative training manual was developed—"Predicting Southern Pine Beetle and Disease Trends" (Mason, Hertel, and Thatcher 1985)—that contained a summary (description, inputs, outputs, accessibility, sources of additional information) for each model. This served as the main reference source for informal training of Federal and State pest management specialists. The notebook was updated semiannually and distributed to a broader audience in mid-1985.

Three formal training sessions were held in early 1984—in Georgia, North Carolina, and Louisiana. A total of 22 specialists attended. Practical examples were used and, where appropriate, each attendee had hands-on experience at a computer terminal. Following the training, the specialists were asked to use the information themselves, pass it on to others in their States or areas of operation, and provide feedback to developers for modification or improvement.

Participation in Professional Society, Association and Landowner Meetings

The Program management team in both ESPBRAP and IPM and cooperating State and Federal pest management specialists have made an effort to highlight new technology by developing and presenting displays with special themes at forestry-related meetings throughout the South. A special effort has been made to reach foresters through their annual State or regional Society of American Foresters or forestry association meetings (Texas, Louisiana, Mississippi, Southeastern, and Appalachian Society of American Foresters) and one SAF regional technical conference (held in Baton Rouge, LA, in 1982). Team members also presented papers at several national and regional symposia and workshops.

Information Management and Decision Support Systems

A broad array of computer models for assessing timber growth, beetle and disease impact, host-pest interactions, and management actions was developed or assembled through the two successive Programs. (A partial list is presented in appendix II, item 5). The large number and complexity of models and variation in their geographic applicability made knowledge of their availability, access, and operation difficult for users. To heighten user awareness and encourage application of the new technology, it was apparent that an urgent need existed to properly package and streamline means for gaining access to the systems. Several computer models were produced to make this information more accessible, interpretable, and user-friendly. These included the Integrated Pest Management Decision Key, the Southern Pine Beetle Decision Support System, CLEMBEETLE, and ITEMS (Integrated Timber and Economic Management Simulator).

The **Integrated Pest Management Decision Key** (IPM-DK) was independently developed by pest management specialists in the Southern Region and Southeastern Station (Anderson and others 1982), which contributed greatly to the technology transfer needs of the IPM Program. The IPM-DK is an interactive, user-friendly, microcomputer program that lists pest management options for the southern pine beetle, annosus root rot, fusiform rust, littleleaf disease, and other tree pests. The program considers environmental factors, economics, geographic location, pest interactions, and a variety of management options. New information can be incorporated into the system as it becomes available without waiting for final publication.

The **Southern Pine Beetle Decision Support System** (SPBDSS) developed at Texas A&M (Saunders and others 1985) is an interactive mainframe computer system designed to help decisionmakers use computerized and noncomputerized information to solve relatively unstructured questions. This system is capable of selecting and operating models in several subject areas—impact, population dynamics, economics, utilization, and stand growth and yield. Information provided permits the manager to make better decisions concerning different management situations.

The SPBDSS can be used in a number of ways. It can serve as a retrieval system to access data and models in response to user requests. Any model can be accessed and run independently. It can also be used to identify and select model(s) that would provide information most applicable to the user's local situation. The user can then access, sequence, and run the models of interest to obtain answers to his questions. Finally, the DSS can provide automatic selection and sequencing. After a question is asked, the DSS leads the user through a series of prompts, selects appropriate models, asks for necessary input data, runs the models, and displays the output. To date, 36 models dealing with southern pine beetle population dynamics, host tree dynamics, stand hazard rating, economics, impact evaluation, and utilization have been assembled and made available for the retrieval and model identification/ selection processes described. Twelve models have been interactively webbed together for automatic processing.

CLEMBEETLE was developed at Clemson University (Hedden 1985) to simulate losses from bark beetles and the effects of management practices on single or multiple stands for periods as short as a year or as long as a rotation. The program consists of a series of submodels for estimating the probability of southern pine beetle spot occurrence, the number of trees killed as a result of spot growth, the growth of timber stands, and the effect of stand treatment on timber growth and beetle impact. The program can be run on a mainframe computer or on one of several microcomputers—Radio Shack TRS 80, Apple II, or IBM-PC.

ITEMS (Integrated Timber and Economics Management Simulator) is designed to simulate the performance of pine stands under varied management regimes and beetle infestation levels (Vasievich and Thompson 1985). The model's primary application is to test the economic effects of such management activities as site preparation, stand establishment, partial cutting, harvesting, and type conversion. The model projects the development of one or more stands over a period of years and contains components for cost and revenue projections for various management practices as well as routine accounting functions. Output is in the form of reports for each year of simulation.

The Fusiform Rust Yield−Slash model (Nance and others 1985) was developed at the Southern Forest Experiment Station to predict yields for unthinned slash pine plantations infected with fusiform rust. The system is an interactive, user-friendly, computer program that can be accessed on Forest Service Digital or Data General computers. Rust mortality functions were developed from data collected in six Southern States and incorporated into an existing stand growth and yield model, Unthinned Slash and Loblolly Yields for Cutover Sites in the Western Gulf (USLYCOWG). The model requires rust level input at age 5 and predicts timber yields by diameter class at rotation age. A similar model is being developed for unthinned loblolly pine plantations infected with fusiform rust.

Demonstration Projects

The IPM Program sponsored demonstration projects in Texas, Mississippi, Alabama, and South Carolina to provide a means for transferring new technology to forest industry, National Forests, consultants, and/or private, nonindustrial landowners. In addition to these projects, the USDA Forest Service's Southern Region State and Private Forestry provided additional funds over a 3-year period (1981−83) to develop, package, and deliver new or improved technology to landowners with small holdings in eight Southern States. All of these projects achieved a great deal in the area of technology transfer and showed that the demonstration approach is a very effective means for accomplishing it. The sections that follow summarize work funded by both the Integrated Pest Management RD&A Program and the Southern Region to develop, package, and deliver new technology.

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II. TECHNOLOGY TRANSFER THROUGH DEMONSTRATION PROJECTS

HAZARD RATING STANDS FOR SOUTHERN PINE BEETLE AND ANNOSUS ROOT ROT IN ALABAMA

James R. Hyland and Robert C. Kucera[1]

INTRODUCTION

The two major pests in Alabama's pine resource are the southern pine beetle (SPB) and annosus root rot (ARR). Annual mortality resulting from SPB outbreaks has been valued at an average of $8 million during the last 10 years. Annual mortality due to ARR has been valued at $2.2 million over the same period. ARR losses also include a 4 percent growth reduction of live, infected trees, and this growth loss coincidentally increases the SPB hazard. Management of the State's forests offers the best long-term approach for reducing these losses.

The TREASURE Forest Plan is an approach designed to help the Alabama Forestry Commission forester or ranger use the latest technical information to assist forest landowners with their management needs. Special efforts have been made to design the plan around a particular concept. The TREASURE concept focuses on forest management strategies that consider all resource values that are compatible with landowner objectives. These values include outdoor recreation, timber, watersheds, esthetics, forage, environmental protection, and wildlife.

The plan also offers advantages to the forester when assisting forest landowners. Being standardized, it enables the forester to provide a consistent service regardless of variables like career experience, landowners' knowledge, and geographic location. Also, it encourages the forester to consider all available resource opportunities and options. Greater cooperation with other agencies and resource managers can be enhanced through this broad approach. And, because of computer capabilities, the forester has access to current data on every aspect of forest management. Demonstration forests have been one means of highlighting this overall TREASURE concept.

The demonstration forests in Alabama are a cooperative effort among the Alabama Forestry Commission (AFC), the Extension Service, and the Soil Conservation Service (SCS). There are 34 demonstration forests statewide totaling 19,578 acres and ranging from 140 to 2,000 acres. These forests are used locally as training sites for landowner conferences on all aspects of forest management (fig. 1).

The IPM demonstration project on Alabama's TREASURE forests and private lands had seven primary objectives:

1. Identify the best SPB hazard-rating system for Alabama.
2. Use SPB hazard rating on demonstration forests.
3. Determine the presence of and map ARR in recently cut stands.
4. Field test the cubic-foot ARR system developed by Alexander at Virginia Polytechnic Institute and State University (VPI&SU).
5. Monitor SPB and ARR interactions.
6. Use SPB and ARR preventive control approaches in TREASURE Forest Plans.
7. Package and deliver SPB/ARR hazard-rating technology to foresters, consultants, and landowners.

APPROACHES TO MEETING THE OBJECTIVES

Selecting the Best SPB Hazard-Rating System

The Alabama Forestry Commission felt that demonstration forests were a good place to "get the word out" on hazard ratings. To do this, two foresters were hired to hazard rate each demonstration forest for SPB.

The necessary data were taken for six hazard-rating systems—MS Hazard A (Kushmaul and others 1979; Nebeker and Honea 1984); MS Hazard B (Kushmaul and others 1979; Nebeker and Honea 1984); Sader Hazard (Sader and Miller 1976); P Hazard GA (Belanger 1985; Belanger and others 1981); TX Hazard (Mason 1985; Mason and others 1981); and AR Hazard (Ku 1985; Ku and others 1981). Field data were taken on a five-chain grid designed to pick up "pockets" that might exist in a stand. The collected data were sent to Mississippi State University (Nebeker and Honea 1984) for analyses. At the same time, stands were rated for management plan purposes by using the TX Hazard and Sader Hazard systems. The TX Hazard system was used in the lower Coastal Plain and the Sader system in the rest of the State.

After 2 years of data collection and analyses by Mississippi State University, one system was determined to be best for Alabama. The Kushmaul B system was later modified by Nebeker and Honea (Mississippi State), and renamed "MS Hazard B." It identified five hazard classes. In Alabama, the revised system is called the Mississippi–Alabama (MS-AL) system, but in Mississippi it is referred to as "Mississippi Hazard B." Hazard classifications are obtained by calculat-

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Figure 1—Landowner field conference on forest and pest management.

ing a discriminant score and determining which hazard class is associated with that score.

The MS-AL system uses the following inputs: 1) Pine basal area/acre, 2) stand age 3) site index, and 4) total basal area/acre. The hazard classifications are obtained by calculating a discriminant score and determining which hazard class is associated with that score.

Score = 1.8342 (pine BA) + 0.4085 (total BA) + 0.705 (age) + 0.88 (site index) − 206.315.

> 220 = Very high
168-219 = High
62-167 = Medium
11- 61 = Low
< 10 = Very low

Hazard Rating the Demonstration Forests

Each demonstration forest was rated using the TX Hazard and Sader Hazard systems and an overlap map of the SPB and ARR ratings and recommendations to lower the hazard rating of high-hazard stands were sent to the landowner. These data were added to the management plan. The data will be used for timber cutting, planning (priority setting), and monitoring potential SPB and ARR infestation sites. The demonstration area will also be used to train other local landowners.

Evaluating and Mapping ARR-Infected Stands

Nine of the 34 demonstration forests were selected to determine the best method for rating soils as high or low ARR hazard. Information on 26 soil types was collected using a tube sampler, SCS soil maps, and a combination of the sampler and maps. These data were then analyzed to determine the best method of classifying the soils.

Combining tube sampling in the field with hazard classification based on SCS soil series descriptions was found to be the best method for hazard rating soils. The tube sampling was limited to verifying the accuracy of the SCS maps. The soils were rated as high or low hazard based on internal drainage and texture, mainly in accordance with the procedure developed by Koenigs (fig.2).

In the case of soil associations in which both high and low ARR hazard soils were combined in a mapping unit, the forester could rate the entire area as high or low ARR hazard. In this study, soil associations having both high-and low-hazard soils were classified as high ARR hazard. This was a conservative approach that focused landowner attention on prevention. It was felt that the absence of preventive action where it might be needed could result in greater potential loss.

As a result of this work, it was concluded that the best method of hazard rating stands for ARR is to use the soil

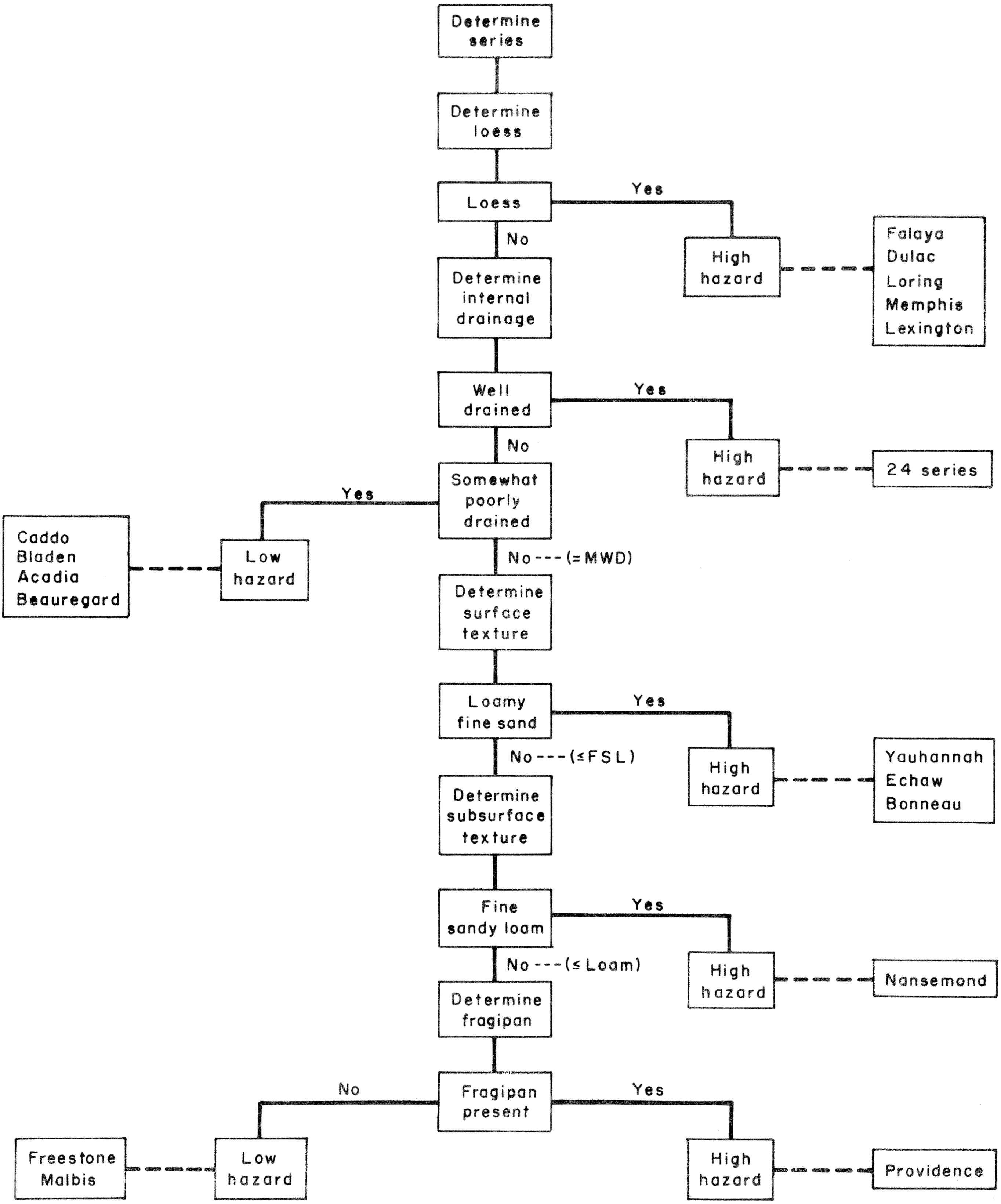

Figure 2—Annosus root rot soil series legend classification key.

maps and check them for accuracy occasionally with the tube sampler. Foresters were also encouraged to become familiar with the soils in their working area.

Field Testing the Cubic-Foot Soil Sampling System

A technique has been developed at Virginia Polytechnic Institute and State University to enable the forester to determine the actual level of annosus root rot infection and the corresponding growth rate of infected trees. This has provided a basis for making stand management recommendations. The cubic-foot ARR colonization system was evaluated in thinned pine stands in Alabama (fig. 3). The data included years since thinning, d.b.h., live crown ratio, 5-year growth increment, and cubic-foot root colonization percentages. Data were taken using 20 cubic-foot samples per stand scattered uniformly over the stand. At each plot, the following data were collected: presence of ARR/SPB, ARR hazard according to the texture of the top 12 inches of soil and internal drainage, and data on four trees (d.b.h., radial growth for last 5 years, height to live crown, and total height). Increment cores were sent to VPI&SU for analysis. At every other plot (a total of 10 in each stand), a 1-cubic-foot soil sample was taken. The number of healthy roots and total number of roots in this cubic-foot sample were recorded. These data were then provided to Dr. Sam Alexander at VPI&SU for analyses.

Figure 3—Removal of cubic-foot soil sample to determine percentage infection of pine roots by annosus root rot.

Some of the data from thinned stands were needed to determine growth as affected by ARR infection. Experience had shown that as infection levels increase, growth rates differ from those that would be expected.

It was concluded that the cubic-foot sample for determining the percentage of root infection was a practical sampling approach. The cubic-foot sample was also found to be a helpful diagnostic technique for trees that have no visible conks.

Monitoring SPB/ARR Interactions

The presence and interactions of SPB and ARR in the same stands were monitored. Locations of confirmed ARR were mapped. High-hazard ARR sites were referenced to stands hazard rated and/or infested with SPB. Conversely, medium- to high-hazard stands for SPB or those actually infested by the beetle were referenced to ARR hazard and presence. In certain instances, for the purpose of making management recommendations, SPB hazard ratings were increased to the next more serious level on a site where ARR was present. Hazard-rating maps were made a part of the management plans on the demonstration forests.

The monitoring will continue to be an ongoing effort by the AFC and the results used to verify and update future hazard ratings and management plans.

Using Preventive Techniques in TREASURE Forests

In any plan involving a pine stand, the forester is required by the Alabama Forestry Commission to include SPB and ARR hazard ratings and management recommendations. The recommendations are standardized for consistency and the records maintained on the AFC computer.

Packaging and Delivering SPB/ARR Technology

Technology transfer has been accomplished through training sessions, the use of slide-tapes, magazine articles, TV public service announcements, show-me sessions, and the like. These have all been prepared and presented to train foresters and enable them to include IPM prevention techniques in their management plans and to acquaint landowners with those techniques that will improve the success of their efforts.

Training sessions have been provided to foresters and rangers in each of the 10 Commission districts. Two sessions held for industry and consultant foresters were attended by a total of 75 foresters. Dr. Evan Nebeker, Mississippi State University, and Dr. Sam Alexander, VPI&SU, served as instructors. Followup sessions were held with district and individual company personnel. (Industry sessions were cosponsored by the Alabama Forestry Association.)

A 20-minute slide-tape on "Management of SPB and ARR" was produced, with each district office provided a copy for use during landowner training sessions in each county.

The Commission publishes a magazine entitled "Alabama's TREASURED Forests," which is directed at the State's landowners. The Pest Management staff is responsible for submitting two articles per issue The following articles on

SPB/ARR have been published in the magazine thus far:

"Know annosus root rot and react quickly." (by Kucera); 1(1):18; 1983.

"Hazard rating—a strategy for battle against the beetle." (by Hyland); 2(1):26–28; 1983.

"Control the southern pine beetle." (by Hyland); 2(4); 1983.

"Southern pine beetle and annosus root rot management." (by Hyland and Kucera); 4(1):17–18; 1985.

To promote the use of SPB hazard rating, a 30-second public service announcement (PSA) was produced. This PSA was sent to the 24 TV stations serving Alabama. In general, the PSA said: "It takes 30 years to grow a pine tree, but in only 30 days the southern pine beetle can destroy the tree. This destruction can be prevented. Contact your local AFC Office." The PSA won first prize in the International Association of Business Communicators Annual Awards Presentations.

During the last 2 years, each of the 34 demonstration forests in Alabama has held at least one show-me type training session on SPB and/or ARR. The attendance for each session ranged from 50 to 100.

INFLUENCE OF THE DEMONSTRATION PROJECT ON ALABAMA FORESTS

Spinoffs from the management plan recommendations were directed at simplifying field foresters' decisions and backing them up with economic information. These efforts included:

1. Developing the "Annosus Root Rot Management Plan for Alabama."
2. Establishing a demonstration area in thinned pine stands using *Phlebia gigantea* in Houston County to prevent the spread of ARR. An economic analysis was conducted to demonstrate the value of preventing ARR in stands treated with *P. gigantea* vs. untreated stands.
3. Establishing a demonstration area in Anniston, where three stands were treated differently: one as a control, one with stumps treated with borax, and one with stumps treated with *P. gigantea*. Cost analyses of the different treatments are underway.
4. Organizing a demonstration of the VPI&SU sampling technique in Alabama at which interested pest management researchers and land managers were invited to comment on objectives, methods, and underlying theory.
5. Conducting a statewide survey to determine the incidence and severity of ARR.
6. Transferring the new or improved technology by internally updating AFC forest management policy and incorporating SPB and ARR hazard rating into the computerized TREASURE Forest Management Plans.

The success of this demonstration project has changed the general thinking of foresters from a "control SPB when it attacks" attitude to a "prevent the attack and thereby reduce losses" outlook. ARR thinking has changed from a "that's no problem" view to one of "we'd better do something."

Pine stands that have been hazard rated (or will be rated) will be monitored for SPB and/or ARR mortality in the future. Data will be used to validate and update the hazard ratings.

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EFFECTS OF THINNING IN REDUCING STAND RISK TO SOUTHERN PINE BEETLE IN THE GEORGIA PIEDMONT

Terry S. Price[1]

INTRODUCTION

Over the past 20 years, the Georgia Forestry Commission (GFC) has pursued an aggressive southern pine beetle (SPB) control program that has varied in intensity from year to year. During the early 1960's, more than 5.5 million board feet of timber and 14,000 cords of beetle-infested wood were cut and chemically treated by the Commission. In the last 11 years, SPB outbreaks have increased in frequency and severity (fig. 1). Over 1.1 million cords of pulpwood and 195 million board feet of timber were salvaged during this period. The outbreak that occurred in 1979 killed more timber than previous outbreaks in the 1970's (table 1).

The correlation between SPB losses and forest structure is especially well illustrated by changes that have occurred in the forest resource of the Upper Piedmont (fig. 2) during the last two decades. Since 1953, the volume of softwood growing stock (trees less than or equal to 9 inches d.b.h.) has increased by 122 percent, while pine sawimber volume (trees greater than 9 inches d.b.h.) has increased 207 percent (table 2). These dramatic changes have resulted in a steady increase in stand density. It is this high density of pine sawtimber in combination with poor site conditions in the region that has resulted in extensive timber losses to the SPB. Moreover, dollar and volume losses of pine stumpage in the region between 1972 and 1980 are the highest reported for any subregion in the Southern United States, over $50 million or $2 per acre per year in the susceptible forest area (table 1).

Aggressive State and Federal programs of bark beetle detection and suppression have significantly reduced losses caused by the SPB. However, long-term reductions in losses to these insects can only be achieved by increasing the intensity of forest management. Since nonindustrial private landownerships account for over 4.6 million acres of susceptible pine forests (loblolly and shortleaf) in the Piedmont region of Georgia, the necessity for keeping these landowners informed of the latest technology and encouraging them to pursue management actions on a timely basis is quite apparent.

Activities such as thinning of overdense stands and harvesting of overmature pines can result in a reduction in severity of future SPB outbreaks (Belanger and Malac 1980). Demonstrating the value of thinnings in reducing pest impacts is most important. Nonindustrial private landowners throughout the Piedmont area of Georgia who have suffered severely from past outbreaks have traditionally been reluctant to reinvest in pine forestry. They have felt that no defenses were available to them for warding off or preventing beetle outbreaks. Some landowners in the region have even liquidated their pine stands as a means of alleviating the SPB problem. Also, these pine stands have not been reforested; instead, poor, low-quality hardwoods have claimed the sites.

The main objectives of the demonstration project instituted in Georgia were to show the nonindustrial private landowner (NIPL) a way of coping with SPB outbreaks as an alternative to clearcutting and, if possible, to compare two SPB hazard-rating systems. Other objectives were to develop guidelines for managing pine stands to reduce bark beetle-caused losses and to carry out accelerated technology transfer activities.

APPROACHES TO MEETING THE OBJECTIVES

Thinning Demonstrations

The basic approach used to demonstrate to the NIPL the value of selective thinnings was to identify susceptible loblolly/shortleaf pine stands throughout the Piedmont region of Georgia. These stands were chosen based on stand density, species composition, tree size, and location. Each stand was hazard rated by GFC entomologists using two rating systems—P Hazard GA (Belanger and others 1981) and TX Hazard (Mason 1979).

GFC foresters used the following marking guidelines:

1. Remove as many fusiform rust-infected trees as possible.
2. Favor loblolly pine over shortleaf.
3. Remove as many overmature trees as possible in uneven-aged stands.
4. Use selective marking; do not row thin in plantations.
5. Thin each stand so that the residual basal area (BA) will be equivalent to the site index.

There was no charge to landowners for marking services. The GFC foresters recommended thinning practices that minimize stand damage.

A total of 27 stands located in 16 counties was thinned during the project (table 3). Over 10,000 cords of suppressed, diseased, and highly susceptible trees were removed from the 27 stands by commercial sale. A wooden sign was erected on each site to inform the public about the demonstration.

Each landowner appeared to be satisfied with the results of the thinnings. SPB activity was not observed in any of the thinned stands nor in any adjacent unthinned stands. Beetle populations have been endemic throughout the region since 1980, except for a few isolated outbreaks that occurred in overmature dense stands.

The two hazard-rating systems proved to be useful in determining a stand's relative susceptibility to beetle attacks. The Piedmont model tended to rate more in the moderate category, whereas the Texas model tended to rate more in the high

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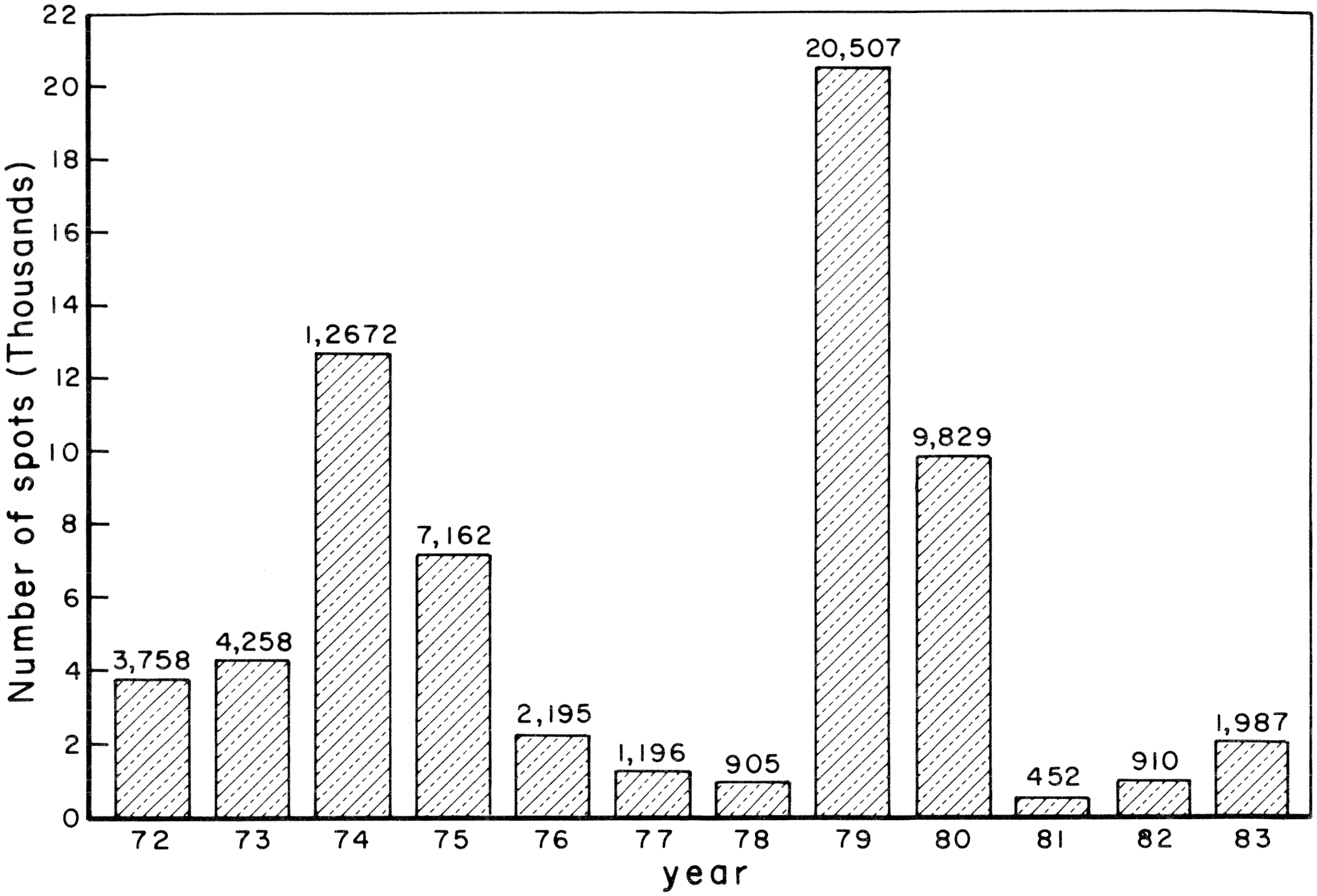

Figure 1—Number of southern pine beetle spots detected by aerial survey.

Table 1—*Southern pine beetle damage estimates in Georgia 1962, 1972–80*[1]

Calendar year[2]	Estimated volume salvaged[3] Cords	Estimated volume salvaged[3] M fbm	Total volume killed Cords	Total volume killed M fbm	Stumpage values[4] Pulpwood $/cords	Stumpage values[4] Sawtimber $/M fbm	Total value $
1962	0	0	1,785,240[5]	958	5.00	40	8,964,520
1972	13,976	10,532	35,836	11,627	6.00	65	970,771
1973	124,527	20,904	389,740	60,804	6.00	65	6,290,700
1974	179,736	22,386	402,254	43,700	10.00	70	7,081.540
1975	46,413	7,441	52,665	7,643	15.00	70	1,324,985
1976	15,609	3,446	21,677	4,221	15.00	70	620,625
1977	5,614	481	15,915	636	15.00	107	306,777
1978	1,682	180	6,487	582	16.00	118	172,468
1979	390,285	71,592	542,991	105,054	18.00	147	25,216,776
1980	384,194	57,169	528,316	78,575	21.00	110	19,737,886

[1] Information collected from State and Federal pest control specialists.
[2] Initial year based on available State records.
[3] Includes estimates on Federal, State, and private lands.
[4] Estimates from State pest specialists; same values assigned to timber salvaged.
[5] Actual volume of timber chemically treated plus estimated volume killed with no treatment.

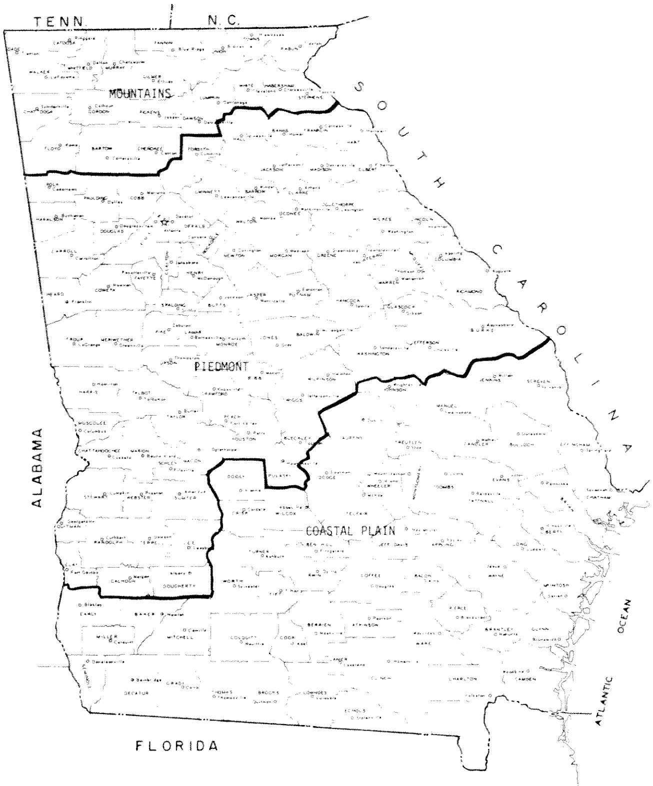

Figure 2—Broad geographic subregions in the State of Georgia.

category. However, the stands rated (whether moderate or high) needed to be thinned. The basal area prior to thinning averaged 131 square feet per acre in the 27 stands (range 80 to 200).

Packaging of Management Guidelines

A manual entitled "Guidelines for Managing Pine Bark Beetles in Georgia" was developed during the project (Karpinski and others 1984).

The manual provides guidelines for predicting, evaluating, and preventing bark beetle outbreaks, with the text outlined so that users can develop management strategies to suit their own particular forest conditions and management goals. Chapter 1 highlights the history of SPB activity in Georgia and correlates increases in beetle population levels with changes in forest structure. The chapters on aerial detection and ground evaluation provide information needed to set priorities for direct control. Procedures are given for ranking the susceptibility of stands to beetle attack. Silvicultural practices are recommended to lower the probability of attack in stands and reduce losses should attacks occur. The last chapter was designed specifically for industrial and large NIPL's to enable them to develop an integrated approach to managing pine bark beetles.

Other Technology Transfer Activities

Four panel exhibits (Expo System), seven training programs, three demonstrations, and a field trip were carried out during the project. Approximately 3,750 people attended SPB prevention thinning and hazard rating demonstration projects

Table 2—*Changes in commercial forest area, sawtimber volume, and growing stock from 1953 to 1982 in the Upper Piedmont*

Item	Change for the period—			
	1953–61	1961–72	1972–82	1953–82
	Percent			
Forest area				
Softwood	20	3	−17	4
Sawtimber volume				
Softwood	32	99	17	207
Growingstock volume				
Softwood	24	76	2	122

at various locations in the Piedmont. Several hundred pieces of literature were distributed at each meeting.

Two portable exhibits to be used as training aids were developed. One was a loblolly pine model (52 inches tall, 18 inches diameter) that was used to train resource managers in bark beetle identification. The tree was displayed in Atlanta for 2 days during Georgia-on-Parade activities. More than 1,000 people viewed the tree model, resulting in many inquiries. The other exhibit was a 4- by 2-foot scale model table display that illustrated an unmanaged loblolly/shortleaf pine stand and a well-managed loblolly pine stand. This exhibit was used for periods of several weeks at the Macon Museum of Arts and Sciences and elsewhere. Both of these exhibits will be available for future meetings and conferences throughout Georgia.

INFLUENCE OF DEMONSTRATIONS ON GEORGIA FORESTS

Those involved in this project found that demonstrations are a very important way to "sell" forest pest management techniques in Georgia. The project enabled the GFC to emphasize the identification and thinning of stands susceptible to SPB attack and spot growth. Although the effects of the thinnings may not be immediately evident, the stage has been set to further the proper management of pine stands and the reduction in beetle-caused losses in the State.

Immediate benefits of the project were:

1. GFC field foresters were exposed to the various hazard-rating systems during the early stages of the project and now consider stand hazard rating as part of the way they do business.
2. Public awareness has been increased, and landowners will now be alert to developing beetle problems.
3. Georgia landowners now know that clearcutting is not necessary to halt or prevent beetle outbreaks. Hopefully, the continuation of the project theme (thinning pine stands to reduce or prevent losses) will encourage them to consider future timber investments in the State.

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Table 3—*Individual stand data, Georgia thinning demonstration*

County	Acres	Stand type[1]	Hazard system		Species[2]	Age	Average pine BA	
			Piedmont	TX Hazard			Before	After
Baldwin	20	Natural	Moderate	Moderate	Lob/Shtlf	28	80	60
Baldwin	20	Natural	Moderate	Moderate	Lob/Shtlf	31	100	63
Banks	20	PP/Nat	Moderate	High	Lob	PP 30	PP 160	90
						Nat 33	Nat 120	80
Carroll	40	PP	Moderate	High	Lob	22	120	95
Coweta	35	Natural	High	High	Lob	31	166	96
Coweta	20	PP	Moderate	High	Lob	23	200	110
Coweta	60	PP	Low	Moderate	Lob	22	95	75
Coweta	20	Natural	Moderate	High	Lob	33	133	100
Forsyth	30	Natural	Moderate	High	Lob	37	146	85
Franklin	21	Natural	High	Very high	Lob	28	130	85
Gwinnett	45	PP	Moderate	High	Lob	27	160	80
Hart	20	PP	Moderate	Moderate	Lob	29	118	90
Hart	42	PP	Moderate	High	Lob	23	125	90
Heard	200	PP	Moderate	High	Lob	22	152	105
Heard	35	PP	Moderate	High	Lob	22	123	95
Henry	50	PP	Moderate	High	Lob	23	172	96
Jasper	225	Natural	Moderate	High	Lob/Shtlf	23	140	88
Jasper	40	PP	Moderate	Very high	Lob	22	120	80
Jasper	50	Natural	Moderate	High	Lob/Shtlf	33	144	85
Jones	70	Natural	Moderate	Moderate	Lob	31	92	82
Morgan	40	Natural	Moderate	Very high	Lob/Shtlf	46	123	82
Spalding	30	PP/Nat	High	High	Lob	PP 25	PP 170	94
						Nat 34	Nat 136	75
Spalding	40	Natural	Moderate	High	Lob	33	140	95
Spalding	40	Natural	Moderate	High	Lob	26	120	95
Talbot	99	Natural	Moderate	Moderate	Lob/Shtlf	42	90	77
Crawford	6	Natural	Low	Moderate	Lob	22	113	86
Crawford	36	Natural	Low	Moderate	Lob	19	116	95
Total	1,354	27						

[1] PP = planted pine stand
Nat = natural pine stand
[2] Lob = loblolly pine stand
Shtlf = shortlead pine

METHODS OF DETECTING, SUPPRESSING, AND PREVENTING SOUTHERN PINE BEETLE LOSSES IN MISSISSIPPI

William E. Lambert[1]

INTRODUCTION

The first recorded epidemic of the southern pine beetle (SPB) in Mississippi occurred in 1952 in the southwestern part of the State. An estimated 5 million cubic feet of timber worth $450,000 was destroyed. Since that time, the area affected by SPB has grown until all of the State supporting a loblolly/shortleaf pine host type has been infested at one time or another during the intervening 33 years.

The volume damaged since the first epidemic has often varied but the value of the timber has always increased (table 1). Today, a relatively small epidemic, in terms of area affected, can be costly. Although Mississippi has lost a total of $33.8 million dollars worth of timber to the SPB in that first and subsequent epidemics, there has been a tendency since to view this pest as an insect problem rather than a timber management problem.

This prevailing view has led to a crisis management approach to the SPB. During epidemic years, manpower, time, and money are extensively expended in "controlling the beetle." This only treats one symptom of a larger problem, and once that symptom subsides, the problem is forgotten until the next epidemic. During the years between outbreaks, when prevention activities should be stressed, the only reference to SPB is the question: "When do you think they'll be back?"

For all the recent research that has achieved a better understanding of the SPB, its management and prevention, little of this new knowledge and technology has been used. There has been a continuing need to make the resource forester, as well as the forest landowner, more aware of currently available information and technology and to demonstrate its usefulness.

A project to demonstrate recent developments in suppression and prevention tactics was begun by the Mississippi Forestry Commission in 1980. Project objectives were to: 1) Evaluate seven SPB hazard-rating systems and determine which one would be most applicable for use in Mississippi, 2) develop demonstrations of thinning as a means of reducing stand susceptibility to beetles, 3) demonstrate the utility of commonly available farm equipment in salvaging beetle-infested trees, 4) develop a series of videotapes with accompanying "how-to" type publications to educate landowners and forest resource personnel on SPB and appropriate forest management practices for preventing or reducing SPB-caused timber losses, 5) evaluate the usefulness of Agricultural Stabilization and Conservation Service (ASCS) 10- by 10-inch black-and-white contact prints for aerial detection surveys and hazard rating, and 6) demonstrate the value of LORAN-C navigation equipment in conducting aerial surveys.

APPROACHES TO MEETING THE OBJECTIVES

Hazard Rating Evaluation

Several hazard-rating systems have been developed for various parts of the Southeast. However, their effectiveness in more than one geographic area has not been demonstrated.

Table 1—*Southern pine beetle damage estimates in Mississippi, 1971–80*[1]

Calendar year[2]	Estimated volume salvaged[3]		Total volume killed		Stumpage values[4] Pulpwood	Stumpage values[4] Sawtimber	Total value
	Cords	M fbm	Cords	M fbm	$/cords	$/M fbm	$
1971	0	3,000	0	3,000	0.00	50	150,000
1972	537	7,172	537	7,172	6.00	50	361,822
1973	579	7,229	579	7,229	8.00	50	366,082
1974	329	7,474	329	7,474	8.00	50	376,332
1975	488	9,600	488	9,600	8.00	60	579,904
1976	4,023	16,949	9,823	37,949	9.00	60	2,365,347
1977	8,597	8,651	13,409	15,670	8.00	115	1,909,322
1978	2,267	4,093	8,187	8,053	5.25	140	1,170,402
1979	40,246	13,799	108,540	29,784	9.00	155	5,593,380
1980	77,630	34,137	190,632	98,933	11.00	128	14,760,376

[1] Information collected from State and Federal pest control specialists.
[2] Initial year based on available State records.
[3] Includes estimates on Federal, State, and private lands.
[4] Estimates from State pest specialists; same values assigned to timber salvaged.

[1] Forest Entomologist, Mississippi Forestry Commission, Jackson, MS.

Consequently, 649 pine stands were hazard rated during the summers of 1981, 1982, and 1983 to determine the degree of effectiveness of 7 of these systems in Mississippi. One data collection point was taken every 5 acres. The rated stands were monitored by aerial photographs taken annually and these were examined for evidence of SPB activity. Activity discovered during the collection of the field data was noted on the data sheets.

The first and second summer's data from 511 stands were collected from the general population of pine stands of suitable host type. Other selection criteria were that a stand must have a minimum of 20 percent pine component and be in private nonindustrial ownership. Part of the second summer's data were taken in three counties in the northern, central, and southern regions of the State, respectively, that had experienced severe SPB problems in the past.

The third summer's data were taken from random stands that had SPB infestations present. Since the development of the other hazard-rating systems involved taking a data point from SPB infestations, an additional data collection point was taken at the origin of the spot in these infested stands. It was also thought that the conditions at the spot origin led (or contributed) to the spot initiation.

Seven hazard-rating systems were evaluated. These systems were 1) ARKANSAS HAZARD (Ku and others 1981), 2) COAST PROB (Hedden 1985), 3) Georgia (Belanger and others 1981)[2], 4) and 5) Kushmaul A and B (Kushmaul and others 1979), 6) Sader (Sader and Miller 1976), and 7) TEXAS HAZARD (Mason and others 1981). The ARKANSAS, COAST PROB, Georgia, Kushmaul A and Kushmaul B hazard systems were modified by Mississippi State University in order to make them more comparable. The interpretation of the discriminant scores was changed to include five hazard classes in those systems that did not have five classes. The "micaceous red clays" variable in the Georgia system was not used, since Mississippi does not have that soil type. Kushmaul A and B were designated "Mississippi Hazard A" and "Mississippi Hazard B."[3]

Nebeker and Honea[4] in their analysis of these data (table 2) found that of the seven systems evaluated, the ARKANSAS and Mississippi Hazard A and B worked best on infested stands and spots in Mississippi. Of these three systems, the Mississippi Hazard B performed better on infested stands than the ARKANSAS or Mississippi Hazard A and nearly as well on infested spots.

Mississippi Hazard B did place 2 percent fewer infested spots in the high-hazard category than either the ARKANSAS or Mississippi Hazard A system, rating 66 percent of the stands high hazard compared with 68 percent for both of the other systems. However, it also placed 3 percent fewer infested spots in the low-hazard category than Mississippi Hazard A and 2 percent fewer than ARKANSAS HAZARD. Mississippi Hazard B rated 3 percent low hazard, whereas Mississippi Hazard A and ARKANSAS rated 6 percent and 5 percent low hazard, respectively.

[2] This hazard system has been replaced by the PIEDMONT RISK system for use in Georgia.

[3] Nebeker and Honea; personal communication.

[4] See footnote 3.

Table 2—*Percentage of infested stands and spots by hazard-rating systems and hazard-rating class in Mississippi*

Hazard-rating system	Hazard class[1] High		Medium		Low	
Mississippi Hazard B	46	66	58	32	6	3
Mississippi Hazard A	42	68	45	26	13	6
ARKANSAS	39	68	36	27	15	5
TEXAS	30	47	45	38	25	15
Sader	27	51	23	23	50	25
COAST PROB	13	41	35	36	52	23
Georgia	15	28	31	32	54	40

[1] First column under each hazard class relates to percentage of infested stands; second column under each hazard class relates to percentage of infested spots at point of origin.

Because the Mississippi Hazard B system also has three of its five variables (total basal area, pine basal area, and number of stems per acre) capable of being manipulated to reduce a stand's hazard, it was selected for rating stands in Missisippi. The Mississippi Hazard A system has only one of two variables (pine basal area) that could be manipulated and the ARKANSAS HAZARD system has only two of four variables (total and hardwood basal area) with this capability.

The Mississippi Hazard B system has been developed for a simple computer program that will run on the Apple II and compatible microcomputers. With this capability, hazard rating will be included in the Commission's future forest management plans, which will also consider SPB control as well as other needed forest management practices.

General facts about hazard rating, what it is, how to use it, and examples of two rating systems, using Mississippi Hazard A and B, are explained in a videotape and an accompanying publication entitled "Applying a Southern Pine Beetle Rating System," released by the Mississippi Forestry Commission (see table 3).

Thinning Demonstrations

Although thinning (as a part of stand management) has been recognized as a means for reducing SPB susceptibility, many landowners are still reluctant to do any thinning on their properties. To encourage thinning as a management practice, several demonstrations were installed across the State in which stands were partially thinned. This resulted in a potential for comparison of thinned versus unthinned areas.

It was hoped that, in addition to the added benefits of more and faster growth, some beetle infestations would occur on these areas. If occurring in the unthinned portion, the preference of the beetles for denser, slower growing stands could be shown. If occurring in the thinned portion, the slower growth of the infestation and the correspondingly reduced damage could be demonstrated. Any SPB infestations that occurred could likely be salvaged using commonly available farm equipment. This would demonstrate to landowners that in many cases they would not necessarily be dependent on a

Table 3—*Videotapes and publications developed for technology transfer in the Mississippi demonstration project*

Videotape title	Companion publication	Subject
Forestry is Good Business	Cultural Practices Are Good Business	Costs/benefits of management practices
Leave Tree Marking of Susceptible Pine Stands	Leave Tree Marking of Susceptible Pine Stands	Thinning and competition concepts and methodology
Removing Competing Hardwoods	Removing Competing Hardwoods From Pine Stands	Thinning techniques
Detecting and Preventing the Southern Pine Beetle	Detecting and Preventing the Spread of the Southern Pine Beetle	Identifying susceptible stands, spot detection and location, setting control priorities, selecting treatment
Applying a Hazard System for the Southern Pine Beetle	Applying a Southern Pine Beetle Rating System	Stand hazard rating

pulpwood cutter or logger for salvage but could do the work themselves. Even if the landowner did not want to go to the trouble of hauling the wood to a yard, it could be skidded to a roadside or other easily accessible point and sold from there. In this way, the smaller or more inaccessible infestations not ordinarily salvaged would be more likely to be controlled.

Because many landowners were unwilling to "tie up" their property for the project's duration or did not want to be involved, only a few properties located in accessible or visible areas were available for use in this phase of the project. Of these, only two were actually thinned due to poor market conditions. No infestations occurred in either area, but infestations in other stands were salvaged using farm equipment. In these demonstrations, infested trees were cut and bucked into manageable log lengths, then skidded to a roadside or accessible loading point with logging chains and hooks or logging tongs attached to a farm tractor drawbar. Ford 4110 rubber-tired farm tractors were used for skidding.

A great deal of landowner interest was generated in the salvage demonstrations, and, on the whole, this part of the project was a success.

Landowner Education and Technology Transfer

Much of the current knowledge on SPB management and control has not been widely used. Thus, to educate landowners and forest resource personnel and present the information gained from this project, a series of five videotapes (table 3) was produced. This series, entitled "Forest Management Practices," covered in each tape an aspect of forest management tied to SPB management, prevention, or control.

The lead-in tape for the series was "Forestry Is Good Business." This program was intended to set the stage for the rest of the series by introducing landowners to various management practices, demonstrating their need, and pointing out how they would be economically beneficial in the long run with more monetary gain prior to and at harvest. Another benefit was fewer beetle problems.

Thinning and competition were covered in "Leave Tree Marking of Susceptible Pine Stands" and "Removing Competing Hardwoods." "Detecting and Preventing the Southern Pine Beetle" dealt with identifying susceptible stands, detecting and confirming the presence of southern pine beetles, evaluating infestations, setting control priorities, and choosing a treatment method. The final tape in the series, "Applying a Hazard System for the Southern Pine Beetle," covered hazard rating, what it is, how to take measurements needed to get a rating, and two examples of stand rating using two different systems.

Each videotape was accompanied by a "how-to" type publication (table 3). These corresponded to the tapes and served as a reference for the viewer. All of these videotapes may be purchased from the Mississippi State Cooperative Extension Service.

Aerial Detection Using ASCS Photography

The use of aerial photos in detection surveys and in hazard rating large areas has immense potential benefits in SPB management. Aerial photos can increase the accuracy of infestation plotting and thereby save time in ground location. In the Mississippi project, hazard rating of large areas could only be efficiently accomplished using aerial photos due to the time and expense involved. This delineates the areas with the greatest potential for infestations to occur, allowing the concentration of survey efforts and other resources in areas where benefits would be greatest.

This phase of the project attempted to accomplish its objective using photography that was generally available. Black-and-white contact prints from the Agricultural Stabilization and Conservation Service were selected. For aerial detection work, these photos were excellent. In comparison with standard sketch-mapping techniques that use 1/2-inch- to 1-mile-scale highway maps, the ASCS photos made it much easier to keep track of a position and reorient should an observer become lost. Since the photos conformed to natural terrain features, accurate plotting was possible. This, coupled with photo use in ground checking, avoided a great deal of lost time locating inaccurately plotted infestations and orienting locations plotted in map sections with few or no landmarks available.

The ASCS photos were taken for uses other than interpretive analysis and their resolution is poorer than that of mapping-quality photography, often resulting in a certain amount of blur or fuzziness under magnification. Hence, their usefulness in hazard-rating work proved to be limited, since the intent was to take as much information from photos as was normally taken from ground work. The relatively small scale used in the ASCS photos, 1/40,000 and 1/58,000, made measurements error prone and interpretation difficult. This was further compounded by the fact that the photos were not always taken during leaf-off condition, which is essential for accurate distinction between pine and hardwood stands.

Two of the hazard-rating systems compared in this project were originally intended to be used in conjunction with aerial photos to acquire stand information. However, neither of these systems proved to be accurate enough for use in Mississippi. (A system using gross measurements or stand features could possibly be developed, but this was neither the intent nor the purpose of this project).

Electronic Navigation for Aerial Surveys

A LORAN-C electronic navigation unit was acquired during the project to demonstrate the value of such equipment in increasing aerial survey accuracy (Dull 1980). It made possible the reflying of the same flight lines, permitting a more reliable evaluation of the progress of spot growth. In situations where the pilot also had to act as an observer and the LORAN was tied into the autopilot, attention could be concentrated more on plotting rather than being divided between plotting and staying on flight lines. When detection surveys were undertaken in remote areas and infestation levels were low, the latitude and longitude of spots were determined with the LORAN unit rather than by positions plotted on highway maps or photos. Exact locations could thus be determined.

Some areas of the State that were surveyed under Spanish land grants are nearly a jigsaw puzzle in the way the sections are arranged in townships. These sections are of varying shapes such as circular, triangular, or other nonsymmetrical designs. In some cases, more than 50 to 60 sections exist per township. In these areas, the use of a navigation unit like the LORAN was the only way to establish flight lines that the pilot could fly or refly.

Other Project Activities

Other activities of the Mississippi demonstration project included use of the videotapes in training or other presentations. Although their use was somewhat limited due to delays in receiving the accompanying publications, 12 sessions involving field day presentations, county forestry committees, field personnel training, civic groups, and group displays were presented. The audience attending these sessions totaled 498. Further use of these tapes and publications for landowner meetings and field personnel training is in the planning stage.

INFLUENCE OF THE DEMONSTRATION PROJECT ON MISSISSIPPI FORESTS

Although some of the objectives of the project were not fully met, as a whole, they served to redirect the emphasis of our program in some areas and refine efforts in others. Mississippi is now moving toward incorporating SPB hazard rating in forest management plans. Whenever a timber stand is cruised and evaluated for a management plan, information on its susceptibility to SPB will also be considered. Our insect and disease report form is being revised so that an area containing reported beetle infestations can be hazard rated and that information made available to the landowner. Information on hazard rating, SPB, forest management practices, and their benefits relative to both SPB prevention and financial goals is available to landowners and forest resource personnel in the form of videotapes and publications. Improvements in aerial survey techniques have been incorporated into our annual and presuppression surveys.

The present and continued use of the knowledge gained in identifying stands susceptible to SPB, informing landowners of beetle prevention and control tactics, and emphasizing the value of sound forest management practices and improved survey techniques will be of immense benefit to the State in the future. These results will constitute an important step in the direction of integrated pest management and away from pest control.

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INCORPORATING PEST MANAGEMENT TECHNOLOGY INTO LAND MANAGEMENT DECISIONMAKING: HOLLY SPRINGS NATIONAL FOREST, MISSISSIPPI

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INTRODUCTION

The Holly Springs Ranger District (RD) of the Holly Springs National Forest (NF) consists of 128,300 acres. The District experienced its first southern pine beetle (SPB) outbreak in 1979, which resulted in a total of 2,680 M fbm of pulpwood and sawtimber being salvaged on an SPB suppression project implemented in fiscal year 1980. There is also a history of annosus root rot (ARR) in the area; however, its total impact is yet unknown. These circumstances, together with the expressed interest of Holly Springs personnel, created an opportunity to demonstrate the incorporation of new pest management technology into National Forest management practices.

To be extensively utilized, new pest management information must be readily accessible. Available information, heretofore, had not been in a simple, easy-to-access package for National Forest resource managers. Information such as SPB spot data or the hazard rating of a particular stand had to be requested through the Forest Pest Management (FPM) field offices of the Forest Service's State and Private Forestry organization. Control and prevention recommendations for one pest sometimes conflicted with those for another (e.g., thinning stands to discourage SPB buildup could lead to annosus root rot problems), causing confusion and requiring interpretation before a decision could be made. In addition, Southern Region National Forest computerized stand data, the Continuous Inventory of Stand Conditions (CISC), had to be requested through the Forest Supervisor's office, thus preventing a District Forester from easily combining resource information with pest management information. Consequently, many forest management decisions had to be made without utilizing all the pest management information available.

The objective of the Holly Springs project was to demonstrate the feasibility of incorporating existing and new pest management technologies into National Forest land management decisionmaking. Forest pest management technology was to be made readily available through automatic data-processing equipment, which would result in its more rapid, expanded utilization.

APPROACH TO MEETING OBJECTIVES

Interactive Data Processing

At the beginning of the demonstration project, a microcomputer was purchased for the FPM Field Office in Pineville, LA. SPB recordkeeping systems, SPB spot growth models, the IPM Decision Key (Anderson and others 1985), and economic models for various pests were placed on this computer and made available in an interactive format known as the FPM System (fig. 1). A portable computer terminal was placed on the Holly Springs NF so that District personnel could access these programs. They were also trained to access the USDA Forest Service computer in Fort Collins, CO, to directly obtain CISC data.

An employee trained in both forestry and pest management and knowledgeable in computer use was placed in the District office at Holly Springs to enhance communication between District personnel and FPM. In addition, an effort was made to include district personnel in all discussions that required either forestry information or data collection for making a pest management decision.

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 0. FINISHED

SPB INFORMATION SYSTEM

 1. SPBIS DATA ENTRY
 2. SPBIS SUMMARY
 3. SPBIS SPOT PRIORITY

MISCELLANEOUS PROGRAMS

10. PRE-B/C ANALYSIS
11. B/C WITH AND W/O A PROJECT
12. TFS SPOT GROWTH MODEL
13. MESSAGE SENDER--NOT FOR GENERAL USE
14. LIST A FILE
15. EDITOR

INTEGRATED PEST MANAGEMENT-DECISION KEY

20. FOR THE MAJOR SOUTHERN PINES (WITH HAZARD RATING OPTION)
21. FOR THE MAJOR SOUTHERN PINES (WITHOUT HAZARD RATING OPTION)
22. FOR SOUTHERN HARDWOODS
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Figure 1—Menu for the FPM System interactive microcomputer programs.

[1] Respectively, Entomologist, Plant Pathologist, and Entomologist, USDA Forest Service, Southern Region, Forest Pest Management, Pineville, LA; Timber Management Assistant, USDA Forest Service, Southern Region, Holly Springs National Forest, Holly Springs, MS; Computer Specialist, USDA Forest Service, Southern Region, Forest Pest Management, Atlanta, GA; and former Biological Technician, USDA Forest Service, Southern Region, Forest Pest Management, Pineville, LA, (currently County Forester, Texas Forest Service, Pittsburg, TX).

The authors gratefully acknowledge the Forest Supervisor and staff, National Forests in Mississippi, and the staff of the Holly Springs NF for support and assistance during this project. Special thanks are extended to Clint Floyd, District Ranger; Art O'Farrell, formerly District Soil Scientist; and Brent Botts, Forester. Their interest, enthusiasm, and support were major reasons for the project's success.

SPB risk rating.—Studies of bark beetle/site/host interrelationships across the South have led to identification of certain site/stand characteristics consistently associated with SPB infestations (Coster and Searcy 1981). Based on this knowledge, predictive techniques (stand risk ratings) have been developed to rate forest stand susceptibility to SPB attack.

Lorio and Sommers (1981) developed a two-phase SPB stand risk-rating system for the Kisatchie NF in Louisiana that utilizes CISC data. The system is called NF RISK. The system was tested and then implemented on the Holly Springs NF in 1979.

The first version of the NF RISK system uses a FORTRAN computer program, RISK, which accesses the CISC information at the USDA Forest Service Computer Center. It searches five data fields—forest type, stand condition class, method of cut, operability, and site index—and prints out a listing of high-, medium-, and low-risk stands for an entire National Forest Ranger District. Because CISC does not include data on basal area, method of cut and operability were used as general indicators of stand density.

An improvement in the NF RISK system permitted National Forest personnel to include individual stand basal areas in the risk rating, as well as to update CISC stand risk ratings, as new silvicultural prescriptions were completed. Thus, an entire Ranger District could be risk rated over a 10-year period using actual field-collected data.

NF RISK was judged to be the best SPB hazard/risk rating system for implementation on the Holly Springs RD because of three factors: 1) It was designed for National Forests, 2) it required no additional data collection, and 3) the Holly Springs NF has forest stand conditions similar to the Kisatchie NF.

Summary program results comparing the CISC data for Holly Springs and the Kisatchie revealed that while forest type, age distribution, and stand condition classes were similar, there was a significant difference in average site index for loblolly and shortleaf pine. Therefore, the site index parameters in the NF RISK program were lowered. The resulting list of high-and medium-risk stands seemed to accurately reflect the areas where significant resource loss would take place if SPB infestations were to occur. Respectively, 13, 17, and 70 percent of the stands on the Holly Springs NF were rated as high, medium, and low risk (fig. 2). This information was used to update the CISC data. The improved version of NF RISK was also implemented. A supplement to the "Compartment Prescription Handbook for the National Forests in Mississippi" was written to allow inclusion of pine basal area and SPB risk rating based on field data on the CISC forms. These risk codes serve as constant reminders of potential SPB problems in these stands.

SPB Information System (SPBIS).—A computerized record-keeping system had already been developed and revised several times for use on National Forest Ranger Districts with SPB suppression projects. The purpose of the system was to provide information on individual SPB infestations for historical use and documentation of suppression costs. These records had heretofore been maintained on the Forest Service computer at Fort Collins and were difficult to access. Records were provided to FPM only after a spot was controlled and offered little benefit to the District.

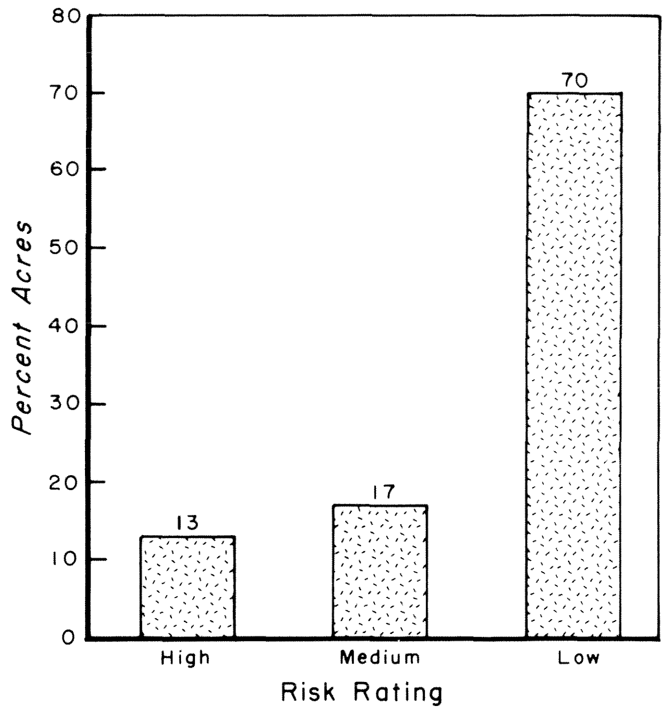

Figure 2—Percentage of total regulated acres on the Holly Springs National Forest by SPB risk class, as classified by NF RISK, February 1985.

After consultation with District personnel, an improved information system (SPBIS) was devised for the microcomputer. Some time-consuming data collection was deleted and information added that would set priorities for spot control and generate summary reports required by Supervisor's Offices. This system, in combination with the terminal in the District Office, allowed foresters to input and have immediate access to their SPB data (fig. 3).

SPBIS was initially field-tested on the Holly Springs, but a 1983 SPB outbreak in Texas allowed the first field testing of the system under epidemic conditions. Because only minor portions of the data were valuable to the Districts, SPBIS was further modified so the records could be accessed with a data-base management program (written by Robert Uhler, USDA Forest Service, Southern Region). This allowed the Districts to sort data and get totals on any information contained in their records. It also enhanced user acceptance of the system since information could be retrieved by location, spot size, control date, control treatment, or other criteria, and included volume totals. Since RECORD KEEPER[2] can be used to analyze the data in different combinations of spot size, control treatments, and elapsed time for different control activities by spot priority, problem areas can be detected without actually visiting spots. During technical assistance trips, time can be spent discussing and visiting suspected problem areas without having to rely on their accidental discovery in the field.

[2] A computerized spread sheet program to be used with SPBIS.

---LOCATION------			-----SURVEY--------			---------GROUND CHECK-----------						-------SALE PREP------			-------SUPPRESSION------				-----SECONDARY TRT----		
					GR.IN			# INF					SAW	PULP		PRIM	# OF	SUP		SAW	PULP
SPOT	COMP	STAND	DATE	TYPE	TREES	DATE	INF	TREES	TBA	PBA	P/S	DATE	VOLUME	VOLUME	DATE	TRT	TREES	TRT	DATE	VOLUME	VOLUME
2001	0085	00	841001	A		841002	Y	25	90	70	S	841022	68	0	841106	S					
2002	0051	00	841001	A	15	841002	Y	15	90	70	S	841023	87	0							
2003	0072	00	841001	A	8	841003	N	2	110	80	S	841003	0	0	841003	D					
2004	0072	00	841001	A	3	841003	N	0	110	80	S	841003	0	0	841003	D					
2005	0021	00	841001	A	10	841003	Y	18	90	90	S	841023	19	0	841106	S					
2006	0010	00	841001	A	4	841003	Y	55	80	70	S	841023	97	0	841105	S					
2007	0012	00	841001	A	8	841005	N	0	90	90	S	841005	0	0	841005	D					
2008	0023	00	841001	A	6	841004	N	0	80	80	S	841004	0	0	841004	D					
2009	0011	00	841001	A	2	841009	N	0	80	70	S	841009	0	0	841009	D					
2010	0011	00	841001	A	4	841009	N	0	100	100	S	841009	0	0	841009	D					

Figure 3—Example of data listing from the Southern Pine Beetle Information System (SPBIS).

SPB priority program.—In conjunction with SPBIS, another computer program was written that accessed the District's ground check data and assigned a control priority. This program was based on work by Billings and Pase (1979) and was also field tested in Texas, especially on the Sam Houston National Forest. It provides information on the number of additional trees that will be killed in 30 days and the number that will be actively infected in 30 days (Billings and Hynum 1980) (fig. 4). This allows the District to concentrate on spots that are most likely to grow.

SPB summary program.—During SPB outbreaks, the National Forest Supervisor's Offices often need data on either the status of control efforts or the volume of timber removed. This information can be obtained by utilizing a program that reads the necessary information from SPBIS and then summarizes data for the report. Most Supervisor's Offices have a terminal or computer capable of accessing the FPM microcomputer in Pineville, LA, so a status report can be obtained at any time (fig. 5).

Management Approaches for Annosus Root Rot

ARR hazard rating.—Hazard rating for ARR using soil characteristics has been of interest since a southwide survey found higher levels of ARR damage in thinned stands with sandy soils than in those with loamy or clayey soils (Powers and Verrall 1962). A workable hazard-rating method based on a survey of thinned plantations in Virginia was developed by Morris and Frazier (1966) and further substantiated by other researchers (Alexander and others 1975; Froelich and others 1966). Survey work by the Southern and Southeastern Forest Experiment Stations (Froelich and others 1977; Kuhlman and others 1976) identified a number of soil series that often sustained severe ARR infections.

To utilize this soils information, a list of mapped soil series on the Holly Springs RD was prepared using Soil Conservation Service soil series descriptions. Series were placed in a generally decreasing order of sand content and increasing clay content. Hazard rating was done according to methods detailed in the research cited above (table 1). While the method of hazard rating by soil series of Froelich and others (1977) initially was judged best for the Holly Springs, the hazard-rating method was later modified to designate silt loam soils as moderate hazard and add Smithdale as high hazard (Mistretta and others 1983). Mylar overlays of district soils maps were color coded to indicate high- and moderate-hazard soil series and the maps bound in a notebook (for District use) that included a detailed explanation of the hazard ratings and guidelines for using them (fig. 6). These mylar hazard maps can be directly overlaid on stand maps during future prescription processes and will be particularly useful because SPB hazard from CISC files or the prescription process can be easily coded on stand maps, and hazard of both SPB and ARR directly compared. A composite map of the District showing both SPB risk and ARR hazard was made for use in planning. During the hazard-rating process, District personnel were shown the various hazard classes of soils in the field.

Disease status.—A survey of 23 thinned loblolly, shortleaf, and mixed stands was made to provide the District with information about the abundance, distribution, and impact of ARR. The disease was found to be widespread and common in loblolly stands (table 2) with damage mostly moderate. Less than 10 percent of the shortleaf pine stands had evidence of root rot. Fifty percent of the stands with both loblolly and shortleaf had root rot. Survey results indicate that the disease is most likely to cause problems in loblolly plantations; however, as more shortleaf plantations are established and thinned, ARR problems may increase for this species.

Annosus sampling procedure (ASP).—To provide the District with more specific information about root rot, a cooperative arrangement was made with Dr. Sam Alexander of Virginia Polytechnic Institute and State University (VPI&SU) to field test the annosus sampling procedure. Four thinned loblolly pine plantations were selected for sampling and 20 plots of four trees were established in each. Trees were measured for height, d.b.h., radial growth, and live crown ratio, and a 1-foot-square by 1-foot-deep hole was dug at 10 sample points and the pine roots removed and inspected for symptoms of ARR. Percentage of infection was then calculated for the plantations, utilizing root counts from all 10 samples (Alexander and others 1985) (table 3).

NATIONAL FOREST-13 RANGER DISTRICT-1

HIGH PRIORITY

SPOT NO.	COMP	STAND	RISK SCORE	30 ATK	DAYS TRA
0081	0051	00	100	49	62
0073	0050	00	90	102	130
0074	0058	00	90	57	71
0080	0094	00	90	38	50
0075	0046	00	90	33	43
0077	0034	00	80	17	23
0076	0005	00	70	23	31
0079	0041	00	70	18	25
2096	0094	00	70	9	13

MEDIUM PRIORITY

SPOT NO.	COMP	STAND	RISK SCORE	30 ATK	DAYS TRA
0230	0002	10	60	15	21
0078	0082	75	60	4	7
2094	0099	00	60	0	1
0045	0073	00	50	8	12
0046	0022	00	50	7	11
0013	32		50	2	6
2002	0051	00	50	2	5
2099	0099	00	50	0	1
2103	0094	00	50	0	1
2051	0093	00	50	0	1
0083	0071	00	50	0	1
2100	0068	00	50	0	1
2052	0022	00	50	0	1
2087	0010	00	50	0	1
2082	0010	00	50	0	1
2053	0009	00	50	0	1
2088	0008	00	50	0	1
2067	0099	00	50	0	0
2085	0069	00	50	0	0
2066	0067	00	50	0	0
2065	0067	00	50	0	0
0059	0081	00	40	0	1
2054	0008	00	40	0	1

LOW PRIORITY

SPOT NO.	COMP	STAND	SCORE	30 ATK	DAYS TRA
0056	0037	00	30	0	0
2095	0099	00	20	0	1
2069	0071	00	20	0	1
2097	0069	00	10	0	0
2098	0068	00	10	0	0
0008	23		0	0	1

ATK = ADDITIONAL TREES KILLED
TRA = TREES REMAINING ACTIVE

Figure 4—Example of computer output showing a priority listing for spots that need to be controlled.

NATIONAL FOREST-13 RANGER DISTRICT-1
REPORTING PERIOD: 84/10/01 TO 85/12/31

TOTAL PULPWOOD MARKED. 9
TOTAL SAWTIMBER MARKED 1965
NUMBER OF SPOTS MARKED 48

PULPWOOD SALVAGED. 0
SAWTIMBER SALVAGED 1861
SPOTS SALVAGED 21
SPOTS TREATED (CUT/LEAVE). 23
TREES TREATED (CUT/LEAVE). 3745
SPOTS GONE INACTIVE. 20
SPOTS TREATED (TOTAL). 74

PULPWD MARKED BUT NOT TRT. 8
SAWTBR MARKED BUT NOT TRT. 97
SPOTS MARKED BUT NOT TRT. 2

DATE OF LAST FLIGHT. 85/02/26
SPOTS OBSERVED-LAST FLIGHT 0
TOTAL NUMBER OF NEW SPOTS. 87

Figure 5—Summary of southern pine beetle control data obtained from SPBIS.

To help validate this method, three 1/20-acre plots were established in each plantation and all the trees pulled out with a bulldozer. Each plot tree was measured and percentage of root infection calculated from an examination of the totally exposed root systems. These data, together with similar data from all over the South, were used to develop the growth and yield model GY-ANNOSUS (Hokans and Alexander 1985), described below.

GY-ANNOSUS model.—To utilize the stand and ARR infection data, researchers at VPI&SU modified a growth and yield model for thinned loblolly pine plantations and designated the modification GY-ANNOSUS (Hokans and others 1985). The model predicts the cubic foot yield loss due to root disease at specified points in the future (fig. 7). Infection percentage and stand parameters obtained in the ASP were used to drive the computerized growth and yield model.

Projected yield losses for the four plantations at the next thinning (10 years after thinning) ranged from 5 to 15 percent (table 3). Infection levels in these plantations ranged from 17 to 33 percent. All four plantations were on silt loam soils (Lexington and Providence) that had initially been rated as high hazard. Based on this level of infection and yield loss, the hazard rating of silt loam in this area was reduced to intermediate, as previously mentioned.

Economics of borax treatment.—To demonstrate the use of the computer model "Economic Analysis of Borax Treatment" (available as a separate program on the IPM Decision

Table 1—*Annosus root rot hazard for soils series on the Holly Springs National Forest according to various workers and as used in the Integrated Pest Management Demonstration Project*

Soil series	Morris and Frazier 1966	Froelich et. al. 1966 Alexander et. al. 1975	Kuhlman et. al. 1976 Froelich et. al. 1977	Mistretta et. al. 1983	Hazard rating applied[1]	As modified or interpreted[2]
Eustis	High	High	High	—	High	High
Lucy	High	High	High	—	High	High
Troup	High	High	High	—	High	High
McLaurin	High	High	High	—	High	High
Smithdale	High	High	—	High[3]	High	High
Ruston	High	High	High	—	High	High
Jena	Low	Low	—	—	Low	Low
Bibb	Low	Low	—	—	Low	Low
Ochlockonee	Low	Low	—	—	Low	Low
Maben	Low	Low	—	—	Low	Low
Mantachie	Low	Low	—	—	Low	Low
Oaklimiter	Low	Low	—	—	Low	Low
Sweatman	Low	Low	—	—	Low	Low
Tippah	Low	Low	—	—	Low	Low
Lexington (loess)	Intermed.	Low	High	—	High	Intermed.
Chenneby	Low	Low	—	—	Low	Low
Dulac (loess)	Intermed.	Low	High	—	High	Intermed.
Bude	Low	Low	—	—	Low	Low
Calloway	Low	Low	—	—	Low	Low
Cascilla	Intermed.	Low	High	—	High	Intermed.
Providence	Intermed.	Low	High	—	High	Intermed.
Grenada	Intermed.	Low	—	—	Low	Low
Loring (loess)	Intermed.	Low	High	—	High	Intermed.
Gillsburg	Low	Low	—	—	Low	Low
Falaya (loess)	Low	Low	High	—	High	Intermed.
Arkabutla	Low	Low	—	—	Low	Low

[1] This scheme was used as a starting point and soil hazard maps were coded accordingly.
[2] Based on our field surveys, we feel this more accurately represents the hazard.
[3] Based on a report (Mistretta and others 1983) of damage in 4 of 5 stands surveyed on this soil on the Bankhead National Forest, Alabama.

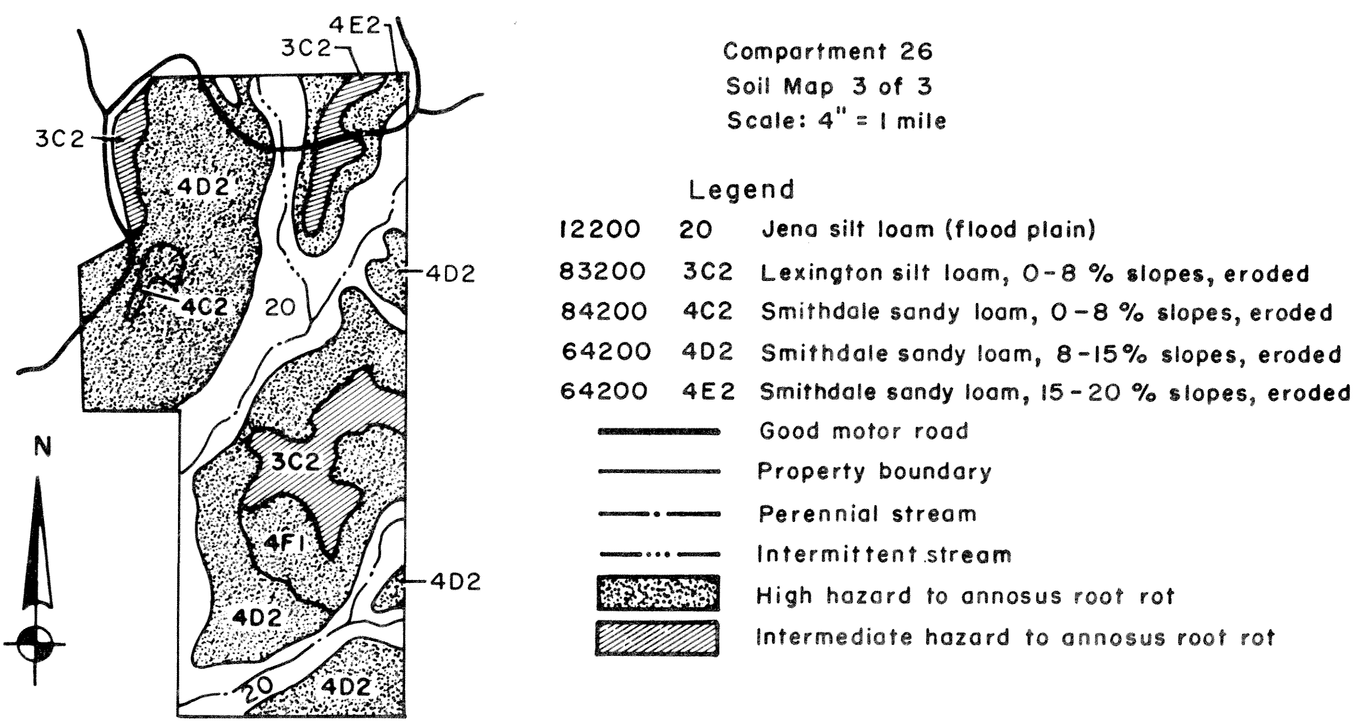

Figure 6—Annosus root rot hazard map.

Key), data were collected from four loblolly stands marked for their first thinning. After stand parameter input, the model predicts a percent return on investment (in borax treatment) after taxes (table 4). Utilizing yield-loss percentages generated by GY-ANNOSUS results in a relatively accurate reading of the output table (fig. 8).

Other Approaches

IPM Decision Key.—The IPM Decision Key, written by a team of entomologists and pathologists and a silviculturist, is an interactive program designed for a microcomputer. Questions are asked that require forest stand data and short-term management plans. A list of management recommendations is then provided for SPB, pales weevil, fusiform rust, ARR, pitch canker, and littleleaf disease.

This program was already developed at the time the Holly Springs demonstration project was initiated. The project objective was to determine how applicable the Decision Key was to National Forests. The major concern of field foresters was that, for use in compartment prescription writing, more specific information was needed. For instance, one recommendation on high-hazard annosus sites is to increase spacing in the next plantation. Specific information is needed in the compartment prescription on the required spacing for planting. In some cases (such as this one), research information is not available, but, if this option is chosen, the District foresters

CUBIC-FOOT VOLUME PROJECTIONS FOR THINNED LOBLOLLY PINE PLANTATIONS
ON HIGH ANNOSUS HAZARD SITES. (VERSION 1.0)

STAND IDENTIFIER : HS-28-1   ANALYST : STARKEY
SITE INDEX (BASE AGE 25) : 55 FEET   DATE : 3-21-85
ANNOSUS INCIDENCE : 19 PERCENT

	INCIDENCE = 19 %			NO DISEASE			DIFFERENCE		
AGE	BASAL AREA (SQFT)	OB VOL TO 4IN TOP (CUFT)	VOL YIELD (CUFT)	BASAL AREA (SQFT)	OB VOL TO 4IN TOP (CUFT)	VOL YIELD (CUFT)	OB VOL TO 4IN TOP (CUFT)	VOL YIELD (CUFT)	YIELD LOSS (%)
30	88	1991	----	88	1991	----	0	----	----
31	91	2114	----	91	2124	----	10	----	----
32	93	2236	----	94	2257	----	20	----	----
33	96	2358	----	97	2389	----	31	----	----
34	98	2478	----	99	2521	----	42	----	----
35	100	2597	----	102	2651	----	54	----	----
36	102	2715	----	105	2781	----	66	----	----
36	80	2016	699	80	2016	765	0	66	8.6
37	82	2119	----	82	2127	----	8	----	----
38	84	2222	----	85	2239	----	17	----	----
39	86	2324	----	87	2350	----	26	----	----
40	88	2425	----	90	2460	----	35	----	----
41	90	2526	----	92	2571	----	45	----	----
42	92	2625	----	94	2680	----	55	----	----
43	94	2724	----	96	2789	----	65	----	----
44	96	2822	----	98	2896	----	75	----	----
45	98	2918	----	100	3003	----	85	----	----
46	100	3013	----	102	3109	----	96	----	----
47	101	3108	----	104	3214	----	107	----	----
48	103	3201	----	106	3318	----	117	----	----
49	105	3293	----	108	3421	----	128	----	----
50	106	3383	----	110	3523	----	139	----	----
50	0	0	3383	0	0	3523	0	140	4
TOTALS			4082			4288		206	

Figure 7—Output table from GY-ANNOSUS.

ECONOMIC ANALYSIS OF BORAX TREATMENT

LOB, SLASH, SHORT, OR LONG..	LOB
STAND AGE..................	26
STEMS/ACRE.................	380
SITE INDEX (BASE AGE 50)....	93
AVERAGE DBH................	8.7
AVERAGE HEIGHT.............	60
% STEMS THINNED............	43
HRLY RATE OF CHAINSAW OPER..	10
COST/100 LBS. OF BORAX......	33.68
HARVEST AGE................	36
PULP OR SAW HARVEST (P/S)...	P
PRESENT PRICE/CORDS.........	10
MARGINAL INCOME TAX (%).....	20
INFLATION RATE (%)..........	4

BEFORE TAXES AT HARVEST

MORTALITY DUE TO ANNOSUS %	WITH TREATMENT VOLUME (CRDS)	WITH TREATMENT VALUE $	WITHOUT TREATMENT VOLUME (CRDS)	WITHOUT TREATMENT VALUE $	LOSSES AVERTED $	RETURN ON COST OF TREATMENT %
5	43.12	705.12	40.97	669.87	35.26	4.74
10	43.12	705.12	38.81	634.61	70.51	12.26
15	43.12	705.12	36.66	599.35	105.77	16.90
20	43.12	705.12	34.50	564.10	141.02	20.32
25	43.12	705.12	32.34	528.84	176.28	23.03
30	43.12	705.12	30.19	493.59	211.54	25.29
35	43.12	705.12	28.03	458.33	246.79	27.24
40	43.12	705.12	25.87	423.07	282.05	28.95
45	43.12	705.12	23.72	387.82	317.30	30.48
50	43.12	705.12	21.56	352.56	352.56	31.86

AFTER TAXES AT HARVEST

MORTALITY DUE TO ANNOSUS %	WITH TREATMENT VOLUME (CRDS)	WITH TREATMENT VALUE $	WITHOUT TREATMENT VOLUME (CRDS)	WITHOUT TREATMENT VALUE $	LOSSES AVERTED $	RETURN ON COST OF TREATMENT %
5	43.12	648.71	40.97	616.28	32.44	6.22
10	43.12	648.71	38.81	583.84	64.87	13.84
15	43.12	648.71	36.66	551.41	97.31	18.55
20	43.12	648.71	34.50	518.97	129.74	22.01
25	43.12	648.71	32.34	486.53	162.18	24.76
30	43.12	648.71	30.19	454.10	194.61	27.06
35	43.12	648.71	28.03	421.66	227.05	29.03
40	43.12	648.71	25.87	389.23	259.48	30.77
45	43.12	648.71	23.72	356.79	291.92	32.32
50	43.12	648.71	21.56	324.36	324.36	33.72

ESTIMATED FUTURE PRICE = $ 16.35/CORDS
ESTIMATED ANNUAL GROWTH RATE = 3.56%
ESTIMATED COST OF TREATMENT = $ 22.19/ACRE

Figure 8—Output table from economic analysis of borax treatment.

Table 2—*Characteristics of thinned stands surveyed for annosus root rot on the Holly Springs National Forest*

Compartment/stand	Species	Approx. years since thinning	ARR	Conks Windthrow Mortality Stringy rot	Damage[1] level	Approx. soil texture
8/18	Loblolly	5	Yes	X X X O	Moderate	Silt loam
29/15	Loblolly	4	?	O X X O	Light	Silt loam
72/7	Loblolly	5	No	O O O O	None	Silt loam
99/2	Loblolly	5	No	O O O O	None	Silt loam
00/1	Loblolly	4	Yes	X X X O	Moderate	Silt loam
14/19	Loblolly	6	Yes	X X X X	Moderate	Silt loam
28/1	Loblolly	5	Yes	X X X X	Moderate	Silt loam
29/22	Loblolly	5	Yes	X X X X	Moderate	Silt loam
10/14	Shortleaf	5	No	O O O O	None	Silt loam
12/12	Shortleaf	7	No	O O O O	None	Sandy loam
14/21	Shortleaf	7	Yes	O X X O	Moderate	Sandy loam
19/5	Shortleaf	5	No	O O O O	None	Silt loam
46/22	Shortleaf	9	No	O O O O	None	Silt loam
59/10	Shortleaf	4	No	O O O O	None	Silt loam
77/1	Shortleaf	7	No	O O O O	None	Silt loam
77/24	Shortleaf	7	No	O O O O	None	Clay loam
89/10	Shortleaf	9	No	O O O O	None	Silt loam
106/12	Shortleaf	7	No	O O O O	None	Sandy loam
106/20	Shortleaf	5	No	O O O O	None	Silt loam
10/19	Mix	6&1	Yes	X X X O	Moderate	Silt loam
13/10	Mix	7	?	O X X O	Light	Sandy
13/20	Mix	7	?	O X X O	Light	Sandy
44/2	Mix	10	Yes	X X X X	Moderate	Silt loam/sand

[1] None = no noticeable damage from ARR.
Light = little evidence of ARR: a few dead trees present.
Moderate = A few to several infection centers of 1-3 trees; occasional windthrows and/or broken stems on ground.
Severe = several to many infection centers with >3 trees; many windthrows and/or broken stems on ground.

must decide on planting density and include it in the prescription.

Thinning priority program.—This computer program was developed for the microcomputer (by forester Brent Botts of the Holly Springs RD) to determine commercial thinning priority for work not completed during the scheduled year. The program considers the following stand variables: basal area, average stand d.b.h., volume, age, site index, access, method of harvest, and ARR hazard. Each variable is then weighed based on its importance in determining the thinning priority. The implementation of this method resulted in an estimated savings of $570 to the District and also improved use of personnel. Since the program concept was developed by a forester, it provides an excellent example of the acceptance and integration of pest management considerations along with forest stand conditions in the decisionmaking process.

TECHNOLOGY TRANSFER TO OTHER NATIONAL FORESTS

As previously described, the computerized system of recording (SPBIS) and tracking SPB spots was field tested on the National Forests in Texas. It has since been implemented on all seven Districts in the State, on three Districts of the Kisatchie NF, and on three Districts of the National Forests in Mississippi. Before the end of 1985, SPBIS will probably be implemented on at least four more National Forest Districts in Louisiana and Mississippi. Two noticeable advantages of

Table 3—*Stand parameters, percent infection, and percent yield loss (predicted by GY-ANNOSUS) of thinned loblolly pine plantations on the Holly Springs National Forest infected with annosus root rot.*

Compartment/stand	Age	Basal area	Mean d.b.h.	Mean height	Site index base age 25	Percent infected	Yield loss (%) 10 yrs. after first thinning
8/18	30	86	9.8	62	56	33	15
14/19	33	120	10.0	62	53	5	5
28/1	30	88	9.8	61	55	19	9
29/22	26	82	10.4	58	57	17	10

Table 4—*Estimated percent return on investment in borax treatment at the next harvest for four loblolly pine stands on the Holly Springs National Forest, assuming infection with annosus root rot occurs at previously measured levels.*

Compartment pay unit	Age	Stems/ acre	Mean d.b.h.	Mean height	Site index base age 50	Percent stems marked for removal	Percent return (harvest in 10 yrs.) after taxes (5-15% yield loss)	
							Pulp	*Saw*
120/2	26	380	8.7	60	93	43	6-18	31-46
82/5A	28	340	8.8	57	95	41	6-19	32-41
82/5B	29	300	9.6	76	114	57	4-12	24-38
66/19	19	540	8.5	58	127	56	2-14	26-41

the computerized SPBIS are: 1) It has been well received on all of the Forests, and 2) the data appear to be more accurate than is the case with previous data-collection systems.

Prior to this project, only the Kisatchie NF had implemented risk rating. Since this project's initiation, NF RISK has been implemented on National Forests in Mississippi, Texas, and Alabama (Nettleton 1983).

The annosus sampling technique and GY-ANNOSUS appear to be useful tools for providing information to the land manager on infection levels and potential growth loss due to this disease. In addition, they complement the program "Economic Analysis of Borax Treatment" by providing estimates of yield loss. This technique, used with success on private land in Alabama and on Federal land in South Carolina, will soon be implemented on other National Forests in Mississippi and on the Bankhead National Forest in Alabama. ARR hazard rating has been accomplished for both the Bankhead NF in Alabama and the Sam Houston NF in Texas and is being implemented on other Mississippi National Forests. Efforts are underway to make this new technology available through a fact sheet and an annosus root rot slide-tape program that includes the annosus sampling procedure. Plans are underway to incorporate GY-ANNOSUS in FPM's interactive computer system to make it easily available to land managers.

INFLUENCE OF THE DEMONSTRATION PROJECT ON THE NATIONAL FORESTS IN MISSISSIPPI

The Holly Springs NF demonstration project was highly successful in incorporating forest pest management practices in forest management decisionmaking. SPB and ARR hazard rating have been included in the compartment silvicultural prescription process, which allows pest management considerations to be applied at the time when stand management is planned for the next 10-year period.

Implementation of technology important in managing pest outbreaks was also successful. Guidelines for determining priorities were implemented for the removal of SPB spots during a severe epidemic, and the SPBIS program was modified to fit the needs of the Holly Springs NF. New techniques for evaluating ARR and predicting damage were field-tested and demonstrated to district personnel.

Technology found applicable on the Holly Springs project was subsequently implemented on National Forest land in Texas, Louisiana, Mississippi, and Alabama and on Federal land in South Carolina. Expanded implementation is planned for Mississippi and Alabama National Forests. Support and acceptance of the technology were a direct result of the exposure provided by this project. Important to its success were: 1) Establishment of a close working relationship with District personnel, 2) presentation of information in a format useful to the practitioner, and 3) easy access to the information needed to make resource management decisions. Future technology transfer efforts in the Southern Region will continue to build on these elements and the relationships developed during this demonstration project.

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DEMONSTRATING THE EFFICACY OF THINNING FOR REDUCING SOUTHERN PINE BEETLE IMPACTS IN NORTH CAROLINA

Coleman Doggett[1]

INTRODUCTION

Epidemics of the southern pine beetle (SPB) have been known to occur at irregular intervals in North Carolina since the mid-1700's (Price and Doggett 1978). During the most recent epidemic, which occurred between 1960–76, an estimated 1,340,914 cords of pulpwood and 606,850 M fbm sawtimber valued at nearly $39 million was killed by the beetle (table 1).

Around 19.5 million acres of North Carolina is in commercial timberland, or approximately 63 percent of the State's total acreage. Of this, over 6.5 million acres is in pine type susceptible to SPB attack. The ownership pattern of this resource is of interest. About 5.2 percent of North Carolina's commercial forest land is contained in the National Forest System; 10.9 percent is owned by forest industry; 3.8 percent is owned by other public agencies; and a sizable 80.1 percent is owned by some 250,000 private individuals.

The variety of interests, abilities, and assets of private owners makes a unified, well-coordinated approach to pest management difficult. Experience has shown that while these landowners are certainly more interested in SPB control during outbreak periods, they are not willing to adopt measures to alleviate future outbreaks. Consequently, private nonindustrial landowners were the targeted audience for a demonstration on how SPB incidence and impact can be reduced through application of current technology.

Analysis of current technology reveals that the impact of SPB is influenced by a number of factors, most of which the landowner cannot control. For instance, soil type, species, and stand density have been identified as factors influencing beetle activity (Hicks 1980). The land manager, however,

Table 1--*Southern pine beetle damage estimates in North Carolina, 1960–80*[1]

Calendar	Estimated volume salvaged[3]		Total volume killed		Stumpage values[4] Pulpwood	Stumpage values[4] Sawtimber	Total value
year[2]	Cords	M fbm	Cords	M fbm	$/cords	$/M fbm	$
1960	0	0	0	200	5.00	35	7,000
1961	0	0	0	5	5.00	35	175
1962	10,000	5,000	20,000	10,000	5.00	35	450,000
1963	20,408	10,121	24,008	11,921	5.00	35	537,275
1964	5,565	47,740	6,565	5,740	5.00	35	233,725
1965	28,108	19,281	43,108	31,281	5.00	40	1,466,780
1966	28,758	26,485	32,758	29,485	5.00	40	1,343,190
1967	2,876	2,008	4,876	3,508	5.00	40	164,700
1968	26,037	10,776	56,037	20,776	5.00	40	1,111,225
1969	35,867	15,197	65,867	30,197	5.00	40	1,537,215
1970	26,579	16,558	51,579	31,558	5.00	40	1,520,215
1971	6,388	600	7,388	610	5.00	45	64,390
1972	31,415	8,622	32,615	11,122	6.00	80	1,085,450
1973	79,414	41,573	138,614	73,573	6.00	80	6,717,524
1974	198,331	82,949	353,331	147,949	6.00	50	9,517,436
1975	213,004	92,160	401,004	164,160	6.00	50	10,614,024
1976	77,615	26,248	103,164	34,771	6.00	50	2,357,534
1977	53,665	6,169	78,740	9,195	7.35	100	1,498,239
1978	37	0	537	20	7.25	97	5,833
1979	1,578	589	64,416	38,919	7.50	140	5,931,780
1980	5,815	1,354	241,822	58,766	7.50	105	7,984,095

[1] Information collected from State and Federal pest control specialists.
[2] Initial year based on available State records.
[3] Includes estimates on Federal, State, and private lands.
[4] Estimates from State pest specialists; same values assigned to timber salvaged.

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cannot practically change the soil type on his property, and, in most instances, must work with tree species already established. The major factor that may be effectively manipulated by the landowner or manager is stand density, which may be controlled by thinning. In North Carolina, thinning is usually accomplished by commercial operators who utilize the thinned material for pulpwood or sawtimber. Thus, we set as our project's objective the demonstration of the practicality and efficacy of commerical thinning to reduce SPB damage in the State.

APPROACHES TO MEETING THE OBJECTIVES

Upon determination that commercial thinning was the most practical option for reducing SPB impact, it was necessary to conduct a survey to evaluate whether commercial thinning could be done on a statewide basis. Consequently, a questionnaire was prepared and sent to all county offices to determine the availability of thinning operations. The questionnaire asked county personnel to classify thinning opportunities in their counties as 1) readily available, 2) usually available, 3) difficult, or 4) not available. The results of this survey revealed that in only 30 of the State's 100 counties was commercial pulpwood thinning readily available. In another 23 counties, commercial thinning was usually available, while in the remaining 47, it was difficult or impossible to obtain thinning contractors (fig. 1). Obviously, it was important to concentrate our demonstration areas in those counties where thinning opportunities were greatest.

The next part of our project focused on selecting those counties where SPB had traditionally been a problem. This was done by determining the number of years that showed SPB activity during the 1960–76 outbreak period (fig. 2).

Based on thinning opportunity and past SPB incidence, four counties were selected for demonstration projects. These were Vance, Davidson, Cleveland, and Polk Counties (fig. 3).

Technicians were hired in the selected counties with the sole responsibility of carrying out thinning operations in pulpwood-size stands. These technicians contacted local landowners, explained the program, and offered to make timber examinations. During the examination, a form was completed that detailed stand conditions (fig. 4). The form was developed in cooperation with Dr. Fred Hain, an SPB researcher affiliated with North Carolina State University. The form served the dual function of determining appropriate management recommendations and forming the basis for research analysis in future outbreaks. Data collected on the form included stand species, age, height of dominants, diameter range, basal area, soil type, bark thickness, proportion of live crown, and radial growth rate.

If the timber examination indicated the need for thinning, a brochure (North Carolina Forest Service 1982) explaining the value of thinning as an SPB mitigation measure was given to the landowner. If the landowner agreed to have timberland thinned, the technician marked the crooked, diseased, and suppressed trees for removal with the goal of reducing stand density to a basal area of 80 to 90 square feet. After marking the trees, the technician gave the landowner a list of timber buyers in the area. When actual cutting began, the technician made frequent checks to be sure that the stand was cut as marked and that no undue damage occurred to the residual trees. Following this procedure, some 125 different tracts containing over 1,500 acres were marked and thinned.

DISCUSSION AND CONCLUSIONS

Commercial thinning is an excellent approach to controlling stand density. Research indicates that the less dense stands resulting from thinning should have fewer SPB problems and, when problems do occur, their impact will be less than in dense stands. Although approximately half of the State of North Carolina has little or no thinning operations available commercially, the Piedmont region, traditionally

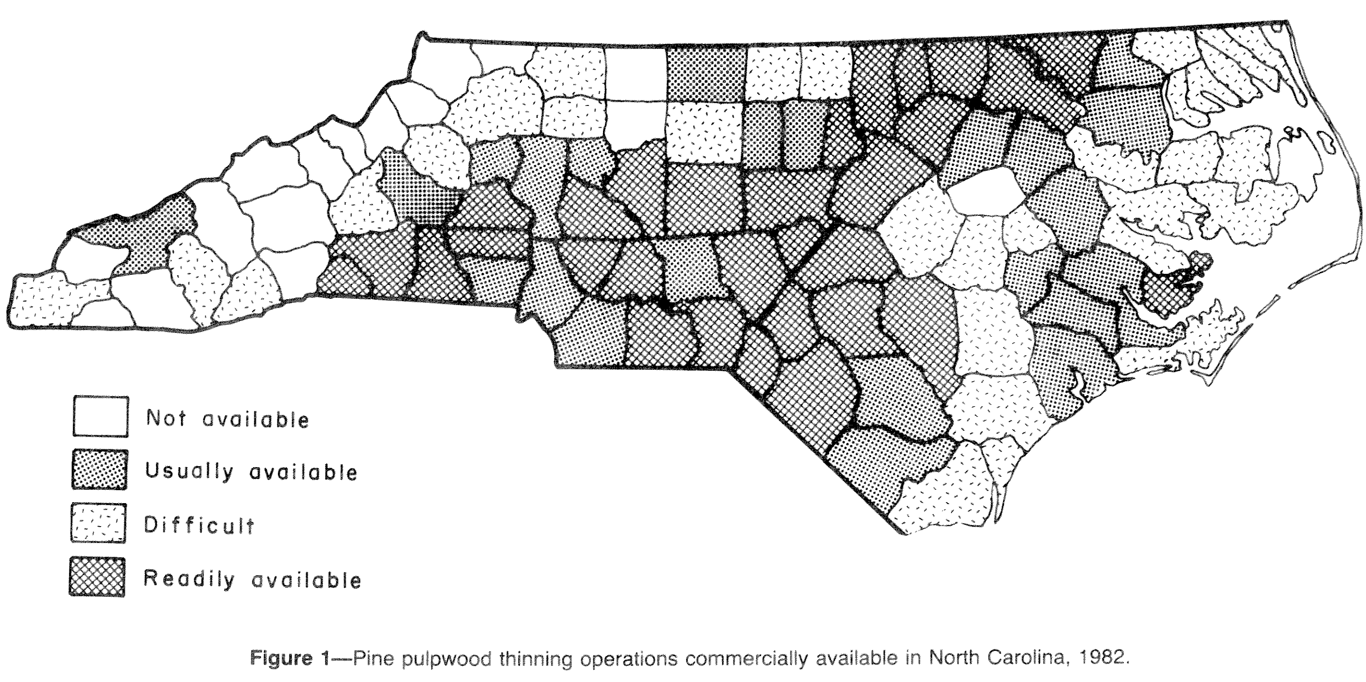

Figure 1—Pine pulpwood thinning operations commercially available in North Carolina, 1982.

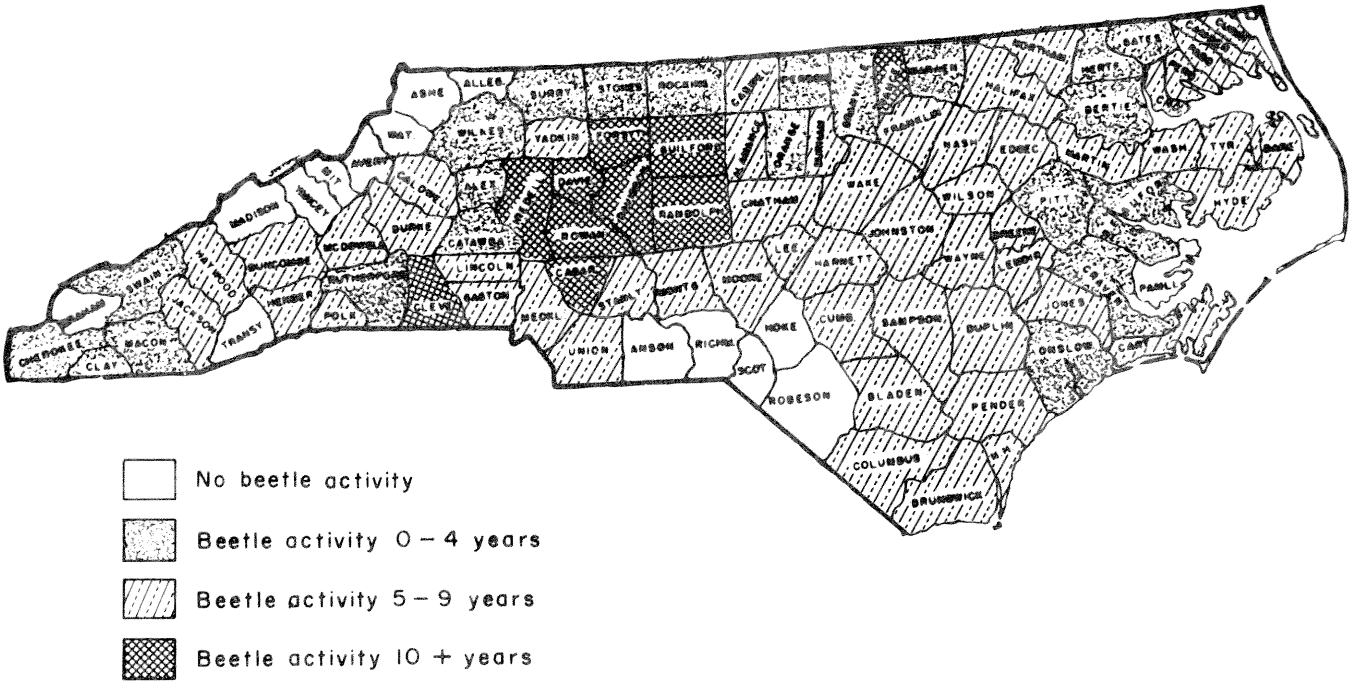

Figure 2—Southern pine beetle occurrence in North Carolina, 1960-76.

the worst SPB problem area, offers the best commercial thinning opportunities.

A thinning demonstration project conducted in North Carolina from 1980–83 indicates that if an effort is made to contact landowners and provide a complete thinning job (e.g., marking and cutting supervision), landowners are receptive to utilizing the operation as an SPB mitigation tool. Although no severe SPB outbreak has occurred since the thinning project ended, when the next outbreak does occur, the project's results will enable us to compare the thinned stands with nearby unthinned stands to demonstrate the technique's effectiveness in reducing SPB damage.

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Figure 3—Counties where SPB thinning projects were located, North Carolina Demonstration Project.

SPB THINNING PROJECT

Landowner ______________________ B_____ S_____ P_____

Address ______________________ ______________________ County

____

TRACT #					
Acres					
Species (by %)					
Age					
Height of dominants					
Diameter Range					
BA pine					
BA other overstory spp.					
BA to cut					
Soil					
Year last cut					
Date marked					
Date thinned					
Cords per acre removed					
Bark thickness (5 random trees)					
Proportion of live crown					
Radial growth (# rings per last inch)					

If a thinned stand is attacked, redo this form for the attacked plot. Take one bark thickness sample per five trees - maximum of 20 sample trees.

____

Data taken by:

Figure 4—Stand condition form developed for North Carolina thinning projects.

DEMONSTRATING INTEGRATED PEST MANAGEMENT ON NATIONAL FORESTS IN SOUTH CAROLINA AND GEORGIA

William H. Hoffard and Steven W. Oak[1]

INTRODUCTION

Forest pests have always been major problems on the Tyger and Enoree Districts of the Sumter National Forest (South Carolina) and the Chattooga and Oconee Districts of the Chattahoochee–Oconee National Forest (Georgia). With the exception of the northern third of the Chattooga District (an area located within the Southern Appalachian Mountains), the Districts are entirely on the Piedmont plateau, where decades of land abuse have eroded much of what once was productive topsoil. On the poor soils that remain, tree growth is often slow, and the area's forest cover is susceptible to two of the most significant pests of southern pine: southern pine beetle (SPB) and littleleaf disease (LLD).

During the latest SPB outbreak (1979–80), millions of cubic feet of timber were killed by the beetle on National Forest Ranger Districts in the area described earlier. Likewise, LLD impact within these areas has been enormous. Southwide, at least 15 million acres have been affected by this disease, and damage has been serious enough to affect management on some 5 million acres.

Because of this grim history, these Districts were selected for an Integrated Pest Management (IPM) demonstration project. The project had four primary objectives.

1) Identify existing IPM technologies for the management of pine pests on National Forests.
2) Communicate the IPM technology to Forest Service land managers.
3) Illustrate how the IPM technologies can work to maximize use of National Forest lands for different objectives.
4) Coordinate the work on the Sumter National Forest with the companion demonstration project on State and private land being conducted by Clemson University and the South Carolina Forestry Commission.

APPROACHES TO MEETING THE OBJECTIVES

Identifying Existing IPM Technologies: Objective 1

Several survey and evaluation methods were screened and the ones found most appropriate for the demonstration area (fig. 1) were selected following consultation with area land managers. The techniques chosen were easy to apply and required a minimum of fieldwork for implementation.

While LLD and SPB were of principal concern, fusiform rust, annosus root rot (ARR), and pales weevil were also considered.

Fusiform rust.—Land managers were supplied with a hazard map for fusiform rust generated from an earlier survey of the Sumter National Forest. In the demonstration area, rust is a management concern in limited areas or individual stands. Computer programs for economic analysis of some rust management strategies are part of the IPM Decision Key (Anderson and others 1982; Redmond 1985) and were provided to assist decisionmakers.

Annosus root rot.—As with fusiform rust, ARR is not a major concern within the demonstration area. Nevertheless, high incidence may occur in individual stands, causing severe damage. A root-sampling technique (Alexander 1984) was used in the demonstration area to assess disease incidence and growth loss in individual stands. Further, economic analyses for stump treatments with borax following thinnings were provided through the IPM Decision Key.

Pales weevil.—For this pest, land managers were supplied with the latest management information, as well as an economic analysis computer program. Similar to the fusiform rust management economic model, this program helps land managers determine whether chemical treatment of seedlings or a delay in planting provides the most economical protection against weevil attacks on trees planted in recently cut forests.

Littleleaf disease.—Littleleaf is the most significant disease in the demonstration area. Efforts, therefore, were concentrated on hazard mapping. Methods for predicting LLD damage in shortleaf and loblolly pine stands were developed from intensive research in the Piedmont during the 1940's and 1950's. Investigations were centered in the heart of the demonstration area on the Calhoun Experimental Forest, Sumter National Forest, making the results directly applicable to project needs.

Individual stand hazard was determined by using a rating scale that assigned point values for the critical soil factors—erosion class, soil consistency, depth to zone of greatly reduced permeability, and subsoil mottling (Campbell and Copeland 1954). Though quite accurate, the system requires onsite soil evaluation. Instead, soil series were placed in one of three damage classes based on the close association between risk and the internal drainage characteristics of the soil series (Campbell and Copeland 1954). This approach can be applied without costly, labor-intensive fieldwork.

We interpreted the damage classes as disease-hazard classes and summarized (from published Soil Conservation Service (SCS) County Survey Reports) the internal drainage characteristics critical to the point prediction system of the 20 soil series already grouped by Campbell and Copeland for the area (1954, table 1). We then evaluated the same characteristics for the previously unclassified soil series and assigned them to the appropriate hazard class (table 2). These hazard classes were the foundation from which individual stand haz-

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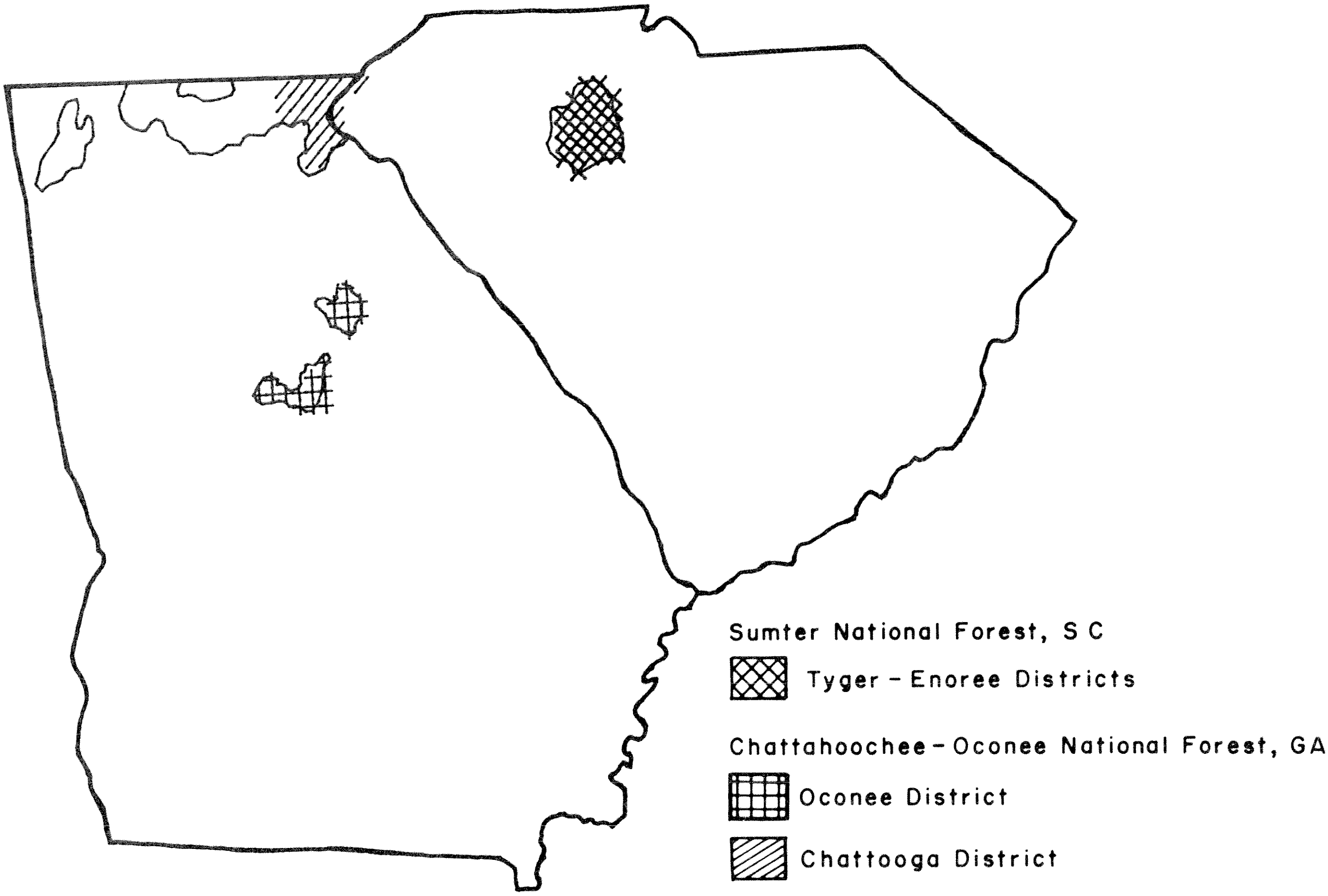


Figure 1—Regional map showing location of districts in demonstration area.

Table 1—*Internal drainage characteristics of soil series in the Sumter National Forest with known relationships to little-leaf damage classes*

	Internal drainage characteristics[1]			
Soil series[2]	Damage class[2]	Subsoil	Permeability	Mottles
Wilkes, Vance, Orange, Catawba, Mecklenburg, Herndon, Tatum, Manteo	High	Mostly clay	Slow to moderately slow with marked reduction at 12 inches or less. *exception:* Herndon	Present within 18–24 inches
Louisa, Madison, Appling, Helena	Inter-mediate	Mostly clay	Moderate to moderately slow without marked change. *exception:* Helena	Usually greater than 24 inches
Lloyd, Nason, Durham, Lockhart, Cecil, Georgeville, Davidson, Alamance	Low	Loamy clay or coarser	Moderate without marked change.	Usually greater than 36 inches

[1] In: Camp and others 1975; Camp and others 1960; Hardee 1982.
[2] Association of soil series with damage class. In: Campbell and Copeland 1954.

Table 2—*Soil series found within the Sumter and Oconee-Chattahoochee National Forests classified for littleleaf disease risk according to internal drainage characteristics of previously classified soils (ref. table 1)*

High	Intermediate	Low		
Winnsboro	Vaucluse	Worsham	Tirzah	Buncombe
Iredell	Colfax	Wickham	Rion	Armenia
Goldston		Wehadkee	Pacolet	Chewacla
Efland		Wateree-Rion	Louisburg	Blanton
Enon		Toccoa	Hiwassee	Altavista
Susquehanna		Enoree	Congaree	Red Bay
		Ailey	Lakeland	Starr
		Orangeburg	Eston	Gwinnett
		Norfolk		

ard classes were determined. Clearly, SCS County soil survey maps were essential to hazard mapping.

Southern pine beetle.—As with LLD, emphasis on SPB was on implementation of stand risk-rating systems and combining the systems with other technology.

Table 3 shows the risk-rating systems used. All systems, with the exception of the LLD system, are products of either the Expanded Southern Pine Beetle Research and Applications Program (ESPBRAP) or the Integrated Pest Management Research, Development, and Applications Program for Bark Beetles of Southern Pines (IPM). A more detailed explanation of each SPB rating system follows:

PIEDMONT RISK (Hedden 1985b): This system uses three variables to rate stands for SPB risk: 1) Slope, 2) clay component of soil, and 3) shortleaf pine component of the stand. Table 4 shows how these variables are considered in determining whether risk of SPB attack is high, medium, or low. Since all this information is available through SCS maps and stand records, the ratings can be assigned without onsite visits.

P HAZARD GA (Belanger and others 1981): This system was developed for the Georgia portion of the demonstration area. Four variables (soil surface depth to "A" horizon, radial growth of dominant and codominant trees for the last 5 years, average live crown ratio for all pines, and percentage of loblolly in the total pine component) are used to develop a discriminant score. In turn, this score determines relative susceptibility to SPB as very high, high, medium, or low. This system was not used in the demonstration area, except as a means of validating NF RISK (see below).

Table 3—*Risk-rating systems employed in South Carolina–Georgia IPM demonstration area*

Rating system	District			
	Tyger	Enoree	Oconee	Chattooga
LITTLELEAF	X	X	X	
PIEDMONT RISK	X	X		
NF RISK			X	X
MTN RISK				X
P HAZARD GA[1]			X	

[1] Used to validate NF RISK modification

Table 4—*PIEDMONT RISK system for southern pine beetle*

	Score
Shortleaf pine:	
Yes — more than 50 percent of the pine is shortleaf	1
No — less than 50 percent of the pine is shortleaf	0
Steep slope:	
Yes — slopes are greater than 10 percent	1
No — slopes are less than 10 percent	0
Clay soil:	
Yes — clay loam, clay, silty clay (>28 percent clay)	1
No — sandy loam, sandy clay loam, loam (< 28 percent clay)	0

Risk class	*Risk value* (total score)
high	3
moderate	2
low	1

NF RISK (Lorio and Sommers 1981): NF (National Forest) RISK uses existing computer-based data stored in CISC (Continuous Inventory of Stand Conditions), the program and file the National Forest System uses to describe the changing status of its forest stands. The system has been successfully used to rate for SPB risk on the Kisatchie National Forest in Louisiana. Through confirmation with historical records, it was found that certain CISC data, such as "Stand Condition Class" (e.g., "immature sawtimber"), could be reliably associated with SPB risk. With the assistance of Roger P. Belanger of the Southeastern Forest Experiment Station, the system was modified for conditions on the Oconee and southern Chattooga (Piedmont section) Districts in Georgia. Modifications for the Georgia Piedmont principally reflected site index differences and Piedmont littleleaf influences as they relate to SPB risk. Figure 2 shows the modified flowchart sequence for the Georgia Piedmont.

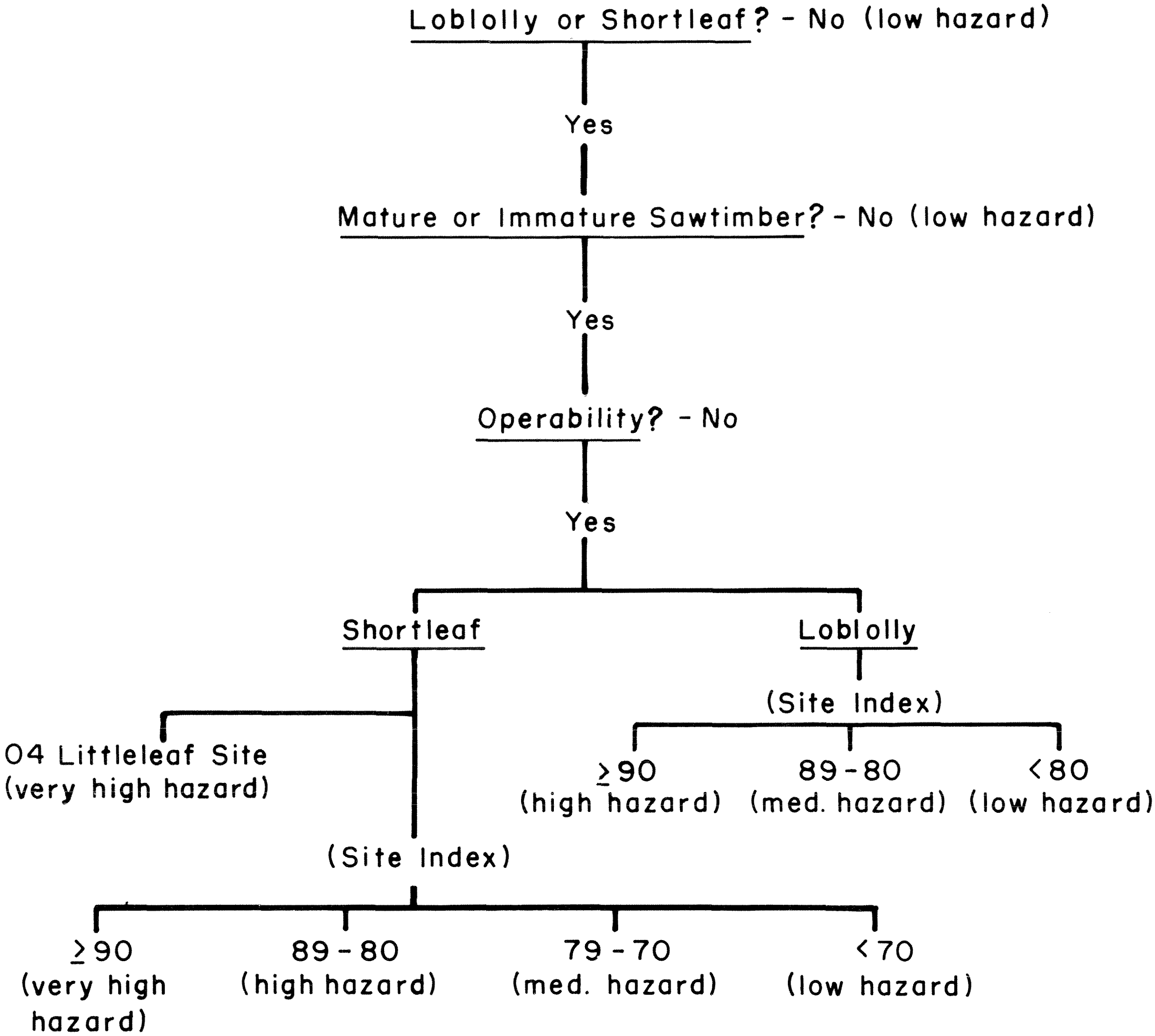


Figure 2—NF RISK flowchart modified for the Oconee National Forest.

Figure 3 shows the percentage of very high, high, medium, and low risk stands on the Oconee and Piedmont regions of the Chattooga District.

MOUNTAIN RISK (Hedden 1985a). This system reliably projects SPB risk in mountain stands where shortleaf, Virginia, pitch, and Table Mountain pines are a significant component of the forest cover. The system was developed within the demonstration area and, when applied in a larger area, correctly rated more than 80 percent of the stands.

Communicating IPM Technology to Land Managers: Objective 2

Assimilation and continued application of IPM technology require that the products of hazard rating (hazard maps) be provided in a form that is compatible with current management methods. Maps were prepared to aid in the compartment prescription process at the Ranger District level.

Three distinct phases were involved in providing information and involving land managers in the application of hazard rating. The first phase made them aware of the procedures used in rating stands for SPB and LLD and in developing hazard maps. Project personnel converted SCS maps to the scale of currently used compartment maps, color-coded soil types according to hazard, set criteria for determining individual stand hazard, and manually produced hazard maps.

In a second phase, only the essential information (SCS soil maps at the appropriate scale, with hazard classes coded) was provided to land managers. This gave them the flexibility of developing their own criteria for hazard rating stands. For example, one manager might rate a stand high hazard if 50 percent of its acreage was on high-hazard soil, while another might consider any high-hazard soil as sufficient reason for a high rating.

The final phase supplemented this flexibility by computerizing the mapping process for increased speed and accuracy in data retrieval and map reproduction, long-term data storage, and use of information developed for pest management for other resource management situations. This was accomplished

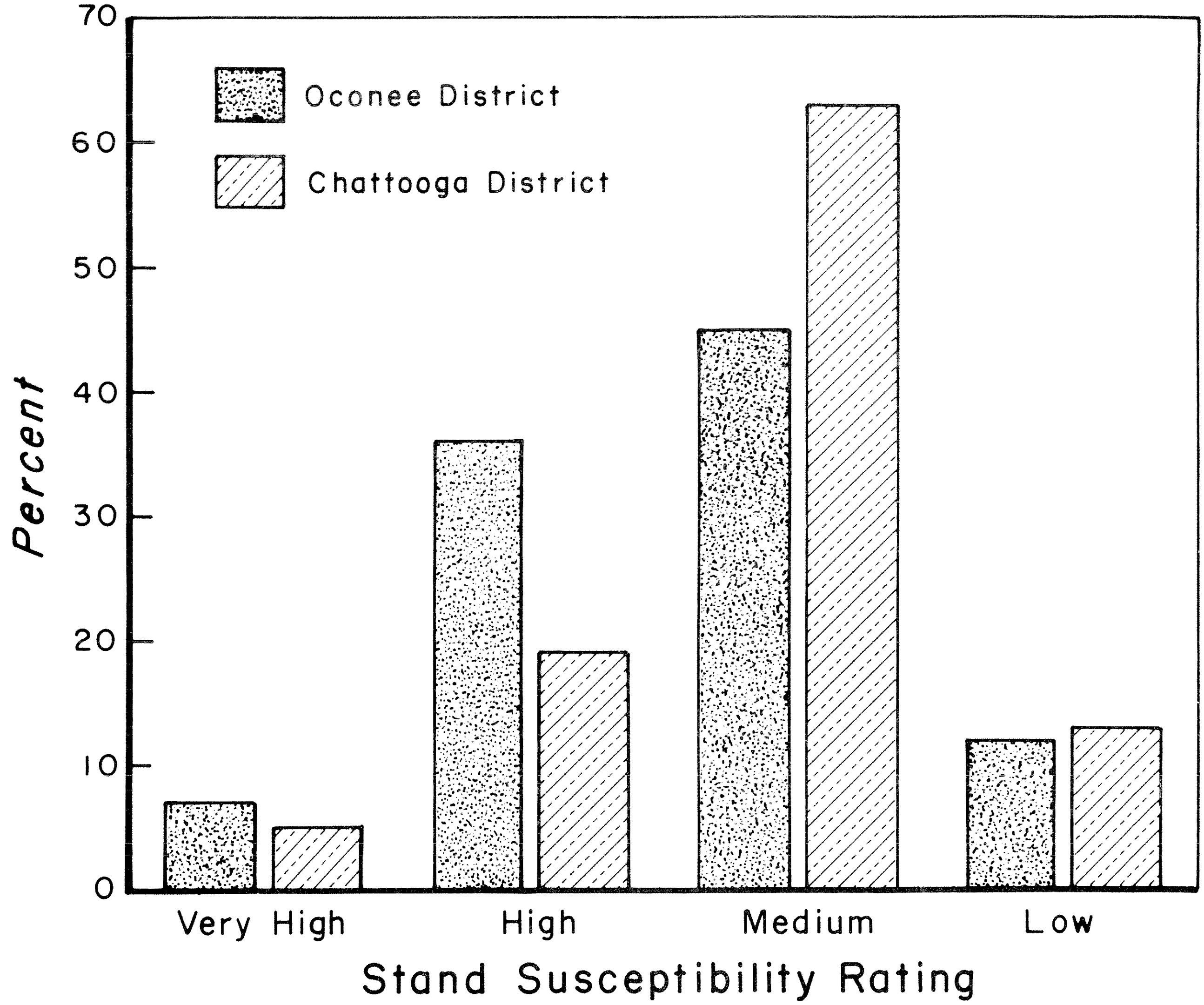


Figure 3—Percentage of total acreage susceptible to southern pine beetle as classified by NF RISK (Piedmont region only).

by using a computerized Geographic Information System (GIS) developed by R.L. Beveridge of the USDA Forest Service, Region 4, Boise, Idaho (Beveridge and Knapp 1984). This GIS consists of programs prefixed PEST and was originally developed to assist in summarizing and mapping forest pest data collected during aerial surveys of 13.5 million acres of forest land in the West. It allows entry of point data (e.g., beetle spots) or polygon data (e.g., an area of high-hazard soil), data summary and editing, map plotting, and the overlaying of data files to determine areas of commonality (e.g., overlaying soil hazard with forest type—fig. 4).

PEST programs were originally developed to store and edit plot data over a large geographic area (half of a 7.5-minute quad map or about 110 mi^2) using a Hewlett-Packard desktop computer, digitizer, and plotter. Modification was needed to run the programs on our equipment and process information for a much smaller area (about 4 mi^2). While losing the capability of generating larger area maps (e.g., showing LLD hazard soils on an entire District or Forest), it did allow for the production of hazard maps for individual compartments at the same scale as maps currently in use on the Ranger Districts.

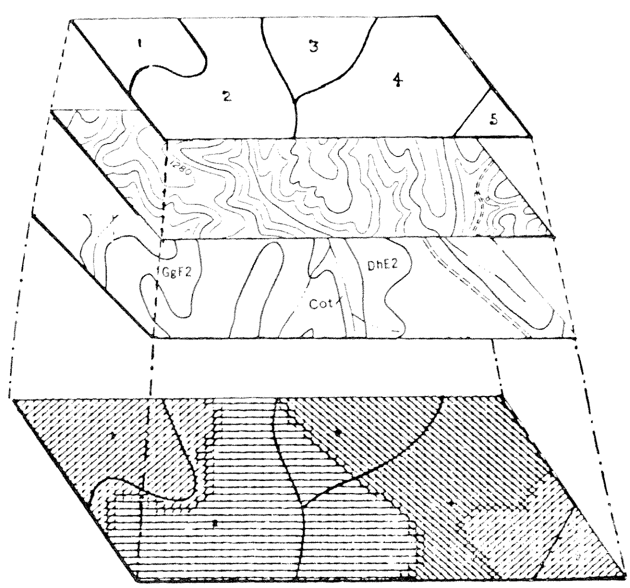


Figure 4—Diagrammatic representation of how the Geographic Information System compares various strata. Digitized map (*bottom*) is based on "stacking" data from three strata (in this case, stand, topographic, and soils information).

The steps involved in generating maps similar to hazard maps with PEST programs are described in Beveridge and Knapp (1984).

A stand boundary map can be plotted on a transparency film and directly overlayed onto the LLD soil hazard map to assist land managers in locating relative positions of various hazard class soils within existing stands (figs. 5 and 6). When combined with the tabular summary of acreage by hazard class for each stand, these maps allow informed decisions to be made about hazard rating of existing stands. Further, they can be used in monitoring high-hazard areas during pest outbreaks, in decisionmaking for intermediate cultural treatments (e.g., preventive or salvage thinning), and in lowering the pathological rotation age.

Illustrating How IPM Technologies Work on National Forest Lands: Objective 3

The third objective of the project was accomplished in four steps:

1) Demonstration of computerized decisionmaking aids.
2) Incorporation of hazard-rating and decisionmaking aids into the compartment prescription process.
3) Survey of previously undocumented losses from LLD in loblolly stands.
4) Field demonstrations of the assessment techniques and applications.

Demonstration of computerized decisionmaking aids.—Miniterm computer terminals were placed on the Tyger and Enoree Districts in South Carolina. These terminals provide access to technology available on the Forest Pest Management host computer in Doraville, GA. Programs available to the Districts included the Integrated Pest Management Decision Key, which considers a variety of variables in formulating pest management recommendations for specific site-stand-pest conditions, and several economic models that permit a detailed financial analysis of pest management alternatives. These economic models dealt with such pests as fusiform rust, ARR, SPB, and pales weevil.

Additional technology was also transferred to District personnel through training sessions, publications, and close work with individual professionals.

Incorporation of hazard-rating and decisionmaking aids into the compartment prescription process.—The hazard-rating maps were placed in compartment prescription files for continuing reference. They will be used for 10 years, after which the areas will be reexamined and management options reevaluated.

The maps and tables will influence silvicultural prescriptions, including thinning, species selection, and stand conversion. This information helps to ensure that pest management is considered in formulating silvicultural strategies.

Survey of previously undocumented losses from LLD in loblolly stands.—A survey of LLD in loblolly pine stands was carried out on the Tyger and Enoree Districts cooperatively with Clemson University (Dr. Frank Tainter) and Sumter National Forest personnel. The survey was conducted in response to concerns by Forest Service foresters that loblolly was sustaining noticeable damage in many areas and management guidelines for such stands were not available. Symptoms included yellow foliage, foliage dwarfing and tufting, branch dieback, and reduced annual increment. Land managers also reported "negative growth" over 10-year measurement periods in some damaged stands due to the combined effects of tree mortality and very poor growth.

We illustrated the losses by surveying damaged stands and determining: a) Incidence of damage, b) growth reduction due to LLD, and c) inception of growth reduction relative to expression of crown symptoms. It is hoped that results of the survey will be useful in determining pathological rotation ages on different hazard sites, scheduling presalvage thinnings, and determining the need for stand conversion to hardwoods.

Preliminary analyses indicate that: 1) Trees with light and severe crown symptoms (impacted trees) grow significantly less than healthy trees but do not differ from each other; 2) growth of impacted trees culminated between age 30 and 40 but had not culminated in healthy trees by age 50, 3) incidence of impacted trees averaged 15 percent on high- and intermediate-hazard soils and 5 percent on low-hazard soils.

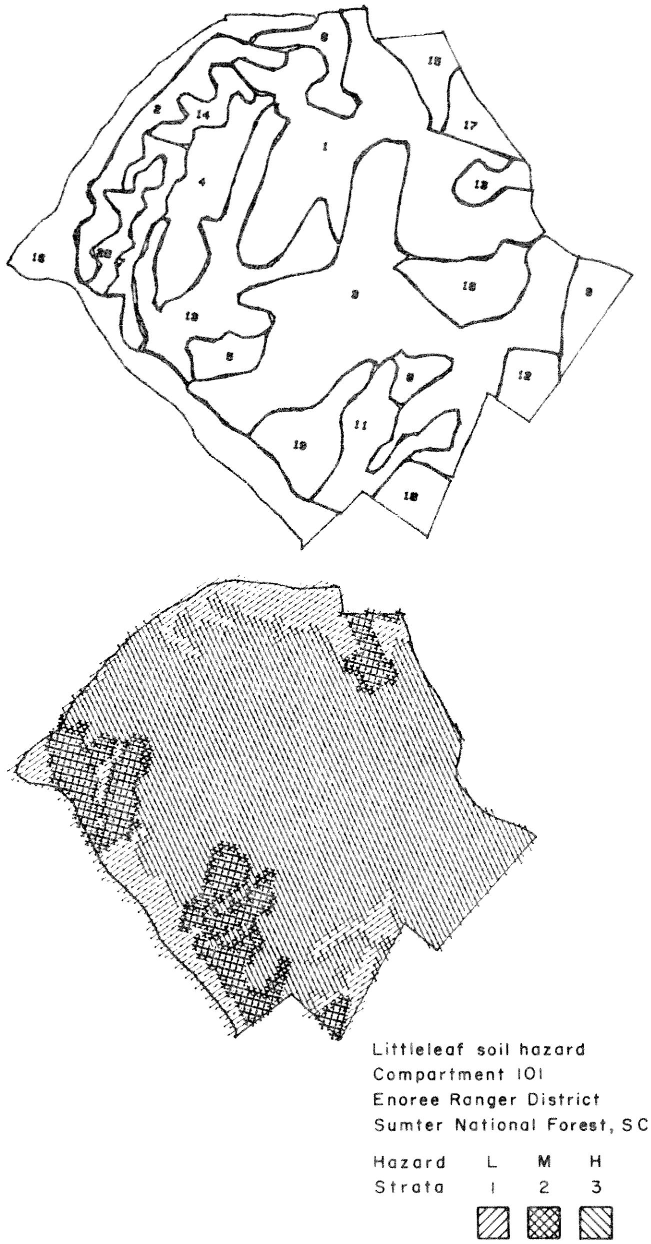
Further analysis is needed to determine: 1) The relationship between the onset of crown symptoms and growth reduction (this will aid in survey and damage assessment), and 2) specific guidelines on stand management (the level of reduction that warrants action).

Field demonstration of the assessment techniques and applications.—The ARR sampling technique was demonstrated on the Savannah River Plant and on four National Forest Ranger Districts outside the Piedmont demonstration area. This disease can cause mortality or growth reduction and can be a significant constraint to management in thinned pine stands. Until recently, evaluation of ARR losses was limited to mortality. With the new ARR sampling system, growth reduction can also be determined. Root samples are systematically taken in thinned pine stands, the percentage of infected roots discovered, and the growth loss quantified through a computer growth and yield simulator called GY-ANNOSUS (Hokans and Alexander 1985).

The need to reinstate ARR preventive stump treatment was demonstrated after the sampling system was applied in four thinned but untreated pine stands on the Savannah River Plant. High disease incidence was also present in thinned stands outside the traditional ARR high-hazard area.

Coordination With South Carolina's Companion Demonstration Project on State and Private Land: Objective 4

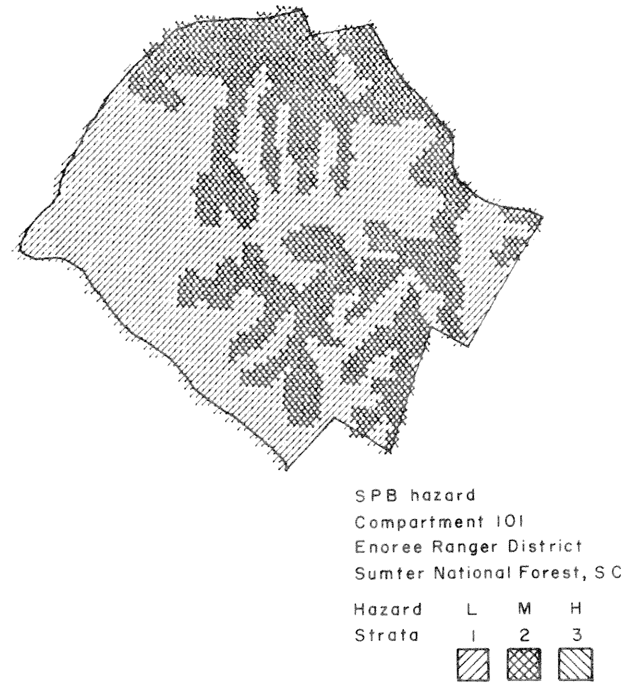
The companion projects conducted in concert with the Forest Service-funded project by Clemson University and the South Carolina Forestry Commission had significantly different objectives, emphases, and client groups, but addressed the same issue— the implementation of current IPM technologies to reduce pest-caused losses in South Carolina. Close coordination and cooperation were needed not only to avoid duplication of effort but also to bring the results of the individual projects to as many groups as possible. Efforts ranged from extensive collaboration on specific projects to more limited roles as sources for information about other project



STAND	STRATA 1	STRATA 2	STRATA 3
1	25.26	8.36	159.13
2	14.77	9.33	26.74
3	34.49	29.95	197.37
4	0.00	.76	45.22
5	.54	2.31	16.04
6	17.91	0.00	9.26
7	6.49	12.83	12.61
8	0.00	0.00	12.36
9	0.00	0.00	25.30
10	12.76	6.70	6.63
11	6.81	6.02	38.38
12	0.00	0.00	16.76
13	7.42	11.96	119.06
14	3.03	0.00	16.90
15	12.14	10.95	4.50
16	101.69	26.63	18.45
17	0.00	.22	22.77
18	0.00	0.00	40.36
19	1.15	18.70	23.46
20	4.76	6.41	7.35
TOTAL	249.22	151.13	818.65

COMPARTMENT 101
SUMTER NATIONAL FOREST,
ENOREE RANGER DISTRICT
ACREAGE OF LITTLELEAF BY
HAZARD CLASSES (STRATA)
AND STANDS.

Figure 5—Littleleaf disease hazard map produced by GIS with tabular output. Stand map (*top*) is electronically overlayed on soils map (*middle*). The accompanying computer program (*bottom*) tabulates stand acreage by hazard class. Stand and soil hazard maps can be manually overlayed by plotting one map on a transparency.



STAND	STRATA 1	STRATA 1	STRATA 2
1	66.49	42.03	83.73
2	29.04	0.00	14.54
3	77.65	90.88	104.91
4	11.44	35.35	.61
5	15.42	.51	3.17
6	0.00	3.64	22.64
7	24.12	3.10	0.00
8	0.00	10.96	1.52
9	0.00	19.23	7.89
10	6.27	6.21	11.94
11	5.63	33.40	11.17
12	0.00	14.27	4.76
13	47.29	59.71	38.86
14	14.88	1.75	2.83
15	10.26	0.00	14.64
16	57.28	64.30	19.84
17	2.36	0.00	20.17
18	21.35	1.92	20.38
19	17.51	5.33	20.75
20	15.08	0.00	0.00
TOTAL	422.07	392.59	404.33

COMPARTMENT 101
Sumter N.F., ENOREE R.D.
ACREAGE OF SOUTHERN PINE
BEETLE BY HAZARD CLASSES
(STRATA) AND STANDS.

Figure 6—Southern pine beetle soil risk map produced by electronically resorting soil series according to criteria identified in the PIEDMONT RISK system. Soil hazard is one of three components that determine SPB risk.

Figure 7—Stand risk for southern pine beetle on Compartment 154, Oconee National Forest, as determined with modified NF RISK.

activities. For example, the survey of LLD occurrence and losses in loblolly pine on the Sumter National Forest involved collaborative planning, field data collection, and data analysis with the Clemson project. Similarly, a slide-tape on LLD and its effective management was jointly developed by Clemson and USDA Forest Service investigators.

LLD hazard-rating methods were taught at formal workshops organized by Clemson University. Combined participation of all projects in informal status reporting sessions for different client groups served the objectives of all. Finally, USDA Forest Service land managers were informed through workshops and field demonstrations of the portable sawmill (South Carolina Forestry Commission), the ARR management system and sampling method, the IPM Decision Key, and other pest management software available to foresters (Clemson), and the Clemson Pest Management Information Center.

CONCLUSION

The South Carolina–Georgia project demonstrated the importance of considering pests in forest resource management. With the latest technology (much of it developed through ESPBRAP and the IPM Program), foresters and technicians can accurately rate LLD and SPB risks. Computer programs like the Integrated Pest Management Decision Key and economics models help foresters devise prescriptions for management of LLD, fusiform rust, ARR, SPB, and pales weevil that are practical and cost effective. Computerized technology is now in a form that is easy to understand and adapt to existing conditions.

The demonstration project concentrated on the specific needs of the Federal forester. Efforts were made to ensure that the appropriate technology was adapted to the Southern Region's existing specifications and formats. Examples include digitizing hazard maps to the same scale as USDA Forest Service compartment prescription maps and modifying the CISC system to project SPB hazard with existing site/stand data.

One important element of technology transfer is continued application. Since compartment data are reevaluated and updated at 10-year intervals, the maps and other information provided by this project for each compartment file will be used by foresters for at least a decade.

Throughout the project, work was coordinated with the companion South Carolina demonstration project to prevent duplication of effort and ensure a more comprehensive approach.

In the years to come, Forest Pest Management in the Southern Region will continue to monitor District use of the technology to verify its validity and consider the incorporation of new information as it becomes available.

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SOUTHERN PINE BEETLE PREVENTION AND CONTROL MEASURES FOR NONINDUSTRIAL PRIVATE LANDOWNERS IN SOUTH CAROLINA

Michael C. Remion and Andrew J. Boone[1]

INTRODUCTION

Southern pine beetle (SPB) has become an increasingly important pest of pine forests in South Carolina. As early as 1804, General Charles Pinckney described the severity of the SPB problem when he reported the loss of 5,000 acres in a 7,000-acre pine plantation 26 miles north of Charleston. In a recent outbreak (1972–74), over 781,000 cords and 251,000 M fbm of pine were killed by the insect (table 1).

In October 1982, a cooperative Federal–State–university demonstration project was implemented in South Carolina. This project involved the cooperative interaction of the South Carolina Forestry Commission (SCFC), Clemson University, and the USDA Forest Service. The overall goal of the State project was to provide nonindustrial private forest (NIPF) landowners with small holdings with effective control and prevention measures to reduce current and potential timber losses caused by the SPB. The objectives were to:

1. Develop educational displays for the identification, prevention, and suppression of SPB infestations.
2. Develop a training program for SCFC personnel to improve and standardize SPB aerial and ground detection and suppression approaches.
3. Demonstrate the use of aerial photography and radio navigation aids in locating spots.
4. Develop and demonstrate a stand hazard-rating system for SPB in the Piedmont Region of South Carolina.
5. Develop leaflets and public service announcements relating to SPB identification, timber utilization, prediction, prevention, and suppression.
6. Demonstrate silvicultural practices to reduce stand susceptibility to SPB attack.
7. Conduct portable sawmill (Mobile Dimension Saw®) demonstrations.

Work on objectives 4 to 6 was contracted to the Clemson University Department of Forestry (CUDF) by the Commission.

APPROACHES TO MEETING THE OBJECTIVES

Educational Displays

This approach was designed to educate and inform NIPF owners and forest managers of the proper techniques of identifying, preventing, and suppressing SPB spots. To achieve this goal, the SCFC constructed permanent, modular display units complete with lighting systems for each of its seven districts. Two copies each of three photographic transparency sets and graphics were developed for these display units. These visual aids displayed information on the identification of the SPB and the damage it causes, recognition of SPB high-hazard stands, and the use of forest management practices to prevent or reduce losses, and the proper application of effective control methods. The displays were used at large landowner association meetings, State fairs, and farm-city week festivals.

SPB slide-tape programs and projectors were provided to all SCFC districts. These programs were used by Commission foresters to transfer the latest technology concerning SPB identification, hazard rating, prevention, and control to forest landowner associations and related groups. Forty-five presentations were made involving approximately 1,350 landowners, foresters, and forestry technicians.

Training for SCFC Foresters

The SCFC is responsible for detecting and suppressing forest pest outbreaks on both State and private lands in South Carolina. An urgent need existed to intensify training of SCFC personnel involved in SPB aerial and ground detection and suppression operations. Accordingly, 18 training sessions were conducted for 124 SCFC personnel using techniques such as slides and maps to achieve the level of awareness desired.

Personnel involved as observers in aerial detection and suppression surveys were shown aerial slides of SPB infestations of known size. From these slides, the size (number of trees) of the spots was estimated and recorded. Instructors then compared each observer's estimate with the known number of trees in each infestation to determine accuracy in estimating infestation size. Training continued until all observers reached 90 percent accuracy in estimating spot size.

Training was also conducted in the field with personnel involved in SPB suppression activities. This training included locating spots using aerial photographs, delineating spot boundaries for control, and laying out roads for access to spots that were to be salvaged.

Use of Aerial Photographs

This effort focused on demonstrating the use of aerial photographs as an aid in locating SPB infestations for suppression. In 1981–82, the SCFC joined with the USDA FS Aerial Survey Team from Doraville, GA, to cooperatively test an

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Table 1—*Southern pine beetle damage estimates in South Carolina 1960–80*[1]

Calendar year[2]	Estimated volume salvaged[3]		Total volume killed		Stumpage values[4]		Total value
	Cords	M fbm	Cords	M fbm	Pulpwood $/cords	Sawtimber $/M fbm	$
1960	0	390	0	3,900	0.00	32	124,800
1961	0	221	0	2,210	0.00	34	75,140
1962	11,400	400	43,000	90,000	5.00	36	3,455,000
1963	250	324	1,650	2,162	7.00	32	80,734
1964	50	46	360	455	7.00	32	17,080
1967	834	701	8,340	7,009	7.00	37	317,713
1968	1,352	1,009	13,517	10,093	7.00	40	498,339
1969	1,604	629	16,044	6,292	6.00	35	316,484
1971	400	30	1,470	142	6.00	30	13,080
1972	15,500	7,918	250,000	12,218	7.00	52	2,385,336
1973	120,135	7,640	284,335	124,440	8.00	89	13,349,840
1974	193,310	16,911	247,310	114,541	7.00	70	9,749,040
1975	85,214	10,606	85,214	31,235	7.00	60	2,470,598
1976	19,274	510	19,274	510	7.00	60	165,518
1977	236	25	393	42	7.00	54	5,000
1978	0	0	0	0	0.00	0	0
1979	41,800	6,722	46,815	28,010	12.00	160	5,043,380
1980	173,095	1,474	184,099	23,586	13.00	106	4,893,403

[1] Information collected from State and Federal pest control specialists.
[2] Initial year based on available State records.
[3] Includes estimates on Federal, State, and private lands.
[4] Estimates from State pest specialists; same values assigned to timber salvaged.

aerial sampling method for measuring timber mortality caused by bark beetles over a large area of mixed ownership in South Carolina. Aerial color infrared negatives resulting from this test were used to make photographic prints for the demonstration project.

Prints for all of the forested area in 31 counties were provided to SCFC project foresters in the respective districts. A full set of these same photographs was retained by SCFC's Insect and Disease Section. Ten training sessions were offered to 45 SCFC foresters to instruct them in the use and interpretation of new photography. The photographs provided the SCFC with an initial baseline record for a continuous recordkeeping system of SPB infestations throughout the State. They were also being used by project foresters for hazard-rating stands for management plans, suppression activities, thinnings aimed at reducing stand SPB hazard, and maintaining healthy forests.

The SCFC established an aerial photography cooperative committee to make prints of the new photography available to landowners. Committee members included representatives from the SCFC, consulting foresters, and industrial foresters. Through this committee, 3,600 prints were provided at cost to some 84 landowners throughout the State.

In years to come, this newly acquired photography will be used to prepare SPB occurrence and severity maps for each county affected by SPB and ultimately to validate SPB hazard-rating systems.

Development of a Stand Hazard-Rating System

To develop an SPB hazard-rating system in the Piedmont Region of South Carolina, Clemson University and the Commission collected data on more than 50 SPB spots. SPB losses in the Piedmont were found to be closely related to stand density, soil, and host tree characteristics. Using data collected during the project and logistic models (Reed and others 1980) developed in other States relative to probability of SPB occurrence, Clemson developed an SPB hazard-rating system for the Piedmont Region. This system addressed both SPB spot incidence and spread. The newly developed system was field tested by SCFC foresters and found to correctly rate stands 82 percent of the time.

This system's methodology was later published (in leaflet form) (fig. 1) under the IPM Demonstration Project (Hedden

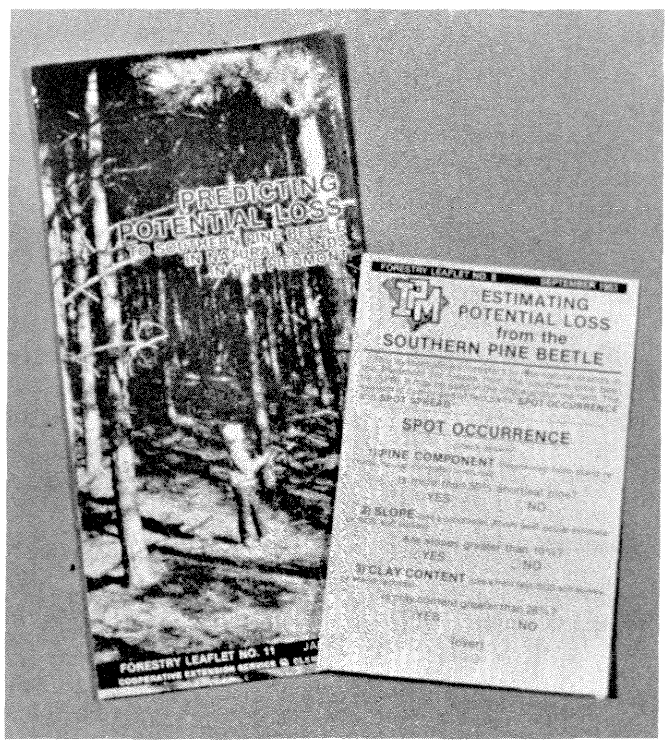

Figure 1—Hazard-rating and prediction leaflets for the southern pine beetle in the South Carolina Piedmont.

and Karpinski 1983; Karpinski and others 1984). Twelve training sessions involving 84 SCFC foresters and industrial foresters were conducted to train them in the use of the system.

SCFC project foresters are currently using this system in woodland examinations and incorporating the results into management plans.

Leaflets and Other Educational Materials

This effort was designed to develop educational materials relating to the identification, prevention, and control of SPB. The material developed by Clemson was targeted at the nonindustrial, private landowner. Leaflets prepared and distributed by Clemson's Department of Forestry and Cooperative Extension Service and the SCFC are tabulated in table 1.

These publications were developed to meet the needs of the NIPF owners in South Carolina and an estimated 10-year supply was printed. During the 1984 SPB outbreak, approximately 5,000 copies of each publication were distributed to forest landowners and industrial forest managers who have CFM programs.

In addition to these publications, three 30-second public service announcements (PSA's) for television were prepared (table 2). These announcements addressed the identification of SPB infestations, the prevention of SPB spots through forest management practices, and the control of SPB spots.

Table 2—*Summary of leaflets, fact sheets, and public service announcements prepared for use in the South Carolina demonstration project*

Project	Prepared by	Media	Title (description)
Educational material	Clemson University Cooperative Extension Service and Department of Forestry	Forest Leaflet 5	Identifying the southern pine beetle
		Forest Leaflet 6	Salvage removal, a method for controlling SPB infestations
		Forest Leaflet 7	Cut and leave, a method for controlling SPB infestations
		Forest Leaflet 8	Estimating potential loss from the southern pine beetle
		Forest Leaflet 11	Predicting potential loss to southern pine beetle in natural stands in the Piedmont
		TV PSA	30-second announcement on SPB infestation identification
		TV PSA	20-second announcement on SPB prevention
		TV PSA	30-second announcement on SPB control
Portable sawmill	Clemson University Cooperative Extension Service and Department of Forestry	Forest Leaflet 9	Portable sawmill operators in South Carolina
		Forest Leaflet 10	So . . . you want to buy a portable sawmill!
		Forest Leaflet 12	Don't leave your trees to rot in the woods . . utilize them!
	SCFC	Fact sheets	Integrated pest management project in SC
			Portable sawmill lease demonstration conducted by the SCFC (two fact sheets)

They were targeted at landowners to inform them of approaches for dealing with the SPB problem in South Carolina.

Copies of the three PSA's were provided to all TV stations within the State and also those in adjoining States that telecast to South Carolina. Copies of the spots were also provided to the Information and Education Section of the Commission for further use.

Illustrating the Feasibility of Silvicultural Practices

This effort was initiated by Clemson to demonstrate the compatibility of silvicultural practices for reducing stand hazard to SPB with the diverse management objectives of the NIPF owners. To achieve this goal, demonstration areas on NIPF lands were established to illustrate to consulting foresters, SCFC foresters, extension workers, and landowners with small holdings the feasibility of using silvicultural practices to alter stand conditions favorable to SPB attack.

Seven demonstration areas were established in the Piedmont of South Carolina, and management plans were prepared for each tract based on the landowner's objectives. Silvicultural prescriptions to reduce stand hazard were included in each plan and the practices implemented on each tract. Following treatment of the demonstration areas, a monitoring program was initiated to document effectiveness of the practices in reducing SPB losses over the years.

To date, approximately 10 visits have been made to each of the demonstration areas for "show-me" trips. Complete slide series have been developed for each tract showing "before and after" silvicultural treatments. Additional pictures will be taken in future years to document the actual effects of the various treatments in reducing and/or preventing losses due to SPB.

Demonstration and Use of the Portable Sawmill

The sawmill demonstration work in the South Carolina project (fig. 2) has involved three phases: Phase I was concerned with planning, purchase, and training; Phase II involved demonstrations in the Piedmont Region of South Carolina; and Phase III involved demonstrations in the Sandhills and Coastal Plains Regions of South Carolina.

Three methods were used: 1) Public demonstrations, 2) lease demonstrations, and 3) sawmill study demonstrations. (See table 3 for a summary.)

Public demonstrations.—Public demonstrations were organized and targeted to reach the nonindustrial, private landowner. Each public demonstration was scheduled for a single day, and the public was invited to attend by means of radio-television announcements and news releases. SCFC personnel organized the meetings and demonstrated the sawmill, and Clemson Extension personnel presented educational programs at each session.

Landowners involved in the demonstrations were required to cut and deck their own logs and provide two individuals to assist SCFC personnel during the demonstration. Landowners retained the lumber sawed during the demonstrations for their own personal use at no charge.

Through December 1984, some 30 demonstrations had been conducted in 17 different counties, reaching a total of 16,234 people. In 1985, an additional 15 public demonstrations are scheduled.

Lease demonstrations.—Lease demonstrations were offered for small, private landownerships on the following priority basis: 1) Landowners with active beetle infestations, 2) landowners with beetle-killed (inactive) timber, and 3) landowners with thinning operations scheduled to reduce SPB hazards.

Under a lease demonstration agreement, landowners were required to cut and deck their own logs, provide at least two individuals to assist SCFC personnel in loading logs and stacking lumber, and pay $10 per board foot of lumber sawed and a one-time $20 "setup" fee. In cases where less than 1,000 board feet was sawed, a minimum fee of $120 was incurred by the landowner.

The maximum time allowed for each lease agreement was 2 weeks or 40 working mill hours, whichever occurred first. Under terms of the agreement, the SCFC leased the mill and two operators to maintain and physically operate the mill. Lumber sawed during these demonstrations was retained by the landowner. Lease demonstrations were open to the general public at the landowner's discretion.

Through December 1984, a total of 16 lease demonstrations had been conducted in six different counties reaching 163 people. An additional 10 lease demonstrations are planned during 1985.

Sawmill studies.—Seven sawmill studies were conducted during Phase II. These involved the collection of data to prepare a brochure on cost analysis, efficiency, and effectiveness of the Mobile Dimension portable sawmill.

Table 3—*Summary of portable sawmill demonstrations in South Carolina for the period August 1983–December 1984*

Type of demonstration[1]	Demonstrations	Counties covered	Total visitors	Mill operation	Total sawed
	Number			*Hours*	*Board feet*
Public	30	17	16,234	216	46,021
Lease	16	6	163	217	46,780
Sawmill study	7	5	151	95	15,383
Totals	53	--	16,548	528	108,184

[1] Educational programs were presented at all public demonstrations by the South Carolina Forestry Commission and or the Clemson University Cooperative Extension Service.

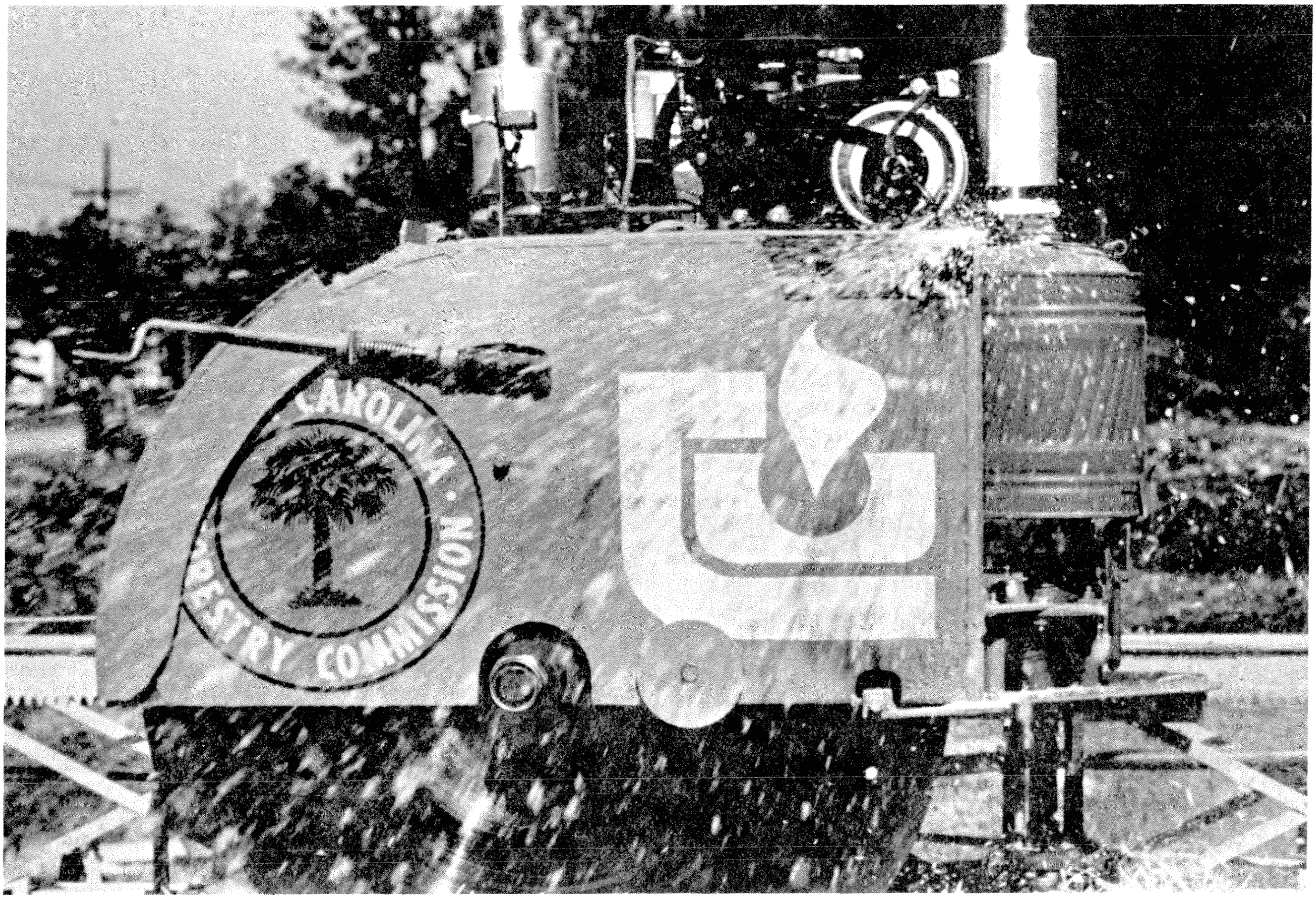

Figure 2—Use of portable sawmill process for beetle-killed sawlogs on nonindustrial private lands.

Variance in lumber thickness and width was measured on boards at the ends and midpoints. Also, logs were scaled prior to sawing and lumber scaled following sawing to determine the waste factor. Detailed fixed and variable costs were recorded to determine actual costs per 1,000 board feet of lumber produced.

During Phase III of the sawmill demonstration, the Commission plans to develop and print a pamphlet on air drying and stacking of lumber and a manual on cost analysis and efficiency of the Mobile Dimension portable sawmill. Leaflets and fact sheets prepared and distributed during this project are also tabulated in table 1.

The SCFC constructed a portable display on IPM and an appropriate sign to accompany the sawmill demonstrations. A video program was also developed by the SCFC for use at public demonstrations when only the mill was on display. This program was effectively used with the sawmill at the South Carolina State Fair in October 1983. An estimated 12,500 people visited the exhibit.

Ongoing training sessions with project foresters, conducted by the SCFC Insect and Disease Staff, focus on new IPM technologies to encourage and stress the importance of incorporating IPM practices in management plans on State and private forest lands.

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INTEGRATED FOREST PEST MANAGEMENT PRACTICES IN SOUTH CAROLINA

D. L. Ham, C. Karpinski, F. H. Tainter, and R. L. Hedden[1]

INTRODUCTION

In South Carolina, losses caused by forest pests have been unnecessarily high, especially on nonindustrial private ownerships, which comprise over 70 percent of the commercial forest land in the State. Southern pine beetle (SPB), littleleaf disease, fusiform rust, annosus root rot (ARR), as well as other pests, cause mortality and growth losses conservatively estimated to have exceeded $8 million each year during the 1970's (Anderson and others 1981; Price and Doggett 1982). Historically, convincing farmers and other landowners to implement sound forest management practices, which would include pest management, has been very difficult.

Private landowners (as well as many professional foresters) lack a real understanding of the value and compatibility of forest/pest management practices with various ownership objectives. As a result, pest management has often been left to chance, and serious losses have occurred when landowners have had to respond to crisis situations.

A demonstration project involving the cooperative efforts of Clemson University, the South Carolina Forestry Commission, and the USDA Forest Service appeared to be the best way of increasing implementation of the latest pest management approaches. Because of the extensive forest acreage owned by nonindustrial private individuals, we believed that there was primarily a need to address this ownership group. Although considerable attention was focused on this audience, cooperative interaction with professional resource managers and Extension specialists also enhanced efforts to reach the principal users, the nonindustrial landowners. Cooperative Extension Service personnel and agency, industry, and consulting foresters had the personnel network and local contacts to make technology transfer effective. By receiving training, materials, and information through the Integrated Pest Management (IPM) project, these professionals also increased our ability to disseminate information and, in all cases, participated in a true cooperative spirit.

Our ultimate goal was to provide the most up-to-date technology on forest pest management and to present and demonstrate it in a manner that would convince landowners of its value and applicability to their specific situations. This approach was in keeping with our philosophy throughout the project that technology transfer must go beyond simply packaging information. It must interpret results and information while educating the user about its value and applicability.

The project focused on the major pest problems in South Carolina, the SPB/littleleaf problem in the Piedmont and fusiform rust and annosus root rot in the Coastal Plain. Specific emphasis was placed on: 1) Rating stand susceptibility to pest attack, 2) encouraging cultural or management practices to prevent or reduce pest losses, 3) recommending direct control tactics, and 4) utilizing damaged pines.

[1] Respectively, Associate Professor, former Extension Forester, and Professors, Department of Forestry, Clemson University, Clemson, SC.

APPROACH TO MEETING THE OBJECTIVES

IPM Technology Evaluation

Initial activities involved evaluating existing pest management technology and determining its potential for use in South Carolina. Suitable existing materials were either used in their original form or modified for local needs. SPB risk/hazard rating systems were reviewed to determine which ones landowners could use to identify stands that needed cultural treatment. Particular emphasis was given to the Coastal Probability and Piedmont Probability systems (Hedden 1985a, 1985b). Computer software was also evaluated and, if found to be suitable, incorporated in the project. Specific software included CLEMBEETLE (Hedden 1985c), IPM Decision Key (Anderson and others 1982), FUSIFORM RUST—SLASH (Nance and others 1983), and YIELD, a timber yield forecasting and financial planning program (Hepp 1984).

Video materials and supplies of publications on the four pests were obtained and distributed (table 1). In addition, decisions were made concerning the development of new IPM printed and video material. Finally, different types of portable sawmills were compared. A Mobile Dimension Saw® (described by Remion and Boone in section II) was purchased, assembled, and transferred to the SC Forestry Commission to promote better utilization of pest-killed pine timber.

Developing New Materials and Techniques

As the project moved into the development phase, producing quality printed and videotaped material was a high priority. To accomplish this, a graduate assistant in graphic arts joined the project to help with photography; handle all aspects of publication layout, illustration, and typesetting; and help with design and printing of exhibit materials (table 1).

Project identification.—To focus attention on the IPM project, a logo was designed and used on all materials produced during the project (fig. 1). The logo was so well received that the Clemson University Cooperative Extension Service IPM Committee asked to use it on all Extension Service IPM-sponsored materials and programs in South Carolina. In addition, a similar (but different) logo was designed for 4-H Club IPM programs. The logo idea proved very effective in drawing attention to the project.

Both the Coastal Probability and the Piedmont Probability hazard-rating systems were modified to make them more useful to professional foresters and landowners without technical background. For each system, a card was printed for field use in stand ratings. A leaflet was also published to explain each

Table 1—*Publications, movies, and videotapes produced by the South Carolina Demonstration Project*

Description	Title	Author	Date released
Leaflets			
Clemson Univ. Coop. Ext. Serv., For. Leafl. 5 (6 p.)	Identifying the southern pine beetle	Ham, D. L.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 6 (6 p.)	Salvage removal: a method for controlling southern pine beetle infestations	Ham, D. L.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 7 (6 p.)	Cut and leave: a method for controlling southern pine beetle infestations	Ham, D. L.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 8 (4 p.)	Estimating potential loss from the southern pine beetle	Hedden, R. L.; Karpinski, C.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 9 (6 p.)	Portable sawmill operators in South Carolina	Tainter, F. H.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 10 (8 p.)	So . . . you want to buy a portable sawmill!	Tainter, F. H.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 11 (6 p.)	Predicting potential loss to southern pine beetle in natural stands in the Piedmont	Karpinski, C.; Ham, D. L.; Hedden, R. L.	1984
Clemson Univ. Coop. Ext. Serv., For. Leafl. 12 (6 p.)	Don't leave your trees to rot . . . utilize them!	Tainter, F. H.	1983
Clemson Univ. Coop. Ext. Serv., For. Leafl. 13 (6 p.)	Predicting potential loss to southern pine beetle in the Coastal Plain	Karpinski, C.; Ham, D. L.; Hedden, R. L.	1984
Clemson Univ. Coop. Ext. Serv., For. Leafl. 14 (4 p.)	Estimating potential loss to southern pine beetle in the Coastal Plain	Karpinski, C.; Ham, D. L.; Hedden, R. L.	1984
Movies			
"The New Breed"	A 15-min. 16 mm film on portable sawmills as a tool in pest management.		
"Littleleaf"	A 15-min. 16 mm film on littleleaf disease history, cause, and impact.		
Videotapes			
"Identifying southern pine beetle attacks"	A 30-sec. videotaped public service announcement	S.C. For. Comm.	—
"Preventing southern pine beetle infestations"	A 30-sec. videotaped public service announcement	S.C. For. Comm.	—
"Direct control of southern pine beetle spots"	A 30-sec. videotaped public service announcement	S.C. For. Comm.	—

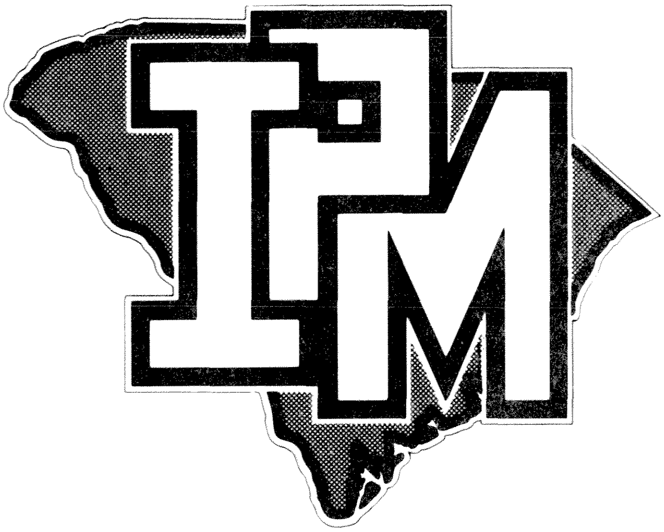

Figure 1—Logo for the Integrated Pest Management Demonstration Project in South Carolina.

system and use of the card. These publications, Forestry Leaflets Nos. 8, 11, 13, and 14, are listed in table 1.

Technology adaptation.—Another modification of existing technology was the conversion of the SPB management simulation model CLEMBEETLE from the mainframe computer to microcomputer versions. These were considered more accessible and would be more widely used by foresters in assisting landowners in pest management decisionmaking. CLEMBEETLE was converted to run on Radio Shack TRS 80 models II, 12, and 16, and on Apple II. The Radio Shack version was distributed to all county Extension offices where it would be readily accessible to Extension and South Carolina Forestry Commission personnel. The USDA Forest Service and other State forestry agencies with Apple II computers were primarily interested in the Apple version.

CLEMBEETLE and other decisionmaking models can illustrate the impact of pests under various site, stand, and pest conditions and, indirectly, indicate management practices to minimize pest impact. To maximize preventive efforts, however, the models should be used and stand treatments implemented when pest populations are at endemic levels.

Promotional materials.—Because of the impact and importance of the SPB in South Carolina, three additional Forestry Leaflets (Nos. 5, 6, and 7) were developed. Respectively, these dealt with identifying the southern pine beetle and its control using salvage removal and cut-and-leave methods. These leaflets have been widely used, including a request from the Louisiana Forestry Commission for 300 copies of each for distribution in that State. The Georgia Forestry Commission also requested that we make minor modifications (State name and logo changes) to Leaflets Nos. 6, 7, 8, and 11, and make them available for reprinting and distribution in Georgia.

To promote the increased utilization of pest-killed timber, three Forestry Leaflets (Nos. 9, 10, and 12) were published that dealt with the use of portable sawmills. In addition, posters or charts were developed that illustrated the financial returns possible from utilizing a portable sawmill onsite for landowner consumption of wood products rather than selling pest-killed timber for lower priced products (i.e., pulp). Other publications relative to portable sawmills and a study, "Economic and Operational Analysis of Portable Sawmill," are underway at this writing.

Exhibits featuring the overall IPM project as well as pest management computer applications were developed. The IPM Newsletter was started and is now published on a periodic basis. Considerable movie and videotape footage was taken. As a result, two 16 mm movies, "The New Breed," (dealing with the portable sawmill) and "Littleleaf," and three videotape public service announcements about the SPB were produced. In addition, videotapes about fusiform rust and annosus root rot are now being prepared. A slide-tape on littleleaf disease is also being provided, and the USDA Forest Service assisted in developing and implementing a littleleaf stand hazard-rating system for use on the Sumter National Forest in South Carolina (see related report by Hoffard and Oak, section II).

Computer applications.—The final area explored during the project was computer applications of IPM. This involved three distinct approaches. First of all, software service was provided to professional foresters and county Extension personnel in South Carolina. This included the distribution of pest management decisionmaking software. In addition, assistance was provided or the software actually run on both microcomputers and the mainframe computer at Clemson using data supplied by private landowners, agencies, and forest industry.

Second, electronic mail was used to quickly transmit IPM information to the field on a timely basis. The third area involved the use of an interactive call-in system. This technique disseminated information on pest status but was a more passive approach than electronic mail. Text information on various pests as well as a bulletin board for meetings or activities related to pest management were included in the interactive call-in system, which was designated as the Pest Management Information Center (PMIC) at Clemson University.

Clemson Extension Forestry maintained the PMIC on a TRS 80 model 16B microcomputer that was compatible with the statewide network of computers in each of the county Extension offices. Considerable time and effort were devoted to developing the software for handling the information on the host microcomputer as well as the communications software.

Disseminating IPM Information

Packaging and providing IPM information and management recommendations to foresters and landowners were rewarding aspects of the project. The portable sawmill demonstrations sponsored by the South Carolina Forestry Commission in cooperation with the local county Extension offices provided an excellent means of attracting landowners to field demonstrations and workshops. An educational program could then be presented that concentrated on local pest management problems and solutions as well as the economic justification for utilizing a portable sawmill. Various other county Extension-sponsored landowner meetings provided a similar opportunity to present IPM information.

IPM information was also presented to professional groups in South Carolina and elsewhere in the Southeast. Publications, exhibits, and computer demonstrations were often used to promote the project activities and philosophy. An Annosus Root Rot Workshop (Wedgefield, SC, May 23, 1984) that addressed the latest annosus sampling and management strategies and economic considerations was well received. The 1985 Clemson Forestry Forum (March 12, 1985) involved many IPM workers and covered most of the major pests. The project staff also participated in a statewide Extension IPM tour that provided an excellent opportunity to promote and gain support for forestry IPM programs with State and National Extension administrators.

Five tracts established during an earlier demonstration project were utilized. This involved working with five landowners with very different management objectives. The goal of the project was to demonstrate that pest management considerations could and should be incorporated during the early stages of the forest management plan preparation regardless of the landowners' management objectives. Consulting foresters cooperated in the project by assisting in the planning stages and implementing the silvicultural recommendations that included approaches to minimize the potential for SPB attack. These demonstration areas are now being used to illustrate this approach to other landowners in the State.

Publications, Movies, and Videotapes Produced

There were 10 publications, 2 feature films, and 3 videotapes produced during the demonstration project. These are summarized in table 1.

IMPACT OF DEMONSTRATION PROJECT ON SOUTH CAROLINA FORESTS

The guiding philosophy throughout the project was that successful persuasion of foresters and landowners to implement IPM strategies required presentation of the information in a professional, innovative manner. However, regardless of how good the information and materials, landowners must be motivated to implement them. A good return on an investment is one of the best motivators of all. With this logic foremost, every opportunity was used to emphasize the economic benefit of implementing pest management practices. Computer growth and yield software with financial analysis was especially helpful in making this a successful approach.

Stressing the economic impact of underutilizing pest-killed timber made the portable sawmill successful. For example, landowners were told that loggers seldom bought small volumes of timber because the high costs involved in moving equipment and personnel make it uneconomical. However, when a logger is willing to cut small volumes of salvageable sawtimber, landowners will normally have to accept a substantial reduction in price to compensate the logger for these additional costs. Figure 2 was used to illustrate that the price range paid for salvaged trees is consistently lower (usually pulpwood prices) than their potential value as sawtimber.

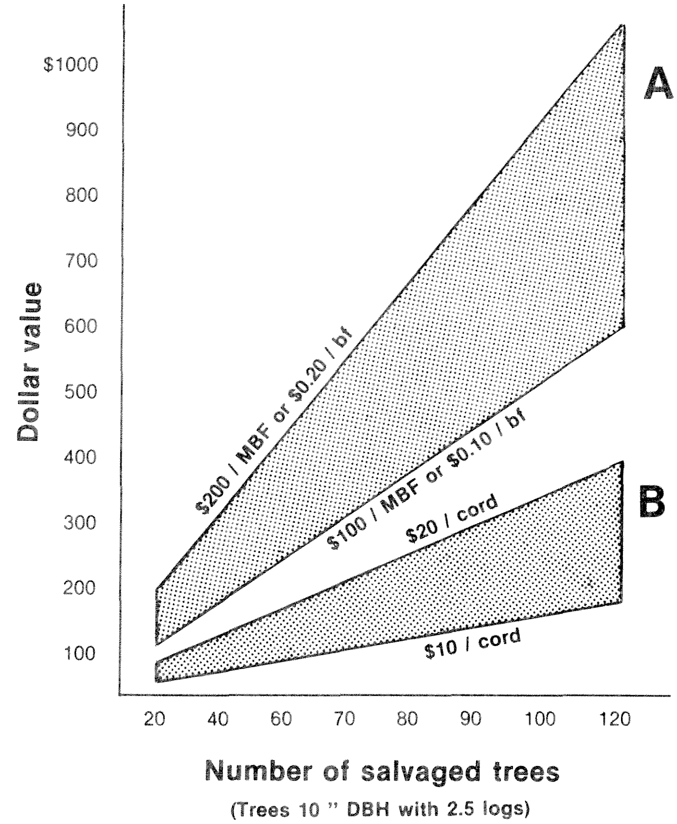

Figure 2—Price range for green sawtimber compared with price range for pulpwood that is commonly paid for small volumes of pest-killed timber.

Rather than sell pest-killed timber for pulpwood prices or let it go to waste, landowners can use portable sawmills to cut quality lumber at a cost well below market price.

Once the "dollar and cents" costs and returns from utilization had the attention of the audience, they were usually very receptive to considering other aspects of pest management. The economic approach also caught the attention of county Extension Service personnel. County agents routinely assist farmers and landowners with small holdings in the cost/benefit aspects of their agricultural operations. As a result, they have the confidence of that audience and can be very effective in disseminating forest pest management and economic information.

Initiation of three pest management projects by county Extension personnel is evidence of some of the IPM project impact on this audience. Two field projects to demonstrate the economic justification of thinning to reduce SPB losses are being installed. Another project to hazard rate pine stands in one county for annosus root rot and establish demonstration plots has also begun. These projects were initiated by county personnel using funding obtained through the Clemson University Cooperative Extension Service IPM Committee.

Many of the approaches used in the South Carolina Demonstration Project had a positive influence on other IPM programs in South Carolina. The Extension IPM Committee, aware of the magnitude and commitment of the project, supported and promoted many of its ideas and approaches. Some of these innovations, such as the IPM logo and computer communications software, have been adapted for IPM programs concerned with pests of other commodities in other university departments. Forestry interests will certainly be actively represented on the Extension IPM Committee in the future.

The Pest Management Information Center will continue to be maintained on the Radio Shack system or possibly in the future on a larger statewide computer communications system. Computer communications is a dynamic new area, and this demonstration project has been influential in initiating its use for pest management information dissemination in South Carolina.

CONCLUSIONS

The IPM project provided the Department of Forestry and the Cooperative Extension Service at Clemson University with the funding and flexibility to initiate a very ambitious pest management demonstration project. However, our responsibilities, attention, and work in integrated forest pest management will not stop with the termination of Federal funds. Activities during the IPM project have built an excellent foundation for future work and successful approaches have been developed that will continue to be used and improved. One of the important successes of the project was establishing the commitment of county Extension personnel to forest IPM. This will ensure the demand and continuing support for our forest pest management Extension work and dissemination of information.

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SOUTHERN PINE BEETLE TECHNOLOGY TRANSFER IN TEXAS

R. F. Billings, C. M. Bryant, V, H. A. Pase, III, K. A. Wilson, and C. Walker[1]

INTRODUCTION

Outbreaks of the southern pine beetle (SPB) have been notably persistent and severe in the 12 million acres of commercial forest lands in east Texas. In one continuous outbreak that lasted from 1958 to 1977, more than 58,000 multiple-tree infestations were detected on non-Federal lands, accounting for an estimated loss of 154 million cubic feet of pine timber. The threat of SPB infestations has been deemed one of the most serious restraints to improving forest productivity on both industrial and private nonindustrial lands in Texas.

In 1980, a 5-year cooperative project was initiated by the Texas Forest Service (TFS) to demonstrate, validate, and implement new technology for the integrated management of SPB and related pests within a two-county area of east Texas. The demonstration area corresponded to TFS administrative District 9, consisting of Polk and Tyler Counties in their entirety. These two counties consistently ranked among the more heavily infested counties during the 1958−77 SPB outbreak. Collectively, Polk and Tyler Counties contain over 1,100,000 acres of commercial forest lands of which 870,000 acres (77 percent) are in SPB host type (pine or oak-pine). The topography ranges from highly susceptible lowland sites to less susceptible rolling hills and uplands. Landownership is typical of southeast Texas counties, consisting of 76 percent industrial ownership, 23 percent nonindustrial, and 1 percent public lands (Kirby State Forest and the Beech Creek Unit of Big Thicket National Preserve).

The intended audience targeted by the East Texas Demonstration Project included the major forest industries in Texas, Texas Forest Service field foresters, and small, private landowners in the area. Major forest industries in Texas were involved directly in the project through the formation of a landowner advisory board (table 1). This nine-member board, consisting of one representative from each major company and the TFS Area Forester, met periodically with project personnel to review plans and accomplishments and to provide guidance in project activities.

Table 1—*Membership in landowner advisory board*

Name	Organization
Irwin Grillot	Champion International, Inc.
Wayne Foster	St. Regis Paper Company
Robert Larsh	Kirby Forest Industries, Inc.
Darwin Foster	Temple-Eastex Forests
Johnny Sutton	Wirt Davis Estate
Ronald Gresham	Owens-Illinois, Inc.
Herbert Branch	International Paper Company
Finis Prendergast	Louisiana Pacific
Gary Lacox	Texas Forest Service

The overall goal of the demonstration project was to acquaint concerned landowners, both industrial and private, with new technology available for the prediction, prevention, evaluation, and suppression of the SPB. Development, implementation, and validation of new SPB prediction and hazard-rating systems in Texas also were important features of this technology transfer effort.

APPROACH TO MEETING OBJECTIVES

SPB Hazard Maps

Research in recent years has documented that high basal area per acre, large-size trees, and poorly drained bottomland sites are associated with a high incidence of SPB infestation in east Texas. TX HAZARD, a hazard-rating system based on these factors (Mason and others 1981), was used to develop hazard maps for all pine stands greater than 10 acres in size in the two-county area (table 2). Stand data were obtained from 1978 color-infrared (CIR) print photography (scale = 1:20,000). Stand delineations were made and parameters of percent pine, percent crown closure, average d.b.h., pine basal area, and stand height were interpreted from the photos for each pine stand. Stand delineations were then transferred to acetate overlays for United States Geological Survey (USGS) orthophoto quadrangle maps (scale = 1:24,000), using a Kail reflective enlarger. Landform classifications, generated from USGS topographic maps, were combined with stand data to generate an SPB hazard classification (low, moderate, high, or extreme) for each stand (fig. 1).

An 85 percent correct classification of hazard was verified by visiting a 10 percent random sample of the stands in each quadrangle and measuring the actual hazard on the ground using the hazard-rating guide (TX HAZARD) shown in table 2. In the same manner, ca. 50 percent of all stands classified

[1] Respectively, Principal Entomologist and Entomologists, Texas Forest Service, Lufkin, TX; and District Forester, Texas Forest Service, Livingston, TX.

(Many Texas Forest Service personnel provided assistance in various aspects of this demonstration project, including Martha Johnson, Anita Weisenger, Charles Ware, Alan Smith, Steve Tracy, Davin Ivans, Mike Caughey, Carol Riggs, Elmer Freshour, Pat Bryant, Dan Mott, Elray Dominey, Tom Hartz, Ed Barron, and the District 9 field crews. We also thank Dr. Robert Maggio, Cathy Wilson, Ken Morris, and Russel Irons for their assistance with hazard map digitization, and Charles Palmer, Texas Natural Resource Information Service, for providing aerial photographs and generating the final grid block hazard map. Their efforts contributed greatly to the success of this project.)

Table 2—*Method of rating relative susceptibility of pine stands to SPB attack and timber loss in a two-county area in east Texas.*

	RIDGE			OTHER TERRAIN			BOTTOM			
	TREE HEIGHT (feet)			TREE HEIGHT (feet)			TREE HEIGHT (feet)			
Pine Basal Area (sq ft/acre)	<50	50-75	>75	<50	50-75	>75	<50	50-75	>75	HAZARD
<80	low	low	low	low	low	low	low	low	med	
80-120	low	low	med	low	med	med	med	med	high	
>120	low	med	med	med	high	high	med	high	high	
	<6	6-12	>12	<6	6-12	>12	<6	6-12	>12	
	TREE DIAMETER (inches)			TREE DIAMETER (inches)			TREE DIAMETER (inches)			

SOURCE: Mason, G.N. TX HAZARD. In: Mason, G.N.; Hertel, G.D.; Thatcher, R.C., compilers. Predicting southern pine beetle and disease trends. Pineville, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station and Southern Region Forest Pest Management; 1985:62-63. [Administrative training aid]

as high or extreme hazard were visited on the ground to confirm correct classification. High altitude CIR NASA positive transparencies taken in July 1980 and January 1981 were used to update the stand and hazard classifications of those stands that had been logged or thinned since 1978. The final hazard maps were reproduced in 5 mil chromatic film and later digitized by personnel of the Texas A&M University Department of Forest Science for permanent storage and subsequent updating. Acreages were computed for each hazard class and ownership category.

Copies of the SPB hazard maps pertaining to a given ownership were provided to each major forest industry with holdings in Polk and Tyler Counties. Also, a complete set of maps was provided to the TFS District 9 office in Livingston. To encourage hazard reduction, each company was also given a listing of all high- and extreme-hazard stands on their lands and asked to provide feedback to project personnel with regard to which stands were to be treated prior to 1985.

Many of the stands rated as high or extreme hazard are located on nonindustrial private lands. These landowners were contacted either in person by TFS district personnel or by mail to inform them of the situation and to encourage silvicultural treatments.

Of the 754,535 acres of current pine host type (> 10 years of age) in Polk and Tyler Counties in 1981, 57,038 acres (8 percent) and 29,739 acres (4 percent) consisted of stands rated as high and extreme hazard to SPB, respectively. Of the total acreage in high- and extreme-hazard stands, 56 percent belonged to forest industry, 39 percent to small private landowners, and the remainder (5 percent) to the Big Thicket National Preserve.

A survey was conducted in 1983 to document the extent to which high- and extreme-hazard stands had been treated since 1981 to reduce SPB hazard. A random sample representing 10 percent of all such stands on private lands and 13 percent on industrial lands was revisited during the summer and fall of 1983. Results revealed that during the 2-year interim, 24 percent of all high-hazard stands had been harvested on industrial lands, 33 percent had been thinned, and 43 percent had received no treatment. On small private holdings, the respective figures were 8 percent harvested, 13 percent thinned, and 79 percent no treatment.

With the return of high populations of SPB in 1983 and 1984, an opportunity was provided to validate these stand hazard maps. The locations of spots reported from detection flights (68 in 1983 and 232 in 1984) were correlated with stand hazard classifications. Results (fig. 2) served to validate the TX HAZARD system. More than three times as many infestations per 1,000 acres of hazard class occurred in stands rated as high or extreme hazard as in those rated as low hazard. Also, many of the spots reported in stands rated as low or moderate hazard were found to occur in "high hazard" pockets of dense timber. The reduced occurrence of spots in stands rated as extreme hazard in 1984 probably reflects the fact that a greater number of these stands have been thinned or harvested since 1981 compared with stands in the other hazard categories.

An unexpectedly high number of infestations was recorded in 5- to 14-year- old pine plantations, particularly during 1984 (fig. 2). This observation suggests that SPB is capable of expanding its range of hosts to include plantations as young as 5 years of age. Interestingly, of 106 infested stands ground checked by project personnel in the demonstration area in 1984, 98 percent had either never been thinned or had remained unthinned for at least the past 6 years. This testifies to the benefits of thinning as a preventive tool.

Areawide Hazard-Rating System for SPB

A practical system for mapping the abundance and distribution of suitable habitat for SPB was developed to quantify areawide hazard for all commercial pine forests in east Texas (Billings and Bryant 1983). The system was developed by comparing the frequency of SPB infestations per TFS grid block (18,000-acre unit) during the period 1973–77 to host conditions prevailing within the grid block at the time, the

Figure 1(a)—Project forester Charles Bryant delineates forest stands on color infrared stereo aerial photographs, one step in the process of developing southern pine beetle hazard maps. (All photos courtesy Texas Forest Service.)

latter information sampled from 1974 high-altitude aerial photography. To hazard rate a grid block with this system, 20 systematically distributed 30-acre circular photo plots are inventoried for the presence of pine host type, its density and percent coverage, and landform in a simple dichotomous (yes or no) sampling procedure. Values are then used in a hazard-rating equation to discriminate between high-hazard grid blocks and those in which the host conditions are insufficient to support outbreaks of the beetle. The final product is an areawide hazard map showing the distribution and abundance of pine host type and areas where severe beetle problems are most likely to occur.

To date, 656 grid blocks covering over 11,800,000 acres have been hazard rated using current 1980–83 aerial photography (scale = 1:120,000). Currently, 5 percent, 11 percent, and 84 percent of the grid blocks are rated high, moderate, and low hazard, respectively, in central and southeastern counties of east Texas. In a further application, the current hazard rating for each grid block was combined with the frequency of SPB infestations detected in 1982–83 in the same grid

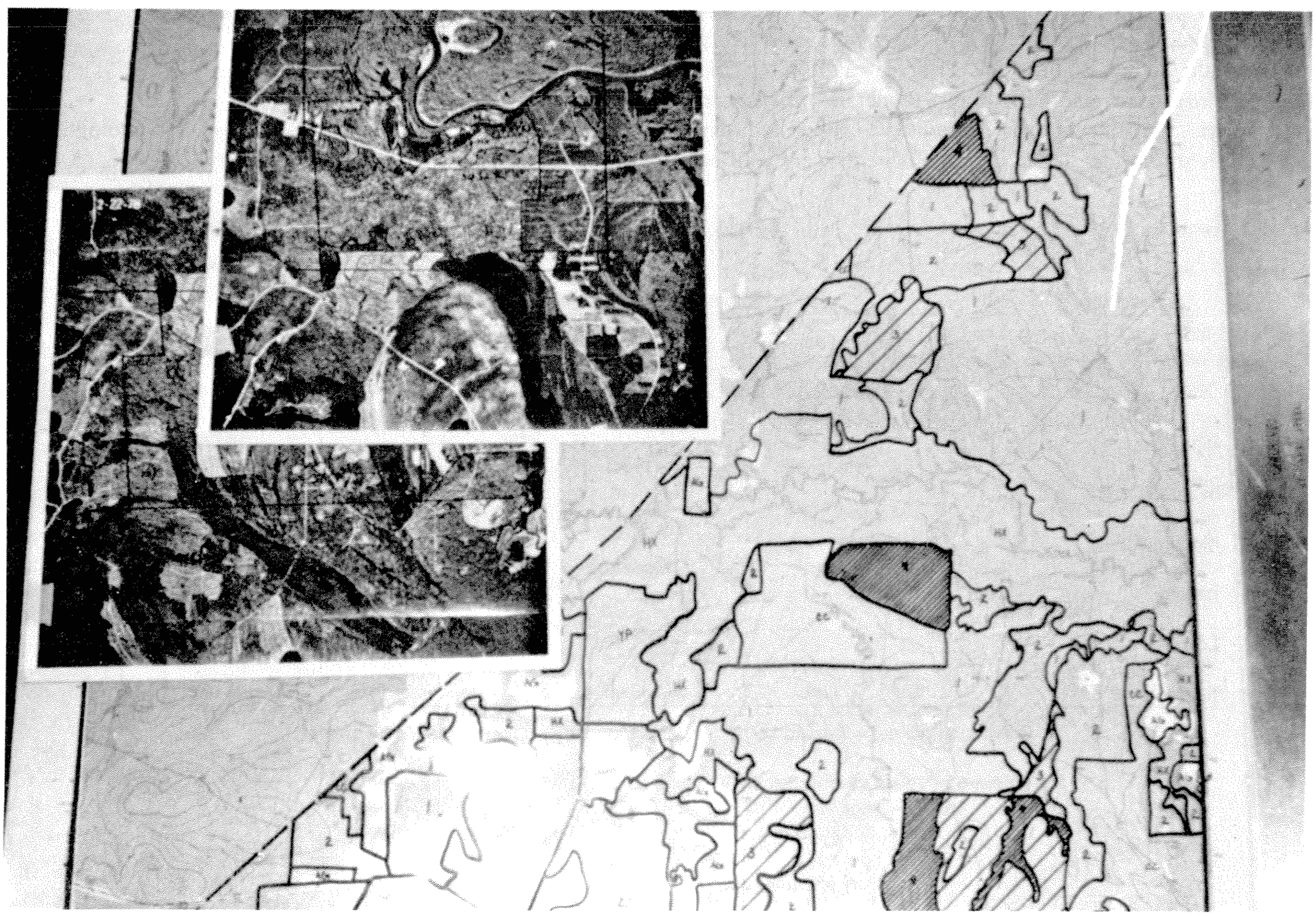

Figure 1(b)—Example of final southern pine beetle hazard map for a portion of the two-county demonstration project.

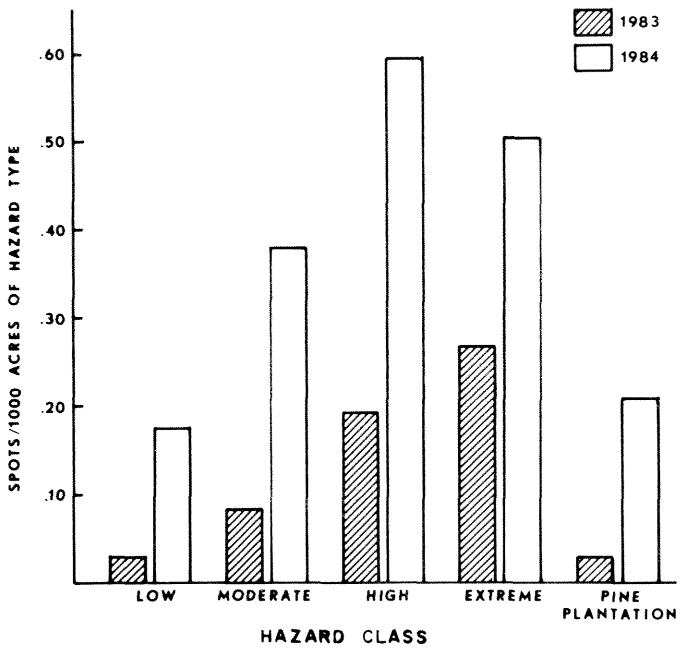

Figure 2—Average numbers of southern pine beetle infestations (10 or more trees) detected in Polk and Tyler Counties during 1983 and 1984 by stand hazard class.

block (table 3). The result was a risk classification or forecast of which specific grid blocks in east Texas would most likely suffer beetle outbreaks in 1984. Prior to the 1984 beetle season, a listing of extreme-, high-, moderate-, low-, and very low-risk grid blocks was distributed to forest industry and TFS field foresters. Other interested clients were notified through "Texas Forestry," the monthly publication of the Texas Forestry Association.

Records of 6,166 confirmed SPB infestations (spots) detected in east Texas within 504 grid blocks during 1982–1984 were compiled and summarized to validate the grid block hazard-rating system. Over the 3-year validation period, the average number of spots per grid block was 62.9 in high-hazard grid blocks, 20.7 in moderate-hazard grid blocks, and 6.6 in low-hazard grid blocks. Infestation levels by grid block hazard class for 1982–83 and 1984 are illustrated in figure 3.

A postseason evaluation of SPB risk classifications, based on 4,759 muliple-tree infestations detected in east Texas in 1984, revealed that the 10 grid blocks rated as extreme risk supported an average of 89.2 spots per grid block (ca. 5 spots per 1,000 acres). By contrast, those identified as high, moderate, low, and very low risk had an average of 40.1, 16.9, 11.1, and 3.6 spots per grid block, respectively. Clearly, the basic objective of the risk-rating system was met: 26 high- and extreme-risk grid blocks were identified prior to the 1984 beetle season. By the end of 1984, these grid blocks, representing only 5 percent of the outbreak area, had supported a disproportionate number (32 percent) of all new infestations. This risk-rating system is to be updated annually with the previous year's infestation records. A new list of grid blocks by risk category will be distributed to field personnel in preparation for each new beetle season.

Aerial Photo Missions and the Loran-C

From 1980–82, black-and-white stereo aerial photographs at a scale of 1:15,840 were obtained for 30 USGS 15-foot

Table 3—*Procedure used to assign 1984 risk classes to TFS grid blocks, based on hazard class and recent beetle infestation level*

Grid block hazard		SPB Infestation index (spots/grid block in 1982 and 1983) 0(0)**	1-10(1)	11-30(2)	>30(3)	
High hazard	(3)*	Moderate	High	High	Extreme	R I S K
Moderate hazard	(1)	Low	Moderate	Moderate	High	
Low hazard	(0)	Very Low	Low	Moderate	Moderate	

Risk rating points = hazard points + population index points + proximity points***

Where 6 or 7 = Extreme risk of SPB infestations in 1984
4 or 5 = High risk
2 or 3 = Moderate risk
1 = Low risk
0 = Very low risk

* Hazard points
** Population index points
*** If grid block is located adjacent to a high-hazard grid block having >30 spots = 1 point.

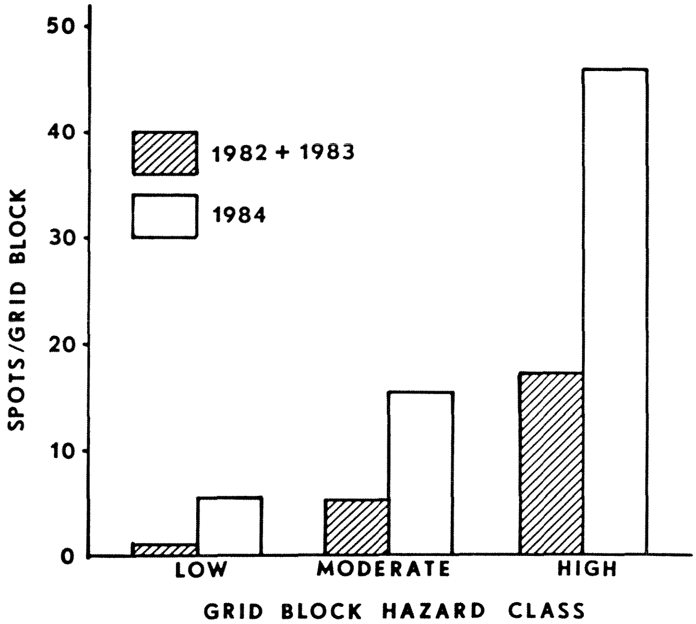

Figure 3—Average numbers of southern pine beetle infestations (10 or more trees) detected in Texas Forest Service grid blocks (18,000-acre units) during 1982-83 and 1984 by grid block hazard class.

quadrangles in east Texas, covering 4.9 million acres. These photo missions were flown with a Texas Forest Service De Havilland Beaver equipped with a Zeiss 9- by 9-inch format camera and a Loran-C radio navigation system. These missions provided an opportunity to test the Loran-C, a navigational system that has greatly aided aerial photography and SPB survey flights (Dull 1980). These tests revealed that the Loran-C operated well in most areas of east and central Texas, except near latitude N 30° 30′ where performance was erratic and unreliable. East Texas is located along the western fringe of the Southeast U.S. Loran-C Chain, which causes operational problems in certain areas.

The aerial photographs have been very beneficial to field foresters for forest and pest management work. Also, the photography has served as the foundation for updating quadrangle maps used by the TFS and forest industry for SPB and fire detection. A library of aerial photo negatives is maintained at the Pest Control Section office in Lufkin, where prints are available upon request to all interested parties.

SPB Decision Support System

A computer-based Southern Pine Beetle Decision Support System has been developed at Texas A&M University in cooperation with the East Texas Demonstration Project. A completed version is now available for use. The system is designed to help decisionmakers organize and use available information and technology to address SPB-related problems. Computer models used to project stand growth, predict SPB spot growth, evaluate economic impact, ascertain the costs and benefits of control efforts, evaluate utilization options, and hazard rate stands are linked by an interactive executive program. In addition, an information system provides SPB "fact sheet" recommendations for particular problems.

As a part of the demonstration project, the Pest Control Section is testing and implementing various components of the system. Several spot growth and damage prediction models have been compared with actual spot growth data. Modifications based on these tests have improved overall model performance. Approximately 30 infestations were monitored in 1982–83, and data from these spots have been used to further validate the models.

Microcomputers and IPM

An Apple III microcomputer and peripheral equipment were installed in Lufkin and contributed significantly to the quality and efficiency of Forest Pest Control Section operations as well as the integrated management of SPB. Word processing, statistical analysis, data transfer, data compilation, communications, and decision support are among the areas in which the microcomputer system has been used.

Additional microcomputer facilities were installed at Lufkin and the Texas Forest Service District 9 office in Livingston. These systems provide field foresters with access to available microcomputer technology for forestry and forest pest management and increase the efficiency of SPB operational data transfer.

Several SPB models were programmed for access on the Apple III microcomputer. These include the IPM Decision Key developed by the USDA Forest Service (Anderson and others 1982), stand hazard models (Mason and others 1981), TFS spot growth models (Billings and Hynum 1980), and annosus root rot management guidelines (Alexander and Anderson 1982). Advantages of having models on the microcomputer include ready accessibility (no phone lines required), low cost of operation, and the interactive mode. A major roadblock to the prompt transfer of computer-based SPB models, however, is the fact that most State and industrial field offices in Texas currently do not have access to computer hardware. This limitation should be overcome in time as the cost of microcomputer hardware declines and more field foresters gain access to such equipment.

Portable Sawmill

To increase the utilization of beetle-killed trees on small private holdings, the project purchased a Mobile Dimension Saw® in 1980 and installed it on a 22-foot trailer. Three TFS technicians were trained in sawmill operation and maintenance. The utility and availability of this portable sawmill were then advertised by means of demonstrations, folk festival parades, news releases, and television reports. The sawmill, together with a trained operator, has been leased to numerous landowners in Polk and Tyler Counties to convert green or beetle-killed trees to rough-cut dimension lumber (fig. 4). Although cost of operating the mill averaged $0.08 per board foot, productivity was found to vary with size and quality of logs, dimension of lumber sawed, and experience of mill operators. The largest job to date consisted of 14,000 board feet of beetle-killed trees sawed on the Alabama Coushatta Indian Reservation. The sawmill provides a practical alternative to those local landowners unable to sell their beetle-infested

Figure 4(a)—Portable sawmill used in the East Texas Demonstration Project to produce rough-cut dimension lumber from beetle-killed pines.

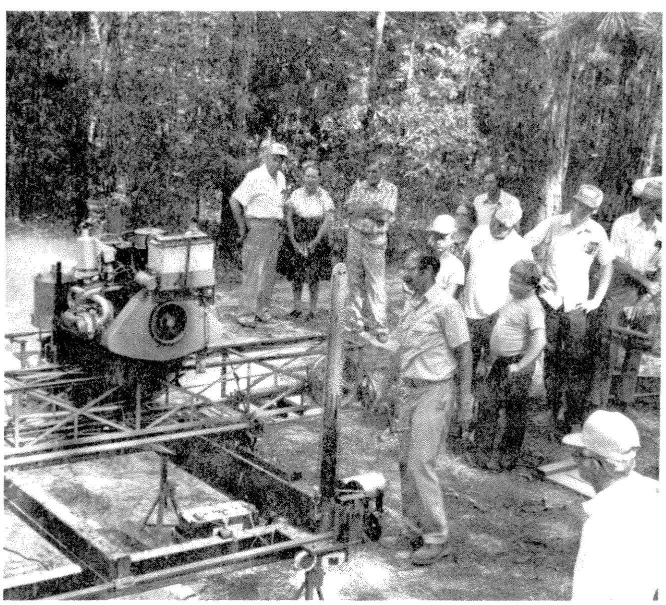

Figure 4(b)—Project coordinator Ron Billings demonstrates the portable sawmill as part of a landowner tour on the Kirby State Forest near Woodville, TX.

timber to salvage contractors. Since successful implementation of the portable sawmill in the east Texas demonstration project, other sawmill operations with similar equipment have been initiated in Texas, South Carolina, and other southern States to utilize beetle-killed trees.

Technology Transfer

Considerable effort was devoted to technology transfer throughout the duration of the demonstration project. Project plans and accomplishments, the availability of new pest management technology, and SPB status reports were communicated to east Texas landowners and to other interested parties by means of a newsletter entitled "Spotlight on Southern Pine Beetle." This single-page newsletter was prepared and distributed quarterly throughout the duration of the project. Plans are to expand this newsletter to include other pests of importance to Texas forestry and widen the distribution throughout east Texas. Accomplishments in the demonstration project also were the subject of other news releases, seminars, and landowner tours. Demonstrations of the portable sawmill served to increase attendance at numerous landowner meetings held to spread the word of project activities.

Field crews with TFS and forest industry were trained in new procedures for aerial detection, setting ground check priorities, direct control tactics, and beetle prevention (fig. 5). To communicate new technology available for detection, suppression, and prevention of SPB, two new publications were issued. One, a pocket-size booklet entitled "Southern Pine Beetle—Field Guide for Hazard Rating, Prevention and Control" (Texas Forest Service Circ. 259), has received wide acclaim, not only in Texas but across the South. The second publication, prepared in the format of a USDA Agriculture Handbook for distribution southwide as part of the IPM program's Integrated Pest Management Handbook series, is entitled "How to Conduct a Southern Pine Beetle Aerial Detection Survey" (Texas Forest Service Publ. 267). In addition, videotape training programs have been prepared on new aerial detection and ground check procedures. A complete list of publications and audio-visual materials produced by the East Texas Demonstration Project appears in table 4.

Members of the Landowner Advisory Board were encouraged to communicate project accomplishments to others within their respective organizations. Even after completion of the demonstration project, training aids, demonstrations, and publications will be used in a continuing effort to provide the Texas forestry community with the latest technology for integrated management of SPB.

Figure 5—Project entomologist Joe Pase conducts field training on improved methods for evaluating a southern pine beetle infestation and setting control priorities for the benefit of Texas Forest Service district crews.

Table 4—*Publications and audiovisual materials produced during the East Texas Demonstration Project, 1980–85*

Description	Title	Authors	Date released
Procedural guides			
Tex. For. Serv. Circ. 259, 10 p.	Southern pine beetle: field guide for hazard rating, prevention and control	Billings, R.F.; Bryant, C.M., V	1982
Tex. For. Serv. Circ. 267, 19 p.	How to conduct a southern pine beetle aerial detection survey	Billings, R.F.; Ward, J.D.	1984
Tex. Agric. Exp. Stn. MP-1518 24 p.	Procedural guide for using the interactive version of the TAMBEETLE model of southern pine beetle population and spot dynamics	Turnbow, R.H.; Coulson, R.N.; Hu, L.; Billings, R.F.	1982
Journal articles			
Z. angew. Entomol. 96:208-216	Developing a system for mapping the abundance and distribution of southern pine beetle habitats in east Texas	Billings, R.F.; Bryant, C.M., V	1983
Trade magazine articles			
J. Forestry 79:816	Texas project gets beetle when its down	Anonymous	1981
TF News 61:12-13	Have sawmill: will travel—portable sawmill aids beetle prevention program	Billings, R.F.	1982

Table 4—*Publications and audiovisual materials produced during the East Texas Demonstration Project, 1980–85 (continued)*

TF News 62:2-5	Southern pine beetle in Honduras: new approaches to an old problem	Billings, R.F.	1983
Tex. Forestry 24(5):1,6,7	New approach developed to forecast SPB outbreaks	Billings, R.F. Bryant, C.M.	1983
TF News 63:6-8	SPB hazard rating	Bryant, C.M.	1984
Tex. Forestry 22(7):2, 11, 12	Pine beetle demonstration project established in Polk and Tyler Counties	Tex. For. Serv.	1981
TFS Publ. 127: 11-17	Southern pine beetle demonstration project	Tex. For. Serv.	1982
Proceedings papers			
Proc. Society of Am. Foresters National Convention, Orlando, FL	Implementing new southern pine beetle technology in east Texas	Billings, R.F.	1982
Tex. Agric. Exp. Stn. MP-1553 p. 1-5	Forest pests in east Texas: past approaches, future challenges	Billings, R.F.	1984
Proc. Third Biennial Southern Silvic. Research Conf. 5 p.	Hazard-rating system aids southern pine beetle prevention in Texas	Bryant, C.M.	(In press)
Soc. Am. For. Publ. 82-05: 121-124	Microcomputers aid southern pine beetle management	Bryant, C.M.; Pase, H.A., III; Billings, R.F.	1982
TFS Publ. 136: 17-21	IPM demonstration project	Tex. For. Serv.	1984
Newsletters			
Distributed quarterly	Spotlight on southern pine beetle - progress report from the east Texas demonstration project		Since 1980
Audio/Visual Aids			
Videotape program on how to groundcheck southern pine beetle infestations and set control priorities.			
Videotape program on SPB aerial detection surveys (In preparation)			

IMPACT OF THE DEMONSTRATION PROJECT ON TEXAS FORESTS

This IPM demonstration project has proven to be a successful means for implementing new SPB technology within the State of Texas, where forest managers have long been plagued by beetle problems. The development, application, and validation of the TFS grid block hazard-rating system is considered a major contribution to new SPB technology. This grid block hazard-rating system provides a convenient, inexpensive, and practical means for monitoring the distribution and abundance of suitable host conditions on a regional basis. When combined with data on recent beetle activity to provide an annual risk classification for each grid block (table 3), the system provides reliable and timely SPB infestation predictions of value to all forest landowners and administrators in east Texas.

The preparation of hazard maps of all individual stands in Polk and Tyler Counties was a time-consuming task. But, coupled with cooperative efforts by forest industry to treat high-hazard areas, this effort is now paying dividends. Polk and Tyler Counties have a history of severe SPB problems.

Yet, during 1982 and 1983, no confirmed SPB infestations were detected in Polk County and only 74 spots (out of 1,407 statewide) were reported in Tyler County. Many of the latter were on ownerships where forest management is not practiced.

In 1984, despite the occurrence of 5,120 multiple-tree infestations statewide, only 77 and 130 new spots (> 10 trees) were reported in Polk and Tyler Counties, respectively. A ranking of counties by total numbers of 1984 spots reveals that 9 other counties had more infestations than Tyler County and 12 reported more than Polk County. This is a substantial improvement from the previous outbreak (1973–77) when Polk County ranked fifth and Tyler sixth. Although the reduced level of SPB activity in the demonstration area may be due partly to factors unrelated to our project efforts, the fact remains that Polk and Tyler Counties have escaped the severe SPB-caused losses that currently plague many nearby counties outside the demonstration area.

The return of SPB to east Texas provided an opportunity to validate the statewide grid block hazard- and risk-rating systems as well as stand hazard maps developed for Polk and Tyler Counties. Each system proved reliable in that the highest concentration of new SPB infestations occurred in grid blocks and in stands rated as high or extreme hazard (or risk).

CONCLUSIONS

As beetle populations increase again in east Texas, technology transfer efforts have become increasingly important. Numerous field foresters and technicians with little previous experience with SPB are being taught effective approaches to aerial detection, ground check evaluation, control, and prevention. As part of its pest management responsibilities, the Texas Forest Service will continue its technology transfer program in an effort to make landowners in other counties aware of the latest methods for dealing with the SPB problem in east Texas.

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DEMONSTRATING EFFECTIVE MANAGEMENT MEASURES FOR SOUTHERN PINE BEETLE IN VIRGINIA

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INTRODUCTION

The southern pine beetle has reached outbreak populations in Virginia at regular 10-year intervals since the mid-1950's. During these outbreaks, which have ranged from 2 to 4 years in duration, damage estimates averaged well over $1 million per year (table 1).

A major factor contributing to these periodic outbreaks is the presence of unmanaged, overmature stands of native pines, particularly in the Piedmont, which are highly vulnerable to beetle attack. Unthinned younger pine stands are rapidly increasing in number in Virginia and expected to contribute additional "beetle-fodder."

The limited availability of woods labor for thinning young pine stands remains a concern; more mechanized procedures must be developed if the thinning so vitally needed is to be accomplished. Education of landowners, consulting foresters, and forest industry in regard to the value of good silviculture is mandatory if the challenge of "beetle-proofing" Virginia's pine stands is to be met.

A major demonstration project funded by the USDA Forest Service was conducted during the calendar years 1982–84. This multifaceted project strongly emphasized education through demonstration of silvicultural techniques, equipment, photo technology, and economic studies.

A second demonstration project was instituted in 1979 with financial assistance from USDA Forest Service, Integrated Pest Management RD&A Program on a State forest in Piedmont Virginia. It consisted of an on-the-ground application of the IPM findings from the Expanded Southern Pine Beetle Research and Applications Program (ESPBRAP).

A summary of the results of successful efforts to meet the objectives of the 1982–84 demonstration project follows.

APPROACHES TO MEETING THE OBJECTIVES

First Objective

The project's first objective was to select five Piedmont counties and identify high-hazard pine stands in need of thinning or harvest (cooperatively with Virginia Polytechnic Institute and State University).

Standard ASCS 1:40,000 black and white photographs of five counties (Lunenburg, Nottoway, Halifax, Mecklenburg, and Prince Edward) were evaluated. In addition, the information was transferred in two counties (Lunenburg and Nottoway) to a county map, and actual measurements of the acreage in the different hazard categories were made by Virginia Polytechnic Institute and State University (VPI&SU). These photos were made available to the consulting foresters (involved

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Table 1—*Southern pine beetle damage estimates in Virginia, 1960–80[1]*

Calendar year[2]	Estimated volume salvaged[3] Cords	Estimated volume salvaged[3] M fbm	Total volume killed Cords	Total volume killed M fbm	Stumpage values[4] Pulpwood $/cords	Stumpage values[4] Sawtimber $/M fbm	Total value $
1961	18,000	0	30,000	0	5.00	0	150,000
1964	63,000	0	90,000	0	6.00	0	540,000
1970	0	9,000	0	15,000	0.00	40	600,000
1972[5]	4,843	14,485	6,247	28,441	6.00	40	1,175,122
1973	4,843	14,485	6,247	28,441	6.00	40	1,175,122
1974	4,843	14,485	6,247	28,441	6.00	40	1,175,122
1975	4,843	14,485	6,247	28,441	6.00	40	1,175,122
1976	4,843	14,485	6,247	28,441	6.00	40	1,175,122
1977	159	0	265	0	6.79	0	1,800
1979	50	0	200	0	6.70	91	1,339
1980	90	0	389	0	8.25	69	3,209

[1] Information collected from State and Federal pest control specialists.
[2] Initial year based on available State records.
[3] Includes estimates on Federal, State, and private lands.
[4] Estimates from State pest specialists, same values assigned to timber salvaged.
[5] A total of 31,230 cords and 142,205 M fbm was reported killed from 1972–76. To provide uniformity within the table, these figures were divided by 5 years to show an average by year.

in Fourth Objective) for use in locating stands most in need of thinning. Maps and photos were then transferred to the individual county offices for use by Virginia Division of Forestry (VDF), industry, and consulting foresters working in those counties.

Second Objective

The second objective was to lease and demonstrate four promising, new pieces of equipment suitable for selective thinning in young pine stands and plantations.

The Division arranged 6-month equipment leases in cooperation with Chesapeake Corporation who secured reliable operators to evaluate the equipment's usefulness. We also conducted time/production evaluations on several of these pieces of equipment, which showed the MOR-BELL® Logger and the CASE UNILOADER® to be economical and effective in harvesting selectively thinned pine pulpwood.[2] Equipment demonstrated was: 1) Farmi winch, 2) MOR-BELL Logger, 3) MOR-BELL Shear, and 4) CASE UNILOADER 1845. During the lease period, numerous pulpwood yard operators, pulpwood crew supervisors, and industry foresters observed the equipment in field operations. All of the equipment demonstrated was sold to operators in Virginia and currently is being used for thinning.

Third Objective

The third objective was to arrange for equipment demonstrations. A 2-day working equipment demonstration was held in Essex County, VA, September 29–30, 1981. Fifteen pieces of logging equipment applicable to thinning operations were demonstrated. A total of 85 persons including consultants, industry, and Virginia Forestry Division foresters attended. A second, smaller, demonstration of the CASE UNILOADER was conducted over a 2-day period in the summer of 1982 with the cooperation of the Utilization Branch, VDF.

Fourth Objective

The project's fourth objective was to contract with consulting foresters to demonstrate the value of thinning in reducing future beetle outbreaks.

Contracts were made (by competitive bids) to thin 150 acres on private land in each of five southern Piedmont counties (Lunenburg, Halifax, Prince Edward, Louisa, and Mecklenburg). The consultant marked the stands for their first thinning, arranged for contractors (if requested), and supervised the cutting. A 30-acre limit per landowner was imposed. Twelve roadside signs calling attention to the thinning designed to reduce beetle damage were erected. Thinning operations have been completed on 90 percent of the selected tracts in the five counties; inspections have been conducted on 75 percent of the thinned tracts to date and will be completed in 1985.

[2] Grimm, Phil. Cost and production report on small mechanical thinning equipment. [Rep. dated September 1, 1982]. 5 p.

Fifth Objective

The fifth objective was to revise Division thinning publications and publish thinning guidelines.

A thorough review of VDF recommendations for thinning pine stands was completed, with some modifications and additions. A thinning pamphlet (5,000 copies) was developed and printed.

Sixth Objective

The sixth project objective was to determine ownership of pine stands in need of harvest or thinning, contact the involved landowners, apprise them of the high-hazard nature of these stands, and urge proper management.

Consequently, the Division mailed 50 letters to landowners of high-hazard stands in both Mecklenburg and Lunenburg Counties. Response was well above that expected: 45 to 50 responses per county were received requesting examination and recommendations. Assistance in servicing the requests was provided by the Insect and Disease Branch of VDF and Phil Grimm, Utilization Forester. (Additional letters were not mailed as anticipated due to lack of personnel to service responses.)

Seventh Objective

The seventh objective involved contracting with VPI&SU for a study to determine the economic value of various thinning regimes to reduce bark beetle damage.

This study (Burkhart and others 1984) incorporated the various available models of beetle populations, rates of spread, etc., with a population growth and yield model for Virginia developed by the VDF and by Dr. Harold Burkhart, VPI&SU. The results revealed the value of positive returns for all thinning regimes tested to reduce beetle attack over the 45-year rotation on the average to better sites. Values ranged from \$7.55 per acre on an average site at a rotation age of 45 (with one thinning to 80 ft^2 basal area at age 20, at two beetle spots per 1,000 acres of host type), to \$15.48 per acre where two thinnings had been done at age 20 to 35 under the same conditions; the better the site, the greater the gain.

Eighth Objective

The project's final objective was to illustrate the effectiveness of silvicultural control of the southern pine beetle.

The major goal was demonstrating the effectiveness of pine stand density manipulation to reduce beetle damage. All stands containing pine (ranging in age from 15 to 60 years) on a site called the Cole Tract were examined, marked, and harvested to reduce the basal area to 80 square feet. Periodic aerial surveys were conducted to compare beetle activity on the treated versus a nearby companion tract where management intensity was considerably lower. The results of those surveys are given in table 2. Beetle activity remained low until an outbreak occurred in 1983, when the first real occasion arose to evaluate the treatments.

To date, technology transfer has been limited to inclusion of the information on success in training meetings for VDF

Table 2—*Number of SPB spot infestations on treated (Cole) and untreated (Walker) tracts in the Virginia Piedmont*

	Number of beetle spots with red-topped trees	
Flight date	Cole	Walker
7/79	0	3
2/80	1	2
8/80	3	13
7/81	3 (singles)	3 (singles)
12/83	0	21 (16.3 acres total kill)

chief wardens, technicians, and foresters in 1983 and 1984. Plans for future information transfer will include a short magazine article for the Virginia Forestry Association.

INFLUENCE OF DEMONSTRATION PROJECTS ON VIRGINIA FORESTS

All of the objectives described above were designed to demonstrate the value of thinning to reduce beetle damage. Existing photo interpretation technology was applied to locate stands in need of thinning and harvest, and efforts to contact landowners with problem stands were instituted. The demonstration and evaluation of promising new equipment for selective thinning provided pulpwood producers a chance to view, observe, and evaluate. Thinning demonstrations on the State Forest and on private land in five Piedmont counties will provide a long-term testimony to the value of intermediate cuts in pine management. Consulting foresters under contract with the Division experienced firsthand the value of thinning. A bulletin on thinning benefits was widely distributed.

The results of the Demonstration Project provided additional information to support our arguments for better silvicultural management of our pine stands in Virginia. A series of meetings with forest industry in 1985 helped to present the case for better silvicultural management.

Publications generated by the projects included: "Evaluation of Thinning for Reduction of Losses from Southern Pine Beetle in Loblolly Pine Stands," by Burkhart and others 1985, submitted to *Southern Journal of Applied Forestry* (pending acceptance); "Thin Your Pines—It's Good Business" (a pamphlet), published by the Virginia Division of Forestry, 1983; "Identification of High-Hazard Stands for Control Measures of Southern Pine Beetle," by Smith and others 1981 (Remote Sensing Research Report 81−2, 14 p.).

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III. SUMMARY AND CONCLUSIONS

Technology transfer was a focal point of the Integrated Pest Management Research, Development and Applications Program for Bark Beetles of Southern Pines from the inception of the Program in 1980. The primary function of this activity was to develop, package, and transfer information in various forms to a diversity of users. To accomplish this, it was necessary to describe the information that would be transferred, to identify the audience(s), to determine what would be accomplished by providing the information, to organize an approach to transferring the technology, to determine the best way(s) to communicate the information, and to evaluate the outcome of the transfer effort.

To reach a broad and diverse spectrum of landowners and managers in 13 southern States required that the IPM Program and Southern Region specialists work through recognized regional or local forestry organizations and associations with established communications networks. Primary transfer agents included State and Private forestry staffs, State forestry organizations, Extension specialists, and larger industrial and forestry association organizations engaged in broadscale pest control activities. Representatives from these groups were continually involved in the planning and execution of work at the Program or project level throughout the life of the Program, and were in large part responsible for the success of its technology transfer efforts. Researchers engaged in more applied studies also contributed to this effort. The close working relationships among these diverse groups and individuals produced new ideas, made researchers aware of operational constraints, and assured that many end products would be of direct use to the ultimate consumers.

Projects to demonstrate improved technologies and "best management practices" were found to be a very effective means for transferring new information to forest industry, National Forests, consultants, and private nonindustrial landowners. By evaluating the results of technology transfer and providing feedback to the developers on a continuing basis, it was assured that the new technology would be more readily understood and accepted by its final users. This evaluation procedure covered not only the process (how things were done) but also the products (information and delivery systems) and the consequences (impact) of the transfer efforts.

Feedback on the demonstration project approach to technology transfer was very positive. Improved, standardized approaches to detection, evaluation, prevention, prediction, and suppression were implemented by many organizations. Procedures were validated under operational conditions or improved for field application as a result of user feedback. Each organization involved shared the results within its own organization and with others with whom they customarily worked. This approach reached the greatest numbers of people and utilized the most qualified transfer agents. It also offered the opportunity for the ultimate user to get involved, provided a means for foresters and landowners (working hand-in-hand with specialists) to observe and discover the application of new technology on their own land, and to work on their own problems within the limits of their own management objective(s) and forest and economic conditions.

IV. APPENDIXES

APPENDIX I—SCIENTIFIC NAMES OF SPECIES MENTIONED IN THIS PUBLICATION

Insect species

Black turpentine beetle	*Dendroctonus terebrans* (Oliv.)
Ips engraver beetles	*Ips avulsus* (Eichh.)
	Ips grandicollis (Eichh.)
	Ips calligraphus (Germ.)
Pales weevil	*Hylobius pales* (Herbst)
Southern pine beetle	*Dendroctonus frontalis* Zimm.

Disease species

Annosus root rot	*Heterobasidion annosum* (Fr.) Bref.
Fusiform rust	*Cronartium quercuum* (Berk.) Miy. ex Shirai f. sp. *fusiforme*
Littleleaf disease	*Phytophthora cinnamomi* Rands
Pitch canker	*Fusarium moniliforme* Sheld. var. *subglutinans* Wollenw. and Reink.

Tree species

Slash pine	*Pinus elliottii* Engelm. var. *elliottii*
Loblolly	*Pinus taeda* L.
Shortleaf	*Pinus echinata* Mill.

Other organisms

Blue stain	*Ceratocystis minor* Hedgc. (Hunt)
Competitive fungus	*Phlebia gigantea*

APPENDIX II—TECHNOLOGY TRANSFER GOALS, OUTPUTS, AND PARTICIPANTS DURING THE IPM PROGRAM, 1981–85

Item 1—*Targets and outputs of the Integrated Pest Management Program for Bark Beetles of Southern Pines*

Targets	Outputs
Methods for measuring and predicting impacts for making control decisions.	Procedures for measuring bark beetle and disease impacts.
	Procedures for predicting bark beetle and disease impacts.
	Models for southern pine beetle (SPB), fusiform rust, and annosus root rot impacts.
	Benefit/costs of management strategies.
Increased utilization of beetle-killed timber.	Sawmill decision model.
	Field procedures for determining utilization potential of beetle-killed timber.
Measurement and roles of biological and environmental factors affecting beetle populations.	Sampling techniques for SPB (in standing trees) and *Ips* populations (in standing trees and logging residue).
	Description of beetle, fungal, and microenvironmental interactions.
Methods for measuring and predicting host susceptibility to beetle attack.	Identification of host and environmental conditions favoring beetle attack and brood development.
	Models for describing and predicting host susceptibility to beetle attack.
Suppression and prevention tactics for bark beetles.	Management guidelines to reduce pest losses in natural and planted stands.
	Identification of harvesting and thinning practices contributing to bark beetle- and tree pathogen-caused losses.
	Bark beetle behavioral chemical (attractant) formulations and deployment strategies.
	Registration of Dursban® and/or Sumithion® for *Ips* spp. and/or black turpentine beetle control.
	Determinations of efficacy and safety of additional chemicals for bark beetle control.
Development and incorporation of pest management strategies into forest management programs.	Development of pest management systems for SPB-*Ips* complex.
	Pest management approaches incorporated into forest management programs.

Item 2—*Technology transfer teams formed during ESPBRAP and IPM Programs*

Technology transfer team	Team leader and affiliation	Program involvement
Silvicultural practices and stand-rating systems	Roger P. Belanger USDA Forest Service Southeastern Forest Experiment Station	ESPBRAP
	Roger Dennington USDA Forest Service Southern Region	IPM
Guidelines for utilizing beetle-killed timber	Robert F. Westbrook USDA Forest Service Southern Region	ESPBRAP
Socioeconomic guidelines	Joseph Lewis USDA Forest Service Southern Region	ESPBRAP
New insecticides and improved spray systems	John W. Taylor USDA Forest Service Southern Region	ESPBRAP
Sampling methods and predictive models	Fred M. Stephen University of Arkansas	ESPBRAP
Aerial survey and navigation systems	J. G. Denny Ward USDA Forest Service Southern Region	ESPBRAP
Behavioral chemicals	Thomas L. Payne Texas A&M University	ESPBRAP
Host/pest interactions	T. Evan Nebeker Mississippi State University	IPM
Integrated pest management strategies—decision support system	Robert N. Coulson Texas A&M University	ESPBRAP
	Michael D. Connor USDA Forest Service Southern Region	IPM

Item 3—*Approaches for preparation, packaging, and delivery of written and audiovisual materials*

A. *ESPBRAP/IPM Program-supported communications*

1. USDA Agriculture Handbooks, Technical Bulletins, and Agriculture Information Bulletins.
2. USDA Forest Service General Technical Reports and special reports.
3. Feature articles in professional and trade magazines.
4. Training/education aids: slide-tapes, management guidelines, portable displays, hands-on microcomputer demonstrations, training sessions for Federal and State pest management specialists.
5. Program newsletters

B. *Investigator-generated communications*

1. Technical or semipopular articles in domestic and foreign journals, government publication series, university series, and industry or association magazines.
2. Computerized information on mainframes, minicomputers and microcomputers.
3. Training/awareness workshops for Federal, State, industry, nonindustrial landowners and managers, and consultants.
4. Training aids: slide-tapes, movies, videotapes, public service announcements.
5. Fact sheets, leaflets, and circulars.
6. Project newsletters (Texas Forest Service Spotlight on Southern Pine Beetle; Clemson University Integrated Pest Management Newsletter).
7. Portable displays.

C. *Communications through other organizations*

1. Feature articles in professional and trade magazines.
2. Presentations at regional, national, and international symposia, work conferences, and meetings.
3. Sale of slide-tapes through SOUTHFORNET.
4. Highlight statements in professional society (Entomological Society of America, Society of American Foresters), association, Cooperative Extension Service, and Forest Service newsletters.
5. Participation in continuing education courses at universities.
6. Sale of videotapes through Mississippi State Cooperative Extension Service.

Item 4—*Expanded Southern Pine Beetle R&D Program, Integrated Pest Management RD&A Program, USDA Forest Service, Southern Region, and State forestry organization publications and audiovisual aids*

Series, title, and publication year	Series no.
USDA Agriculture Handbooks	
Southern Pine Beetles Can Kill Your Ornamental Pine (10/78; reprinted 1980)	H&GB 226
A Mill Operator's Guide to Profit on Beetle-Killed Southern Pine (4/79)	AH 555
A Field Guide for Ground Checking SPB Spots (11/79; reprinted 7/80, 8/83)	AH 558
An Aerial Observer's Guide to Recognizing and Reporting SPB Spots (4/80)	AH 560
How to Identify Common Insect Associates of the SPB (7/80; reprinted 10/81)	AH 563
Woodpeckers and the SPB (7/80; reprinted)	AH 564
Loran-C Radio Navigation Systems as an Aid to SPB Surveys (11/80)	AH 567
A Guide for Using Beetle-Killed Pine Based on Tree Appearance (3/81)	AH 572
Direct Control Methods for the SPB (3/81; reprinted 8/83)	AH 575
Silviculture Can Reduce Losses from the SPB (12/80)	AH 576
How to Interpret Radiographs of Bark Samples from Beetle-Infested Pines (3/81)	AH 577
How to Conduct a SPB Aerial Detection Survey (6/84)	TFS Circ. 267
Identification and Biology of Southern Pine Bark Beetles (3/85)	AH 634
Rating the Susceptibility of Stands to SPB Attack (4/85)	AH 645
Distinguishing Immatures of Insect Associates of Southern Pine Bark Beetles (12/85)	AH 641
SAMTAM—A Guide to Sawmill Profitability for Green and Beetle-Killed Timber (In press)	AH 648
Managing Piedmont Forests to Reduce Losses From the Littleleaf Disease-Southern Pine Beetle Complex (In press)	AH 649
Integrated Pest Management in Southern Pine Forests (In press)	AH 650
Use of an Attractant to Disrupt SPB Spot Growth (In preparation)	AH ____
USDA Forest Service Technical Bulletins and General Technical Reports	
Site, Stand and Host Characteristics of SPB Infestations (1981)	TB 1612
Evaluating Control Tactics for SPB (11/79)	TB 1613
Modeling SPB Populations (11/80)	TB 1630
The Southern Pine Beetle (10/80)	TB 1631
Field and Laboratory Evaluations of Insecticides for SPB Control (11/81)	GTR SE-21
Utilization of Beetle-Killed Southern Pine (12/85)	GTR WO-47
Thinning Practices in Southern Pines—With Pest Management Recommendations (12/85)	TB 1703
Technology Transfer in Integrated Forest Pest Management in the South (12/85)	GTR SE-34
USDA Agriculture Information Bulletins	
Southern Pine Beetle Program Accomplishments Report (1/81)	AIB 438
Integrated Pest Management in the South—Highlights of a 5-Year Program (11/85)	AIB 491
USDA Forest Service Southern Region Forest Pest Management Technology Update—Southern Pine Beetle Fact Sheets	
Use of beetle-killed timber for lumber (10/79)	1
Use of beetle-killed timber for pulp, plywood, and paneling (10/79)	2
Setting control priorities for the SPB (10/79; reprinted 4/84)	3
An aerial observer's guide to recognizing and reporting SPB spots (4/80)	4
Insecticides for the SPB (10/79; reprinted 3/83, 4/84)	5

Series, title, and publication year	Series No.
Woodpeckers can help control the SPB (5/80)	6
PTAEDA: A loblolly pine growth model (6/80)	7
FRONSIM, a computer program model (6/80)	8
Use of behavioral chemicals for SPB suppression—a research update (7/80)	9
Rating the susceptibility of pine stands to SPB attack (10/80)	10
The ESPBRAP site-stand data file (10/80)	11
Loran-C navigation (12/80)	12
Use of beetle-killed timber for particleboard and hardboard (12/80)	13
TBAP-Timber benefits analysis program (12/80)	14
Salvage removal (1/81)	15
Cut-and-leave (1/81)	16
Chemical control (1/81; reprinted 2/84)	17
Pile-and-burn (1/81; reprinted 7/84)	18
A method for assessing the impact of SPB damage on esthetic values (5/81)	19
Economic impact of the SPB on recreation—one approach (5/81)	20
Silviculture: A means of preventing losses from the SPB (6/81; reprinted 4/84)	21
Setting control priorities using emergence: attack ratios—a research update (9/81)	22
DAMBUGS—A case study (9/81)	23
Buffer strip (5/82; reprinted 7/84)	24
Utilization of beetle-killed southern pine based on tree appearance (5/82)	25
Use of computer simulation models to predict expected tree mortality and monetary loss from SPB spots—a research update (1/83)	26
A research update: FERRET—the question analysis routine for the SPB decision support system (1/83)	27
Texas hazard-rating guide (4/83)	28
A computerized literature retrieval system for the SPB (5/84)	29
SAMTAM: Sawmill analysis model for green and beetle-killed southern pine timber (2/85)	30
Utilization guides for green and beetle-killed timber (Submitted 6/83)	
CLEMBEETLE*	
TAMBEETLE*	
TFS spot growth*	
Arkansas SPB*	
PIEDMONT RISK*	
SPB COMP*	
Fusiform rust yield—slash*	
GY-ANNOSUS*	
SPB decision support system*	
MS Hazard B*	
NF RISK*	
TFS GRID HAZARD*	
AR HAZARD*	
MOUNTAIN RISK*	
IPM Decision Key*	

Series, title, and publication year	Series No.
Aerial GA*	
Borax for annosus prevention*	
Estimating the severity of annosus root rot in loblolly pine stands*	
Slide-tapes	
The biology and identification of the SPB. (46 slides, 7-minute tape)	
Insects associated with the SPB. (79 slides, 14-minute tape)	
Building among the pines. (121 slides, 19-minute tape)	
Control methods for the SPB. (80 slides, 16-minute tape)	
Silviculture can reduce SPB losses. (65 slides, 9-minute tape)	
Chemical control of SPB. (50 slides, 9-minute tape)	
Applying integrated pest management in southern forests. (80 slides, 14-minute tape)	
Fusiform rust (In preparation)	
Annosus root rot: management strategies to minimize damage (In preparation)	
Littleleaf management strategies (In preparation)	
Portable displays	
Hazard rating for SPB, annosus root rot, fusiform rust, and littleleaf disease	
Utilization of beetle-killed wood	
Integrated forest pest management	
Professional journal articles	
The Southern Lumberman (Applefield 1983; Westbrook and others 1981)	
Southern Journal of Applied Forestry (Thatcher and others 1982)	
Forest Farmer (Belanger and others 1983; Thatcher 1984, 1985)	
The Consultant (Hertel and others 1983)	
Forests and People (Branham 1984; Branham and Nettleton 1985)	

* All of these fact sheets were submitted in 1984 or/ 1985 and will have been issued by the time this publication goes to press.

Item 5—*Models used in training pest management specialists in predicting southern pine beetle and disease trends, tree mortality, and economic losses*

Models	Purpose
Hazard rating	
TFS Grid Hazard	To rate susceptibility of Texas Forest Service 18,000-acre grid blocks to SPB infestation.
AR Hazard	To estimate relative susceptibility of Arkansas pine stands to SPB attack.
MS Hazard B	To determine the relative hazard of timber stands to SPB attack in Mississippi and Alabama.
TX Hazard	To rate relative susceptibility of pine stands to SPB attack and timber loss in Gulf Coastal Plain.
NF Risk	To rate relative risk of pine stands to SPB attack on National Forests in the South.
Piedmont Risk	To determine the risk of natural stands suffering loss due to SPB attack in the Piedmont.
Mountain Risk	To evaluate forest stands in the southern Appalachians for susceptibility to SPB infestation.
Trend models	
SPB Comp	To predict a change in SPB-infested area from the previous year for specified multicounty climatic districts.
Aerial GA	To predict the number of SPB spots per acre in a given year for the Piedmont of Georgia.
Southeast Surveil	To project the percentage of the southeastern U.S. with SPB activity in current year based upon SPB activity in a subsample of the region.
Southeast Predict	To predict SPB infestation coverage over the Southeast for next year based upon SPB activity in the current year in a subsample of the region.
Spot growth models	
TAMBEETLE	To predict short-term (30 to 90 days) growth potential of existing SPB spots, tree mortality, and economic losses in currently infested planted and natural stands.
Arkansas SPB	To predict short-term (30 to 90 days) SPB population growth, tree mortality, and economic loss in currently infested loblolly and/or shortleaf pine stands.
TFS Spot Growth	To predict tree mortality and economic losses caused by SPB infestations over next 30 days during summer months.
E/A Ratio	To predict the relative increase in number of SPB-infested trees on a spot-by-spot basis during next 3 to 6 months.
Management simulation	
CLEMBEETLE	To simulate the probability of spot occurrence and expected loss caused by SPB in single or multiple loblolly or shortleaf pine stands for periods as short as a year or as long as a rotation.
ITEMS (Integrated Timber/Economics Management Simulator)	To simulate the performance of one or more pine stands under varied management regimes and levels of SPB activity over a period of years.
Management information and decision support systems	
SPB Decision Support System	To help forest and pest managers analyze questions regarding southern forest and SPB pest management and to provide the latest technology available for management decisionmaking.
IPM-DK (Integrated Pest Management Decision Key)	To provide a listing of currently recommended management options for preventing or reducing losses caused by insects and diseases in a variety of management situations.
Other	
SPBEEP (Southern Pine Beetle Economic Evaluation Procedure)	A computerized procedure for analyzing the economic benefits and costs associated with SPB control projects involving salvage removal.
Fusiform Rust Yield—Slash	To predict yields by diameter class at rotation age from unthinned slash pine plantations infected with fusiform rust.
Stump Treatment with Borax	To provide an economic analysis of the use of borax stump treatment during thinning of pine stands on high-hazard annosus root rot sites.

APPENDIX III—IPM PROGRAM APPLICATIONS PLAN

Title: Forest management strategies for preventing or reducing beetle- and pathogen-caused losses: silvicultural treatment of planted stands in the Atlantic Coastal Plain.

Investigators: R. P. Belanger, Principal Silviculturist, T. Miller, Project Leader, R. S. Webb, Assistant Professor, and J. F. Godbee, Project Leader, Pest Management.

Performing Organizations: Southeastern Forest Experiment Station, Athens, GA; University of Florida, Gainesville, FL; and Union Camp Corporation, Rincon, GA.

1. Message: Maintaining healthy stands is the key to effective forest pest management. Guidelines are presented that describe stand, site, and individual tree characteristics that are associated with stands highly susceptible to beetle- and pathogen-caused losses. SPB, *Ips* spp., BTB, fusiform rust, and annosus root rot are the major pests covered. Cultural treatments are recommended that will reduce losses from these pests.
2. Audience: Forest managers, foresters, researchers, pest management specialists, and service and "linker" organizations.
3. Objective: The incorporation of pest prevention strategies into forest management planning and practice.
4. Team: Silvicultural practices and stand-rating systems TT team.
5. Media: Scientific publications, compendia, how-to handbooks, fact sheets, field demonstrations, slide-tape presentations, workshops, and symposia.
6. Evaluation: The effectiveness of technology transfer will be evaluated by determining:

   a. Number of management plans that contain new technology.
   b. Number of acres rated for susceptibility to attack by insects and diseases.
   c. Number of acres treated to reduce losses from insects and diseases.
   d. Biological and economic gains from implementation of pest management strategies.
7. Identifying additional research needs: Implementation of integrated pest management strategies in operational resource management is in its infancy. The researcher, technology transfer specialist, and user must make an effort to recognize and communicate additional research and applications needed to reduce losses from insects and diseases.