

PROCEEDINGS OF THE
NATIONAL SILVICULTURE
WORKSHOP
CHARLESTON, SOUTH CAROLINA
SEPTEMBER 17-21, 1979

THEME: The Shelterwood Regeneration Method

Division of Timber Management
USDA - Forest Service
Washington, D. C.

USDA Forest Service
Forest Management Staff - Library
P.O. Box 96090
Washington, DC 20090-6090

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, \$300

Acknowledgement

Historic Charleston, South Carolina was the site of the 1979 Silviculture Workshop. The objective of the meeting was to discuss state of the art application of the shelterwood regeneration method to forests of the United States. These proceedings include the presentations of the individuals on the program.

Hosts for the meeting were the Region 8 Timber Management Staff, the Francis Marion National Forest and Westvaco Timberlands Division. To these persons and to all who contributed presentations and participated during the session, NFS Silviculture extends our thanks.

Silviculture Branch
Timber Management Staff
Washington, D. C.

TABLE OF CONTENTS

	<u>PAGE</u>
Workshop Agenda	1
Register of Attendees	4

Presentations

Dan Cramsey	Reforestation Activity Reviews	6
Carl Puuri	Herbicides	12
Dick Miller	Nursery Capacity and Needs	15
Carl Puuri	Silviculturist Certification	23
Billy E. Page	Cooperative Forestry Programs	28
David Smith	The Shelterwood Regeneration Method	33
David Marquis	Ecological Aspects of Shelterwood Cutting	40
Jack Usher Bob Naumann William Beaufait	Silvicultural Prescriptions in the Northern Region (Shelterwood) Example)	57
Robert Loomis	Insect and Disease Coordination in Forest Management	80
Edward Smith	Economic Analysis of Shelterwood Cutting	87
David Loftis	Partial Cuts to Regenerate Upland Hardwoods in the Southeast	92
Gordon Langdon	Natural Regeneration of Loblolly Pine	101
Thomas Croker	The Longleaf Pine Story	117
William Boyer	Shelterwood System for Natural Regeneration of Longleaf Pine	124
Jim Edgren	Shelterwood Resource Coordination	129

Douglas Roy	Shelterwood Cuttings in California and Oregon	143
John Hughes	Region 6 Shelterwood Task Force	166
Charles Boldt	Shelterwoods - Black Hills Ponderosa Pine	178
Glenn Jacobson	Shelterwood Status - Payette National Forest	185
Dick Godman	Shelterwoods in the Lake States	189
Carl Tubbs	Shelterwood Methods in North-eastern Types	201
Ivan Sander	Regenerating Oaks	212

Appendix

Bob Blomquist	Shelterwoods - Ecologic Considerations
Region 1	Silvicultural Prescription Process
James Edgren	Trees and Grass
Field Trip Schedule	Francis Marion National Forest
	History Francis Marion National Forest
	Francis Marion National Forest Facts
Optional Field Trip Tour	Westvaco
C. J. Sharp	Overview of Optional Field Tour - Westvaco

Subject: 1979 National Silviculture Workshop

Chairman: Robert E. Gillespie/Carl R. Puuri

Time: September 17 through 20 (21st optional)

Purpose of Meeting: Timber cutting methods to meet silvicultural and management objectives.

September 17 (indoors) - Heart of Charleston Motor Inn

1:00 - 1:30 P.M.	Call to Order	
	Introduction of Participants	Robert Gillespie, W.O.
	Welcome	R-8 Don Eng, Forest Supervisor
	Purpose of Meeting	A. P. Mustian, W.O.
	House Rules and Announcements	R-8, Walt Fox
1:30 - 3:00 P.M.	National News	A.P. Mustian and Robert Gillespie
	Reforestation Activity Reviews	Dan Cramsey, W.O.
	Herbicides	Carl Puuri, W.O.
3:00 - 3:15 P.M.	Break	
3:15 - 5:00 P.M.	Nursery Capacity and Needs	Dick Miller, W.O.
	Silviculturist Certification	Carl Puuri
	NFMA, Regulations	Robert Gillespie
	Open Discussion	

September 18 (indoors) - Heart of Charleston Motor Inn

8:00 - ~~9:30~~ A.M.	The Shelterwood Regeneration Method	David Smith, Yale University
	(Silvicultural Systems)	
	(Choosing the Regeneration Method)	
	(Silvicultural Objectives)	
	(Shelterwood Variations)	

9:30 - 9:45 A.M. Break

9:45 -11:00 A.M. Ecologic Aspects of Shelterwoods David Marquis, NE
 (Creating the Environment)
 (Establishment and Growth of Seedlings)
 (Amount of Shelter)
 (Timing of Treatments)
 (Aesthetic Shelterwoods)

11:00 -12:00 A.M. Prescribing for Shelterwoods Bob Nauman, Bill
 Beaufait, and Jack Usher, R-1
 (Site Evaluation, Defining Objectives)
 (Coordination with NEPA)
 (Meeting NFMA)
 (Interdisciplinary Coordination)

12:00 - 1:00 P.M. Lunch

1:00 - 1:40 P.M. Insects and Disease Coordination
 in Shelterwoods FIDM, R-8

1:40 - 2:10 P.M. Economic Analyses of Shelterwoods Edward Smith,
 Richard Greenhalgh, R-8.

2:10 - 2:30 P.M. Break

2:30 - 3:00 P.M. Partial Cuts to Regenerate Upland David Loftus, SE
 Hardwoods in the Southeast

3:00 - 3:30 P.M. Loblolly Pine Natural Regeneration Gordon Langdon, SE

3:30 - 4:00 P.M. The Longleaf Pine Story Thomas Croker
 U.S.F.S -Retired.

4:00 - 4:45 P.M. Longleaf Pine Shelterwoods William Boyer, SO

4:45 P.M. Discussion of Field Trip Walt Fox, R-8

September 19 (Outdoors) - Francis Marion National Forest

Field trip to Francis Marion National Forest to observe shelterwood treatments in longleaf pine.

September 20 (Indoors) - Heart of Charleston Moton Inn

8:00 - 8:30 A.M.	Shelterwood Resource Coordination	Jim Edgren, R-6
8:30 - 9:15 A.M.	Shelterwoods in the Southwest	Doug Roy, PSW
9:15 - 10:00A.M.	Region 6 Shelterwood Task Force	John Hughes, R-6
10:00-10:15 A.M.	Break	
10:15-11:00 A.M.	Shelterwoods - Black Hills Ponderosa Pine	Charles Boldt, RM
11:00 - 11:30 A.M.	Payette National Forest Shelterwood Success	Ken Jacobson, R-4
11:30 - 12:00 A.M.	Open Discussion	
12:00 - 1:00 P.M.	Lunch	
1:00 - 2:30 P.M.	Shelterwoods to Regenerate Species of the Lake States and Northeast	Dick Godman, NC and Carl Tubbs, NE
2:30 - 2:45 P.M.	Break	
2:45 - 3:30 P.M.	Establishing and Developing Advanced Oak Reproduction	Ivan Sander, NC
3:30 P.M.	Open Discussion Questions and Answers	

September 21 (Outdoors - Optional) - Westvaco

Field trip to Westvaco to observe short rotation management and modern harvesting systems in southern pine management. A bus will leave the motels at 7:30 a.m. and will return to Charleston approximately 5:00 P.M.

Attendance at 1979 Workshop
Charleston, South Carolina, September 17-21, 1979

		Location
A. P. Mustian	Deputy Director, TM	WO
Bob Gillespie	Asst. Director, TM	WO
Carl Puuri	Silviculture, TM	WO
Bill Balmer	Cooperative Forestry, S&PF	SA
David Loftis	Research, Hdwd. Silviculture	SE
Will Charter	Plans & Silviculture, TM	R-5
Ken Estes	Silviculture, Lassen N.F.	R-5
Jim Beavers	Timber Sales, TM	WO
Bill Smith	University Faculty	N.C. State Univ.
Bob Romancier	Research, Asst. Director	PNW
Gordon Langdon	Research, Special Studies	SE
Bob Damon	Director, TM	R-2
Dale Wills	Wildlife, WL	R-2
C. D. McAninch	Silviculture, TM	R-2
Bill Chapparo	Silviculture, TM	R-3
Bill Knispek	Bridger-Teton N.F.	R-4
Orville Engelby	Silviculture, TM	R-4
Glenn Jacobsen	Payette N.F.	R-4
Bob Van Aken	Management Plans, TM	WO
Bob Naumann	Silviculturist, TM	R-1
Bill Wulf	CANUSA Project, TM	R-1
Wyman Schmidt	Research	INT
Bill Boyer	Research	SO
Bryant Watts	Francis Marion N.F.	R-8
Karl Stoneking	Inventory & Plans	R-8
William Beaufait	Silviculture, TM	R-1
Ed Johnson	Tongass N.F.	R-10
David Van Lear	University Faculty	Clemson Univ.
Don Strode	Wildlife, WL	WO
Dan Cramsey	Silviculture, TM	WO
Carl Tubbs	Research	NE
Bill Page	Cooperative Forestry, S&PF	WO
Dick Miller	Silviculture, TM	WO
Don Peterson	Francis Marion N.F.	R-8
David Priester	Research	SE
Walt Fox	Silviculture, TM	R-8
Olen Aycock	Silviculture, TM	R-8
Lois Willis	Silviculture, TM	R-8
Bill Tuttle	Plans & Silviculture, TM	R-9
Al Rogers	Routt N.F.	R-2
Dale Hall	Research	INT
Dick Godman	Research	NC
Bud Twombly	Plans and Silviculture, TM	R-6
Dale Heigh	Director, TM	R-10
Joel Hockinson	Allegheny N.F.	R-9
Dave Marquis	Research	NE
Harold Flake	FIDM, S&PF	SA
Bob Blomquist	Silviculture, TM	R-9

Attendees List Continued

John Hughes	Silviculture, TM	R-6
Jim Edgren	Silviculture, TM	R-6
Pete Stanger	Silviculture, TM	R-6
Doug Roy	Research	PSW
Glenn Davies	Silviculture, TM	R-5
Dick Fitzgerald	Silviculture, TM	R-8
Jack Usher	Director, TM	R-1
Bryan Clark	Director, TMR	WO
Bob Phares	Research, TMR	WO
Bob Loomis	FIDM, S&PF	SA
Dave Johnson	Silviculture, TM	R-10
Charles Bechtel	Kaibab N.F.	R-3
Dick Schaffer	Silviculture, TM	R-3
Wayne Shepperd	Research	RM
Carl Edminster	Research	RM
Chuck Boldt	Research	INT
Ken Ready	Silviculture, TM	R-4
Ed Smith	Inventory & Plans, TM	R-8
Ivan Sander	Research	NC
David Smith	University Faculty	Yale Univ.

REFORESTATION ACTIVITY REVIEWS

D. E. CRAMSEY

Dr. Mark Silber, an industrial consultant, psychologist and president of his own consulting firm, stated "people do not grow unless they are challenged, they do not grow when they have little to overcome . . . they need to run against their own limitations, as well as to build on their strengths." In light of the reforestation challenges this group has faced, a lot of growth has occurred and a lot more will occur as we meet the reforestation challenge over the next few years.

A. BACKGROUND

National Forest Reforestation activities have been subject to numerous reviews during the past 5 years. These have come from outside and within the Service. Congress has pushed for increased efforts in reforestation and in "getting the job done" for several reasons including meeting public demand for goods and to help fight inflation. Increased reforestation results in increased timber yields. Testimony during the Senate and House budget hearings and specialized areas of increases in the President's budget demonstrate this focus on reforestation. Also, active interest in the Forest Service's reforestation program has been evident in several General Accounting Office (GAO) reports, Office of Inspector General review of several Regional programs, and internal reviews by the Forest Service itself. Examples follow.

The GAO Report to the Congress, February 14, 1974, was conducted to "find out whether the Forest Service reforestation program provided for the best possible growth on National Forest land." The study, More Intensive Reforestation and T.S.I. Programs Could Help Meet Timber Demand expressed concern over timber supplies and the rising cost of wood products.

The GAO Report to the Congress, May 11, 1978, also reported on the concern over timber supply and price. In the Report, Need to Concentrate Timber Management on High Productive Lands, the Comptroller General reported that the Forest Service, despite some progress, had not developed an adequate inventory of reforestation needs, nor allocated reforestation funds efficiently in terms of economic return expressed in dollars and production. The GAO was still quite critical of the lack of economic decisionmaking by the Forest Service in allocating the reforestation dollar.

Forest Service Study, May 1978 and July 1978. In December 1976 Chief McGuire approved a plan for study of reforestation and TSI programs on the National Forest, Evaluation of Reforestation and Timber Stand Improvement on the National Forests, May 1978. The main objectives were to identify and evaluate problems and recommended improvements. The evaluation plan and resulting action plan, Action Plan for Reforestation and Timber Stand Improvement on the National Forests, July 1978, highlighted these major issues:

PROGRAM DEVELOPMENT

Direction. There are apparent conflicts in direction to the field, primarily between long-range program planning and short-range budget planning. Direction to identify needs and significantly improve planning, execution, and evaluation of reforestation and TSI programs must be clearly specified if the Forest Service is to meet the intent of the NFMA.

Standards. Existing standards for stocking level control are inadequate for determining treatment needs, setting priorities, and evaluating completed work.

Benefit-Cost Analysis. Benefit-cost analysis is not being used to assist in deciding when, where, and how reforestation and TSI activities are performed.

In-Place Data and Silvicultural Prescriptions. Only about 45 percent of the estimated total reforestation backlog and 35 percent of the estimated total TSI needs have been identified in-place, with silvicultural prescriptions prepared for treatment.

Data Systems. Data systems are not providing adequate support needed in the reforestation and TSI programs. The approach to this problem is not uniform between Regions.

Program Budgeting. Inflation and changing program direction and standards impair the Forest Service's ability to execute planned programs.

PROGRAM EXECUTION

Budget Execution. The process needs strengthening to avoid failure to make targets or to spend funds as allocated.

Technical Problems and Application of Research. Efforts in timber management research on reforestation and TSI problems have been reduced in the past few years.

Environmental Problems. Environmental considerations can require reforestation and TSI techniques that increase costs.

Coordination. Improved coordination among resource programs.

Personnel. Successful reforestation and TSI programs will require more emphasis on the development of qualified personnel. Poor performance in silvicultural efforts often results from weakness in execution, rather than lack of technical knowledge.

EVALUATION AND ACCOUNTABILITY

Evaluation. Evaluation of reforestation and timber stand improvement activities is sporadic and unplanned.

Accountability. All levels of the Forest Service must accept their responsibility to meet reforestation and TSI targets (both quantity and quality) and be held accountable for them.

The Action Plan was approved by the Chief in July 1978. Part of the Plan has been implemented, however because of timing, staffing, ~~etc~~ progress has been slow.

GAO Report to Senator Robert Packwood, April 27, 1979. The purpose of this Report was to assess the Forest Service progress in implementing the Action Plan; the conclusion was:

"The problems cited in our previous reports continue to plague the Forest Service's efforts to reforest lands and to improve existing timber stands. The Forest Service continues to experience difficulty in determining the magnitude of reforestation and timber stand improvement needs and the economic value of accomplishing this work. While the Forest Service developed an action plan to overcome these and other program weaknesses, it will require several years to fully implement and is already behind schedule. As a result, major improvements in the management and operation of these programs cannot be expected in the near future."

GAO pointed out that the backlog acres had been repeatedly overstated by including lands that were later found to be stocked, land that was noncommercial, and lands that are likely to be included in the Wilderness System. They also noted that the cost to reforest the acres in the remaining backlog will be higher than that experienced in the past. The areas are less accessible and located on more adverse terrain. Adding to this, the increased cost caused by inflation makes the need to employ economic criteria in reforestation activities that much more imperative. Their recommendation was that the Secretary of Agriculture direct the Chief to give higher priority to implementing the Plan promptly.

Situation. Reported figures on needs and accomplishments indicate that reforestation accomplishments are not meeting the goals of the NFMA. "The Secretary . . . (will) . . . report to the Congress . . . the amount . . . of all lands in the National Forest System where objectives of land management plans indicate the need to reforest areas that have been cut-over or otherwise denuded or deforested . . . Secretary shall transmit . . . an estimate of the sums necessary to replant . . . an acreage equal to the acreage to be cut over that year, plus a sufficient portion of the backlog of lands found to be in need of treatment to eliminate the backlog within the 8 year period."

The quality and degree of success of reforestation activities need to be reviewed and evaluated. This was highlighted in the National Forest Management Act (NFMA) also. "All National Forest Lands treated from year to year shall be examined . . . and certified by the Secretary . . . as to stocking rate, growth rate in relation to potential Any lands not certified as satisfactory shall be returned to the backlog and scheduled for prompt treatment" The area certified as successfully regenerated must equal the area deforested annually and enough of the backlog to eliminate it by 1985.

The large reduction in the backlog during the last 2 years (700,000 acres, from 2.1 million to 1.4 million) has resulted from stand examination, land classification, and changes in management or use. At the same time, current needs increased 211, 815 acres.

B. OBJECTIVE OF THE REVIEWS

In addition to evaluating some of the areas of concern expressed previously, the objective is to determine if the Forest Service is making progress in these areas:

1. National reforestation activities and Regional directions are responsible to the NFMA.
2. The Forest Service is not creating reforestation needs from harvesting, fire, insect and disease attacks, and other natural disasters in excess of acreage reforested.
3. The short- and long-term planning provides for quality and quantity goals.
4. Reforestation investments are being made on the most productive sites and benefit cost analysis is being used.
5. Identify weaknesses and improve national functional direction and support to the Regions.

C. PROGRESS

Five of the seven planned reviews have been completed and three of the Action Plans have been approved. The remaining two reviews will be completed in fiscal year 1980. The Review schedule is as follows:

<u>Region</u>	<u>Dates</u>	<u>FY</u>	<u>Review Team</u>
1	7/16-28/78	78	Gillespie, Engle, Miller
6	8/21-30/78	78	Gillespie, Engle, Fox
8	10/10-20/78	79	Gillespie, Hughes
5	5/14-25/79	79	Gillespie, Puuri, Laird
9	6/11-22/79	79	Gillespie, Cramsey, Hamilton
4	5/5-16/80	80	Gillespie, Cramsey, Knight
2	6/9-28/80	80	Gillespie, Cramsey, Shaffer

D. FINDINGS

With five of the activity reviews completed, some similar problems were found in several of the Regions. The more common problems are:

1. Preparation of the Needs and Accomplishments reports.
2. Identification of backlog acres and scheduling for reforestation by 1985.
3. Application of economic analysis to prioritize reforestation investments.
4. Accurate preparation of realistic annual program budgets that meet the intent of Congress require coordination of the Region and the Washington Office.
5. Utilization of computer programs or data retrieval systems to record data and plan annual programs.
6. Evaluation, recording, and reporting regeneration results and causes of regeneration losses.
7. Obtainability of quality control and proper followup on regeneration activities.
8. Establishment of Regional nursery stock standards and stocking levels by major species groups or vegetation types.
9. Establishment of guidelines for adequate site preparation.
10. Provision of adequate training for personnel engaged in reforestation activities.
11. Involvement of research in more of the reforestation problem areas.

There are still some questions that will need to be faced and resolved, including criteria for economic analysis, limits of backlog reduction, programing, etc.

If Dr. Silber is right; we will all experience a lot of growth this next year. How much each of us grow, will depend on how we meet these challenges.

By Carl R. Puuri

Herbicides on National Forest Lands

By popular request of several of the Regions, we have included a discussion of herbicides as a topic this afternoon. I will begin with direction from the Chief concerning the use of herbicides. Then I'll list several items bringing you up-to-date on national happenings.

The Chief, in a recent Region 5 Supervisor's meeting, made the following statement concerning the herbicide issue.

"We are not banning the use of all herbicides, but rather are working toward solution through vegetation management plans which include consideration of the economics involved."

Our interpretation of this statement is: As part of the environmental analysis process for each project concerned with vegetation management, we need to define the objectives. In a regeneration project, we would likely need to meet at least two objectives. First, to establish regeneration on the site and second, to ensure that the regeneration is free to grow at predetermined rates through time. To meet these objectives, normally, planned vegetation management consisting of site preparation and release is required.

It will be essential to evaluate all the alternative vegetation treatments available to meet the objectives. This includes considering the various herbicides that will do the job, alternative application techniques, mechanical treatments, etc. The evaluators need to consider two important aspects:

1. If the objectives will be met in terms of managing the vegetation, and
2. The cost effectiveness of each alternative must be evaluated over time, including enough evaluation to determine if retreatment will be needed.

In many cases we do not have good information concerning the cost and effectiveness of alternatives to herbicide use. The Chief's Evaluation of Reforestation and Timber Stand Improvement on the National Forests (May 1978), Issue B-2, explained that environmental considerations may require using techniques for vegetation management in reforestation projects that increase cost or cause postponement of some work. The Chief's Action Plan (July 1978) calls for the evaluation of alternatives to herbicides, and to implement their use where available.

We have fairly complete research information concerning the effects of herbicides on competing vegetation and benefits of herbicides on timber yields. For example, Ron Stewart's (WO-Timber Management Research) recent literature search and review produced a good bibliography relating to the effects of 2,4,5-T on growth and yield. Research information is also available for other herbicides. There is a shortage of specific information on manual, mechanical, and cultural methods of site preparation and plantation release.

In response to the Action Plan for the Chief's Evaluation of Reforestation and TSI on the National Forests, administrative studies have been approved and funded to evaluate alternatives to herbicides. These studies have been approved for Regions 1, 5, 6, 8, and 9. TM and TMR of the Washington Office will establish funding and targets for the fiscal year 1980. An estimated cost of \$105,000 for a 3-year program is estimated for each Region. We want to emphasize the importance of these studies. If we plan to intensively manage our Forests, the information from these studies is urgently needed.

Some other developments in the area of herbicides are:

1. Center for Natural Areas Study (CNA) - The Center for Natural Areas is under contract to conduct a study of all Forest Service pest management and research programs associated with pesticide use. The CNA is a nonprofit management corporation formerly affiliated with the Smithsonian Institution. Herbicides and insect and disease programs will be emphasized in the study. The purpose of the study is to evaluate operating procedures, decisionmaking processes and program coordination concerning pesticide use.

The contract will be completed about June 1980. Regions and Forests have been, and will be, visited where case studies will be selected and investigated.

Policy Analysis (WO) is administering the contract and will evaluate the results.

Phase I of the study is complete. Findings to date are:

A. Not much documented management direction in the Forest Service.

B. Records are not complete concerning:

- a. Amount and kind of herbicide used.
- b. Acres accomplished by method.
- c. Alternative treatments considered.

2. Suspension and Cancellation Hearings - 2,4,5-T - As most of you are already aware 2,4,5-T is not approved for use in silviculture related projects following EPA's emergency suspension order of last spring.

The cancellation hearings for 2,4,5-T will probably begin in November. As you know, a number of Forest Service people including people from the Regions, Washington Office, State and Private, and Research will serve as witnesses. A final decision concerning 2,4,5-T cancellation will probably not be available until late next spring.

Additional background information is needed by Forest Service witnesses. Each Region will receive a questionnaire from the Washington Office concerning the effects that would be expected should the use of 2,4,5-T be banned permanently.

By Dick Miller

Nurseries and Tree Improvement

This afternoon I would like to discuss the Service-wide Nursery Capacity Study, the Region's estimates of planting stock needs, and tree improvement with particular emphasis on managing the genetic resource.

Nursery Capacity

The Service-Wide Nursery Capacity Study has been completed and copies have been sent to each Region and Nursery.

The study was initiated in December 1978 following the appointment of a six-man task force including: Bud Twombly, R-6 (Chairman); Jim Kocer, R-3; Pete Laird, R-1; Chuck Marshall, R-6; Stuart Slayton, R-6; and Richard Tinus, RMFRES. The objectives of the study were to analyze nursery management efficiency and problems, to determine the potential for growing quality planting stock, to compute the long-term capacity for each nursery, and to determine the potential for expansion at each nursery.

The task force acquired initial data by sending a series of questions to each nurseryman. Following a review of the responses, at least two task force members visited each nursery for on-site discussion. The final report includes several recommendations that will require further evaluation and action.

We will be preparing a paper discussing the recommendations and proposing alternatives and actions to implement selected recommendations. This will be reviewed with Chief and Staff and, once approved, will be sent to all Regions.

Actions on several of the recommendations are already underway. Two tables have been added to the Silvicultural Accomplishment Report (FSM 2496.3) to obtain data on sowing and inventories. This information has been requested by Congress for the last 2 years. In addition, FSM 2496.4 has been revised to request the following additional information in the annual nursery report: (1) standard formula for computing annual capacity of bare-root and container production, (2) list of facilities required to upgrade and/or expand the nursery, (3) list of species generally grown at the nursery arranged from the least to most difficult to grow, (4) list of equipment development needs, and (5) list of specific problem areas that require research and/or administrative studies. Nurserymen should be made aware of these new reporting requirements.

The nursery trainee program is still high priority. Presently four trainees are on board (R-1, 5, 6, and 8). The first graduate of the program was in Region 8, and he is now the assistant nurseryman at W. W. Ashe Nursery.

A recordkeeping system for seedling production has been developed and is now being tested. The seed inventory phase of the system will be developed in the near future. All Regions should evaluate this system and use those portions that apply.

Planting Stock Needs

Last June, each Region was asked to estimate its planting stock needs to complete the backlog and maintain the current reforestation program. These data along with the nursery capacity data are to be used to develop strategies for obtaining the required amounts of quality stock.

Nursery capacity data are shown in Table 1. Nursery capacity and planting stock needs data are shown in Figure 1 for each Region and Figure 2 for the combined Western Regions and Eastern Regions. The data suggest that most Regions have ample capacity to meet their needs. Possibilities for sharing nursery capacity among Regions is also evident. We fully realize, however, that a few specific seed sources may be difficult to grow in existing facilities, and that growing stock in another Region's nursery creates additional problems.

Some Regions have estimated their stock needs on the assumption that all acres will be planted. We question the validity of this assumption. It seems as though some acres should be naturally regenerated.

The data also suggest that some Regions did not consider stock availability when estimating stock needs for fiscal years 1980 and 1981. The most probable outcome will be increased pressure on the nurseries in fiscal years 1982 through 1985 to produce adequate quantities of planting stock to complete the backlog as well as maintain the current reforestation program.

Nursery--FA&O

You should be aware that as of fiscal year 1980 nursery construction projects are included in Fire Administration and Other (FA&O) funding. In reviewing project proposals for fiscal year 1981, we noted several projects that should have been financed with nursery funds (035). Instructions for developing the fiscal year 1982 FA&O projects will be improved, and we believe FA&O funds will be limited to the construction of permanent facilities.

Nursery -- Contracting for Stock Production

Several Regions have mentioned problems they have encountered in contracting for the production of bare-root and container planting stock. The problems may be at least partially solved by issuing a Request For Proposal (RFP) to all prospective bidders. This method would enable us to evaluate the bidder's expertise and facilities, and to award the contract to the bidder who had the best chance for producing quality stock that would meet our needs.

Tree Improvement

A popular discussion topic this year has been gene pools and genetic diversity. We have had correspondence with the Sierra Club Legal Defense Fund and the Santee Preservation Society, and a statement was made at the Western Forest Genetics Association meeting that the Forest Service had no policies on conserving the genetic resource.

The Forest Service does have policies that promote conservation of the genetic resource, and I believe its important that you understand these policies and see that they are implemented in the field. Specific policies relating to this issue are (FSM 2475.03): (1) apply genetic principles to all silvicultural prescriptions, (2) use seed collected in a specific seed zone for reforestation purposes in that same zone, (3) maintain genetic variability in reproductive material used to restock National Forest land, (4) cooperate with national and international organizations in efforts to preserve gene resources, and (5) use seedlings from distant sources only after successful performance in evaluation trials.

It is extremely important that silviculturists and geneticists work with Land Management Planners to ensure these policies are included and developed in Forest Plans. Seed sources must be monitored from collection through shipping from the nursery to make sure the seedlings are planted in the appropriate zone.

Some people are concerned that seed orchard seed will reduce genetic diversity. The facts are that seed orchards are based on many parents (usually more than 50) and these parents are selected in local stands within specific seed zones. This ensures that local parents will be used to produce seed for specific zones and the large number of parents will maintain genetic diversity.

A workshop is being planned for April 1980, involving Regional, S&PF, and Research geneticists. The objectives are to develop alternative strategies for managing the genetic resource and to clarify current policy.

Beginning in fiscal year 1980, activity reviews are being scheduled to evaluate regional tree improvement programs. Budgets for tree improvement programs have increased considerably, and we believe a need exists to see that the highest priority work is being accomplished.

TABLE 1

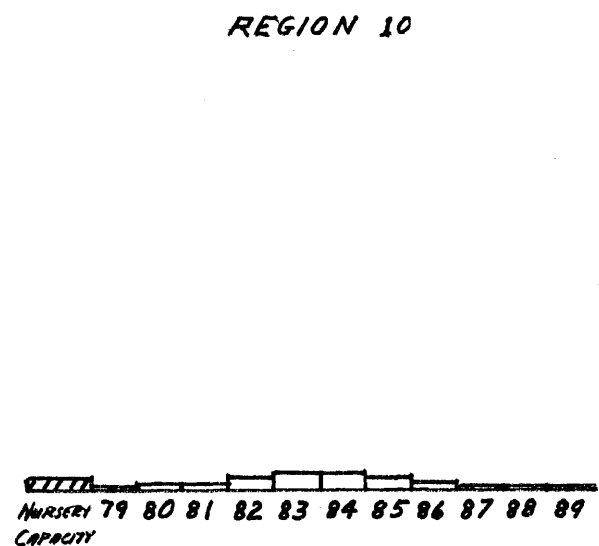
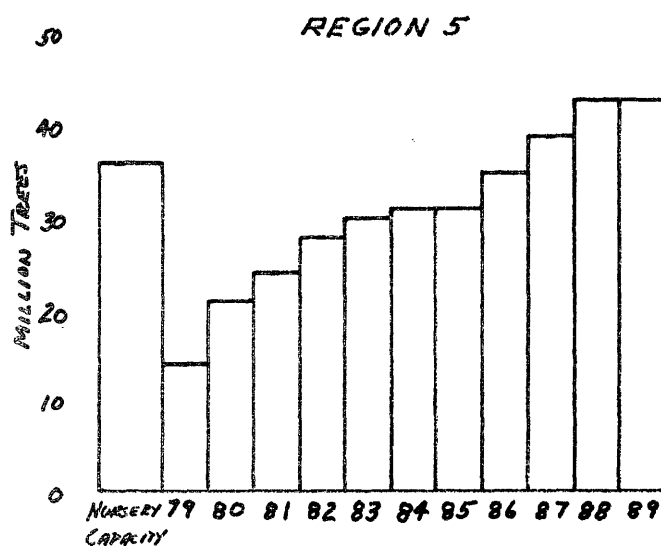
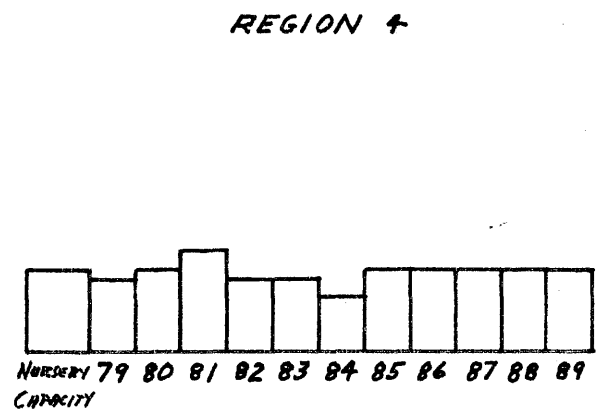
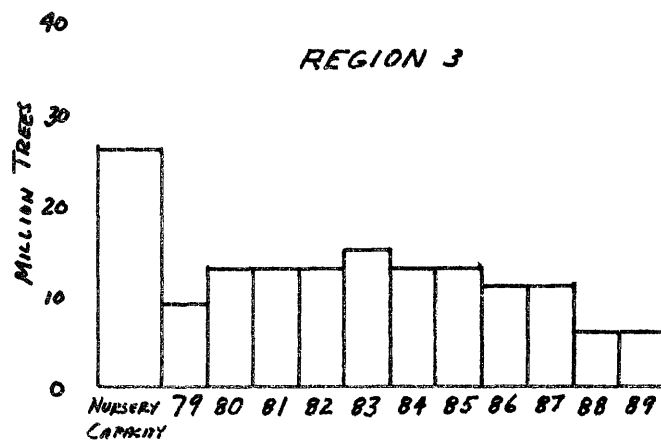
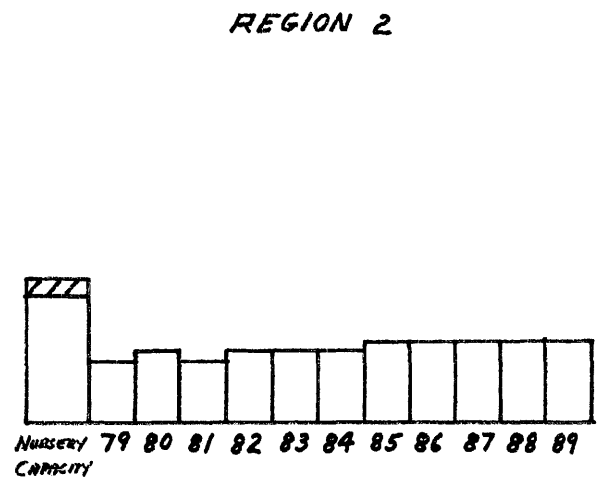
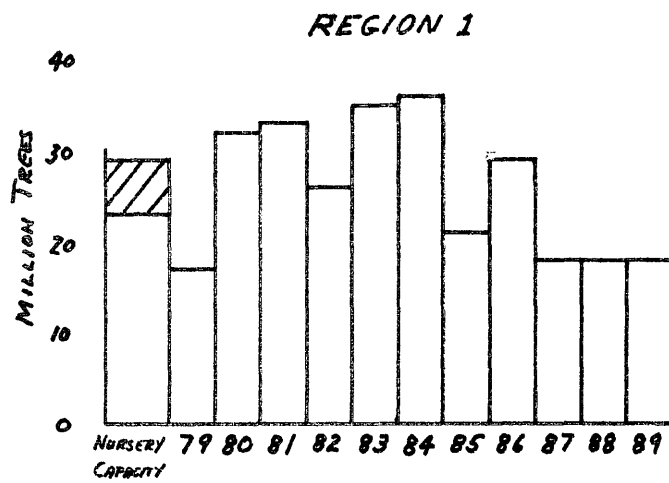
USDA Forest Service Nursery Capacity

<u>Region</u>	<u>Facility</u>	<u>Calculated Capacity^{1/}</u> <u>(MM Seedlings)</u>		<u>Nursery Production FY 81^{2/}</u> <u>(MM Seedlings)</u>	
		<u>Bare Root</u>	<u>Container</u>	<u>Bare Root</u>	<u>Container</u>
1	Coeur d'Alene	22.4	6.1	21.4	3.5
2	Bessey	5.8		1.5	
	Mt. Sopris	7.6	1.6	5.0	1.6
3	Albuquerque	26.2		8.1	
4	Lucky Peak	8.5		7.0	
5	Humboldt	24.9		15.6	
	Placerville	10.7		14.6	
6	Bend	11.7		9.3	
	Beaver Creek		6.7		5.0
	Medford	30.6		28.6	
	Wind River	18.3		22.8	
	Sub Total	166.7	14.4	133.9	10.1
8	Ashe	20.0		23.7	
	Stuart		0.6		0.6
9	Eveleth	11.7		4.2	
	Toumey	12.4		5.9	
	Sub Total	44.1	0.6	33.8	0.6
10	Stikine		1.2		1.1
	TOTAL	210.8	16.2	167.7	11.8

^{1/} Service-wide Nursery Capacity Study--data as of 1/1/79.

^{2/} Response to 6520 Financial Management, July 23, 1979, Fiscal Year 1981 Budget Development

FIGURE 1
NURSEY CAPACITY AND SEEDLING NEEDS BY REGION AND FISCAL YEAR



LEGEND

NURSERY
CAPACITY



CONTAINER STOCK

BARE ROOT STOCK

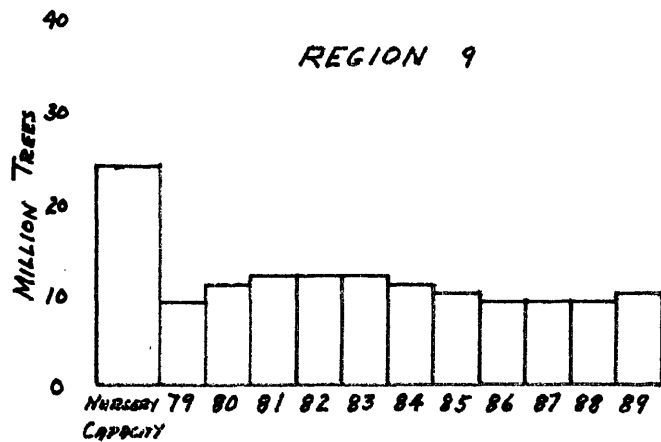
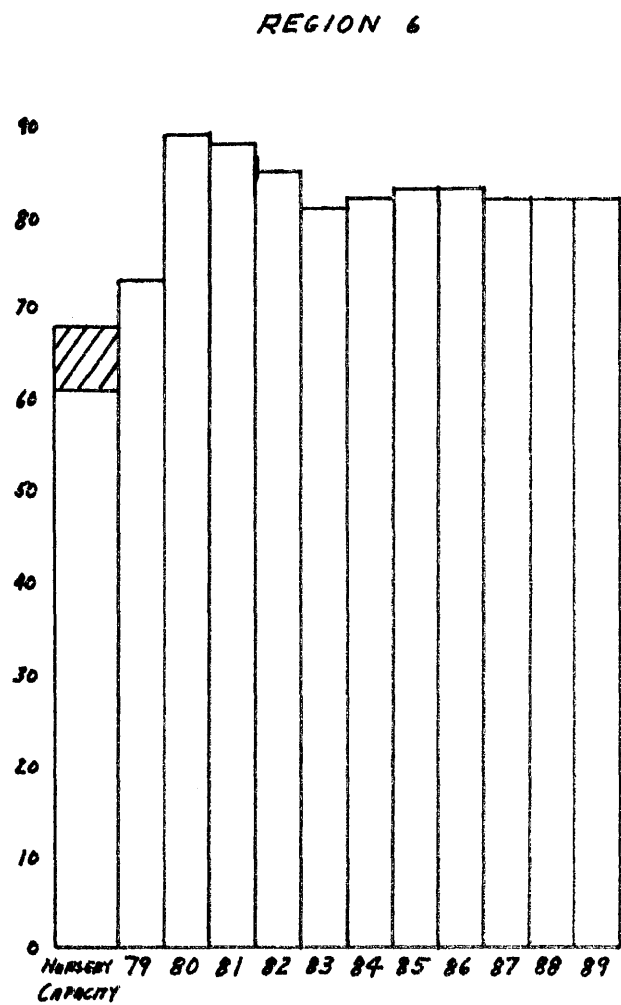
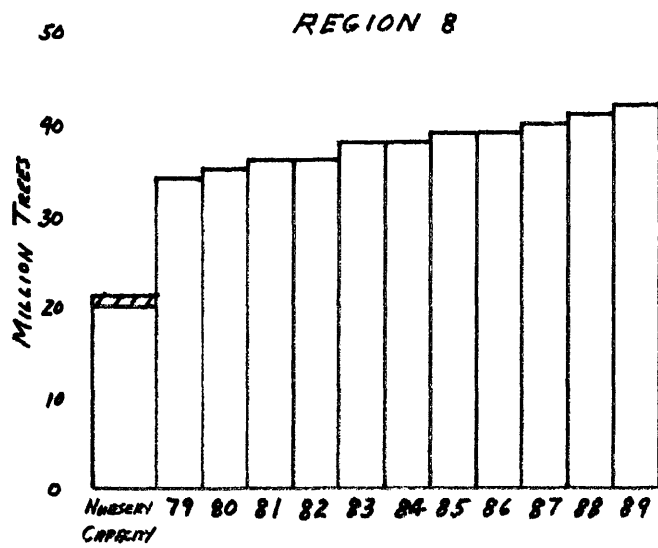
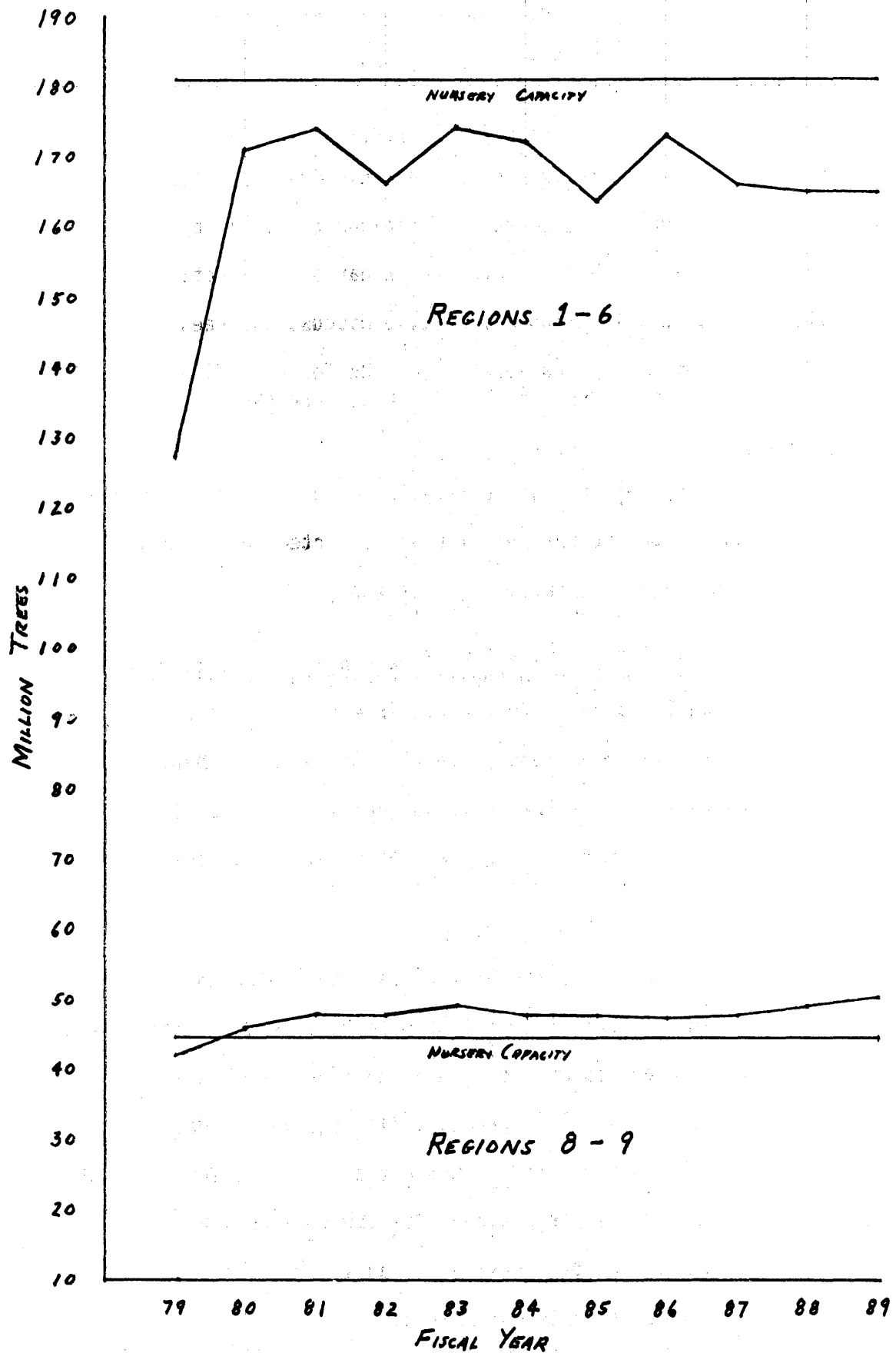


FIGURE 2
NURSERY CAPACITY AND SEEDLING NEEDS BY FISCAL YEAR



Silviculturist Certification

During the next few minutes I will give you an update and open a discussion on silviculturist certification. More specifically, I'll discuss the alternatives and recommendations developed by a work group assigned early this year to review national direction in silviculturist certification. I'll also discuss the need for establishment of minimum national standards for certification.

Background

The Chief's study team headed by LeRoy Bond in 1978 of Reforestation and TSI programs on the National Forests reported on a problem in the National Forest System. Issue B (5) states:

"Some Regions have an intensive training and certification program while others have few requirements. There are no Service-wide minimum requirements or guidelines. Many silviculturists and other National Forest personnel feel there should be minimum requirements developed by the Washington Office."

Recommendation number 8 of the Action Plan concerning this issue states, "W.O.-TM is to give emphasis to silviculturist certification. Together with the development of a quality training program, the Washington Office should monitor Regional programs and develop minimum national standards for certification." Also, for those of you who were at last year's National Silviculture Workshop, you will remember the discussion of a national academy approach to the continuing education of silviculturists.

Also, many Regions have felt a need to upgrade their certification programs. There is a need to both improve on-the-ground quality of prescription writing and to standardize various Regions' certification programs. Standardization would help in transferring silviculturists and their certification between Regions.

A work group, formed early in 1979 by the Chief, was assigned the task of reviewing national direction in silviculturist certification and investigating the need to establish minimum national certification standards.

The work group was headed by Ray Wienmann, Director of Timber Management, Region 5. Other members are:

John Tappeiner	- Region 5
Bill Beaufait	- Region 1
Ron Hamilton	- Region 4
Bill Tuttle	- Region 9
Jack Barrett	- Region 8
Carl Puuri	- Region 6
Bill Anderson	- Washington Office

Task of Work Group

1. Query Regions to see how national certification direction has been implemented to date.
2. Look at similarities and differences between Regions concerning certification.
3. Identify concerns and constraints of various Regions associated with certification and standards for certification.
4. Develop and analyze alternatives to provide a common approach to a more standard national certification program.

The Work Group compared the certification program of each Region. The Group utilized the work of Dr. Jack Barrett (retired University of Tennessee). Dr. Barrett had evaluated the silviculturist certification programs of the western Regions. The Work Group also sent questionnaires to each Region.

Before the Group could develop alternatives and recommendations, it was essential to define the objectives of certification.

Objective of Silviculturist Certification

1. Identifies people with a specified level of skill, knowledge, education, and experience to develop sound prescriptions.
2. Provides line officers with employees having a good foundation in natural and social sciences and a specific minimum level of competence to make land management decisions.
3. Provides state of the art quality in land management projects.
4. Provides qualified individuals to monitor, evaluate, and implement on-the-ground treatment results.

Based on the findings of the Work Group and an analysis of needs, the following alternatives for national silviculturist certification standards were developed.

Alternatives

1. No Change

Present policy without enforcement.

2. Modify and Enforce Policy

Certified silviculturists review and approve prescriptions (rather than prepare them).

3. Enforce Current Policy as Written

All prescriptions written by certified silviculturists.

4. Require Regional Certification Programs Meeting Minimum National Standards.

5. National Core Education with Supplemental Region Program Meeting Minimum National Standards.

6. Modified Recruitment

The work group recommendations concerning the alternatives are as follows:

1. National policy requiring Regional certification programs meeting established minimum national standards.

2. Minimum national standards based on tasks, tools and levels of competence defined by work group.

3. Modify recruitment methods to hire foresters with education and background in science and silviculture.

4. FSH 2478.4 to read "prescriptions for TSI, Reforestation, and Timber removal shall be prescribed or approved after field review by a certified silviculturist."

5. Completion of certification program should be properly recognized by line officer presentation of certificate or award.

The report of the Work Group has not yet been acted on by the Washington Office. Within the next several months, the Division of Timber Management will make recommendations to Tom Nelson. A decision and resulting national direction will follow.

NATIONAL SILVICULTURE WORKSHOP

I AM PLEASED TO BE HERE REPRESENTING STATE AND PRIVATE FORESTRY AND TO PARTICIPATE IN THE NATIONAL SILVICULTURE WORKSHOP. WE TOO ARE CONCERNED ABOUT HOW TO APPLY SILVICULTURAL PRACTICES TO MEET LAND MANAGEMENT OBJECTIVES. THIS INCLUDES THE MAINTENANCE OR ENHANCEMENT OF THE OTHER FOREST RESOURCES BESIDES TIMBER AS WELL. AND WE ARE INVOLVED EITHER DIRECTLY OR INDIRECTLY IN MANY WAYS. THE DIFFERENCE IS THAT WE DEAL WITH THE PRIVATE NON-INDUSTRIAL LANDOWNER, OF WHICH THERE ARE OVER 4 MILLION, WITH AN AVERAGE HOLDING OF 70 ACRES. THESE LANDS COMPRISE ABOUT 60% OF THE NATIONS COMMERCIAL FOREST LAND. THEY HAVE IMPORTANT WATERSHED VALUES AND PRODUCE A SIGNIFICANT SHARE OF THE NATIONS TIMBER, WILDLIFE, FORAGE AND OUTDOOR RECREATION, I.E., A TASK FORCE OF THE SAF RECENTLY LOOKED IN TO "IMPROVING OUTPUTS FROM NONINDUSTRIAL PRIVATE FORESTS." THIS REPORT NOTES THAT 76% OF THE HARDWOOD HARVEST AND 38% OF THE SOFTWOOD HARVEST IS ON THESE TYPE LANDS.

S&PF IS CHARGED WITH ADMINISTERING COOPERATIVE FORESTRY PROGRAMS ON NON FEDERAL LANDS. BASICALLY THESE PROGRAMS COME FROM THE COOPERATIVE FORESTRY ASSISTANCE ACT OF 1978, AND THE WATERSHED PROTECTION AND FLOOD PREVENTION ACTS.

Presented by: Billy E. Page, Cooperative Forestry, S+PF, W.O.
National Silviculture Workshop, September 17-21,
1979, Charleston, S.C.

NOW TO MENTION SOME OF THE PROGRAMS.

UNDER RURAL FORESTRY ASSISTANCE THREE BASIC SILVICULTURAL PROGRAMS ARE PROVIDED; FOREST MANAGEMENT ASSISTANCE, NURSERY, AND TREE IMPROVEMENT. THE FOREST MANAGEMENT ASSISTANCE PROGRAM[^] IS IN THE FORM OF TECHNICAL ASSISTANCE. THIS WORK PERFORMED THROUGH THE STATE FORESTERS INCLUDES ALL OF THE ACCEPTED SILVICULTURAL PRACTICES WE USE TODAY. MUCH OF THIS WORK INVOLVES REFORESTATION WHICH REQUIRES TREES FOR PLANTING, THIS IS WHY WE ARE INVOLVED IN NURSERY AND TREE IMPROVEMENT PROGRAMS AS PART OF THE RURAL FORESTRY ASSISTANCE. AGAIN THIS WORK IS PERFORMED BY THE STATE FORESTERS WITH THE FEDERAL GOVERNMENT PROVIDING TECHNICAL AND FUNDING ASSISTANCE.

THE FORESTRY INCENTIVES PROGRAM (FIP), AUTHORIZED BY CONGRESS IN 1973 PROVIDES FEDERAL COST-SHARING WITH PRIVATE NON-INDUSTRIAL LAND OWNERS FOR TREE PLANTING AND TSI. THE PROGRAM IS JOINTLY ADMINISTERED AT THE NATIONAL LEVEL BY THE ASCS AND THE FS ~~XXXXXX~~. THE PROGRAM IS AVAILABLE IN ALL STATES THAT HAVE DESIGNATED COUNTIES ELIGIBLE FOR PARTICIPATION. THIS AMOUNTS TO ABOUT 1400 COUNTIES FOR A 15 MILLION DOLLAR PROGRAM.

THE FEDERAL COST-SHARE RANGES FROM 50 TO 75% FOR SILVICULTURAL PRACTICES INSTALLED BY THE LANDOWNER. THE MAXIMUM COST-SHARE FOR FORESTRY PRACTICES IS \$10,000 PER LANDOWNER ANNUALLY. THE FOREST LAND MUST BE CAPABLE OF PRODUCING 50 CUBIC FEET OF WOOD PER ACRE PER YEAR. THE ASCS HANDLES THE COST-SHARES AND THE FOREST SERVICE IS RESPONSIBLE FOR PROVIDING TECHNICAL ASSISTANCE. THIS TECHNICAL ASSISTANCE WORK IS DONE BY THE STATE FORESTERS. THE SILVICULTURAL PRACTICES EMPLOYED MUST BE AN APPROVED PRACTICE BY THE STATE FORESTER, AND BE PRESCRIBED IN A FOREST MANAGEMENT PLAN. SINCE 1974, 1.4 MILLION ACRES HAVE HAD SILVICULTURAL TREATMENT.

THE AGRICULTURAL CONSERVATION PROGRAM (ACP) ADMINISTERED BY THE ASCS HAS FORESTRY PRACTICES APPROVED AS PART OF THE ANNUAL PROGRAM. WHEREAS FIP IS AIMED AT TIMBER PRODUCTION, THE CONSERVATION OF THE SOIL AND WATER RESOURCE IS THE PRINCIPAL OBJECTIVE OF ACP. THE FOREST SERVICE HAS THE RESPONSIBILITY FOR PROVIDING THE TECHNICAL ASSISTANCE REQUIRED BY IMPLEMENTING THESE FORESTRY PRACTICES.

SINCE 1936, WHEN THE PROGRAM WAS INITIATED, OVER 6½ MILLION ACRES OF TREES HAVE BEEN PLANTED AND ALMOST 5 MILLION ACRES OF TSI HAS BEEN ACCOMPLISHED ON PRIVATE LANDS.

CURRENTLY IN FOUR NEW ENGLAND STATES WE ARE CONDUCTING A PILOT FUELWOOD PROJECT. THIS IS A ACP PROJECT AND IS AN INTERAGENCY EFFORT BY THE FOREST SERVICE AND THE ASCS. THE OBJECTIVE IS TO PROMOTE THE USE OF WOOD FOR ENERGY AND AT THE SAME TIME ACHIEVE TIMBER STAND IMPROVEMENT AND ENVIRONMENTAL PROTECTION GOALS. TECHNICAL ASSISTANCE IS PROVIDED TO PRIVATE LANDOWNERS BY THE STATE FORESTRY ORGANIZATIONS, PROVIDED THE LANDOWNERS AGREES TO MANAGE THEIR WOODLAND AS SPECIFIED IN A 10 YEAR FOREST MANAGEMENT PLAN. CONSULTING FORESTERS ARE DOING SOME OF THE WORK. TECHNICAL ASSISTANCE INCLUDES PREPARATION OF FMP'S, DESIGNATING TREES FOR CUTTING, AND SUPERVISION OF THEIR REMOVAL. THIS IS DONE AT NO COST TO THE LANDOWNER. THE GOAL IS TO PUT 90,000 CORDS OF WOOD ON THE MARKET. COST-SHARING IS ALSO ALLOWED FOR MINIMAL ACCESS ROAD CONSTRUCTION. MINIMUM TRACT SIZE IS 10 ACRES. AGAIN, THE OBJECTIVE IS TO PROVIDE WOOD FOR ENERGY, WHILE ACCOMPLISHING SILVICULTURAL NEEDS. THIS TYPE OF PROJECT MAY BE EXPANDED TO OTHER STATES WHERE THERE IS A FAVORABLE RESOURCE/DEMAND SITUATION.

ONE EXAMPLE OF A PROGRAM PROVIDED BY THE WATERSHED PROTECTION AND FLOOD PREVENTION LEGISLATION IS THE YAZOO-LITTLE TALLAHATCHIE FLOOD PREVENTION PROJECT IN MISSISSIPPI. SINCE 1947, THE FOREST SERVICE, IN COOPERATION WITH SEVERAL COUNTY, STATE, FEDERAL, AND LOCAL ORGINZATIONS AND AGENCIES, HAS PLANTED OVER 700,000 ACRES TO TREES AND PERFORMED TSI WORK ON 300,000 ACRES. FOREST MANAGEMENT PLANS HAVE BEEN MADE ON APPROXIMATELY ^{300,000}~~300,000~~ ACRES. THESE PLANTATIONS WERE ESTABLISHED PRIMARILY FOR WATERSHED PROTECTION, BUT AS THEY GROW OLDER VARIOUS TIMBER MANAGEMENT PRACTICES HAVE BEEN IMPLEMENTED IN THEM THAT IS COMPATIBLE WITH THE EROSION CONTROL OBJECTIVE. TODAY THESE PLANTATIONS ARE YIELDING OVER 50,000 CORDS ANNUALLY AND WITHIN 5 MORE YEARS WILL BE YIELDING OVER 100,000 CORDS EACH YEAR AS A CONTRIBUTION TO THE LOCAL ECONOMY.

WHAT IS THE OUTLOOK FOR THE FUTURE? THE RPA TIMBER SUPPLY ASSESSMENT TELLS US THAT INCREASED DEPENDENCE WILL BE PUT ON NONINDUSTRIAL PRIVATE LANDS IN ORDER TO SATISFY THE PROJECTED DEMAND FOR WOOD PRODUCTS IN THE YEARS AHEAD.

THE CHIEF HAS CERTAINLY INDICATED THAT INCREASED EMPHASIS WILL BE PUT ON THE S&PF ARM OF THE FOREST SERVICE IN THE FUTURE.

SOME RELIEF MAY BE FORTHCOMING TO THE LANDOWNER IN THE FORM OF TIMBER CROP INSURANCE, LOW-COST LOANS, AND/OR TAX INCENTIVES.

WE ARE EXPERIENCING A REVIVAL IN THE USE OF WOOD AS AN ENERGY SOURCE, AND THERE IS CONSIDERABLE INTEREST IN THE CONGRESS ON DEVELOPING WAYS TO ENCOURAGE PRODUCTION OF WOOD FOR ENERGY.

THE UPSHOT OF ALL OF THIS IS THAT INCREASED DEMAND WILL BE PUT ON THE NONINDUSTRIAL PRIVATE LANDOWNER TO PRODUCE MORE WOOD FOR MORE DIVERSE MARKETS, AND IN TURN CREATE NEW FOREST MANAGEMENT PROBLEMS THAT WILL REQUIRE PROFESSIONAL SKILL TO SOLVE SILVICULTURALLY.

SO, WE IN S&PF NEED TO BE INVOLVED IN THESE WORKSHOPS. WE NEED TO STAY CURRENT ON THE LATEST TECHNOLOGY SO THAT WE CAN EFFECTIVELY HELP WITH TRANSFERRING THIS TECHNOLOGY TO THE FIELD IN ALL OF THE 50 STATES. THIS WILL HELP MAKE S&PF COOPERATIVE PROGRAMS MORE EFFECTIVE.

THANK YOU.

Shelterwood Systems and Regeneration Methods

David M. Smith, Professor of Silviculture, Yale University
School of Forestry and Environmental Studies, New Haven, Connecticut

There are many kinds of shelterwood systems and cuttings. There are only a few attributes that they have in common. The first is that they all involve reliance on advance growth, that is, on regeneration established before the previous stand is entirely removed. The second is the creation of stands that are even-aged or more nearly even-aged than otherwise.

Maintenance of the even-aged condition has many kinds of operational and administrative advantages better known to people who manage forests than to anyone else. The even-aged condition is also one commonly found in nature even though it is hardly a universal one. Many forests have been regenerated by purely natural catastrophic events such as severe fires, windstorms, or insect outbreaks acting singly or in combination. Furthermore, the human propensity to cut forests first and manage them later has created vast areas of even-aged stands. One source has been the sequence of clearance of forests for agriculture and subsequent abandonment to natural reforestation. The other has been the tendency of purely exploitive cutting to harvest virtually everything all at once. Since it is difficult, time consuming, and even wasteful to convert even-aged stands to uneven-aged ones, we are, for practical purposes, condemned to perpetuate many even-aged stands.

The characteristic reliance on advance growth for regeneration can be advantageous or disadvantageous, sometimes simultaneously, depending on the circumstances. There is a powerful advantage in having the new stand in sight before one casts loose from the seed source and other beneficial effects of the trees of the previous stand. There is relatively good opportunity to keep desirable vegetation in command of the growing space throughout the regeneration period. The risk that undesirable kinds of pioneer vegetation will invade can be reduced, although the risk that unwanted plants of the later successional stages will appear or maintain themselves is increased.

There can be all kinds of other advantages from getting regeneration established before the previous stand is entirely removed. One rotation can be telescoped into another such that the average rotation length can be shortened. Instead of running the risk of delay in the resumption of production, there is likely to be some gain in production because of getting a head-start on regeneration and avoiding periods during which the economic production is zero.

If one makes heavier removal cuttings and depends on getting the regeneration afterwards there are many vagaries of people and nature that can lead to delay. With natural regeneration, years can elapse before the next good seed crop. If reliance is placed on planting or artificial seeding, various human propensities for delay and procrastination can take effect. Natural revegetation does not wait on human institutions or seed production by what we regard as desirable species but fills vacant growing space with plants which we may or may not regard as desirable. The only general reproduction method that involves less gambling on regeneration than shelterwood cutting are the various coppice methods in which reliance is placed on vegetative sprouting.

Most of the other attributes of shelterwood management apply to some circumstances and not others. One which applies in many cases also has to do with the timing of natural regeneration and the sporadicity of good seed crops. With many species, shelterwood cutting enables an important degree of freedom from the baneful consequences of unpredictability of seed crops. Although it helps to concentrate seed cuttings in years when there is a good seed crop, it is often possible to make them at any operationally convenient time and simply wait for the seed crops. The old stand continues to grow and earn its keep while remaining a source of seed and shelter. Once the regeneration is established, there is usually considerable latitude in the timing of the removal cuttings. This kind of relaxed approach does carry some risk of invasion by undesirable species. Almost all desirable tree species are sufficiently shade-tolerant in the seedling stages that they can endure protracted holding periods while removal cuttings are being completed.

Another very important but not universal attribute of the shelterwood system is the opportunity that it provides for sophisticated management of the financial investment represented by the value of the trees of the growing stock. It is unfortunate that the financial maturity analysis of single trees that played such an important role in developing American timber management in the period from 1920 to 1950 was associated mainly with so-called "selective cutting." As Duerr, Fedkiw, and Guttenberg pointed out in their 1956 account of financial maturity analysis (USDA Tech. Bul. 1146), the pure application of this idea to even-aged stands leads to a series of thinnings followed by shelterwood cutting.

Not all of the trees in most stands reach financial maturity simultaneously. In even-aged stands, it was observed by someone long ago that "the best trees grow best." In many kinds of stands, discriminating analysis will often reveal that most of the potential value resides in a few dozen of the hundreds or thousands of trees that start on an acre. This general phenomenon is likely to be overlooked unless careful consideration is given to the quality of

trees as well as their sizes. It is entirely overlooked if attention is literally given only to production in terms of tonnage or cubic volume without regard even for tree sizes.

This general effect is greatest with species which command high premiums for fine lumber and wide boards. It is low in importance when trees are grown only for pulpwood or fuelwood. In the case of such bulk commodities, tree size can still have an effect through the high handling cost of small individual stems or pieces; if and when we develop means of handling such trees in bundles at all stages, the effect will vanish. There is, incidentally, an important intermediate condition in which trees are grown mainly for load-bearing construction material and the premium for quality is modest. With such trees the point of financial maturity is usually reached at somewhere around 18 inches DBH. This is because it is usually difficult to achieve rapid diameter growth beyond that stage and the sawing waste lost in converting round stems into square edged timbers is not as great in that size range as in smaller trees.

The main point of all this is that shelterwood cutting becomes a way of acting on the common fact that some of the trees in even-aged stands can continue to earn their way beyond the time when it becomes logical to give some of the growing space over to the next crop.

This kind of manipulation of growing stock is such a valuable characteristic of shelterwood management that there are many instances in which it is the final compelling reason to adopt the practice. The technique may even be applied when there is no particular reason to use shelterwood cutting strictly for regeneration. On the other hand, since it involves harvesting the poorer trees first and leaving the best until last, there are human tendencies that delay embarkation upon shelterwood management just as there is with thinning. The approach is unpopular for anyone concerned with logging. This is especially true because loggers are forced to operate under circumstances where most rewards are immediate and they cannot always depend on participating in the benefits of future growth. If the attainment of future benefits makes logging cost more, the difference must be paid by ownership and not by the loggers.

It was, incidentally, a kind of psychology of immediacy that earlier caused the application of financial maturity analysis to degenerate into the high grading associated with the selective cutting episode of a few decades ago. It is also worth noting that, if we use financial maturity analysis as the only guidepost, the only thing it tells us about culls and small or malformed trees of little or no current value is to leave them cluttering the woods.

Shelterwood cutting can have important advantages for regeneration even though there is more to the shelterwood system than regeneration.

Likewise, even though shelter can be important for regeneration there are times the use of the word "shelter" in the name causes other attributes to be overlooked. However, there are important species that are so dependent on shelter during the seedling stage that we can regard them as being "advance growth dependent." There are also hot or superficially dry sites where almost any kind of species we might want is dependent on some degree of shelter. A very high proportion of the occasional regeneration failures caused by true clearcutting are the result of over-exposure in situations in which the desirable species are either always advance growth dependent or conditionally so.

As the next speaker, David Marquis, will surely indicate to you, many but not all of the important hardwood species do not really tolerate exposure in the stages of germination and establishment. The chief exceptions appear to be birches, true poplars, red alder, and other pioneers. It has long been known that the oaks and other heavy seeded hardwoods had to start as advance growth. However, it has only been in the last dozen years that it dawned on me that the same is true of maples, white ash, black cherry, and many other important hardwood species. The seedlings of the more shade tolerant conifers, such as the hemlocks, spruces, and true firs, are not particularly resistant to exposure either.

We must recognize that there are places where true clearcutting defeats regeneration and may even do so if we plant. This lesson has been learned in the true fir zone of the High Cascades and on south facing slopes and granitic soils in southwestern Oregon. There is altogether too much evidence that true clearcutting, recently embarked upon, is stalling natural regeneration of spruce and balsam fir in the forests of Maine.

While there are exceptions, I see some evidence that the seedlings of almost all desirable tree species do require some sort of shelter. However, it does not always have to be the shelter of tall trees of a shelterwood. The shade of stumps, fragments of wood, or rocks will often suffice. More important may be the role of pioneer herbaceous vegetation. Sometimes this kind of vegetation serves its role and disappears before we perceive that it has done so. It probably could be shown that the annual and perennial grasses that accompany most southern pine regeneration are very important in protecting the seedlings and excluding other competing vegetation.

It is also time that we quit arguing that we have to clearcut to provide enough light for regeneration of Douglas-fir and a host of other tree species (but not absolutely all of them). Most of them need some shelter and we are lucky that herbaceous growth often provides it. There may be plenty of other good and sufficient reasons for true clearcutting but absolute ecological requirements for exposure represent special cases.

Perhaps the most important point about shelterwood cutting and regeneration is that it affords latitude for creating almost any kind of regenerative microenvironment that is desired. This can be regulated by the severity of cutting and also by various treatments of the forest floor. At one extreme, there can be nearly complete exposure and, at the other, with strip shelterwood cutting, combinations of full shade and heavy side shade. However, except at high latitudes, it is just about impossible to cut without letting some direct sunlight onto the ground somewhere, although the duration of such exposure can be reduced.

Natural regeneration by the shelterwood method can have its special and important difficulties. A very common one is irregularity of stocking, usually more in the direction of overstocking than understocking. The surest solution to overstocking is precommercial thinning; the money that one may save in avoiding planting can later get spent on such thinning. However, the timing of precommercial thinning is not as crucial as that of planting; there can always be the hope that postponement of problems will be associated with the development of solutions. The demand for fuelwood is likely to make "commercial" some of what is now "precommercial." There is also still much latitude for mechanization of both precommercial and commercial thinning. The retention of the overwood can sometimes be used deliberately to induce irregularity of height growth and thus of expression of dominance in shelterwood regeneration.

Another critical problem of shelterwood regeneration is that of harvesting the overwood without destroying the regeneration. There are no perfect, single solutions to any problem, but there are some partial ones to this problem that are often adequate. If the overwood is removed very early, the new seedlings may be supple enough to suffer little significant damage. If the regeneration is successively established by use of advancing strip-shelterwood cutting, the felled timber can be drawn out through the parts of the strips that are not yet regenerated.

The harvesting of the overwood can sometimes be used to effect a partial solution to that of overstocking of the new stand. We seldom need to have the released seedlings any closer together than about 8 feet apart. In fact, the taller the new crop the wider is the ideal spacing at the time of the final removal cutting. Well-distributed logging damage under such circumstances can be a blessing even when it seems like severe damage. In practice, the chief source of understocking from overwood removal tends to be limited to the spots where the crowns hit the ground. It can help to drop the crowns into the overstocked patches of regeneration and avoid certain conscientious tendencies to fell them in the sparsely stocked spots where the fewest new trees will be damaged. It is desirable in this and many other silvicultural

connections to urge the development of the narrowest possible kind of machinery for timber extraction.

Another common problem with shelterwood regeneration is that of wandering into situations in which the new species that prosper are more shade tolerant than the ones desired. In practice, this often happens when one gets so intent on manipulating the growing stock of the previous stand that control of composition of the new one gets overlooked. Even if the desired species appear in the regeneration, there may be so little light that they can get overwhelmed by the superior height growth of more shade tolerant associates. The best way to try to forestall this problem is to keep the old stand well closed enough to prevent much regeneration and then make a single-minded seed cutting of the right intensity at a clearly chosen time. If the problem has already arisen, one can destroy the regeneration and start over again or else do release work to free the desirable regeneration if it is there. If one starts over again, it is well to guard against site preparation so intensive that it leads to overstocking of regeneration or opens the way for invasion of unwanted pioneer vegetation.

Natural regeneration by the shelterwood method does not give the direct, positive control of species composition that we sometimes think we want and often seek by clearcutting, site preparation, and planting. There are, however, many kinds of forests in which we tend to underestimate the propensity for mixed stands to sort themselves out in the ways we want. Given the right light conditions, many of the species we prize are quite capable of soaring above their associates. The very fact that they have in nature is part of the reason why they attained the sizes for which we prized them in the past. They do not always do so immediately. Sometimes their emergence waits until quick growing pioneers have died; this process can be accelerated by release cutting. In other cases, it may be a decade or two before the desired species becomes ascendent and its associates are left behind in the lower strata. If we knew more about the development of mixed stands, we might tamper with them less.

Given half a chance, the pines and West Coast Douglas-fir will emerge above almost all of their coniferous associates. In the Appalachian Forest, if cuttings are heavy enough, yellow poplar on good soils will almost always stay ahead of its associates. There is also some evidence that the members of the red oak group may tarry for a decade or two and then, by steady height growth, overtake some of the other hardwoods. Loblolly pine can often keep ahead of its hardwood associates if it has an even start with them and in the open. After patch cuttings in some northern hardwood forests, yellow birch seedlings can overtake pre-established saplings of sugar maple and beech (but probably not paper birch and white ash).

Pure stands can have important virtues but we do not always need them. There are plenty of cases in which we can induce mixed regeneration by shelterwood cutting or other means and then depend on the trees to fight it out to the conclusions we want. If the right species emerge from the ruck there is a good chance that they will be at the wide spacing appropriate to excellent diameter growth. If we spend a lot of money to create pure stands of some of these same species we are likely to condemn ourselves to additional subsequent expenditures for precommercial thinning. For example, one can be very impressed with the excellent diameter growth of emergent cherrybark oaks in mixed stands but it would take a lot of thinning to prevent a pure stand of this species from consisting of more than a collection of slender stems.

The shelterwood system is a good idea and its time appears to have come. All good ideas wait in the wings and come on stage at the appropriate time. Then they get overdone and run into the ground. I have been around long enough to get the eerie feeling that American forestry and National Forest Administration have been through such episodes before.

In the decades before around 1950, the effort to replace short-sighted forest liquidation with conscious long-term timber management produced the episode of infatuation with "selective cutting." In those times, I regarded this procedure as a manifestation of the wrongheadedness of the ruling generation. Since financial maturity analysis was the main basis it seemed to me an invention of wolves in economists' clothing. The whole idea of "selective cutting" was quietly cast down the Orwellian memory hole and some good points went out with the poorer ones.

The next fad has been or is that of the simplest kind of even-aged management with clearcutting and planting. Just how all of those uneven-aged stands suddenly became even-aged without treatment is not very clear. I suspect it was because many of them were not uneven-aged anyhow, but that is another story. It is now perceived that clearcutting has sometimes been overdone, so the next fad may be the pursuit of the logic of even-aged management through shelterwood cutting.

We should by now perceive that there is no universally best silvicultural solution to all of the forest management situations that face us. Every silvicultural system yet devised or to be invented has a place somewhere and the only question is where each one fits best. Furthermore, none of these systems are stylized routines akin to the school figures of figure skating. Each logical system should be a free-form solution designed to fit the circumstances. In fact, it is better to formulate the system first and put a silvicultural name on it afterwards. Furthermore, the best silvicultural solutions are going to be developed by observant, analytical foresters on the ground. Handbooks, textbooks, and other literary devices as well as thoughts from higher headquarters are sources of ideas but not of ready made solutions. Good physicians do not prescribe treatment without examining the patient and so it should be with silviculture.

ECOLOGICAL ASPECTS OF SHELTERWOOD CUTTING

by

David A. Marquis
Principal Research Silviculturist
USDA, Forest Service
Northeastern Forest Experiment Station
Warren, Pa.

Dave Smith has set the stage by defining shelterwood cutting within the even-aged silvicultural system. I'd like to reemphasize the points that shelterwood cutting, like clearcutting and seed tree cutting, is a regeneration method used under even-aged silviculture, and that all three of these regeneration methods create similar kinds of new stands.

Of these three, clearcutting is almost always the least expensive to apply in terms of numbers of entries required into the stand, and therefore in sale preparation and sale administration costs. It produces the maximum timber volume per acre to offset road building costs, and permits the greatest flexibility in selection of logging equipment. Clearcutting is also the least likely to cause damage to residual stems (since there usually aren't any). So other regeneration methods, such as shelterwood cutting, should not be used unless they offer some real advantage over clearcutting.

Shelterwood cutting is a very flexible method. The number of cuts, density of residual stand, interval between cuts and associated cultural practices can be varied over a wide range to achieve different effects. Shelterwoods can be designed to optimize environmental factors to favor seedling establishment of a particular species or to promote seedling growth, or to minimize interference from undesirable vegetation; they can be designed to improve seed production, or to minimize damage from particular insects, diseases, or animals.

However, shelterwoods can achieve these effects only if they are tailored to the specific needs of the situation. The term shelterwood cutting is really only a general term that is used for a rather broad group of similar cutting practices. In prescribing shelterwood cuts for a particular situation, you must also specify exactly how and under what schedule the various cuts will be made. To do that, you need fairly detailed knowledge of the ecological requirements of the various species and the environmental and ecological effects of various types of cuttings in that particular forest situation.

I'd like to describe some of these effects of shelterwood cutting, using data from the Allegheny hardwood forest type in Pennsylvania and New York as an example. The particular form of shelterwood cutting that meets our needs in that forest may not be appropriate elsewhere, but many of the general principals involved can be used to arrive at appropriate cutting regimes for other areas. Let me first describe some of the research that provided the necessary background knowledge.

Allegheny hardwood forests occur primarily on the Plateaus of Pennsylvania and New York in northeastern United States, at elevations between 500 and 2000 feet, where annual precipitation averages 40 inches.

These stands originated after commercial clearcutting during the railroad logging era, between 1890 and 1930. They are second growth stands, replacing the beech-hemlock-maple stands which were originally present on the site. Black cherry, sugar maple, red maple, and white ash are the primary components of the Allegheny hardwood type; and birch, yellow-poplar, beech, and hemlock are common associates.

Like many other eastern hardwoods, the cherry-maple type is usually managed under the even-aged system, with clearcutting used to reproduce stands that have reached maturity. In this type, clearcutting sometimes results in satisfactory natural regeneration, but many clearcuts on the Allegheny Plateau do not regenerate naturally. To give you an idea of the extent of this problem, we surveyed 65 different clearcuts made on the Allegheny National Forest during the early 1970's and found that only about half of them had regenerated satisfactorily.

Deer browsing by an extremely-large population of white-tailed deer is the major factor responsible for these failures. We have found that the presence of a dense understory of advance seedlings is extremely important to natural regeneration. If there is such an understory present, regeneration will be successful after clearcutting in spite of deer browsing.

Unfortunately, most of our Allegheny hardwood stands do not have these dense understories--again, the result of deer browsing. But some stands do contain fairly large numbers of small seedlings. If there are enough of them--about 40,000 per acre--these seedlings will form the basis of a new stand following clearcutting.

Shelterwood cutting offers an appropriate technique to increase the numbers of advance seedlings and therefore permit overstory removal in stands that do not have enough natural seedlings. But we had little experience with shelterwood cutting and did not know what residual densities, how many cuttings, or what intervals between cuttings were needed for best results. To find the answers to these questions, we began a series of studies to look at the environmental factors important in regeneration of Allegheny hardwoods.

EXPERIMENTAL METHODS

The amount of sunlight is one of the most important factors affecting regeneration, so we studied it in several ways. Shade cloth tents were constructed using eight different densities of shade cloth to create lighting conditions that range from nearly full sunlight to nearly full shade.

Inside of each of these shade cloth enclosures, we established seedlings in large plastic containers. And we attempted to keep all environmental factors other than light exposure as uniform as possible. For example, seedlings were irrigated using an automatic control system.

Seed of 12 different species of trees and understory plants were sown in the containers; then weekly observations were made of germination and survival over a 3 year period. Measurements of growth, including both stem and root size were also made over a 3 year period.

A similar attempt was made to study the effect of light exposure in a natural forest condition. In this case, we varied light exposure by cutting various percentages of the overstory trees. Some plots were located in an uncut stand where dense shade existed. In adjacent areas, several intermediate levels of shade were obtained by partial cutting. In one case 1/3 of the basal area was removed; in another treatment, 2/3 of the basal area was removed. And a fourth treatment involved clearcutting of all trees to obtain full sunlight.

As before, seeds of the 12 species were sown during the fall of the year, this time on square-foot seed spots inside a rodent proof cage.

Of course, cutting changes more than just light exposure, altering soil moisture, rate of nutrient decomposition and other factors as well. So we attempted to separate the effects of these other factors using supplementary treatments. Half of the plots in each of the four cutting blocks were irrigated so that they received twice the amount of normal rainfall. In this way we eliminated moisture stress as a factor on half of the plots.

We also attempted to separate the effects of soil competition from crown competition in several ways. On some plots we dug a meter-deep trench to cut the roots of any trees surrounding the plot so that they were no longer withdrawing moisture and nutrients from the soil. As a result, we reduced soil competition without affecting crown competition.

Shade cloth tents were used to do the same thing. In areas where we had cut 1/3 of the basal area, and therefore altered both sunlight and soil competition, we erected a shade cloth tent to bring light exposure back to the level it had been before cutting. The net effect was a change in soil competition as a result of cutting, but no change in light exposure.

Other treatments altered light exposure without affecting soil competition. Cables were attached to the top of trees surrounding some of the sample plots. Using a winch, we physically bent the trees away from the plot, creating a small patch of sunlight much like you would get in a partial cutting. However, in this case we hadn't actually removed any trees. We'd altered crown competition without affecting soil competition.

This same effect was obtained in another way using high intensity Gro-lux fluorescent tubes mounted on each side of some plots to increase light exposure without affecting soil competition.

Other treatments involved heating cables buried in the soil to raise the soil temperature without affecting either light or moisture. Still other plots were fertilized with a complete nitrogen, phosphorous, potassium, calcium fertilizer to provide a treatment in which nutrients were not limiting. And half of each plot was rototilled to provide a mineral soil seedbed in addition to the natural undisturbed seedbed.

In all of these studies, we've kept accurate records of environmental factors such as rainfall and temperature. We measured the amount of soil moisture at each plot, both at the surface and at various depths in the soil. Soil temperatures were likewise measured at the surface and at various depths in the soil. The amount of light exposure received on each plot was also measured; in some cases using a chemical technique, and in other cases with electronic instruments.

In other studies, we have also examined the effect of these same cutting treatments on the natural vegetation, without sowing any seed, or irrigating, or using any other unusual treatments. Instead, plots were established and individual seedlings marked; then all vegetation was tallied each year for six years so that we could observe the changes in natural vegetation resulting from the various cutting treatments.

Some of these other studies involve a wide range in residual stocking densities, from 30 percent up to 100 percent of normal density.

Seed traps were located in some of these stands to estimate the amount of seed produced under various conditions.

Individual trees were also marked and numbered so that we could observe the growth and quality development of the trees under the several residual densities.

And finally, the effects of competing plants such as understory fern and grass, were examined by a series of treatments including weeding of these plants on some plots. The possibility that these herbaceous plants release toxic biochemicals into the soil which interfere with seedling growth was also examined by preparing extracts from the leaves of these herbaceous plants and using the extracts to water black cherry seedlings.

RESULTS

The amount of sunlight received at the ground level increased as the amount of basal area removed in cutting increased, but the relationship is a curvilinear one. Light exposure does not increase markedly unless cutting is heavy. For example, to obtain 50 percent of full sunlight you must remove nearly 75 percent of the basal area.

Cutting also affected the quality or the color of the light under the various treatments. One major difference occurred in the far-red part of the spectrum, beyond 700 nanimeters. In the uncut stand, this far-red component was very high in comparison to the red component. This is not true in the clearcut or other open areas. This high far-red component has been found to affect seed germination and stem elongation of certain species.

Soil moisture was also altered dramatically by the various cutting treatments, with moisture levels in the clearcut remaining high throughout most of the growing season in contrast to the rather low levels of soil moisture observed in the uncut stands. The reason is that, in the uncut, large quantities of water are transpired back into the atmosphere, and the soil there dries out during the growing season. In the clearcut, there are no deep-rooted trees and so little moisture is lost from the soil.

However, there were very important differences with depth in the soil. Right at the surface, the clearcut is drier than the uncut stand because it is exposed to direct solar radiation. Below the top few centimeters, and throughout the rest of the rooting zone, the clearcut had higher moisture than the uncut. However, the top few centimeters of soil are very critical for seed germination and initial growth of seedlings.

Soil temperature is closely related to soil moisture. Surface soil temperatures in the uncut were quite moderate, but those in the clearcut were very high. We have measured temperatures as high as ~~600~~¹⁶⁰°F on many occasions. So the surface soil of the clearcut is very hot and dry--a difficult place for seed to germinate and seedlings to become established. Once they do get their roots down below the top few centimeters, the clearcut is a very favorable

The various species differed widely in germination, mortality, and growth under the environmental conditions tested.

Where moisture stress was eliminated by irrigation, seed of tolerant species like sugar maple, beech, and hemlock showed no response to light exposure. Germination was the same, regardless of whether the light was high or low. But where there was no irrigation (where they received normal moisture stress) there is a very definite response to light exposure. Germination was low in the clearcut where light exposure was high; and germination was high in the shade of the uncut stand. This is really an indirect response of light on soil moisture, and not to light exposure itself.

In contrast, red maple and yellow birch show a definite response to light exposure, even under irrigation. This low germination at low light and better germination at high light is the result of the red, far-red relationship discussed previously.

In all species, mortality was high at low light levels, whether irrigated or not. Light itself was the limiting factor in survival here. When plants were irrigated, best survival occurred in full sunlight. But where there was normal moisture stress, mortality was also high at the high light intensities. Again this is an indirect effect of light causing low soil moisture.

Notice also that high mortality at high light in the clearcuts lasts only for the first year. In later years, mortality was quite low in the clearcut because seedling roots had penetrated deep enough to get into the soil layers where moisture and temperature are much more favorable.

Looking at the 2-year responses of four species as a group (black cherry, sugar maple, red maple, and white ash) we found that germination was good--and about equal--in the uncut and the 1/3 cut. But germination decreased as the amount of cutting increased. Germination of all species was low in the clearcut.

Mortality, on the other hand, was very high in the uncut where light levels were low, and also high in the clearcut during the first year, where soil moisture at the surface was low. Mortality was lowest in the 1/3 cut. As the result of this high germination and low mortality, the number of seedlings surviving after 2 years was greatest in the 1/3 cut.

This advantage was quite significant after 5 to 6 years. On the natural seed spots, we found the number of desirable seedlings to have increased by 49,000 stems per acre compared to the uncut (Figure 8). This is more than enough to bring advance regeneration up to a level where it will easily meet requirements for clearcutting.

However, growth is not stimulated much by the 1/3 cutting; light exposure was not increased enough to permit rapid growth. So, 1/3 cutting may be useful to increase the numbers of seedlings, but we can't expect intolerant species to grow well or survive indefinitely under that light level.

The amount of light also had important effects on the relative size of roots and shoots. Intolerant species grown in the shade had comparatively small roots, and did not survive well when later exposed to full sunlight. But seedlings grown under partial cuts had larger roots and were better equipped to cope with the increased moisture stress when the overstory was removed.

These results suggest that a sequence of shelterwood cutting, with the first or seed cut that removes about 1/3 of the basal area to establish new seedlings, followed in a short period of time by complete removal of the overstory to release the established seedlings, should work well in the Allegheny hardwood type.

The studies of herbaceous plants have shown that this type of cutting favors the expansion of ferns, which interfere with normal seedling development by the release of toxic biochemicals into the soil. In just one year, weeded plots made several times the growth of unweeded plots.

Fern expansion is minimized by maintaining an overstory density of 70 percent or more, but they expand rapidly from shelterwood cutting to lower density--especially on wet soils. So in these areas shelterwood cutting must either be avoided or the ferns must be treated with herbicides prior to cutting. We've found that application of Round-up herbicide will provide nearly complete control of unwanted fern, grass, striped maple, and beech. Although desired seedlings are also killed, seed is not affected and new seedlings will be established following the seed cut, long before the undesirables--which spread largely by vegetative means.

Our standard shelterwood cutting prescription in Allegheny hardwoods stands that lack advance regeneration calls for a seed cut leaving 60 percent residual stocking in the largest, and most desirable seed producing trees in the stand. If fern, grass, striped maple, or beech threaten to interfere with seedling establishment, the understory is treated with an herbicide first. The seed cut allows large numbers of new seedlings to become established, but does not permit rapid growth. As soon as adequate number of seedlings are obtained, the removal cut provides full sunlight for rapid growth to get seedlings quickly above the reach of deer. This normally requires about 5 years, occasionally more.

Some general principles of shelterwood cutting can be illustrated on the basis of these Allegheny hardwood results if we express stand density as a percentage of the maximum basal area that one should expect to find in undisturbed stands of similar size and species composition.

Maximum numbers of new seedlings are established at about 60 percent of full stocking , high germination and low mortality under this degree of shade allows the numbers of seedlings to gradually increase over a period of years. At lower densities, the seedlings grow more rapidly, but fewer become established. At higher densities, germination may be good but mortality is high and few germinants survive more than a few years. If the purpose is to establish new seedlings, about 60 percent residual will produce best results in most forest types. There are exceptions however; for example, heavier cutting may be required in dry climates to make more soil moisture available; or heavier cutting might be required in cold climates to raise soil temperatures for adequate seed germination.

Seed production reaches a peak at about 60 percent of residual stocking . Removing some trees provides room for the crowns of the remaining trees to expand and therefore increases the seed production of those individual trees. However, thinning beyond about 60 percent reduces the total number of trees on the area to the point where total stand seed production begins to decline. So maximum seed production occurs at around 60 percent residual stocking. I would expect this relationship to hold true in most forest types.

Once established, almost all species will grow best in full sunlight, Shelterwood cutting is frequently used in stands that already contain adequate numbers of seedlings, to stimulate those seedlings to grow to larger size before the entire overstory is removed. Some species, such as the oaks, are not likely to maintain a prominent position in the next stand unless the seedlings are large at the time of final cutting.

Although most species grow best in full sunlight, comparative growth rates among species vary greatly with degree of shade. Tolerant species will often outgrow intolerants at stocking levels of 60 - 80 percent while intolerants generally outgrow the tolerants at lower densities. Thus, you can favor or discriminate against certain species of desired or unwanted plants by your choice of residual density and interval between seed and final harvest cuts.

In the Allegheny hardwood type, the pattern of height growth on black cherry would normally call for residual densities of less than 60 percent because of poor growth in shade. But this poor growth turns out to be an advantage, because incidence of deer browsing is much heavier on faster growing seedlings. Small, slow-growing seedlings are not browsed heavily beneath the shade of the 60% shelterwood canopy. But when the overstory is removed completely they respond immediately and grow quickly out of the reach of deer. White pine weevils attack shade-growing terminals much less severely than faster growing ones, and shelterwood cutting is very useful in white pine stands as a result. There are undoubtedly other examples of this kind.

Epicormic branching is also minimal at residual stocking levels above 60 percent. At lower densities, the number of epicormics increases rapidly.

Epicormics can cause serious loss in quality in hardwoods, so densities below 60 percent stocking may be a problem if the interval between seed cutting and final harvest is more than 10 years or so.

Although epicormics may not be a problem in many forest types, other factors such as windthrown and incidence of insects or diseases, can affect the density of residual stocking that will produce best results.

So, a two-cut shelterwood with a light seed cut followed by overstory removal as soon as seedlings are established fits the particular needs of Allegheny hardwoods quite well. Other forest types will require quite different shelterwood prescriptions.

Even within one type, several versions may be useful to serve different objectives. For example, in areas where esthetic uses are especially important, a three-cut shelterwood is useful. The seed cut is made to establish new seedlings as before, but the removal cut is spread over two entries.

The first removal cut opens the stand to a considerable extent, leaving only about 30 percent residual. This stimulates the established seedlings to rapid height growth, but retains the appearance of a forest stand. After the regeneration achieves a height of 10-15 feet, the final removal cut is made. Because a 10-15 foot-tall stand is already in place, the barren appearance of a clearcut or two-cut shelterwood is avoided, and logging debris, skid trails, and similar disturbance are pretty well hidden.

This effect is most pronounced when viewed in the foreground. From a distance, even a three-cut shelterwood appears as an opening, although the impact is reduced to some extent.

In summary, shelterwood cutting is a very flexible cutting method that can be used to achieve a variety of results. The number of cuts, their scheduling, the residual densities after each, and the use of supplementary cultural practices must be prescribed to meet the silvical requirements of the species to be regenerated, and ecological conditions of the forest type or locality.

SILVICULTURAL PRESCRIPTIONS IN THE NORTHERN REGION
WITH A SHELTERWOOD EXAMPLE

BY JACK H. USHER, JOHN R. NAUMANN, & WILLIAM R. BEAUFAIT

TIMBER MANAGEMENT
NORTHERN REGION
USDA FOREST SERVICE
MISSOULA, MONTANA

SEPTEMBER 17, 1979

A PAPER PREPARED FOR PRESENTATION AT THE NATIONAL SILVICULTURE WORKSHOP
IN CHARLESTON, SOUTH CAROLINA, SEPTEMBER 17-21, 1979

SILVICULTURAL PRESCRIPTIONS IN THE NORTHERN REGION
WITH A SHELTERWOOD EXAMPLE

BY JACK H. USHER, JOHN R. NAUMANN, WILLIAM R. BEAUFIT

INTRODUCTION

I NEED TO BEGIN MY PRESENTATION WITH THE STATEMENT THAT WE--MY FELLOW SPEAKERS AND MYSELF--HAVE TAKEN THE NORMAL STAFF OFFICER'S APPROACH TO OUR ASSIGNED TOPIC. THAT IS TO SAY, WE:

1. READ THE TOPIC AS DEFINED ON THE AGENDA FOR THIS MEETING;
2. DECIDED IT REALLY DIDN'T COVER ALL THE THINGS WE WANTED TO TALK ABOUT; AND
3. FORTHWITH, REVISED AND EXPANDED THE TOPIC TITLE TO ENCOMPASS THE SUBJECT MATTER WE WERE DETERMINED AND PREPARED TO COVER.

THEREFORE, YOU SHOULD BE INSTRUCTED TO CHANGE THE AGENDA TITLE TO READ: SILVICULTURAL PRESCRIPTIONS IN THE NORTHERN REGION--WITH A SHELTERWOOD EXAMPLE.

WE INTEND TO COVER OUR TOPIC WITH A THREE-WAY PRESENTATION USING A SORT OF "SANDWICH" APPROACH.

MY PRESENTATION--THE BOTTOM SLICE IN OUR "INFORMATION SANDWICH"--WILL SUMMARIZE THE BROAD POLICY STANDARDS THAT HAVE BEEN ESTABLISHED IN THE NORTHERN REGION TO GUIDE THE SILVICULTURAL PRESCRIPTION PROCESS. I WILL CONCLUDE MY REMARKS BY ILLUSTRATING HOW WE SEE THE PRESCRIPTION PROCESS AND THE PRESCRIPTION ITSELF RELATING TO THE INTERDISCIPLINARY ENVIRONMENTAL ASSESSMENT AND DECISIONMAKING PROCEDURES MANDATED BY

THE NEPA, RPA, AND NFMA LEGISLATION.

BOB NAUMANN WILL THEN PRESENT THE "MEAT" PORTION OF OUR SANDWICH BY EXPANDING UPON THE POLICY AND PROCESS FRAMEWORK I WILL PRESENT AND REVIEWING WITH YOU THE DEVELOPMENT OF AN EXAMPLE SHELTERWOOD PRESCRIPTION FOR A STAND IN THE NORTHERN REGION.

BILL WILL PUT THE TOP SLICE ON OUR INFORMATION SANDWICH IN HIS CONCLUDING PRESENTATION. HE WILL BRIEFLY DESCRIBE THE HISTORICAL PERSPECTIVE THAT LED TO THE DEVELOPMENT OF OUR CURRENT NORTHERN REGION SILVICULTURAL PRESCRIPTION PROCESS AND PRESENT A RESUMÉ OF THE QUALIFICATIONS WE BELIEVE PRESCRIBERS IN OUR REGION MUST HAVE.

NORTHERN REGION POLICY AND GUIDELINES FOR THE DEVELOPMENT OF SILVICULTURAL PRESCRIPTIONS. REGIONAL MANUAL SUPPLEMENTS TO FSM 2478 ESTABLISH THE POLICY GUIDANCE AND STANDARDS FOR THE PRESCRIPTION PROCESS AND FOR THE CONTENT OF THE RESULTING TREATMENT PRESCRIPTIONS. FOR PURPOSES OF BREVITY, I HAVE ELIMINATED MUCH OF THE SUPPLEMENTAL AND EXPLANATORY TEXT IN THE MANUAL AND CONDENSED THE FOLLOWING STATEMENTS TO THE ESSENTIAL POLICY GUIDANCE PROVIDED.

OBJECTIVES OF THE PRESCRIPTION PROCESS. TO PRESCRIBE, IN AN EFFICIENT MANNER, WHICH WILL PRODUCE RESULTS THAT:

1. ARE BASED ON SOUND ECOLOGICAL PRINCIPLES;
2. MEET THE LEGAL REQUIREMENTS OF NEPA, RPA, AND NFMA LEGISLATION AND REGULATIONS;
3. ARE IMPLEMENTED THROUGH TECHNICALLY CORRECT AND ECONOMICALLY FEASIBLE SILVICULTURAL PRACTICES;

4. ACCOMPLISH, OR WILL CONTRIBUTE TOWARDS ACCOMPLISHMENT OF, ESTABLISHED LAND MANAGEMENT OBJECTIVES.

NATURE OF PRESCRIPTIONS. SILVICULTURAL PRESCRIPTIONS WILL BE PREPARED FOR EACH IDENTIFIED STAND IN A TREATMENT AREA, WILL BE SITE SPECIFIC, AND WILL BE DOCUMENTED IN WRITING. SILVICULTURAL PRESCRIPTIONS ARE TO BE WRITTEN AS TECHNICAL AND SCIENTIFIC DOCUMENTS. THEY MAY REQUIRE FURTHER INTERPRETATION TO BE FULLY UNDERSTANDABLE TO LAY READERS.

R-1 PRESCRIPTION PROCESS. THE PRESCRIPTION PROCESS WILL CONSIST OF FIVE STEPS:

1. STAND EXAMINATION
2. DIAGNOSIS
3. DETAILED PRESCRIPTION DEVELOPMENT
4. IMPLEMENTATION
5. EVALUATION

THE FIRST THREE OF THESE STEPS ARE GUIDED BY MANUAL DIRECTION IN OUR REGIONAL SUPPLEMENT TO THE 2478 SECTION OF THE MANUAL. THE LAST TWO STEPS ARE ACTIONS WHICH CARRY THE PRESCRIBED TREATMENT TO THE GROUND AND MONITOR THE RESULTS OBTAINED. WE EXPECT OUR SILVICULTURISTS TO BE DIRECTLY RESPONSIBLE FOR STEPS 1 THROUGH 3 AND PERSONALLY INVOLVED IN STEPS 4 AND 5.

BOB NAUMANN, IN HIS FOLLOWING PRESENTATION, WILL BE DISCUSSING THE PRESCRIPTION PROCESS IN SOME DETAIL, SO I WILL CONFINE MY COVERAGE OF IT TO A BRIEF DEFINITION OF EACH OF THE STEPS INVOLVED.

1. STAND EXAMINATION. TIMBER STAND DATA TO BE GATHERED DURING THIS STEP AND THE SAMPLING DESIGN USED TO GATHER THE DATA DEPENDS, OF COURSE, ON THE NATURE OF THE STANDS INVOLVED AND THE COMPLEXITIES OF THE RESOURCE MANAGEMENT OBJECTIVES ESTABLISHED FOR THE LAND AREA WITHIN WHICH THE PRESCRIPTION STAND IS LOCATED. THIS STEP MUST PROVIDE THE QUANTITATIVE BASIS FOR PERFORMING THE DIAGNOSIS STEP. DATA GATHERING AND COMPILATION IS ALSO ONE OF THE MORE EXPENSIVE AND TIME-CONSUMING STEPS IN THE PRESCRIPTION PROCESS. FOR THESE REASONS, THIS STEP MUST NOT BE TAKEN LIGHTLY OR BECOME A MATTER OF ROUTINE PROCEDURE. IT REQUIRES CAREFUL DESIGN AND PRECISE AND EFFICIENT EXECUTION.

2. DIAGNOSIS. THIS STEP IS THE "GUTS" OF THE DECISIONMAKING PART OF THE PRESCRIPTION PROCESS. IN THIS STEP, THE "WHAT IF" QUESTIONS CONCERNING ALTERNATIVE TREATMENT POSSIBILITIES ARE ASKED, ANSWERED, AND THE RESULTS OF POSSIBLE ALTERNATIVE TREATMENTS ARE EVALUATED. THE FINAL PRODUCT OF THIS STEP IS SELECTION OF THE TREATMENT TO BE IMPLEMENTED.

3. DETAILED PRESCRIPTION DEVELOPMENT. A DETAILED TREATMENT PRESCRIPTION FOR THE CHOSEN ALTERNATIVE IS DEVELOPED. THIS STEP IS THE KEY TO ACCURATE IMPLEMENTATION OF THE PRESCRIBED TREATMENT ON THE GROUND. DETAILS OF THE RECOMMENDED TREATMENT AND PROJECTED RESULTS ARE REQUIRED TO BE OUTLINED IN QUANTIFIABLE STAND STRUCTURE TERMS. ENOUGH DETAIL AND DATA MUST BE PROVIDED TO SERVE AS A BASIS FOR THE PREPARATION OF MARKING GUIDES, TO GUIDE THE FIELD LAYOUT TO SERVE AS DIRECTIONS FOR ACCOMPLISHING THE TREATMENT, AND TO ALLOW FOR QUANTITATIVE MONITORING OF THE RESULTS OF TREATMENT.

c /

4. IMPLEMENTATION. IF THE PREVIOUS STEPS IN THE PRESCRIPTION PROCESS HAVE BEEN CAREFULLY DONE, PROPER IMPLEMENTATION SHOULD BE FACILITATED. THIS IS THE "PAYOFF" STEP IN THE PROCESS. THE BEST TREATMENT PRESCRIPTION IN THE WORLD, IF POORLY OR SLOPPILY EXECUTED, IS OF LITTLE WORTH. IT IS FOR THIS REASON WE EMPHASIZE TO OUR SILVICULTURISTS THAT, WHILE THEIR DIRECT PRESCRIPTION RESPONSIBILITIES END WITH THE PRODUCTION OF A DETAILED PRESCRIPTION, THEIR INVOLVEMENT IN THE MANAGEMENT PROCESS, MOST ASSUREDLY, MUST NOT STOP THERE. THEY MUST PERFORM THE PERSONAL FOLLOWUP THAT IS NECESSARY DURING THE IMPLEMENTATION PROCESS TO ASSURE THE DIRECTIONS PROVIDED IN THE PRESCRIPTION ARE UNDERSTOOD, THAT THEY ARE PROPERLY TRANSLATED BY THE MARKING CREWS, THE GROUND LAYOUT PEOPLE, AND THE CONTRACT ADMINISTRATORS.

5. EVALUATION. THIS IS THE MONITORING PROCESS REQUIRED IN NFMA. IT IS THE NECESSARY CONTROL PROCEDURE WHICH TRACKS THE PATH FROM MANAGEMENT OBJECTIVES AND DIRECTION IN THE LAND USE PLAN TO COMPLETED TREATMENTS IN THE WOODS, AND PROVIDES QUANTIFIABLE AND MEASURABLE ANSWERS TO THE FOLLOWING QUESTIONS:

A. HOW CLOSELY DID THE ACTUAL TREATMENT FOLLOW THE PLANNED TREATMENT?

B. ARE THE DIFFERENCES, IF ANY, SIGNIFICANT TO THE ACCOMPLISHMENT OF THE TARGETED MANAGEMENT OBJECTIVES?

C. WAS THE ORIGINAL PRESCRIPTION REALISTIC AND CAPABLE OF BEING IMPLEMENTED?

D. ARE THERE OPPORTUNITIES TO MAKE FUTURE PRESCRIPTION PROCESSES MORE COST AND TIME EFFICIENT?

RELATIONSHIPS BETWEEN THE PRESCRIPTION PROCESS AND THE INTERDISCIPLINARY ENVIRONMENTAL ASSESSMENT PROCEDURES MANDATED IN NEPA, RPA, AND NFMA.

IN REGION 1, WE SEE THE SILVICULTURAL TREATMENT PRESCRIPTION AND ITS DEVELOPMENT AS AN INTEGRAL PART OF THE DEVELOPMENT OF AN ENVIRONMENTAL ASSESSMENT. WE SEE THE SILVICULTURIST AS A KEY MEMBER OF THE ID TEAM WHENEVER FOREST VEGETATION IS TO BE MANIPULATED TO MANAGE RESOURCES.

FIGURES 1 THROUGH 2, WHICH FOLLOW, ILLUSTRATE HOW WE BELIEVE THESE TWO PROCESSES WILL BE INTEGRATED IN OUR REGION.

FIGURE 1 - SHOWS HOW WE BELIEVE THE SILVICULTURAL PRESCRIPTION PROCESS INTEGRATES WITH THE ENVIRONMENTAL ASSESSMENT PROCESS.

FIGURE 2 - THIS FINAL FIGURE SUMMARIZES THE NORTHERN REGION'S APPROACH TO THE DEVELOPMENT AND IMPLEMENTATION OF THE SILVICULTURAL PRESCRIPTION PROCESS.

THIS CONCLUDES MY PART OF OUR PRESENTATION. I WOULD PREFER YOU HOLD ANY QUESTIONS YOU MIGHT HAVE CONCERNING WHAT I HAVE PRESENTED UNTIL THE CONCLUSION OF OUR JOINT PRESENTATION. IT'S LIKELY THAT EITHER BOB'S OR BILL'S PRESENTATIONS WILL ANSWER MOST OF THE QUESTIONS YOU HAVE. IF NOT, I WILL BE PLEASED TO ANSWER SUCH QUESTIONS AT THE END OF OUR JOINT PRESENTATION.

NOW, BOB NAUMANN WILL GIVE YOU THE "MEAT" SLICE OF OUR INFORMATION SANDWICH.

FIGURE 1

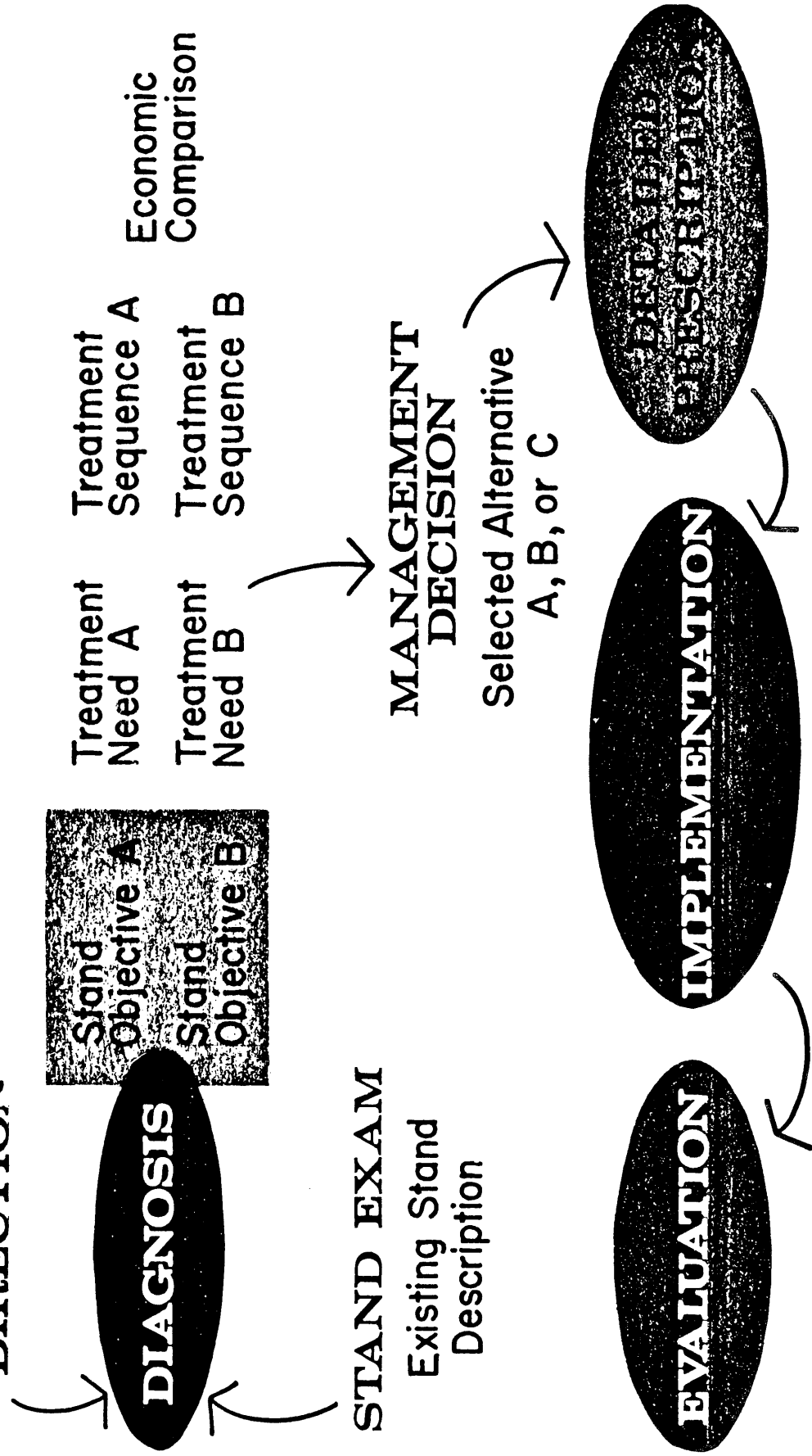
ENVIRONMENTAL ASSESSMENT & SILVICULTURAL PRESCRIPTIONS

NEPA		SILVICULTURAL PRESCRIPTION
1.	ENVIRONMENTAL ASSESSMENT AND DECISION PROCESS	(NO DIRECTLY RELATED PRESCRIPTION STEP)
	A. IDENTIFY ISSUES, CONCERNS AND DECISION NEEDS	
	B. SELECT CRITERIA	1. STAND EXAMINATION
	C. GATHER RELATED INFORMATION	
	D. FORMULATE ALTERNATIVES	
	E. ANALYZE EFFECTS	2. DIAGNOSIS
	F. EVALUATE ALTERNATIVES	
	G. IDENTIFY PREFERRED ALTERNATIVES	
2.	DOCUMENTATION	3. DETAILED PRESCRIPTION
3.	ESTABLISH DECISION DATE	
4.	IMPLEMENTATION, MONITORING AND CONTROL	4. IMPLEMENTATION 5. EVALUATION

FIGURE 2

2 LAND MANAGEMENT DIRECTION

R-1 Silvicultural Prescription Process



DETAILS & EXAMPLES OF THE PRESCRIPTION PROCESS

ALIGNING THE PRESCRIPTION WITH THE NEPA PROCESS EMPHASIZES THAT EACH PRESCRIPTION STEP MUST SERVE A PARTICULAR PURPOSE. THE STEPS IN THE PRESCRIPTION PROCESS OF STAND EXAMINATION, DIAGNOSIS, DETAILED PRESCRIPTION DEVELOPMENT, IMPLEMENTATION, AND EVALUATION EACH HAVE A DEFINITE FUNCTION IN BOTH THE ENVIRONMENTAL ASSESSMENT AND THE PRESCRIPTION. I WOULD LIKE TO DESCRIBE THE DETAILS OF A PRESCRIPTION PROCESS TO YOU WITH SOME ILLUSTRATIONS OF THE PROCESS TAKEN FROM A SHELTERWOOD EXAMPLE.

IT IS AWKWARD TO BEGIN BY KNOWING THAT WE ARE GOING TO PRESCRIBE A SHELTERWOOD. THIS CONSTRAINT PLACES US IN THE MIDDLE OF THE PRESCRIPTION TASK. TO KNOW THAT A STAND SHOULD RECEIVE A SHELTERWOOD ASSUMES THE STAND SHOULD BE HARVESTED AND REGENERATED TO AN EVEN-AGED STRUCTURE. THIS FURTHER ASSUMES THE PRESENT STAND IS NO LONGER ACCEPTABLE, WHICH SUGGESTS WE HAVE SOME IDEA OF WHAT TYPE OF STAND IS ACCEPTABLE. THE PRESCRIPTION PROCESS I WILL DESCRIBE IS DESIGNED TO OPERATE ON THIS TYPE OF THOUGHT PROCESS. RATHER THAN STARTING WITH THE SILVICULTURAL SOLUTION, IT BEGINS WITH SOME STAND DATA AND SOME LAND MANAGEMENT DIRECTION. AND IT ALLOWS THE CHOICE OF A SHELTERWOOD IF THAT TURNS OUT TO BE ONE OF THE TREATMENT NEEDS.

STAND EXAMINATION IS AN IMPORTANT FIRST STEP IN ANY PRESCRIPTION PROCESS. TO BE FACTUAL AND EFFECTIVE, THE PRESCRIPTION MUST BE BASED ON STAND DATA. (SAMPLE DESIGN AND TREE MEASUREMENT IS ANOTHER SUBJECT THAT DESERVES MORE DISCUSSION AT ANOTHER WORKSHOP.)

THE KINDS OF DATA COLLECTED AND ITS RELIABILITY SHOULD BE INFLUENCED BY

THE IMPORTANCE OF RESOURCES TO BE MANAGED. BUT MOST PRESCRIPTIONS CAN BE PREPARED ON THE BASIS OF THE MOST COMMONLY MEASURED STAND ATTRIBUTES, SUCH AS STAND DENSITY, COMPOSITION, SIZE, AND AGE CLASS STRUCTURES AND ON THE BASIS OF STAND HISTORY AND SUCCESSIONAL TREND.

THE DIAGNOSIS STEP, TAILORED TO THE NEPA PROCESS, MAY REPRESENT A DIFFERENT WAY OF USING STAND DATA TO DEVELOP A SILVICULTURAL PRESCRIPTION. THE DIAGNOSIS STEP IN THIS PROCESS MUST RESULT IN ONE OR MORE ALTERNATIVE TREATMENT NEEDS. THE DIAGNOSIS IS ACCOMPLISHED BY ADDRESSING THREE QUESTIONS ON STAND DATA. THESE ARE:

1. CAN THE PRESENT STAND SATISFY THE REQUIREMENTS OF THE LAND MANAGEMENT OBJECTIVE?
2. HOW CAN THE PRESENT STAND BE TREATED TO DEVELOP A CONDITION THAT WILL BETTER SATISFY MANAGEMENT DIRECTION?
3. IF THE PRESENT STAND CANNOT BE TREATED TO MEET MANAGEMENT NEEDS, HOW AND WHEN CAN IT BE HARVESTED AND REPLACED WITH A MORE DESIRABLE STAND?

TO ANSWER THESE QUESTIONS, THE SILVICULTURIST MUST BE ABLE TO VISUALIZE AND DESCRIBE ONE OR MORE OPTIMUM STANDS WHICH CAN BEST MEET THE NEEDS OF THE RESOURCES TO BE MANAGED. COMPARISON OF THE PRESENT STAND WITH THESE OPTIMUM STAND OBJECTIVES SHOULD SUGGEST TREATMENT NEEDS. **(FIGURE 3)** THIS KIND OF DIAGNOSIS SIMPLY ASKS: "WHAT KIND OF STAND WOULD WE LIKE TO BE MANAGING ON THIS SITE TO SATISFY THE ALLOCATED RESOURCES, AND HOW DO WE INITIATE A CHANGE?" THE PROCESS ENCOURAGES LOOKING AHEAD RATHER THAN DERIVING A TREATMENT BASED ONLY ON THE NATURE OF THE EXISTING STAND.

SILVICULTURISTS ALONE CAN OFTEN DESCRIBE OPTIMUM STAND CONDITIONS THAT WILL SATISFY BEST TIMBER VOLUME GROWTH ON A SITE. A LAND ALLOCATION FOR

FIGURE 3
DIAGNOSIS - Treatment Need

	CHARACTER	STRUCTURE	STOCKING	COMPOSITION	TREATMENT NEED
OPTION ONE	Continuous tree cover	Even - aged 1 or 2 stories	BA = 120 - 150 ft. ² in sawlog - size trees	Maximum species diversity w/ tolerant & intolerant	Regenerate w/ shelter - wood
OPTION TWO	Alternate forest & opening w/ grass & forb stage	Even - aged single story	Full stocking not to exceed 120 ft ² BA	Only seral fast growing species	Regenerate w/ clearcut
PRESENT STAND	Old growth Stand with no openings	Uneven - aged overstory with scatter- ed understory groups	85 ft ² BA/A in sawlog component	Mostly DF and LPP w/ some AF L, S, & PP	

MULTIPLE RESOURCES, HOWEVER, OFFERS AN EXCELLENT OPPORTUNITY FOR THE SILVICULTURIST TO INTERACT WITH OTHER DISCIPLINES IN DESCRIBING STAND CONDITIONS OPTIMUM FOR ALL RESOURCES. SOMETIMES THE SILVICULTURIST CAN REFER TO PUBLISHED GUIDES FROM OTHER RESOURCE AREAS. BUT MORE FREQUENTLY, THE SILVICULTURIST MUST TALK WITH OTHER RESOURCE SPECIALISTS AND WORK OUT ALTERNATIVE STAND OBJECTIVES ON A SITE-BY-SITE BASIS.

THE SILVICULTURIST HAS A LEADERSHIP ROLE IN THIS KIND OF INTERACTION. THE END RESULT WILL BE A TREATMENT APPLIED TO A SPECIFIC AREA. THE EFFECTIVENESS OF THAT TREATMENT IN MANAGING ALL ALLOCATED RESOURCES DEPENDS ON BEING SITE AND STAND SPECIFIC IN THE DIAGNOSIS STEP.

FOR EXAMPLE:

1. THE LANDSCAPE ARCHITECT WHO PRESSES FOR SPECIES DIVERSITY IN A CRITICAL VIEWING AREA IS LEAD BY THE SILVICULTURIST TO NAME SPECIES COMPOSITIONS COMPATIBLE WITH THE ECOLOGY OF THE SITE.
2. THE WILDLIFE BIOLOGIST CONCERNED WITH THERMAL COVER IS HELPED TO SPECIFY ATTAINABLE TREE SIZES AND DENSITIES THAT WILL SATISFY THIS IMPORTANT ASPECT OF WILDLIFE HABITAT.

DESCRIPTION OF STAND OBJECTIVES SHOULD BE DONE BY CRITICAL STAND ATTRIBUTES SUCH AS SPECIES COMPOSITION, DENSITY, AND STAND STRUCTURE. COMPARISON WITH THE PRESENT STAND CAN PROVIDE A SOLID JUSTIFICATION FOR THE TREATMENT NEED.

ONE MORE ITEM IS REQUIRED TO COMPLETE THE DIAGNOSIS. THE SILVICULTURIST MUST IDENTIFY A LOGICAL SEQUENCE OF STEPS THAT WOULD FOLLOW IMPLEMENTATION OF EACH TREATMENT NEED AND WOULD CARRY THE RESULTING STAND THROUGH

THE NEXT REGENERATION PERIOD. THIS SEQUENCE IS NOT INTENDED TO BE DIRECTIVE OF WHAT WILL HAPPEN. IT SHOULD BE DESCRIPTIVE OF WHAT LIKELY COULD HAPPEN. (FIGURE 4)

A PROBABLE TREATMENT SEQUENCE MUST BE IDENTIFIED FOR TWO REASONS. FIRST, IT CONFIRMS THE VALIDITY OF THE IDENTIFIED TREATMENT NEED. IT ASSURES THAT THE DIRECTION SET BY THE TREATMENT NEED HAS AN ACCEPTABLE CONCLUSION. SECONDLY, THE IDENTIFICATION OF A LOGICAL TREATMENT SEQUENCE PROVIDES THE BASIC INFORMATION NEEDED TO COMPLET AN ECONOMIC ANALYSIS.

WHEN THE PRESCRIPTION IS PREPARED AS PART OF AN ENVIRONMENTAL ASSESSMENT, AN ECOMONIC ANALYSIS WILL BE PREPARED FOR THE PROJECT AS A WHOLE. THE INFORMATION DEVELOPED IN THE DIAGNOSIS GIVES SILVICULTURAL INPUT TO THE ECONOMIC ANALYSIS SECTION OF THE ENVIRONMENTAL ASSESSMENT.

WITH COMPLETION OF THE DIAGNOSIS STEP, THE PRESCRIPTION PROCESS HAS REACHED A CHECKPOINT. A SELECTION OF ONE OF THE ALTERNATIVES MUST OCCUR BEFORE THE SILVICULTURIST CONTINUES THE PROCESS. WHEN THE LAND MANAGER SELECTS A PREFERRED ALTERNATIVE IN STEP 16 OF THE NEPA PROCESS, HE ALSO IDENTIFIES A PREFERRED TREATMENT NEED. THE SILVICULTURIST CAN THEN CONTINUE THE PRESCRIPTION PROCESS BY PREPARING A DETAILED PRESCRIPTION FOR THE PREFERRED TREATMENT NEED. THIS APPROACH ENCOURAGES EFFICIENT USE OF THE SILVICULTURIST'S TIME. HE DEVOTES CONCENTRATED EFFORT ONLY TO THOSE PROJECTS WHICH WILL LIKELY FOLLOW THROUGH TO COMPLETION. HIS FOCUS IN ONLY ON THE SELECTED ALTERNATIVE.

THE DETAILED PRESCRIPTION IS THE KEY TO SUCCESSFUL IMPLEMENTATION OF THE TREATMENT. IT WILL BE THE DOCUMENT PEOPLE TAKE TO THE FIELD. IT MUST

FIGURE 4.

DIAGNOSIS

TREATMENT SEQUENCE

TREATMENT SEQUENCE		DIAGNOSIS
OPTION ONE: REGENERATE W/SHELTERWOOD		OPTION TWO: REGENERATE W/CLEARCUT
YEAR 1.	SHELTERWOOD SEED CUT @ 8M/A	YEAR 1. CLEARCUT @ 13M/A
2.	DOZER SCARIFY & HANDPLANT 200 T/A	2. BROADCAST BURN & HANDPLANT 500 T/A
10.	OVERWOOD REMOVAL @ 5M/A	10. THIN
60.	THIN @ 4M/A	60. THIN @ 6M/A
120.	SHELTERWOOD @ 10M/A DOZER SCARIFY & HANDPLANT 200 T/A	120. CLEARCUT @ 13M/A BURN AND PLANT 500 T/A
130.	OVERWOOD REMOVAL @ 5M/A	

THEREFORE BE CONCISE AND EASILY UNDERSTOOD. THE DETAILED PRESCRIPTION WILL LIST ACTION STEPS TO BE TAKEN FOR THE NEXT ENTRY IN THE STAND. THE TIMING OF EACH STEP WILL BE RECORDED. SPECIFICATIONS FOR EACH ACTION WILL BE STATED IN ENOUGH DETAIL TO INSURE IMPLEMENTATION CAN MEET THE INTENT OF THE INTENT OF THE PRESCRIPTION. (FIGURE 5)

IF SPECIFICATIONS IN THE DETAILED PRESCRIPTION ARE CLEAR AND COMPLETE, THE SILVICULTURIST HAS GONE A LONG WAY TOWARDS INSURING THE TREATMENT WILL BE SUCCESSFULLY IMPLEMENTED IN THE WOODS. HERE ARE SOME ACTIVITIES TO HELP WITH IMPLEMENTATION:

1. PAPER LAYOUT TO CHECK FOR COMPATIBILITY WITH OTHER RESOURCES, TRANSPORTATION AND LOGGING SYSTEMS.
2. WRITTEN MARKING GUIDES.
3. TRAINING TREE MARKERS.
4. PARTICIPATION IN SELECTION OF CONTRACT CLAUSES.
5. ON-SITE CONSULTATION WITH CONTRACT ADMINISTRATORS AND CREW FOREMEN.

FREQUENTLY, CHANGES MUST BE MADE AS A PROJECT IS LAID OUT ON THE GROUND. CHANGES SHOULD BE ACCOUNTED FOR IN THE IMPLEMENTATION STEP. IT IS HERE THAT A WELL-DEFINED PROCESS HELPS IN CARRYING THROUGH WITH THE ORIGINAL INTENT OF THE PROJECT.

THE SILVICULTURIST MUST PARTICIPATE IN CHANGES AS THEY OCCUR TO DETERMINE IF THEY WILL ALTER THE TREATMENT NEED OR DEVELOP A STAND THAT IS SIGNIFICANTLY DIFFERENT FROM THE STAND OBJECTIVE DEFINED IN THE DIAGNOSIS STEP. THE SILVICULTURIST MAY ELECT TO REENTER THE PRESCRIPTION PROCESS AT THE

FIGURE 5.

DETAILED PRESCRIPTION

ACTION	TIMING	SPECIFICATIONS
MARK SHELTERWOOD	1980	LEAVE 40 WELL - SPACED LARGE CROWN TREES/A FAVOR DF, L, PP, FREE OF INSECTS AND DISEASE.
CUT	BY 1981	
PREPARE SITE	1981	DOZER PILE AND BURN. DISTURBANCE SHOULD PROVIDE MINERAL SOIL PLANTING SPOT ON 12 x 12 SPACING.
HAND PLANT	1982	SPRING PLANT 200 2 - 0 PP/A TO ALLOW NATURAL FILL-IN OF L, LP, DF, & AF.
FIRST YEAR EXAM	1983	MINIMUM ACCEPTABLE STOCKING 160 PP/A.
THIRD YEAR EXAM	1985	MINIMUM ACCEPTABLE STOCKING 400 T/A MIXED SPECIES.

POINT OF CHANGE AND DEVELOP AN AMENDED PRESCRIPTION.

CHANGES SHOULD BE DOCUMENTED ON THE DETAILED PRESCRIPTION.

IDENTIFICATION OF A PRESCRIPTION PROCESS ALLOWS EVALUATION OF ALL, OR PART, OF THE PRESCRIPTION. EVALUATIONS SHOULD BE MADE WITH REFERENCE TO EXPECTATIONS RATHER THAN WITH RESPECT TO THE OUTCOME ALONE. IT IS THUS IMPORTANT TO IDENTIFY AN EXPECTED STAND OBJECTIVE TIED TO LAND MANAGEMENT OBJECTIVES. AND IT IS IMPORTANT TO DOCUMENT THE DETAILED PRESCRIPTION AND RECORD CHANGES AS THEY ARE IMPLEMENTED. WITHOUT A RECORD OF THE ENTIRE PRESCRIPTION PROCESS, THE EVALUATION LOSES MUCH OF ITS POTENTIAL EFFECTIVENESS. THE EVALUATION ITSELF MUST BE DOCUMENTED IF IT IS TO SERVE AS A LEARNING MECHANISM.

SILVICULTURISTS CAN INCREASE THEIR CREDIBILITY BY DEFINING THE PROCESS THEY WILL USE TO PREPARE A SILVICULTURAL PRESCRIPTION. ONCE THAT PROCESS HAS BEEN DEFINED, THE SILVICULTURIST SHOULD STICK WITH ITS INTENT. COMPROMISES WHICH MUST BE MADE BECAUSE OF LIMITATIONS OF FUNDING OR TIME SHOULD BE MADE AT THE SACRIFICE OF DETAIL, AND NOT BY ELIMINATING PROCESS STEPS. DEFINITION OF STEPS IN THE PRESCRIPTION TASK ALLOWS THE PRESCRIPTION TO BE MORE EASILY TIED TO OTHER PROCESSES, NOTABLY THE ENVIRONMENTAL ASSESSMENT. THE PRESCRIPTION PROCESS CAN HELP TO DESIGN AND APPLY THE BEST POSSIBLE TREATMENT TO MANAGE ONE OR SEVERAL RESOURCES ON A GIVEN SITE.

SUMMARY & CONCLUSIONS

THE MONONGAHELA, BITTERROOT AND WYOMING ISSUES HERALDED A NEW PUBLIC SCRUTINY OF SILVICULTURAL PRACTICES ON NATIONAL FORESTS. THE FOREST SERVICE AND OTHER PUBLIC LAND MANAGERS RESPONDED POSITIVELY WITH A SERIES OF INTERNAL STUDIES, ACTION PLANS AND AGENCY DIRECTIVES. THE 2478 SECTION OF THE FOREST SERVICE MANUAL IS ^{fairly} REPRESENTATIVE OF THESE DIRECTIVES WHEN IT REQUIRES SILVICULTURAL PRESCRIPTIONS BE WRITTEN BY FULLY QUALIFIED PROFESSIONALS. AS YOU KNOW, THE NATIONAL FOREST MANAGEMENT ACT AND ITS REGULATIONS USE SIMILAR LANGUAGE.

YOU HAVE SEEN HOW WE IN THE NORTHERN REGION HAVE RESPONDED TO THIS DIRECTION. NOW, I'LL TRY TO PUT OUR RESPONSES IN SOME HISTORICAL PERSPECTIVE, UNDERLINE ONE OR TWO POINTS, AND DESCRIBE WHY WE HAVE TRAINED OVER 200 FORESTERS TO QUALIFY AS MASTER LEVEL SILVICULTURISTS TO WRITE AND REVIEW THESE PRESCRIPTIONS.

WE BEGAN IN 1973 WITH A REGIONAL MANUAL SUPPLEMENT WHICH OUTLINED THE COMPONENTS FOR A SILVICULTURAL PRESCRIPTION. (SEE FIGURE 6.) AS WE CHANGED FROM A CHECKLIST TO A PROCESS CONSISTENT WITH ENVIRONMENTAL ASSESSMENTS, WE HAD TO BE CERTAIN THAT ALL OF THE STEPPING STONES REMAINED. THE TWO PARTS WHICH WORRY ME MOST ARE THE SITE DATA (ITEM 2) AND THE ECONOMIC COMPARISON (ITEM 6).

WE MUST BE ASSURED THAT THEY BE PREPARED TO A STANDARD THAT WILL STAND CRITICAL REVIEW. WE ARE WORKING WITH OUR

A Change from Outline to Process

OLD OUTLINE
FOR PRESCRIPTION

1. OBJECTIVES

Management Direction
Silvicultural Objectives

2. SITE DATA

Landform
Soils
Ecology
Productivity

3. STAND DATA

Species Composition
Structure
History
Growth
Fuels

4. TREATMENT

5. LONG TERM PRESCRIPTION

6. ECONOMIC COMPARISON

7. ALTERNATIVES

**STAND
EXAMINATION**

**DETAILED
PRESCRIPTION**

IMPLEMENTATION

EVALUATION

DIAGNOSIS

FIGURE 6

REGIONAL ECONOMIST TO TRAIN ALL EAR WRITERS TO REDUCE ALL COSTS AND BENEFITS OF ROTATION-LONG TREATMENTS TO STANDARDIZED ECONOMIC TERMS. NON-COMMODITY RESOURCES, SUCH AS WILDLIFE OR SOILS PROTECTION, WILL BE REPRESENTED AS OPPORTUNITY COSTS IN THE THREE ANALYSES LISTED IN FIGURE 7. ALL NUMBERS MUST BE DISCOUNTED TO THE PRESENT.

SITE DATA MUST BE COMPLETE ENOUGH TO BE DEFENSIBLE BY PERSONS OTHER THAN THOSE WHO PREPARED THE EAR OR THE PRESCRIPTION. WE REQUIRE SITE DATA, AS AN INTEGRAL PART OF THE TECHNICAL JUSTIFICATION FOR TREATMENT, TO BE PRESENTED IN THE DOCUMENTATION SECTION OF OUR SILVICULTURAL PRESCRIPTIONS (SEE REGION ONE PRESCRIPTION STANDARDS IN APPENDIX).

OUR WEAKEST SUBJECT IS SITE PRODUCTIVITY IN THE NORTHERN REGION. SITE CAPABILITY FOR TIMBER RESOURCES HAS NOT HAD THE SCIENTIFIC STUDY ITS HAD IN THE EAST. EXTREME CARE MUST BE TAKEN TO REPRESENT THE SITE FAIRLY. THIS IS RARELY POSSIBLE WHEN EXISTING TREES ARE USED FOR MEASUREMENTS OF SITE INDEX. THEREFORE, A HIGH PRIORITY FOR RESEARCH IN OUR REGION IS QUANTIFICATION OF PRODUCTIVE CAPABILITY FOR ALL RESOURCES, INCLUDING TIMBER. ITS THE MOST DIFFICULT JOB IN THE FOREST SERVICE.

FIRST, YOU MUST GET COMMITMENT FROM WILDLIFE BIOLOGISTS, WATERSHED MANAGERS AND LANDSCAPE ARCHITECTS TO DEFINE THEIR OBJECTIVES, QUANTITATIVELY. THEN, YOU MUST INCORPORATE THESE VARIABLES INTO AN EQUATION COMPATIBLE AND CONSISTENT WITH THE NATURAL HISTORY OF THE REGION. FINALLY, ITS NECESSARY TO BUILD THESE INTO A SOUND ASSESSMENT OF BIOMASS POTENTIAL.

IN OTHER WORDS, PUT SOIL AND CLIMATE TOGETHER TO GET A SCIENTIFICALLY DEFENSIBLE MEASURE OF PRODUCTIVITY. WITH THIS, WE CAN GO TO COURT!

ECONOMIC ANALYSIS

STANDARDS

1. PRESENT NET VALUE
2. INTERNAL RATE OF RETURN
3. BENEFIT / COST

PERHAPS YOU NOW SEE WHY ITS BEEN NECESSARY TO PREPARE SILVICULTURISTS TO INTERACT AND COMMUNICATE FULLY, IN THEIR OWN TERMINOLOGY, WITH OTHER SPECIALISTS IN THE FOREST SERVICE AND THE SCIENTIFIC COMMUNITY.

WHERE ELSE WILL LEADERSHIP IN VEGETATION MANAGEMENT COME FROM? ONLY FROM THOSE WITH BROAD AND SOUND ECOLOGICAL BACKGROUND.

BOTH THEORY AND EXPERIENCE ARE REQUIRED OF SILVICULTURISTS CERTIFIED BY NORTHERN REGION STANDARDS. THEY BRING MASTER LEVEL QUALIFICATIONS TO THE PRESCRIPTION PROCESS WE'VE DESCRIBED. WE SIMPLY CAN'T AFFORD LESS.

INSECT AND DISEASE COORDINATION

IN FOREST MANAGEMENT^{1/}

by

Robert C. Loomis, Field Representative
Southeastern Area, Forest Insect & Disease Management

Workshops such as this provide an opportunity to review and reflect on issues concerning different aspects of our work. I suppose the inherent hope of these workshops is to provide a forum to share information, some of which may eventually be applied to the work at our home stations.

My topic, Insect and Disease Coordination in Forest Management, is aimed at doing just that. It's a review of some established concepts with which you are familiar, as well as pointing out some new wrinkles in implementing I&D management principles in forest management procedures.

I&D Loss

Although poorly measured, insects and diseases cause considerable damage to the nation's forests. One estimate suggested that a variety of causes, including insects and diseases, killed 4.5 billion ft³ growing stock nationwide in 1970. Less than 10 percent of this mortality was salvaged.^{2/} In the South, the estimated annual mortality is 1.1 billion ft³ from all causes. This represents about 10 percent of the net annual

^{1/} Presented to 1979 National Silviculture Workshop, Charleston, South Carolina, September 17, 1979.

^{2/} The Outlook for Timber in the United States. U.S. Dept. of Agriculture, Forest Serv., Forest Resource Report No. 20, Oct. 1973. 367 pp.

growth of growing stock, or about 17 percent of the yearly harvest.^{3/} About one-fifth of this mortality is attributed to insects and diseases, and about half is attributed to unknown causes.^{4/} A substantial part of this mortality from unknown causes is probably due to unrecognized insect and disease pests.

In addition to mortality, insects and diseases cause other significant, but largely unmeasured, losses. These include reduced growth, quality, and seed production; lost time in stand establishment; and serious interruptions to achieving planned forest production goals.

I think we'd agree, then, that insects and diseases do considerable damage. The next questions, then, are what's to be done, what process will be used, and who will do it?

Prevention Versus Suppression

The goal of pest management is to reduce insect and disease losses to acceptable levels. The strategy for achieving this goal must include taking advantage of routine forest management and silvicultural practices to make forest stands less favorable for insect and disease growth, thereby preventing damaging outbreaks. Conversely, practices that encourage pest outbreak should be identified and avoided. Some common procedures for reducing stand susceptibility include:

^{3/} Forest statistics of the U.S., 1977. USDA Forest Serv., 1978. 133 pp.

^{4/} These statistics are derived from USFS Forest Survey Reports for the 13 States in Region 8.

- regulating stand density and species composition
- matching site and species
- harvesting at maturity
- using resistant stock or resistant species on hazard sites
- adjusting timing of operations
- salvaging dead and weakened trees
- enforcing standards pertaining to logging damage
- using chemical or biological prevention techniques

With prevention, emphasis is placed on the planned actions taken to lessen the forest's susceptibility to outbreak. This planned approach, done as part of the normal work activity, contrasts with the hectic, crisis atmosphere usually associated with direct suppression. Suppression projects are the result of crisis situations. They interrupt planned activities and, at best, only address the biological result of more basic pest-host relationships.

Pest outbreaks don't just happen! They are a result of basic site-stand conditions that favor an outbreak. If these basic conditions are not changed, then reoccurring outbreaks can be expected. It seems somewhat shortsighted, then, to constantly depend on suppression projects without paying any attention to the underlying causes of the outbreak.

The concept of integrated pest management embodies the preventive approach. This concept implies

- that we have some understanding of pest-host relationships
- that implementation is part of forest management
- that regulatory strategies are based on sound silvicultural practices and on the ecology of the pest-host system

- that combination of tactics are employed which include meshing manipulative practices with selected use of pesticides
- that the strategy is ecologically acceptable

Thus, forest managers are faced with the proposition that forest pest management can only be accomplished as part of the forest management process. Since forest management is a planned, longrange activity, it's essential that pest management considerations be included in each National Forest's resource management plans. In plain terms, we all need to do a better job of evaluating and addressing forest pest considerations in Region and Forest management plans right down through the action-oriented compartment prescription.

It appears to me that 1979, 1980, and 1981 is an excellent period in which to actually do just that. We are all struggling to figure out how to implement the management direction imposed by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA), and its ammendment, the National Forest Management Act of 1976 (NFMA). Since a revised planning approach is being developed and implemented right now, what better time to make forest pest management part of the forest management process. What better time to switch from the crisis mode of direct suppression to the more planned, organized, and effective mode of prevention.

NFMA Implications

The NFMA gives direction to Forest Service planning procedures. Implementation of this direction will probably vary from Region to Region and among Forests within Regions. Nontheless, there are some

requirements relating to forest pest management which will need to be addressed. Let's take a look at some of these.

First of all, NFMA requires an integrated plan for each National Forest administrative unit. This plan will be developed by an interdisciplinary team assisted as needed by technical specialists. The interdisciplinary team is directed "to identify and evaluate public issues, management concerns, and resource use and development opportunities." Sixteen management concerns are specifically listed which should be considered in any region or forest plan, along with others identified by the interdisciplinary team. One of these is to "Protect resources from disease, pests, and similar threats."

In the Purpose Section (219.1), 12 broad principles are stated which are supposed to be the guiding light for all Forest Service resource planning. One of these is to "Protect all forest and range-land resources from depredations by forest pests, using ecologically compatible means."

In the Management and Standards Section (219.13), direction is given with regard to management practices. Plainly stated, all management practices will

- "prevent or reduce serious, longlasting hazards from pest organisms under the principles of integrated pest management"
- "be monitored and evaluated as required to assures that practices..... reduce hazards from insects, disease, weed species and fire."

Other direction given in this section includes specific mention of requirements for timber harvest and cultural treatments. I&D-related provisions state that

- "Timber shall not be harvested where such treatment would favor an abnormal increase in injurious insect and disease organisms."
- "Monitoring will insure as a minimum that destructive insects and disease organisms do not increase following management activities."

This monitoring requirement is quite specific in that the management plan will include provisions for monitoring and evaluation. The monitoring plan will describe

- What will be measured and how often
- Expected precision and reliability
- When evaluation will be reported
- Quantitative estimate of performance

So far, I've touched on what's to be done and what process will be used. The final question is, who will do it? It's clear that integrated pest management will take the collective talents of several disciplines. I've mentioned how forest planners, silviculturists, and sales administrators must be involved. The compartment prescriptionists have an especially important role in that they actually distill all the previous planning effort into specific directions for implementation. Finally, a key input to this whole process, which is usually forgotten about during the press of everyday business, is that from the Forest's

Insect and Disease Management Staff.

FI&DM Staff

Each Region, Forest, and District has a staff of entomologists, pathologists, and related specialists on call to help with particular pest problems and to help implement National Forest Management Act requirements. This staff has responsibility for conducting periodic detection surveys and for evaluating forest pest outbreaks on National Forest land. In addition, it provides staff support in the related tasks of surveillance, prevention, and suppression to Regions, Forests, and Districts. Your Forest Insect and Disease Management Staff may be located at the Regional Office or in field offices, but wherever located, it is available to help. Integrated pest management demands a multi-disciplinary approach. You have an opportunity to include pest management in the resource management on your Forest. The Forest I&D staff shares responsibility with you to see that integrated pest management becomes a reality on the Nation's managed forests.

In closing, I have mentioned that insect and disease problems are important; that prevention through integrated pest management is far better than suppression; that pest management is part of resource management; and that NFMA has several important requirements concerning forest insects and diseases. The final, and perhaps most important point, is that you have a FI&DM staff. Now, put them to work in your Region, Forest, or District.

Economic Analysis of Shelterwood Cutting of Longleaf Pine

Richard A. Greenhalgh and Ed Smith

The economic analysis of alternatives has become a required part of the decisionmaking process. The only trouble is many of the decisions we face involve intangible values that are not amenable to economic analysis. However, our assignment was to make an economic analysis of the shelterwood cutting of longleaf pine which on the surface would appear to be a problem that could be handled in a straightforward manner.

We used a very simple program called "DISCOUNT" which was developed by Region 5 to do our analysis.

There are two possible situations that can exist when the alternative to make a shelterwood cutting is a viable one:

1. There is a sufficient volume available to make an operable cut and still leave enough trees to make a shelterwood.
2. There are not enough surplus trees to make an operable cut and still leave a shelterwood.

For each of the situations we made some assumptions:

1. The one with an operable cut was assumed to have the volume and stocking one could expect to find after a rotation of good management.
2. For the second situation, the stocking and distribution of the trees exactly met the requirements of a shelterwood.

The analysis of the well-stocked stand included the volume and value of the timber removed in making the shelterwood cut. The data given the computer looked like this:

<u>Year</u>	<u>Value</u>	<u>Remarks</u>
0	-121.91	Sale prep and admin. shelterwood cut
2	2540.20	Value of timber cut
3	-100.00	Site prep
9	- 10.00	Prescribed burn - site prep
(11)		(Stand established)

13	- 14.00	Prescribed burn - brown spot control
14	- 48.18	Sale prep and admin. removal of shelterwood
15	1033.40	Value of timber cut
16	- 59.80	Precommercial thinning
33	- 33.15	Sale prep and admin. Commercial thinning
37	100.30	Value of timber cut
51	- 9.49	Sale prep and admin. commercial thinning
52	179.40	Value of timber cut
66	- 21.90	Sale prep and admin. commercial thinning
67	425.00	Value of timber cut

Caution: These and other data used in this discussion are only valid for comparative purposes to indicate preferred practices from an economic perspective. The cost effectiveness of the two practices are addressed, not the financial feasibility of a private or public investment. Land, transportation, and general overhead costs are not included.

For the situation where the shelterwood was already in place we started with site prep at year 0 and the shelterwood cut in year 85 and the cost of preparing and administering the sale in year 83. The computer gave the following results:

<u>Situation</u>	<u>Internal Rate of Return</u>	<u>Benefit/Cost Ratio $\frac{1}{1}$</u>	<u>Net Present Worth $\frac{1}{1}$</u>
Mature stand	354.0	10.1	2119
Shelterwood in place	19.8	2.3	190

1/ 10% discount factor

In either situation the discounted timber value exceeds the identified costs.

We should have stopped with that solution, but we didn't. We decided to compare a shelterwood with a clearcut and plant situation.

The same situation (almost) exists for clearcutting as exists for shelterwood; each has an initial operable cut or does not. The main difference between the situations is that at no time in the shelterwood method regeneration is there bare ground. Then how do we get equitable analysis for clearcutting?

One way would be to start with a mature stand in place and credit the initial value to the clearcutting just as we did with the first situation in the analysis of the shelterwood cutting. The data given the computer looked like this:

<u>Year</u>	<u>Value</u>	<u>Remarks</u>
0	-170.82	Sale prep and admin. clearcut
3	3549.40	Value of timber cut
4	-115.60	Site prep
5	-117.40	Plant
7	14.00	Prescribed burn - brown spot control
30	- 33.15	Sale prep and admin. commercial thinning
31	100.30	Value of timber cut
45	- 9.49	Sale prep and admin.
46	179.40	Commercial thinning
60	- 21.90	Sale prep and admin. commercial thinning
61	425.00	Value of timber cut

The result:

<u>Situation</u>	<u>Internal Rate of Return</u>	<u>Benefit/Cost Ratio <u>1/</u></u>	<u>Net Present Worth <u>1/</u></u>
Clearcut Mature stand	173.0	8.1	2343

1/ 10% discount factor

Clearcutting with a mature stand compares favorably shelterwood cutting with a mature stand. But what about starting the analysis with bare ground?

Starting with site prep as year 0 and the cost of the final harvest cut in year 75 and the value in 76. We found that the results presented a rather dismal picture for clearcutting and if road costs and overhead were added the operation would be more unfeasible.

<u>Situation</u>	<u>Internal Rate of Return</u>	<u>Benefit/Cost Ratio <u>1/</u></u>	<u>Net Present Worth <u>1/</u></u>
Clearcut Bare ground	4.2	0.1	-\$209

1/ 10% discount factor

Obviously, we needed to find some way of getting the shelterwood cutting down to bare ground; so we ran the shelterwood analysis without the cost or value of the removal cut. The results were very comparable with the results we got starting with bare ground and planting:

<u>Situation</u>	<u>Internal Rate of Return</u>	<u>Benefit/Cost Ratio <u>1/</u></u>	<u>Net Present Worth <u>1/</u></u>
Shelterwood no credit for removal cut	4.3	.1	-\$123

1/ 10% discount factor

Never being satisfied with letting well enough alone we tried one more approach in making clearcutting with bare ground equal to shelterwood cutting with only the shelterwood in place. We started the analysis of the clearcutting with the value of and the cost of sale prep and administration of volume equivalent to the shelterwood.

The results were most interesting:

<u>Situation</u>	<u>Internal Rate of Return</u>	<u>Benefit/Cost Ratio <u>1/</u></u>	<u>Net Present Worth <u>1/</u></u>
Clearcut with credit for cost and value of a volume equivalent to the shelterwood	167	3.4	\$491.18

1/ 10% discount factor

The last game we played was to credit shelterwood cutting with only the value of the net growth on the seed trees. The results looked like this:

<u>Situation</u>	<u>Internal Rate of Return</u>	<u>Benefit/Cost Ratio <u>1/</u></u>	<u>Net Present Worth <u>1/</u></u>
Only the value of the net growth on seed trees	5.3	.4	-\$80

1/ 10% discount factor

Legislative direction for the Forest Service emphasizes silvicultural practices and decisions to harvest, by regulation, must include some plan for returning the tree cover. In this context the decision as to which method of regeneration to use probably starts with a mature stand and the analysis should include the values and costs that exist at the time the decision is being made. In the case where shelterwood is a viable alternative the analysis will ordinarily show it in a favorable light. When compared to clearcutting it may or may not prove to be more favorable depending upon:

1. The value of the existing stand. The greater the value of the initial cut the less likely the economic analysis will show any important differences between the two methods of regeneration.
2. The cost of artificial regeneration.
3. The length of time it takes to establish a new stand. The longer it takes to establish the new stand the greater the impact of discounting on the final harvest value.
4. The length of time between the shelterwood cut and its removal. Here again the longer the removal cut is put off the greater the impact of discounting on its value.

PARTIAL CUTS TO REGENERATE UPLAND
HARDWOODS IN THE SOUTHEAST

by

David L. Loftis
Associate Forest Ecologist
Southeastern Forest Experiment Station

I am going to discuss some observations we have made on regeneration after partial cutting in the overstory. But first I need to make two qualifying statements:

- 1) My discussion will cover not the entire Southeastern United States, but rather the Southern Appalachians.
- 2) And rather than upland hardwood sites in general, I will focus on our better sites--coves and moist slopes.

The Southern Appalachians extend from southwestern Virginia to northern Georgia and are bounded on the southeast by the Blue Ridge Mountains and on the northwest by the Unaka Mountains (of which the Great Smoky Mountains are a part). A number of mountain chains--some parallel, some transverse to those above--rise above the intervening peneplains. Bedrock near the Blue Ridge is primarily granite, usually highly metamorphosed; near the Unakas sedimentary rocks, more or less metamorphosed, predominate. Rainfall is extremely variable, ranging from about 100 inches annually in some mountainous areas to less than 40 inches in some valleys. Rainfall during the growing season is usually about one-half the annual total.

There are no simple classification schemes to describe the very diverse second-growth forests of the region as a whole; however, in general, yellow pines (P. echinata, P. rigida, P. virginiana) occupy the xeric, least fertile sites, oaks occupy the intermediate sites, and deciduous species other than oaks dominate the most fertile, mesic sites. Species composition on these very productive sites ranges from pure yellow-poplar to stands of mixed composition, depending on location and elevation. In our work in the Southern Appalachians we have concentrated on the better intermediate sites where a mixture of oaks usually dominates, and the mesic sites where northern red oak is usually a component of the species mixture.

Because of their dependence on advance reproduction for successful regeneration, the upland oaks would seem to be logical candidates for regeneration by a shelterwood method. Our reasons for installing some partial cuts at Bent Creek Experimental Forest in western North Carolina were directly related to oak regeneration--we wanted to be able to regenerate oaks predictably and re-

liably on sites capable of growing trees of veneer and saw-log quality. Our efforts resulted in failure with the oaks and a somewhat unexpected success with other species.

How to cut to promote seed production, provide conditions favorable for seedling establishment, enhance seedling development, and release the new stand--this is the essential information necessary to formulate a shelterwood method for regenerating a species. And this was the information sought when the first study was installed in 1963. Eight 1-acre plots were selected and treatments assigned--two to be clearcut, two to have 33 square feet of residual basal area, two to have 66 square feet of residual basal area, and two to serve as uncut controls. Advance reproduction was inventoried, and acorn traps were established. In other words, we were trying to evaluate a classical shelterwood. A number of problems conspired to thwart the original intent of the study, and acorn production and regeneration have been reported separately (Beck 1977; Beck and Olson 1968; McGee 1967, 1975).

Perhaps the primary reason for modifying the original objectives was the response of yellow-poplar to the various intensities of cutting. Three of these plots are of particular interest to us because their site quality is high enough to produce high-quality oak. Table 1 shows some pretreatment information about these plots.

Table 1.--Pretreatment site and stand conditions in three mixed oak plots.

Plot Number	Site Index	Stand Age	Initial Basal Area	Total Oak Basal Area
	<u>Feet</u>	<u>Years</u>	<u>Sq Ft</u>	<u>Sq Ft</u>
3	73	71	98	79
4	74	79	115	101
6	72	72	108	89

As the oak basal area suggests, these stands were dominated by oaks. Domination by oaks on sites of this quality is common in the Southern Appalachians. In table 2 we can follow the development of regeneration over time on these plots. All three plots had abundant advance reproduction of oaks as well as undesirable species. These plots were thinned from below in the spring of 1963 with the objective of leaving a spatially well-distributed residual oak stand. In addition to the thinning, all subcanopy stems over 4.5 feet tall were cut. This is an important operation and one I will discuss in greater detail later.

Table 2.--Regeneration in partial cuts in mixed oaks.

Plot 3 S.I.=73						
66 Sq Ft of Residual Basal Area Per Acre						
Species	Stems/acre < 5 feet tall		Stems/acre > 10 feet tall (1972)		Dominants and codominants/acre (1979)	
	1963		1965			
	Pre-harvest	Post harvest				
Oaks	5,999	7,061	4,500	28		6
Yellow-poplar	500	6,187	8,125	210		275
Other desirables ^a	313	376	500	2		6
Undesirables ^b	6,625	8,999	7,125	280		306
Plot 4 S.I.=74						
66 Sq Ft of Residual Basal Area Per Acre						
					Final removal cut, 1976	
Oaks	2,812	3,376	3,875	50		36
Yellow-poplar	313	5,813	12,875	198		200
Other desirables ^a	63	250	313	0		0
Undesirables ^b	6,125	7,751	9,124	648		336
Plot 6 S.I.=72						
33 Sq Ft of Residual Basal Area Per Acre						
					Final removal cut, 1976	
Oaks	9,000	10,751	10,062	292		123
Yellow-poplar	125	5,937	8,375	364		108
Other desirables ^a	63	125	188	28		15
Undesirables ^b	2,813	4,562	6,063	954		215

a Hickory, shortleaf pine, black cherry, ash, white pine, sweet birch.

b Mostly red maple, dogwood, sourwood, black locust, sassafras.

The most dramatic change in the post-harvest inventory is the tremendous increase in the yellow-poplar seedlings. Yellow-poplar seed remains viable in duff for as long as 8 years; when conditions are suitable, the seed will germinate. Scarification is not necessary; an increase in solar radiation on the forest floor will stimulate germination. The modest increase in oaks reflects some late germination. By the end of the third growing season, these partially cut plots were very impressive, with thousands of oak and yellow-poplar seedlings well established and apparently ready to make rapid height growth. At this time, however, it was felt that the residual overstory, particularly on plots 3 and 4, would begin to take a toll on the regeneration--that is, cause mortality of yellow-poplar and retard the growth of the oaks.

The next examination of these plots in 1972--nine growing seasons after the initial harvest cut--provided something of a surprise: the intolerant yellow-poplar was doing quite well even on the plots with higher residual basal areas. The status of the oaks was variable. In reviewing the original preharvest inventory of advance reproduction, I would interpret this variation in light of Ivan Sander's findings--namely, that growth of oaks after a harvest cut is a function of size of advance reproduction. Of the 6,000 advanced oak stems per acre on plot 3, only 60 were over 1 foot tall. Of the 2,800 advanced oak stems on plot 4, almost 500 were over 1 foot tall. And on plot 6, 1,000 of the advanced oak stems were over 1 foot tall.

During these 9 years some of the advance oak reproduction died, and new oak seedlings were established in good seed years. However, the fact that yellow-poplar became established in large numbers, survived, and grew made the study of oak establishment academic. Any oak stem which does not respond to release quickly is going to be left behind.

The final column in table 2 shows the present status of these stands. The residual overstory is still intact on plot 3; but the final removal cut was made in 1976 on plots 4 and 6. I think one could safely predict that we have effected a major change in species composition on plots 4 and 6--that is the oak component will be far less than in the original stand. And if the overstory were removed from plot 3, the same would be true there.

Another study involving a shelterwood cutting took place on an excellent site on a northeast-facing slope at a somewhat higher elevation (table 3). The original stand contained northern red oak, yellow-poplar, some chestnut oak, and sweet birch--a mixed stand. The initial cut in 1964 removed about 75 percent of the initial basal area; the residual stand had about 24 square feet of basal area per acre, almost all of which was northern red oak. The under-story of this stand was then sprayed for two successive growing seasons with 2, 4, 5-T to prevent the development of regeneration other than northern red oak. Although some red oak seedlings were established after the cessation of spraying, the hoped-for bumper acorn crop and good seedling catch did not occur. I will not dwell on regeneration development in this stand except to

say that the absence of red oak is conspicuous and to point out that the species composition in this stand is remarkably similar to that in an adjacent clearcut--a mixture of yellow-poplar and sweet birch with an absence of northern red oak.

Table 3.--Regeneration in a mixed stand after a shelterwood cut in 1974.

Species	1974 Milacre stocking (percent)	1979	
		No./acre	Milacre stocking (percent)
Yellow-poplar	24	207	56
Birch	24	87	24
Dogwood	23	14	4
Locust	8	27	7
Red Maple	8	27	7

Our third study, installed in 1970, had a dual purpose: 1) to demonstrate a more esthetically appealing method to produce an even-aged stand, and 2) to have another look at the development of oak regeneration under a partial canopy. Site index in this stand was in the 80 to 90 range for oaks. The species composition was mixed, with the oaks collectively comprising a majority of the basal area. This time approximately 50 percent of the initial 100 square feet/acre of basal area was cut. Again, the subcanopy--small trees and shrubs--was treated at the time the stand was logged; some of the stems were cut, and some were cut and their stumps poisoned.

The preharvest inventory revealed abundant advance reproduction of many species (table 4). Two rather big changes were detected in the post-harvest inventory: 1) the large increase in numbers of yellow-poplar, as in the first study, and 2) a large decrease in red maple seedlings. Most of the red maple seedlings were very small and died when the stand was opened up--a phenomenon we have observed on several occasions.

After 5 growing seasons all of the species represented in the advance reproduction had made some height growth. And even though the oaks seemed to be doing relatively well, most were already overtopped by other species. With the exception of sweet birch, the species which were present 5 years after the harvest cut and have a chance to become part of the new stand were present as advance reproduction or as stored seed.

Table 4.--Regeneration in a mixed stand before and 5 years after a shelterwood cutting.

Species	Stems/acre 4.5 ft.		Stems/acre 4.5 ft. after 5 years	
	Pre-harvest	Post-harvest	Number/acre	Percent
Yellow-poplar	5,350	31,667	1,720	30
Red Oak	2,400	2,600	423	7
Black Cherry	4,250	2,717	436	8
Other Oaks	3,900	3,400	251	4
Birch	83	17	106	2
Other Desirables	701	683	211	4
Dogwood	3,300	2,067	940	16
Red Maple	42,917	7,917	606	11
Locust	183	517	510	9
Sourwood	133	100	110	2
Other Undesirables	3,634	2,316	417	7

During the winter of 1976-77, the final removal cut was made on half of this stand (table 5).

Table 5.--Regeneration in the same shelterwood cutting after nine growing seasons.

Species	Residual overstory intact		Overstory removed	
	Number/acre	Percent	Number/acre	Percent
Yellow-poplar	97	27	160	22
Red Oak	17	5	43	6
Black Cherry	23	7	40	6
Other Oaks	3	1	54	8
Birch	3	1	74	10
Other Desirables	7	2	54	8
Dogwood	10	3	45	6
Red Maple	50	14	54	8
Locust	77	22	97	14
Sourwood	43	12	26	4
Other Undesirables	23	7	65	9

I hesitate to compare the portion of the stand in which the final removal cut has been made with that in which that partial overstory remains because of site differences between the two. However, it does appear that the uncut portion of the stand is becoming dominated by sprout origin stems of less desirable species. The poisoning operation was less than successful since virtually all of the red maple and sourwood are of sprout origin. The black locust, though single-stemmed, are almost certainly root-suckers. The number of stems of desirable species in a favorable competitive position has declined substantially in the last 3 years in the uncut portion of the stand. On the other hand, the portion of the stand from which the overstory has been removed is developing into a fine mixed stand.

Let me turn now to the problems posed by the nonmerchantable subcanopy--the small trees and shrubs. This small tree and shrub layer is composed almost entirely of species which are undesirable from the standpoint of timber production. Most, in fact, seldom attain canopy status. We have known for some time that after removal of merchantable material by clearcutting, the residual material should also be removed to ensure good regeneration. We have observed in some of our old studies that partial cutting in the overstory without any control of subcanopy stems has frequently resulted in the establishment of a continuous subcanopy layer and little, if any, regeneration.

The amount of vegetation in this subcanopy layer varies considerably from stand to stand but can be substantial. Don Beck of the Southeastern Station has made some detailed measurements in 47 stands distributed from Virginia to north Georgia. He found as much as 32 square feet of basal area per acre in the subcanopy with an average of 12 square feet per acre. Working in rotation-aged stands on the Bent Creek Experimental Forest, I found as much as 35 square feet of basal area per acre with a mean of 17 square feet.

Even though the attempt to poison the subcanopy stems in the most recent study was not successful, poisoning may be the best approach to control, particularly when the density of these stems is high. All of these stems will sprout when cut; height growth is rapid and some species (such as red maple) have spreading growth. This condition places a premium on high seedling density and rapid juvenile growth of desirable species. Thus, species such as yellow-poplar and sweet birch are at an advantage in comparison with the oaks, which depend on larger, but far fewer advanced stems.

Another aspect of eliminating the subcanopy is the development of adequate advance reproduction. This, of course, is why shelterwood methods have been recommended for regenerating oaks in the first place. Yellow-poplar will become established at almost any level of disturbance to a stand. If a shelterwood method is to be successful for regenerating oaks on good sites in the Southern Appalachians, the level of disturbance will have to be such that oak seedlings can grow and develop a root system before overstory removal, but yellow-poplar cannot. Even the minimum level of treatment in the studies I

described today was too high. I believe that elimination of the subcanopy is the logical starting point in determining this appropriate level of disturbance. These lower size classes should be dealt with before the canopy is disturbed. And in some cases of high subcanopy density, this may be all that is necessary to accomplish the objective.

The studies I have outlined have both encouraging and discouraging results:

- 1) We can regenerate stands of Southern Appalachian hardwoods on good sites with a two-cut shelterwood and have about the same species composition we would have if we clearcut the stand.
- 2) Height growth will be reduced substantially; among desirable species, no one species appeared to suffer more growth reduction than any other, when viewed from our perspective of species' performance after clearcutting.
- 3) Within the range of cutting intensities we have attempted, we have not had much impact on species composition. The performance of the oaks, in particular, appears to be more a function of the condition of advance reproduction than of cutting intensity.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

LITERATURE CITED

Beck, Donald E.

1977. Twelve-year acorn yield in Southern Appalachian oaks. USDA For. Serv. Res. Note SE-244, 8 p. Southeast. For. Exp. Sta., Asheville, N. C.

Beck, Donald E., and David F. Olson, Jr.

1968. Seed production in Southern Appalachian oak stands. USDA For. Serv. Res. Note SE-91, 7 p. Southeast. For. Exp. Sta., Asheville, N. C.

McGee, Charles E.

1967. Regeneration in Southern Appalachian oak stands. USDA For. Serv. Res. Note SE-72, 6 p. Southeast. For. Exp. Sta., Asheville, N. C.

McGee, Charles E.

1975. Regeneration alternatives in mixed oak stands. USDA For. Serv. Res. Pap. SE-125, 8 p. Southeast. For. Exp. Sta., Asheville, N. C.

NATURAL REGENERATION OF LOBLOLLY PINE

O. Gordon Langdon^{1/}

Abstract.--This paper highlights some of the ecological and silvical characteristics of loblolly pine that provide the basis for recommended natural regeneration methods for various portions of the broad range of loblolly pine.

Additional Keywords: Natural regeneration methods, ecological and silvical characteristics, prescribed burning, hardwood competition, preharvest seed tree release, seed production, seed dissemination, seed- seedlings-in-place.

Loblolly pine (*Pinus taeda* L.) is the "bread and butter" tree for a large and expanding forest industry. It occurs from Maryland to Texas and is a major species on about one-fourth of the forest land in the South. About three quarters of a million acres of loblolly pine are harvested each year. If productivity of this timber type is to be maintained, prompt establishment of a new forest after the harvest cut is a necessity and a key silvicultural activity.

Fortunately, a great deal is known about the tree--its silvical characteristics, its silviculture and management, and its wood properties and utilization. Literally, thousands of articles have been written about the species, including two books--one published as long ago as 1915 (Ashe 1915) and another in 1960 (Wahlenberg 1960). Unfortunately, full use is not always made of what is known about the tree, and many stands (for one reason or another) are not adequately reproduced. Although planting plays an important regeneration role on forest industry lands, 75 percent or more of the loblolly pine stands will probably be regenerated by natural means.

In this paper, I will, first, highlight some of the ecological and silvical characteristics of loblolly, then show how some of the regeneration systems fit these characteristics, and finally introduce you to a new regeneration concept.

^{1/}Principal Silviculturist and Research Project Leader, Southeastern Forest Experiment Station, U.S. Department of Agriculture, Forest Service, Charleston, South Carolina 29407.

ECOLOGICAL CHARACTERISTICS

Loblolly pine occurs in the early and intermediate stages of plant succession as succession progresses from bare soil to an edaphic or physiographic climax. A key factor in how a species fits into a given stage of succession is how it competes with its neighbors, and especially how it competes with its neighbors in an understory.

Loblolly pine usually loses the competitive struggle in an undisturbed understory because it is less tolerant than most of its hardwood associates. In the absence of fire or other control measures, these hardwoods increase in size as the loblolly pine overstory ages. Finally, as mortality takes its toll, the pine overstory breaks up and the hardwood climax components eventually assume dominance of the site (Wahlenberg 1960).

Succession toward the hardwood climax is also hastened if, when the pine is harvested, the hardwoods are left to occupy the site. Such cutting practices prevent the establishment and reduce the growth of loblolly pine probably more than any other known practice. Loblolly pine is an excellent competitor, however, and if given anywhere near an equal chance, will compete successfully with many, if not most, of its hardwood associates.

SILVICAL CHARACTERISTICS

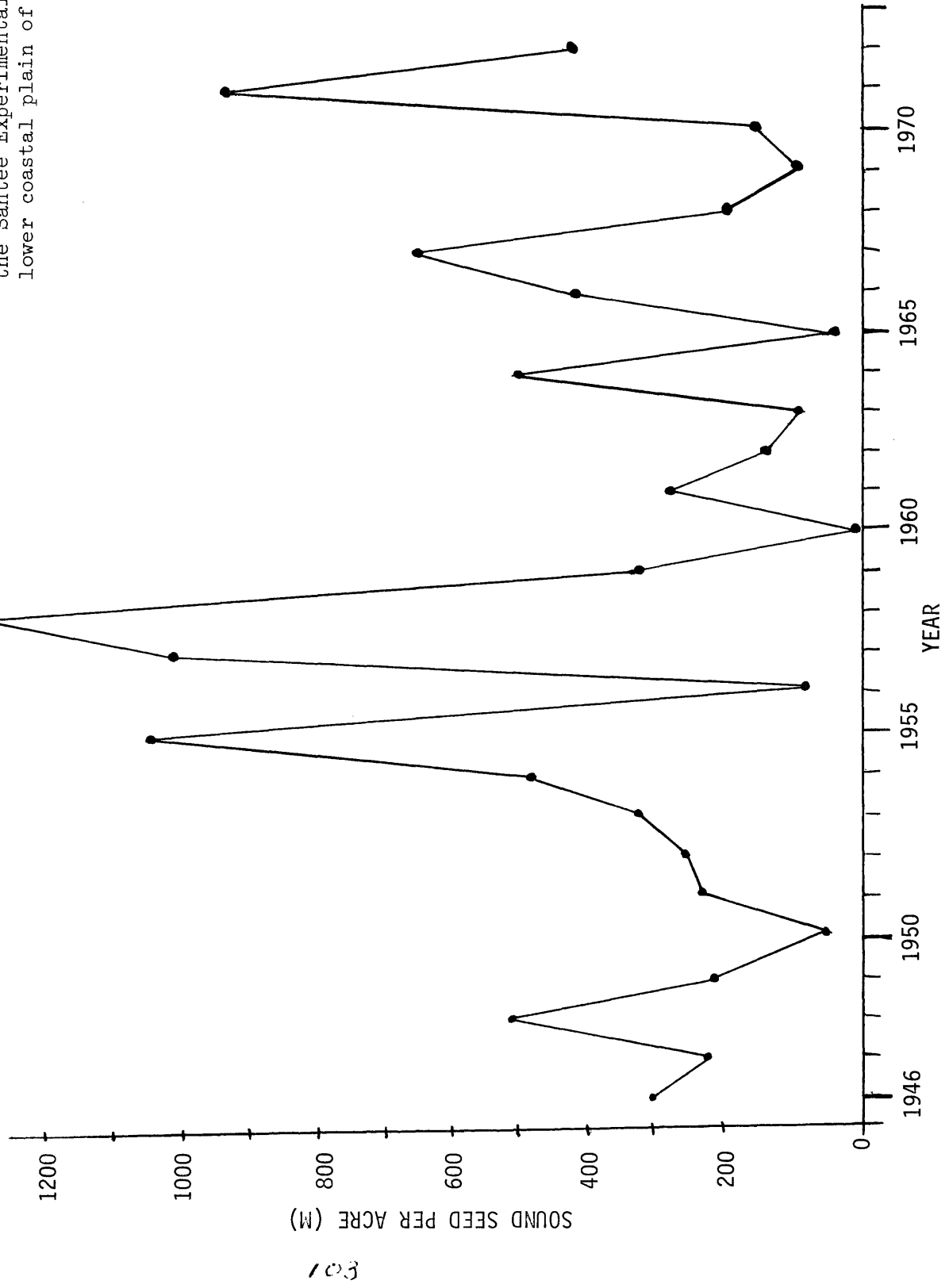
Success in natural regeneration depends on an adequate seed supply, a receptive seedbed, ample moisture during the germination and establishment period, and freedom from competition for space for the seedling to grow. If one or more of these variables are inadequate or limiting, a regeneration failure is a likely result.

Seed Production

An adequate seed supply is the first requisite in the natural reproduction of loblolly pine. Loblolly is a prolific and a rather consistent seed producer in the coastal plains of the Carolinas.

On the lower coastal plain of South Carolina, 27 years of seedfall records on the Santee Experimental Forest revealed several bumper crops (more than 1 million sound seed per acre) and only one year of seed failure (Fig. 1). Similarly, on the lower coastal plain of North Carolina, 8 years of records by Wenger and Trousdell (1957) on the Bigwoods Experimental Forest showed adequate to excellent seed crops and no seed failures (Fig. 2).

Figure 1.--Seed production of loblolly pine on the Santee Experimental Forest in the lower coastal plain of South Carolina.



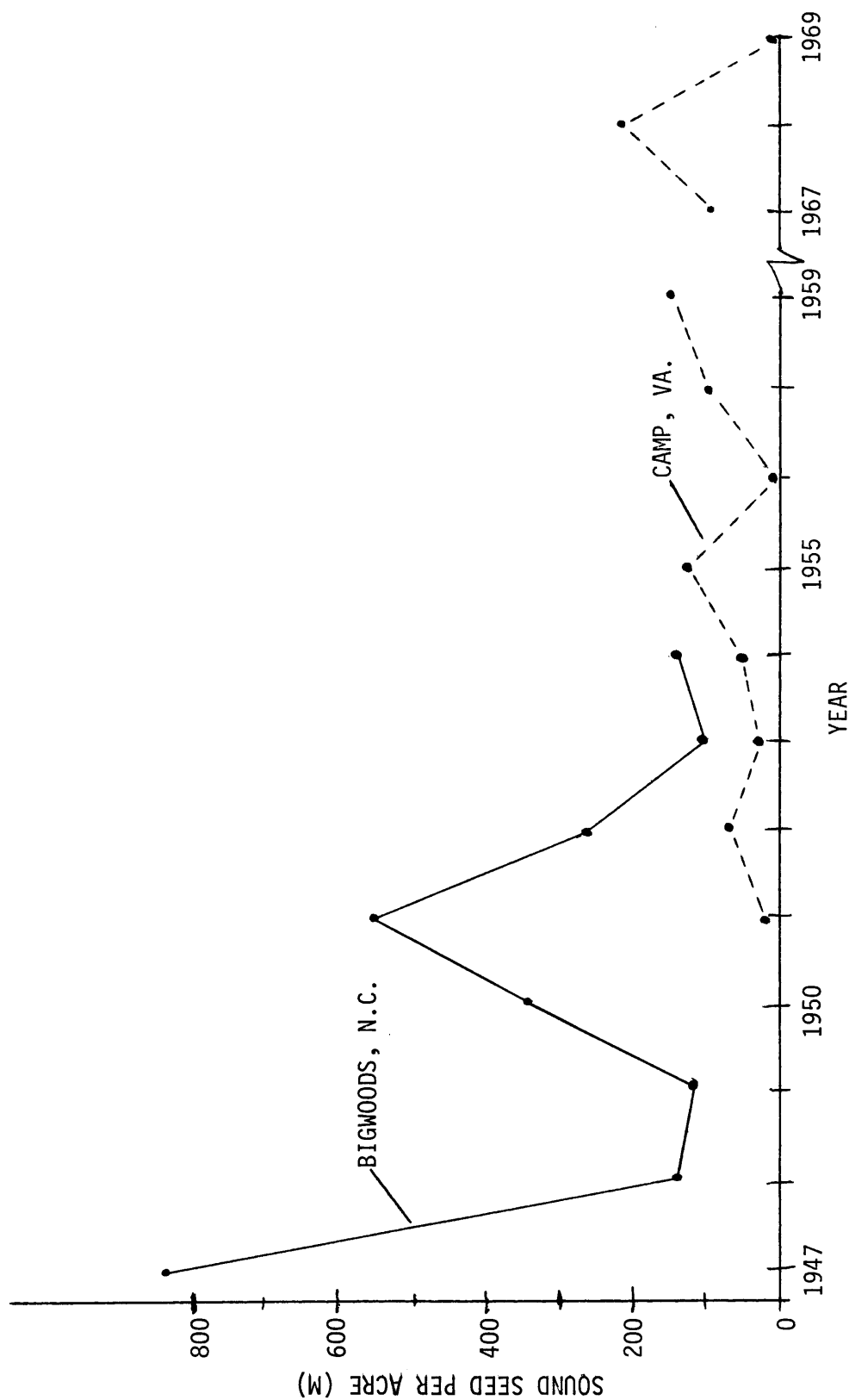


Figure 2.--Seed production of loblolly pine on the Bigwoods Experimental Forest in the lower coastal plain of North Carolina (after Wenger and Trousdell 1957) and the Camp Experimental Forest in the middle coastal plain of Virginia (after Stewart 1965).

Compared to those records from the lower coastal plain, seed production on the Camp Experimental Forest^{2/} on the middle coastal plain of Virginia was neither as consistent nor as prolific. During 11 years of keeping records, Stewart (1965) found that two of those years (18 percent of the years) had seed failures, two had poor seed crops, and seven had quite adequate numbers of seed produced (Fig. 2).

Loblolly seed production in the Piedmont is not as abundant nor as reliable as in the coastal plain (Brender 1973, Wakeley 1947). In the Georgia Piedmont, Brender and McNab (1972) found the frequency of seed crop failure to be 36 percent, which is double that reported by Stewart for the middle coastal plain. Brender and McNab's study also shows that a shelterwood cutting in which large numbers of trees are left for seed reduces the number of seed crop failures and increases the levels of seed production (Fig. 3).

Variation in Seed Crops

Yearly variations in seed crops are related to several factors, some of which are not fully understood (Wenger and Trousdell 1957). Freezing weather at time of flowering often injures or kills the flowers. Drought at other critical periods of the reproductive cycle may reduce seed production. For example, May-July rainfall has been found to be positively related to the setting of flower-bud primordia (Wenger 1957). If a drought occurs during this period, subsequent cone and seed crops will be reduced. Finally, insects may also damage or destroy cones and seeds at various stages of development.

Preharvest Release of Seed Trees

Cone production of loblolly pine seed trees is markedly stimulated (Fig. 4) by releasing them from competitors (Wenger 1954). In order to have adequate amounts of seed the first year after the harvest cut, the seed trees must be released in the winter or early spring three growing seasons before the seed is needed. If seed trees are released later than May 1, cone and seed crop stimulation will be delayed 1 year (Stewart 1965). If seed trees are not released prior to the harvest cut, stimulated seed production will be delayed either 2 or 3 years depending on the time of year that the harvest cut is made.

^{2/} The Bigwoods and Camp Experimental Forests are owned by Union-Camp Corp., Franklin Division, Franklin, Virginia whose cooperation with the Southeastern Forest Experiment Station, Forest Service in making land available and conducting various forestry operations required in the experimental work is gratefully appreciated.

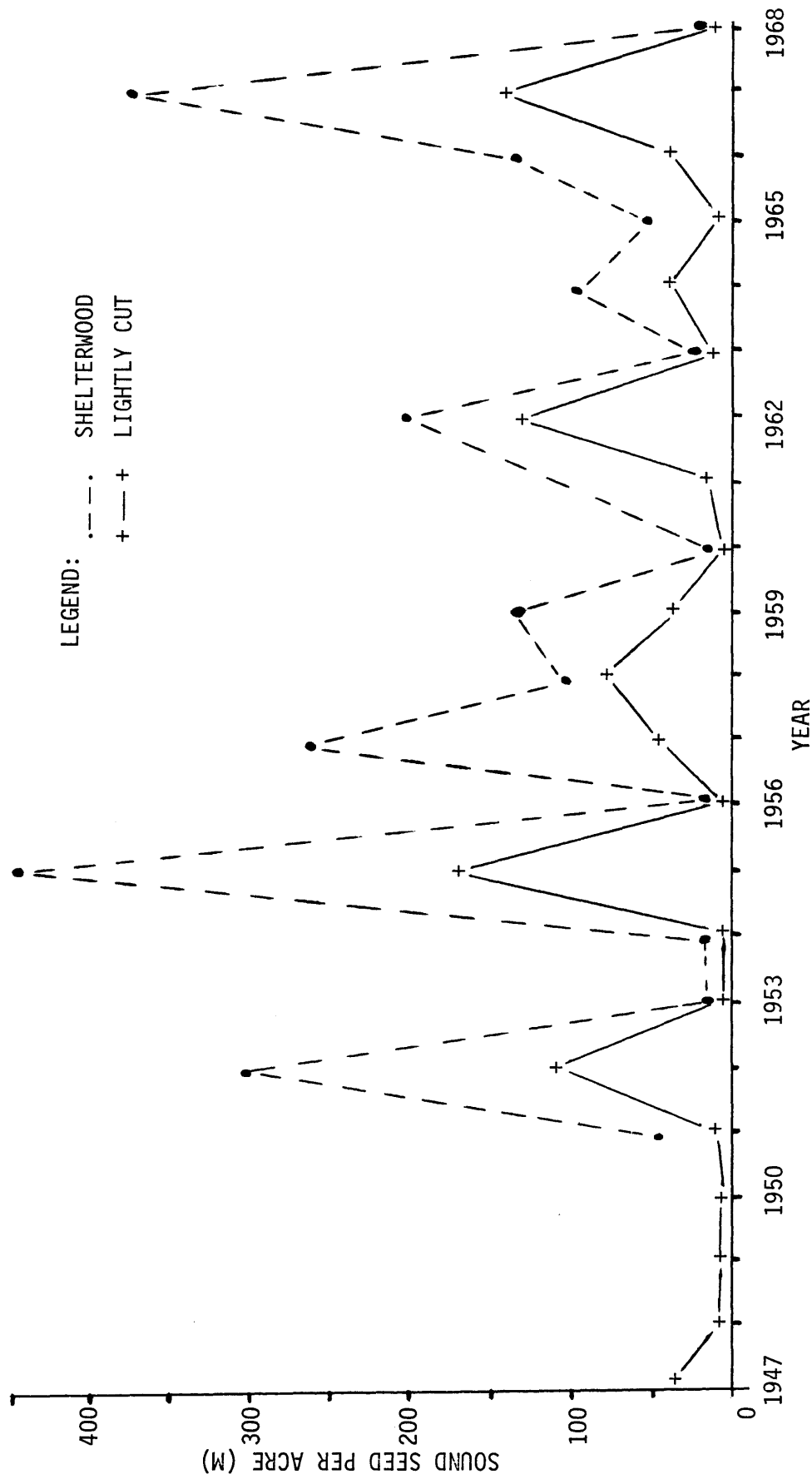


Figure 3.--Seed production of loblolly pine on Hitchitti Experimental Forest in the Piedmont of Georgia (after Brender and McNab 1972).

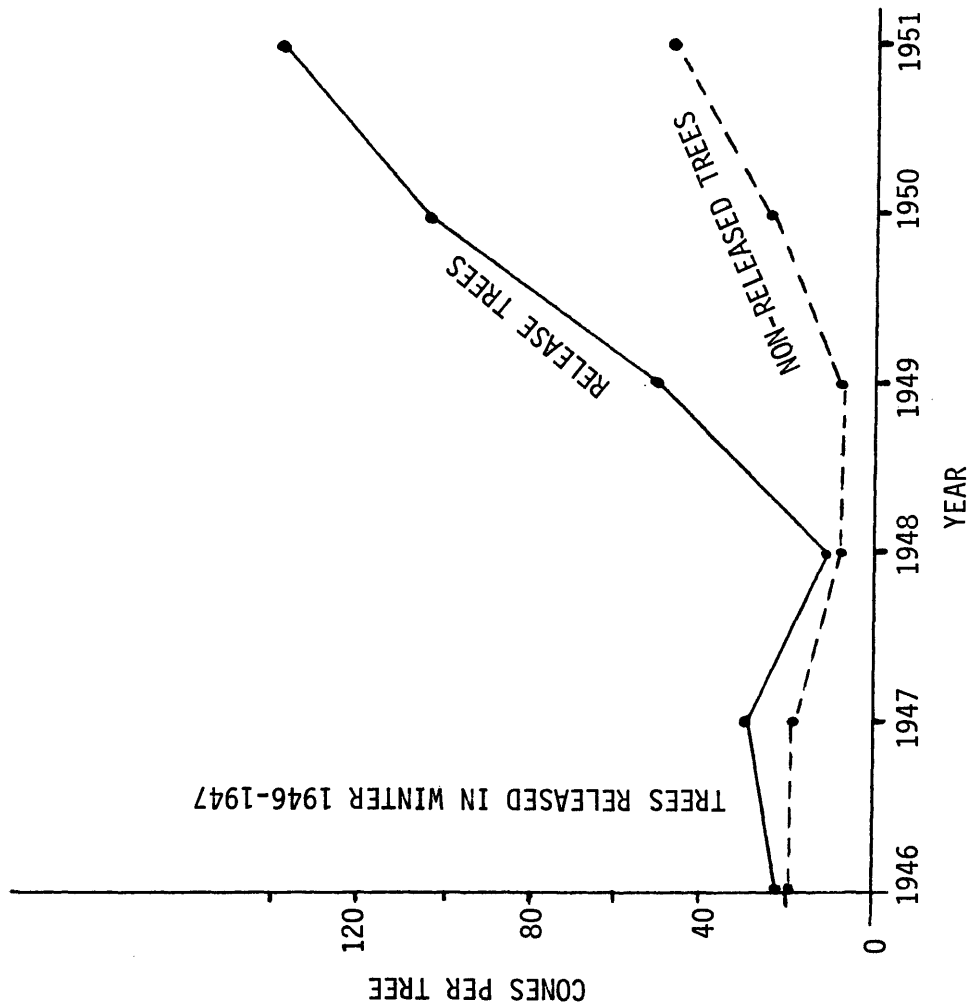


Figure 4.--Effects of preharvest release on cone production of loblolly pine (after Wenger 1954).

Seed Dissemination

Loblolly pine seedfall on the Santee Experimental Forest starts in early October and peaks in November (Fig. 5). By mid-November about 50 percent of the seed crop is on the ground, and by mid-December about 85 percent has fallen (Lotti 1961). Seed dissemination occurs in about the same pattern in the coastal plain of North Carolina (Wenger and Trousdell 1957).

Seed Germination

Loblolly pine seed germination starts in early April when temperatures become favorable. Under a full overstory, germination is often delayed several weeks or more. Thus, the seed lays dormant on the forest floor from 4 to 8 months and is subject to many forms of depredation. Rodents and birds eat an appreciable amount of seed during this period. Rodent populations, although small in uncut stands, build up rapidly after clearcutting and remain high for several years (Trousdell 1954).

Germination of seed and initial seedling establishment of loblolly pine are greatly enhanced by having a disturbed or mineral soil seedbed (Pomeroy 1949). Conversely, litter on the forest floor impedes germination and seedling establishment. Consequently, an increasing quantity of seed is required (table 1) to produce one seedling as one goes from a disturbed (mineral soil) seedbed, to a burned seedbed, and to an undisturbed seedbed. Seed requirements also increase with age of seedbed (Wenger and Trousdell 1957). Heavier textured soils afford a better seedbed (requiring less seed per established seedling) than lighter textured soils (Trousdell and Wenger 1963).

Table 1.--Number of sound seed required to establish one loblolly pine seedling by condition and age of seedbed (after Wenger and Trousdell 1957).

Condition of Seedbed	<u>Age of Seedbed</u>		
	1 Year	2 Years	3 Years
	- - - No. Sound Seeds Per Seedling - - -		
Disturbed	9	36	126
Burned	15	47	134
Undisturbed	46	--	427

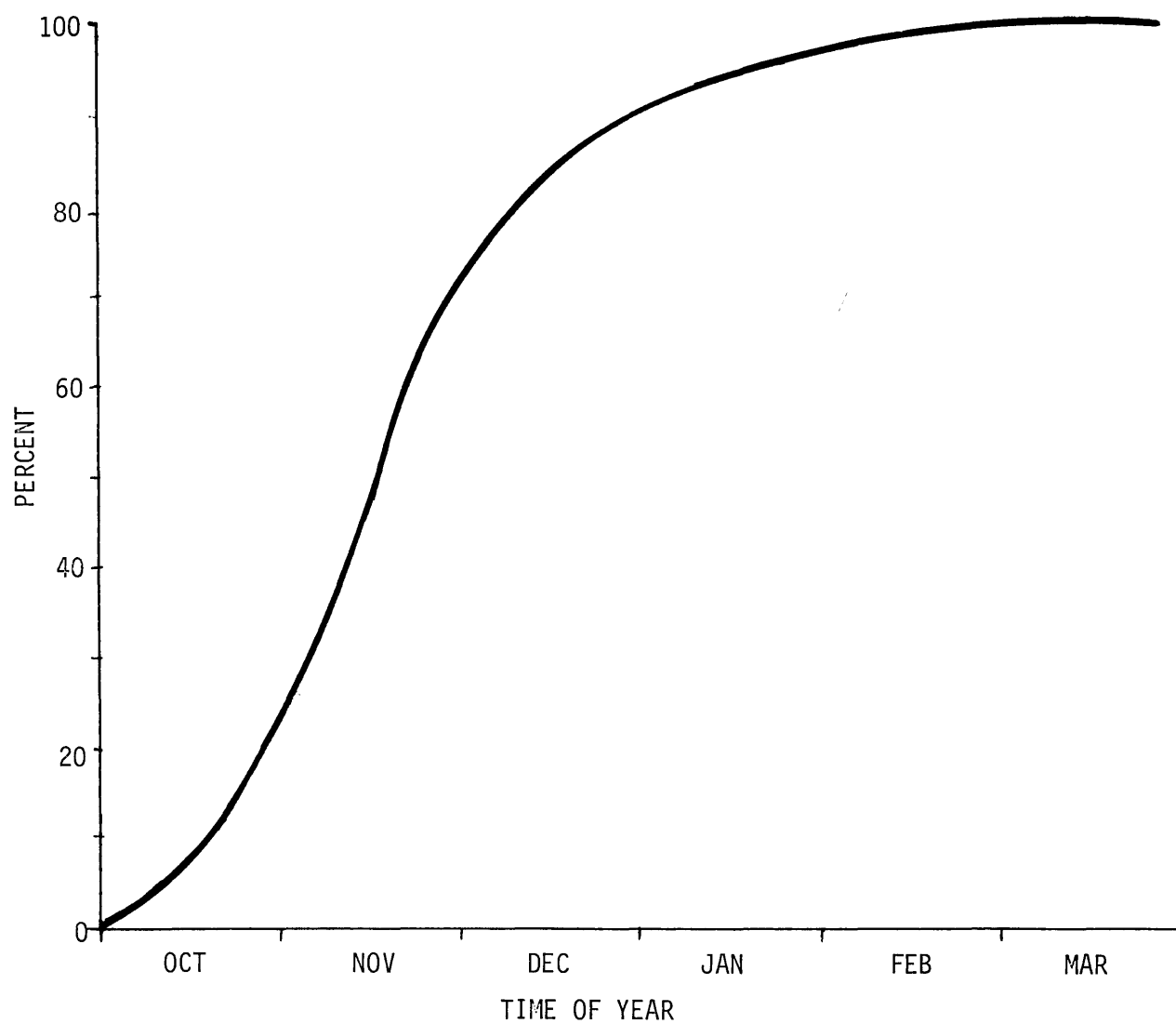


Figure 5.--Time of seed dissemination by loblolly pine
(after Lotti 1961).

Soil Moisture

Soil moisture is a most important factor in the survival of newly germinated seedlings. Trousdell and Wenger (1963) found in a Bigwoods study that April through June rainfall in an interaction with amount of sound seed per acre accounted for 51 percent of variation in first year seedling establishment. Another study conducted in South Carolina and Virginia showed that the seed:seedling ratio decreased as the amount of rainfall between March 15 and May 1 increased (Fig. 6). Past weather records can be used to estimate rainfall probabilities. For example, in a 26-year period on the Santee Experimental Forest, rainfall in the March 15-May 1 period exceeded $3\frac{1}{2}$ inches 75 percent of the time. There was only one year when rainfall in this period was less than $2\frac{1}{2}$ inches.

Hardwood Competition

Even though there is an adequate supply of seed, a receptive seedbed, and ample soil moisture for seed germination and initial seedling establishment and growth, seedlings must have space in which to grow. Competition from large residual hardwoods can greatly reduce pine seedling stocking and subsequent seedling growth (Trousdell and Wenger 1963). These large, residual hardwoods left after a harvest cut should be controlled by chemical or mechanical means. Prescribed winter fires used periodically (every 5 to 7 years) during the rotation are excellent for controlling smaller hardwoods and for keeping the hardwood competition small (Lotti, et al. 1960). Large hardwood competition has a tremendous impact on loblolly pine seedling growth. Long-term studies have shown that controlling the large hardwoods at the time of regeneration doubled loblolly pine growth by age 20 (Langdon and Trousdell 1975), and controlling small hardwoods increased the loblolly pine growth by an additional 20 percent.

REGENERATION METHODS

The ecological and silvical characteristics of loblolly pine lend themselves to managing and reproducing the tree under several even-aged methods.

Seed Tree Method

In the coastal plain where seed crops are heavy and noted for their consistency, and where seed failures are rare, the seed tree method, with seed trees left standing singly or in strips has been used successfully to regenerate loblolly pine. From the knowledge that has been developed on cone and seed productivity, one can compute the minimum number of seed trees of a given size needed to reproduce a stand by types of seedbeds. Ordinarily, seedbeds will be most ideal for seed germination the first year after the harvest cutting. Each year thereafter their receptiveness will steadily decrease.

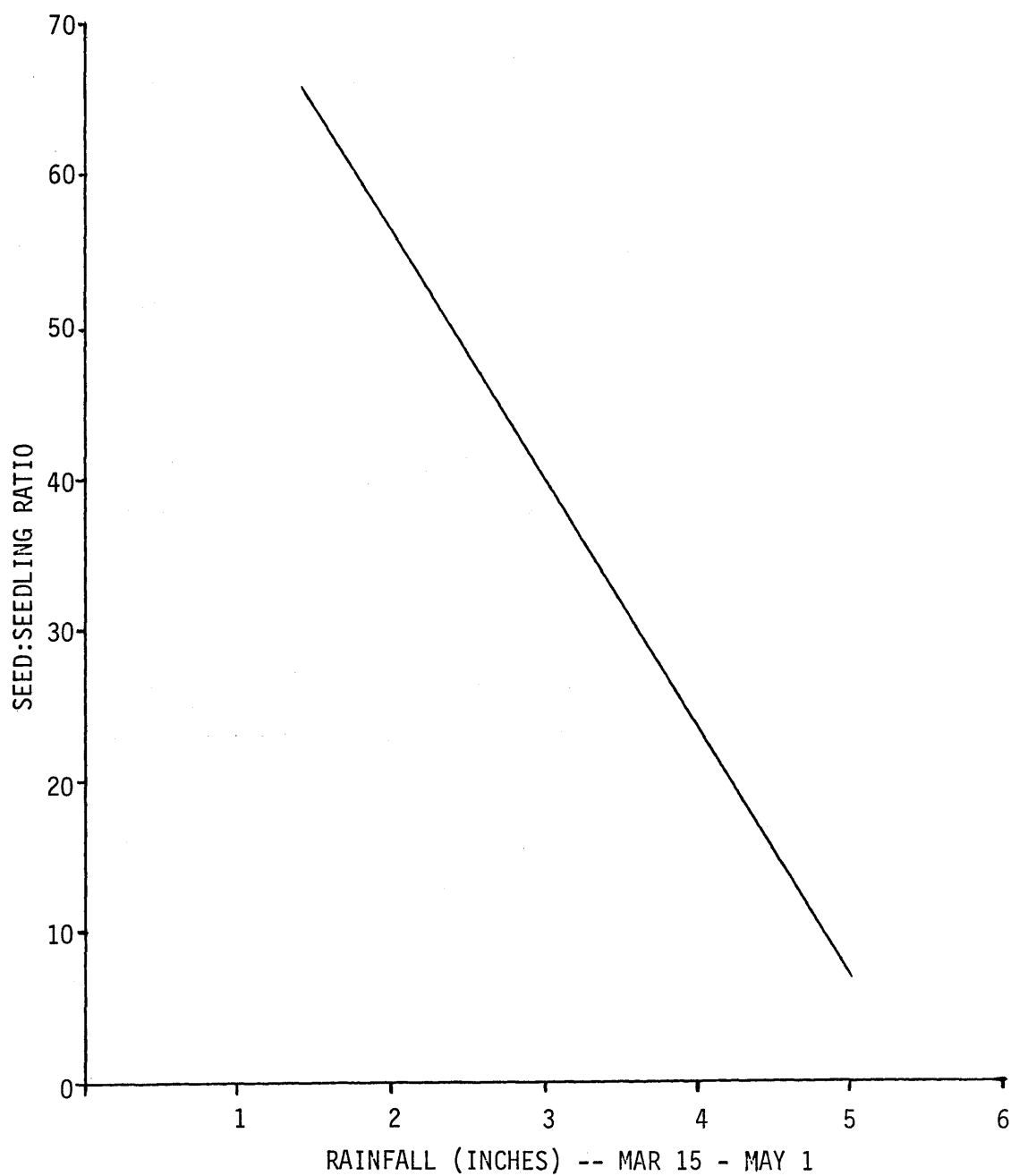


Figure 6.--Relationship between seed:seedling ratio and rainfall between March 15 and May 1.

In order to match an adequate amount of seed with the most receptive seedbed, seed trees should be released two growing seasons prior to the harvest cut. This preharvest release will increase the chances that the seed trees will produce enough seed the first year after the harvest to reproduce the stand. If loblolly pine seed trees are not released, then they will not likely produce enough seed until two years after the harvest cut. This delay increases the chances of a regeneration failure because receptiveness of seedbeds decreases and competition from hardwoods increases after logging and other seedbed and site preparation work (Wenger and Trousdel 1957).

Shelterwood Method

In the Piedmont or other areas where seed crops may not be as dependable as in the coastal plain, the shelterwood method of regeneration offers an attractive alternative to the seed tree method (Brender 1973). This method is recommended, not so much because shelter is needed for loblolly pine seedlings, but rather because more trees are left as a seed source under this method, which results in a more dependable seed supply. There may, however, be instances on droughty sites that shelter may be needed to reduce seedling transpiration and increase seedling survival. A heavy shelterwood may also have a place on very poorly drained sites in lower coastal plains where rising water levels after the harvest cut may impede seedling establishment and early seedling growth (Langdon and Trousdel 1978). If thinnings or other improvement cuts have not been carried out in the stand, then the preparatory or stand conditioning cuts used in this method can also provide for seed tree release.

Prescribed burning should also play a key role in this method in preparing seedbeds and controlling hardwoods. If prescribed burning is done periodically through the rotation, then toward the end of the rotation the advance reproduction that comes in after a good seed crop can be "stored" for a few years under a wide range of overstories (Brender 1973). In such cases, the seed cuttings and removal cuttings used in this regeneration method can be accomplished simultaneously and would be recognized by most observers as a clearcutting. Indeed, that is what it really is; distinctions among regeneration methods may often be blurred.

Clearcutting Method

The clearcutting method is more often associated with artificial than with natural regeneration because the "clearcut-site prepare-plant" system is so commonly used by the forest industry to reproduce loblolly pine. However, clearcutting with natural regeneration using seed from the trees harvested is also a viable alternative. This method, called "seed- or seedlings-in-place", was first conceived by Lotti (1961) after he observed in the coastal plain how prolific a seed producer loblolly pine was, how effective prescribed fire was in controlling small hardwoods and in preparing seedbeds, and how consistently seedling establishment was obtained. The question, then was: Why not regenerate a stand using this knowledge?

The concept (Fig. 7) involves using chemical or mechanical means to control large, unmerchantable hardwoods and prescribed fire to control small hardwoods and to prepare the seedbed. All of these measures are done prior to the harvest cut. The stand to be harvested is the seed source. After sufficient seed has fallen (30 to 50 thousand), the stand may be clearcut. If the stand is clearcut before seed germination in April, the method is called "seed-in-place". If the stand is clearcut after seed germination, it is called "seedlings-in-place", which is, in effect, the "advance" reproduction mentioned previously under the shelterwood discussion.

The concept has been tested in two different years in South Carolina and three different years in Virginia in a study involving 90 plots. Stands were logged in January-February for seed-in-place and in May-June and August-September for the seedlings-in-place treatments. The seed-in-place treatment resulted in more seedlings with better distribution than did either of the two seedlings-in-place treatments (table 2). Differences by treatment in stocking and number of seedlings were largely the result of logging damage. About two thirds of the seedlings initially established were destroyed by the logging. But in spite of this loss, an adequate number of seedlings were surviving at age 3 with a good distribution to assure a well-stocked stand in later years. This clearcutting method has proved to be an effective means of regenerating loblolly pine.

Table 2.--Number, size, and distribution of loblolly pine seedlings at 3 years using the seed- and seedlings-in-place method of regeneration.

Method	Date logged	Seedlings per acre	Stocking ^{a/}	Height tallest ^{b/}
		(no.)	(%)	(ft.)
Seed-in-place	Jan-Feb	10,500	91	3.7
Seedlings-in-place	May-Jun	1,800	49	3.0
Seedlings-in-place	Aug-Sep	1,500	51	2.5

^{a/} Percent of milacres having free-to-grow seedlings.

^{b/} Average height of tallest seedling measured on a milacre.

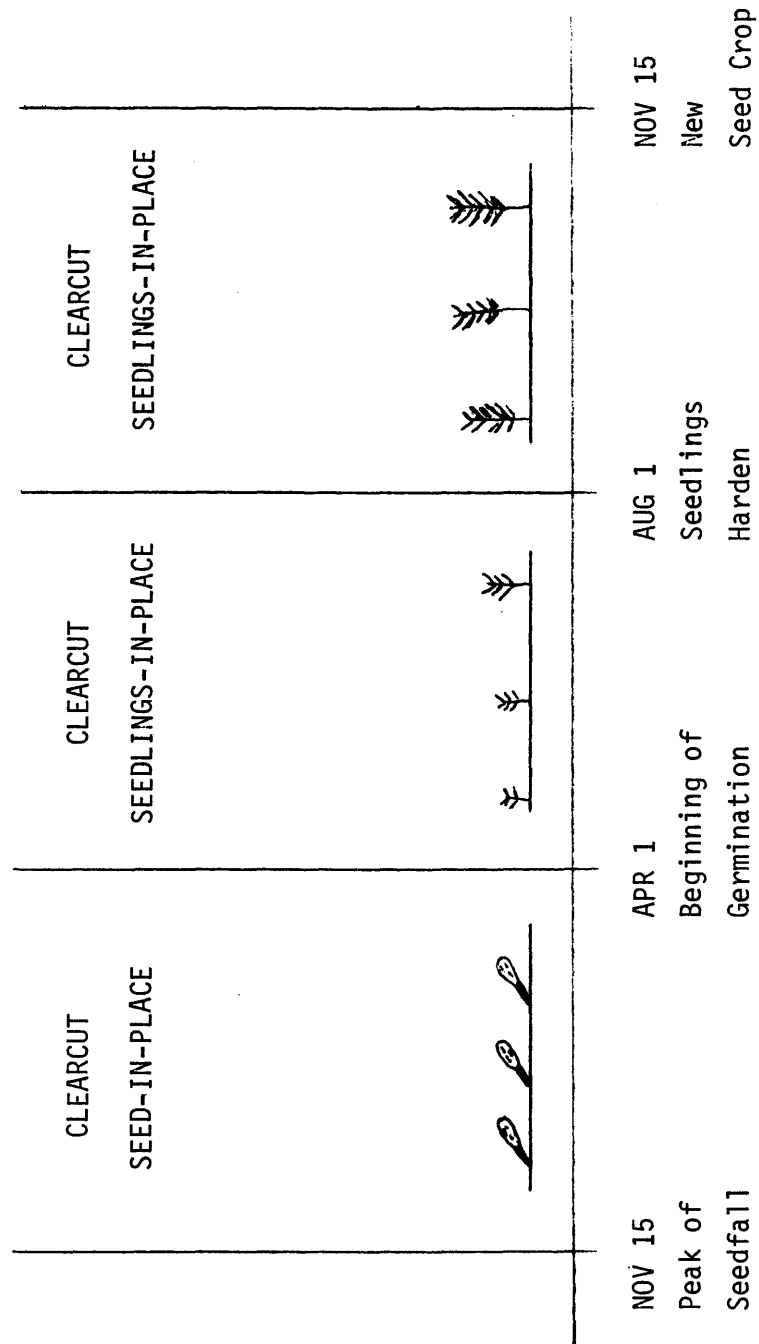


Figure 7.--The seed- seedling-in-place regeneration method by clearcutting.

SUMMARY

The known ecological and silvical characteristics of loblolly pine provide the basis for recommending several even-aged methods of natural regeneration. The seed tree method has been used successfully, but preharvest release of seed trees is highly recommended to help assure sufficient seed to establish seedlings the first year after the harvest cut. The shelterwood method is recommended for the Piedmont and other areas where seed production tends to be erratic, in the lower coastal plain on very wet sites where rising water table levels after a harvest may impede seedling establishment and early growth, or on droughty sites where high overstory shelter may increase seedling survival. The seed- seedlings-in-place variations of the clearcutting method are recommended especially for the Atlantic coastal plain region where seed production is prolific and rather consistent, and where prescribed burning or other measures have been used to prepare seedbeds and control the hardwood competition.

LITERATURE CITED

- Ashe, W. W. 1915. Loblolly or North Carolina pine. N.C. Geol. and Econ. Survey Bull. 24, 176 p.
- Brender, Ernst V. 1973. Silviculture of loblolly pine in the Georgia Piedmont. Georgia For. Res. Counc. Report No. 33, 74 p.
- Brender, Ernst V. and W. Henry McNab. 1972. Loblolly pine seed production in the lower Piedmont under various harvesting methods. J. For. 70: 345-349.
- Langdon, O. G. and K. B. Trousdell. 1975. Increasing growth and yield of natural loblolly pine by young stand management. In Proc. Symp. on Management of Young Pines. Charleston, S.C. Dec. 3-5, 1974. pp. 288-295.
- Langdon, O. G. and K. B. Trousdell. 1978. Stand manipulation: Effect on soil moisture and tree growth in southern pine and pine-hardwood stands. In Proc. Soil Moisture--Site Productivity Symp. Myrtle Beach, S.C. USDA For. Serv., SE Area S&PF, Atlanta, Ga. pp. 221-236.
- Lotti, Thomas, R. A. Klawitter, and W. P. LeGrande. 1960. Prescribed burning for understory control in loblolly pine stands of the coastal plain. USDA For. Serv., Southeast. For. Expt. Stn. Paper 116, 19 p.
- Lotti, Thomas. 1961. The case for natural regeneration. Proc. 10th Annual Forestry Symposium, L.S.U., pp. 16-23.
- Pomeroy, Kenneth B. 1949. The germination and initial establishment of loblolly pine under various surface soil conditions. J. For. 47(7): 541-543.

- Stewart, Joseph T. 1965. Regenerating loblolly pine with four seed trees. Virginia Forests 20(2): 14-15,26,28.
- Trousdell, Kenneth B. 1954. Peak population of seed-eating rodents and shrews occurs 1 year after loblolly stands are cut. USDA For. Serv., Southeast. For. Expt. Stn. Res. Note 68, 2 pp.
- Trousdell, Kenneth B. and Karl F. Wenger. 1963. Some factors of climate and soil affecting establishment of loblolly pine stands. For. Sci. 9(2): 130-136.
- Wahlenberg, W.G. 1960. Loblolly pine. Its use, ecology, regeneration, protection, growth and management. School of Forestry, Duke Univ., Durham, N.C., 603 pp.
- Wakeley, Philip C. 1947. Loblolly pine seed production. J. For. 45(9): 676-677.
- Wenger, K.F. 1954. The stimulation of loblolly pine seed trees by pre-harvest release. J. For. 52(2): 115-118.
- Wenger, K.F. 1957. Annual variation in the seed crops of loblolly pine. J. For. 55(8): 567-569.
- Wenger, K.F. and Kenneth B. Trousdell. 1957. Natural regeneration of loblolly pine in the south Atlantic coastal plain. USDA Prod. Res. Report 13, 78 pp.

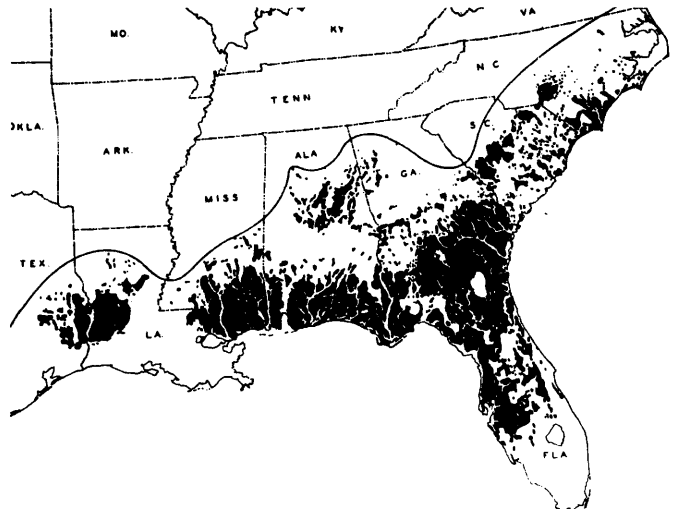
LONGLEAF

THE LONGLEAF PINE STORY

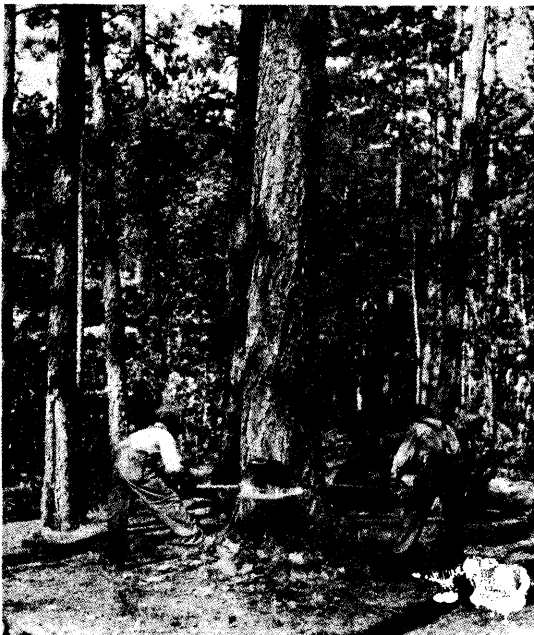
by Thomas C. Croker, Jr.

Longleaf pine forests have always been important in the lives and fortunes of southern people. Indians hunted deer and turkey under these trees and gathered lightwood from the forest floor to warm their lodges. Early mariners waterproofed their sails with pitch boiled from longleaf heartwood by enterprising pioneers. Timbering operations have made millionaires and furnished lumber for humble homes and stately mansions. Many red, white, and black men have sweated, bled, and died harvesting the products of the longleaf forests.

The forest, however, has been more than a storehouse of goods for mankind. It has been a gigantic stage stretching across the Southland where centuries of human drama have been enacted. The longleaf pine story is a fascinating saga of southern history that has touched the



Wahlenberg, Longleaf Pine



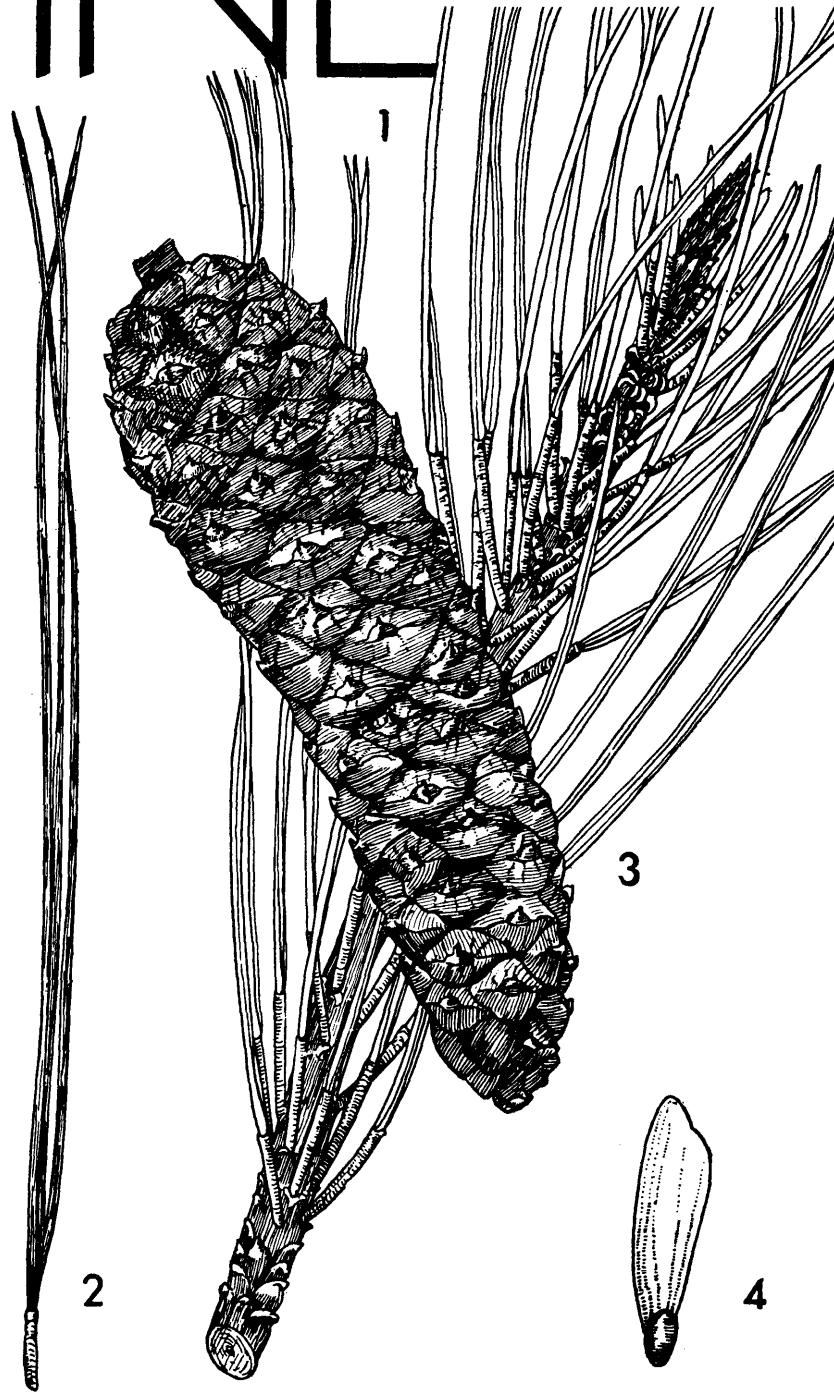
U. S. Forest Service photo, courtesy of the author

lives of millions. There have been times of great rejoicing and prosperity, but also grim times holding little hope for the future. In recent years the forests have been clearcut and replaced with other pines. The original virgin forest of some 60 million acres is gone, and there are now less than 10 million acres of second growth. Even this remnant is rapidly being destroyed. Recent developments, however, suggest that this trend can be reversed and a place in the sun found for the magnificent longleaf pine.

THE VIRGIN FOREST

Open and parklike, the virgin forest dominated some 60 million acres of the prehistoric southern landscape. Like huge wooden soldiers lined up in battle formation, the massive trees dotted the rolling coastal plains in a sea of grass. Gentle breezes, laden with a resinous perfume, rippled the long-strawed crowns and generated music both soothing to the ear and slightly mournful. Occasionally the tranquil scene was disturbed by a killer hurricane that

PINE



Harrar and Harrar, Guide to Southern Trees

Facing page: King of the southern pines, longleaf has been important in the lives and fortunes of southern people for centuries. The map indicates the approximate distribution of longleaf type forest and the northern limit of species occurrence. Above: 1) foliage, 2) needles, 3) closed cone, 4) seed.

crashed ashore from the sea, felling many veteran trees.

The forest, laced with narrow stream bottoms of hardwood and cane, provided an ideal habitat for deer, turkey, quail, and many other animals and birds. Beginning at the extreme southeastern tip of present-day Virginia, the natural range of longleaf pine extended across the Atlantic and Gulf Coast plains into east Texas, with brief excursions into the mountain and piedmont provinces of Alabama and Georgia. It was hemmed in by aridity on the west and by freezing temperatures and heavy soils on the north.

Fire was a natural architect of the forest. Ecologists classify longleaf pine as a fire climax type, meaning that the tree is maintained by regular fires. They speculate that the species' affinity for sandier soils is connected to its complex fire relationship. On such soils the ground vegetation consists of coarse, flammable grasses. Fires originally set by lightning, and later by Indians, frequently spread over thousands of acres in this fuel type. Longleaf seedlings, endowed by nature with supreme resistance to fire damage, found a compatible home in this environment. In fact, their very survival depended on these fires. Without them, aggressive hardwoods and pine competitors would choke out the longleaf. The open, parklike nature of the forest was due to the cleansing action of fire.

The forest was a bountiful storehouse of valuable wood products. Foresters have estimated that the original timber stands contained over 400 billion board feet of the strongest building material in America. In dead and down timber there was an abundance of pitchy heartwood unsurpassed for kindling, torches, house sills, and fence posts.

Admirably adapted to the southern environment by its resistance to fire, insects, and other hazards, longleaf pine stands were guaranteed continued renewal through natural processes. Many seedlings established on the forest floor by the infrequent seed crops escaped damage from the light surface fires. When mature trees were killed by lightning or felled in hurricanes, these seedlings sprang up to repair the break in the canopy.

MAN AND THE FOREST

The story of the first man to enter the longleaf pine forest is lost in centuries of unrecorded history. Since the forest apparently dominated such a large portion of the land, we can assume that it profoundly affected the earliest human inhabitants. We do know something of the activities of the Indians in this forest from journals of the first European visitors.

Longleaf forests provided many of the necessities of life for the woodland Indians of the southeast. Heartwood of longleaf pine furnished fuel

for warming and cooking fires. The warming fires were built on the ground in the center of the wigwam or lodge, and the smoke escaped through a hole in the roof. Soot that collected on the walls was scraped off and mixed with bear oil for war paint and other ceremonial painting. Lightwood splinters illuminated the way on various night excursions. Small trees and bark from the piney woods were used to construct corn cribs, lodges, and other small structures. Many of the village streets were paved with pine bark.

Deer furnished the Indians with food, shelter, and clothing, and deerskins became an important item of trade after the white man arrived. The longleaf pine woods provided an ideal locale for hunting the plentiful deer, which, when threatened by enemies, would hide in the narrow branch bottoms that penetrated the open woods. The hunters soon learned to drive the deer from their hiding places with fire, making death traps of the dense cane and hardwood bottoms. While their companions set the fires, the hunters hid behind the tree trunks in the open woods and slaughtered the terrified beasts as they rushed out to escape the flames. These hunting fires were not extinguished, and they spread throughout the uplands until stopped by a stream or by rain. Fires also were used sometimes as a battle tactic.

Wood products were important in many aspects of Indian ceremonial life, including funerals. Mourners blackened their faces with soot mixed with bear oil. The corpse was laid out in the sun on a pine pole frame, covered with pine bark, and treated with various mixtures. As soon as the flesh was mellow, it was removed and burned. The bones were then cleaned, oiled, and preserved.

The Indians' clearings for gardens and field crops rarely encroached on the longleaf pine forests. The native Americans favored the richer soils near streams rather than the sterile soils of the open woods. Moreover, until the white traders brought axes and other metal cutting tools, land clearing was a slow process. The larger trees could not be felled with primitive cutting tools; instead they were deadened by girdling or killed by piling heartwood around the tree base and setting it afire. No doubt many clearings reverted naturally to pine.

On balance the Indians did not materially change the character of the virgin forest. Their widespread use of fire helped maintain its open nature, and millions of acres of parklike stands stretched across the Southland when the white men came.

The first white men to enter the longleaf pine woods were Spaniards in search of gold. Typical of these was Hernando de Soto who, in 1539, came ashore in Florida from his base in Cuba with a large company of armor-clad soldiers. Many of their supplies were obtained by raids on

Indian settlements, but the conquistadors brought along herds of cattle and hogs to supplement their food supply. During their long journey through the Southland, some of these hogs strayed into the piney woods in search of food. Developing a taste for the nutritious pine roots, descendants of these strays became a serious menace to pine seedlings in later years.

English pioneers who came to the Atlantic coast of America were seeking homesites and farms rather than gold. Generally they settled in the bottomlands near the rivers, but the longleaf forests were important to them. These immigrants crossed the Atlantic in wooden ships whose seams and sails were waterproofed with pitch. They soon discovered that the heartwood of dead pines that had been accumulated for centuries was a rich source of this vital material. Production of pitch and tar became one of their first commercial enterprises. To extract the pitch, heartwood was cut and stacked in specially constructed earthen pits. Slow-burning fires boiled the pitch from the wood and it streamed into a barrel sunk in the ground outside of the perimeter of the circular pit. Tar was extracted from the pitch. Pioneer North Carolinians were especially active in this enterprise and were called "Tarheels," a nickname the state's residents bear to this day.

The settlers drew on the forest resources to construct their homes, outbuildings, and fences. Trees were cut down and pitted into lumber and building logs. Heartwood, virtually immune to decay, made ideal house blocks, sills, and fence posts. Pitsawing was a slow, laborious process. One man stood on a trestle above the log and handled a saw that cut only on the downstroke. The other man worked in the pit and got a face full of sawdust. Only a few boards were produced in a hard day's work.

The pioneers brought cattle, hogs, and work stock with them. These livestock were turned out into the woods for open-range grazing. The settlers, observing the hunting fires of the Indians, soon learned to set fires to green up the grass and control the movement of their cattle. (Cattle are attracted to the green grass in a new burn.) These fires, along with the grazing, helped to maintain the open nature of the longleaf woods. The hogs destroyed many seedlings, however, and the hot grazing fires occasionally did much damage.

The early white settlers created more numerous clearings than did the Indians, although land clearing by the latter increased with the axes brought by white traders. Most of these clearings, however, were located in the richer bottomlands and did not greatly diminish the longleaf forests.

Many writers have described the virgin longleaf forests and the life-styles of their inhabitants. William Bartram, the Pennsylvania botanist, traveled extensively on horseback through these for-

ests in North and South Carolina, Georgia, Florida, and Alabama in the late eighteenth century. He wrote of high, open forests of stately pines, with free circulation of air as contrasted with the troublesome cane swamps. Bartram mentioned the great herds of horned cattle, horses, and deer, and he noted that many areas recently had been burned by the Indians.

Congressman John F. Claiborne, later a federal timber agent, wrote of a trip through the longleaf forests of southern Mississippi in 1849: "For 20 miles at a stretch you ride through these ancient woods — a growth of giant pines unbroken . . . save where rivers or large watercourses intervene."

Historian Nollie Hickman described the early settlers in the longleaf pine forests of Mississippi as "stock raisers and hunters. Their country," he wrote, "was one great pasture where cattle and sheep fed upon wild oats and wire grass in the spring and summer seasons and upon reeds and canes of the bottoms during the winter months. Hardwood and pine mast provided food for large herds of swine. Throughout the woods were squirrels, turkey and deer in great numbers. Grass and wild game were the two fundamentals which determined the basic economy of the piney woods for the greater part of the nineteenth century."

THE TURPENTINERS

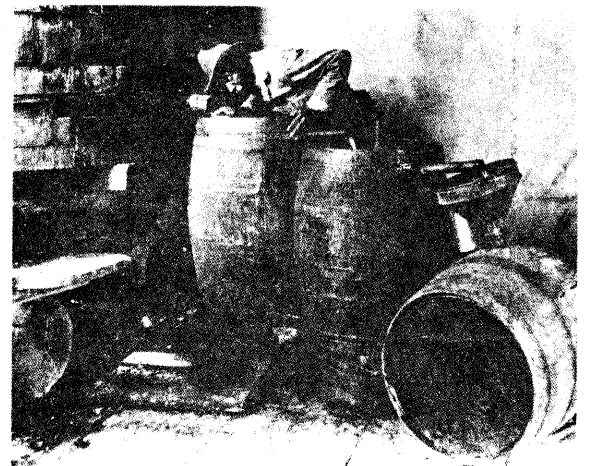
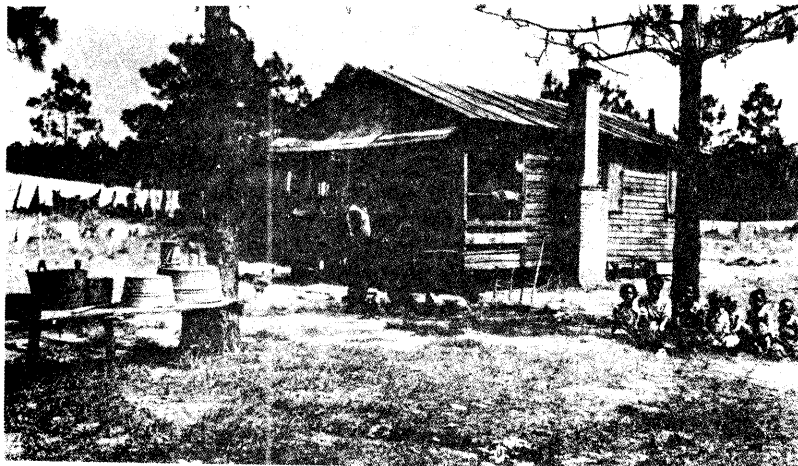
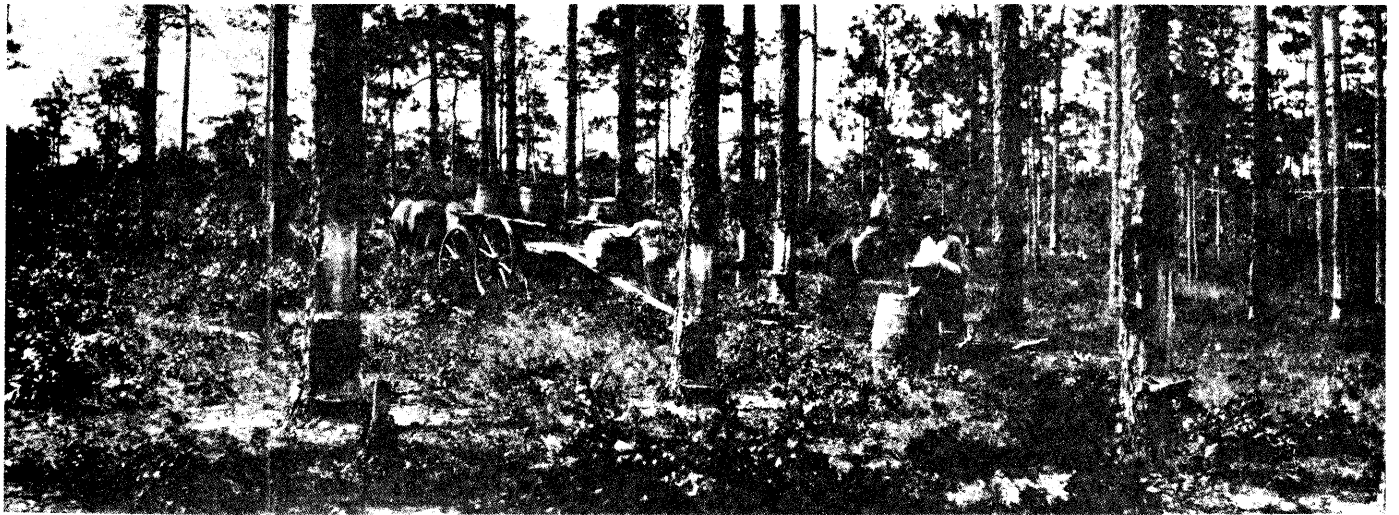
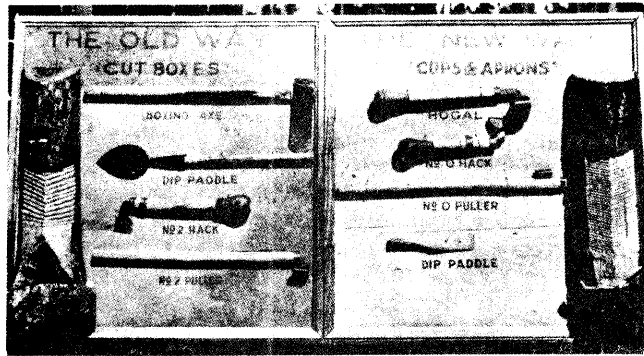
The first commercial enterprise of the European settlers in North Carolina was the production of pitch and tar. Just before the American Revolution a new method of producing naval stores was introduced. Living trees were tapped for their gum or oleoresin. Two valuable products, turpentine and rosin, were extracted from this gum by distillation.

To collect the gum a cavity or box was cut into the base of the tree. Above this box narrow streaks were cut in a V-shaped pattern across the face of the tree with a hook-bladed tool called a hack. This made the gum flow, and new streaks were cut each week during the growing season. After the boxes were filled, the gum was dipped into pails and then emptied into barrels for transportation to the still. At first all gum was shipped to England for distillation. About 1830 copper stills were introduced to the United States, and many new markets were developed for rosin and turpentine.

Until about 1838 the naval stores industry had not advanced south of the Cape Fear River in North Carolina. Most of the products were shipped from Norfolk, Virginia. There was a common belief among turpentiners that trees south of the Cape Fear River would not run gum. This superstition was unfounded, of course, and the industry expanded gradually throughout the longleaf pine belt.

The boxing method was very wasteful of timber and not very efficient. Around the end of the

TURPENTINERS



The Forest Service photos on this page depict various aspects of turpentine operations in Georgia and Florida during the 1920s and 1930s. Top left: Methods of wounding the tree to obtain gum changed with the introduction of cups and gutters and more conservative chipping techniques. Top right: A general view of a turpentine place showing the still in the foreground and workers' quarters in the background. Center:

Workers collect gum and load barrels for hauling to the still. Lower left: Typical quarters for a worker and his family. Lower right: An old-style fire still in which the progress of distillation is followed by listening to the sound of boiling gum at the tail pipe. Turpentine and water run into a separator barrel, then to a settling barrel, and finally the commercial product is piped to an oak barrel for shipment.

nineteenth century, several investigators, including W. W. Ashe and Charles H. Herty, were successful in developing a more conservative and efficient method. The new system employed shallow chipping, and a cup and gutter replaced the destructive box to collect the gum. At first clay cups were used, but metal cups later became popular. Use of the cup-and-gutter system achieved widespread use after 1910.

Lumbermen believed that the turpentine face would weaken the lumber, but this was disproved by Bernhard E. Fernow in 1893. After conservative chipping methods were developed by the Forest Service, it became customary for the naval stores people to face the timber just prior to cutting by the lumbermen.

To protect the turpentine faces from fire, the operators would rake a cleared strip around each tree and control-burn the area. These fires often destroyed newly germinated seedlings, as the block was usually burned annually. Sometimes there was a delay in the burning, however, and seedling stands became established if the first burn had come just before a good seed crop.

Until 1925 most naval stores were produced from longleaf pine timber. In later years the industry gravitated to slash pine stands, but much of the production also came from second-growth longleaf pine.

Naval stores laborers, mostly Negroes, lived in camps provided by the operators. Groceries, work clothes, and other supplies were secured from the commissary. Workers developed special skills, depending on their ambition and talents. The chippers were the highest-caste workers and took great pride in their ability to chip a crop (10,000 faces) in less than a week. Lower-caste workers, sometimes women and children, dipped and hauled the gum. Workers were supervised by woods riders, usually white men paid a daily wage by the operators. Recruitment of labor was a special problem, and each operator was alert to prevent "pirating" of his labor by others. Sometimes an unscrupulous operator would send some of his hands into another camp to lure laborers away. This was dangerous business, and occasionally the recruiters paid with their lives for such practice.

The cup-and-gutter system did not change much until after World War II. Forest Service researchers at Lake City, Florida, developed several new improvements, including bark chipping and chemical stimulation of gum, that have been generally adopted.

As long as the turpentiners merely worked faces on virgin timber a few years before it was cut, the impact on the forest was minimal, especially where the timber was protected from fire. Operations in second-growth timber can be very destructive, or they can fit in nicely with conservative cutting practice. In the latter case, additional revenue is provided and forestry practice is optimized.

Another form of naval stores operation is the extraction of turpentine and rosin from stumpwood in a factory. Stumpwood is the final contribution of the virgin forest to the southern economy.

THE RIVER ERA

Pioneer timbermen depended on water to transport their logs and power their mills. Trees were felled with pole axes and, if they were to be sold as timbers, squared with broad-axes. The logs were skidded to the stream bank and dumped in to be floated to the mill or ship.

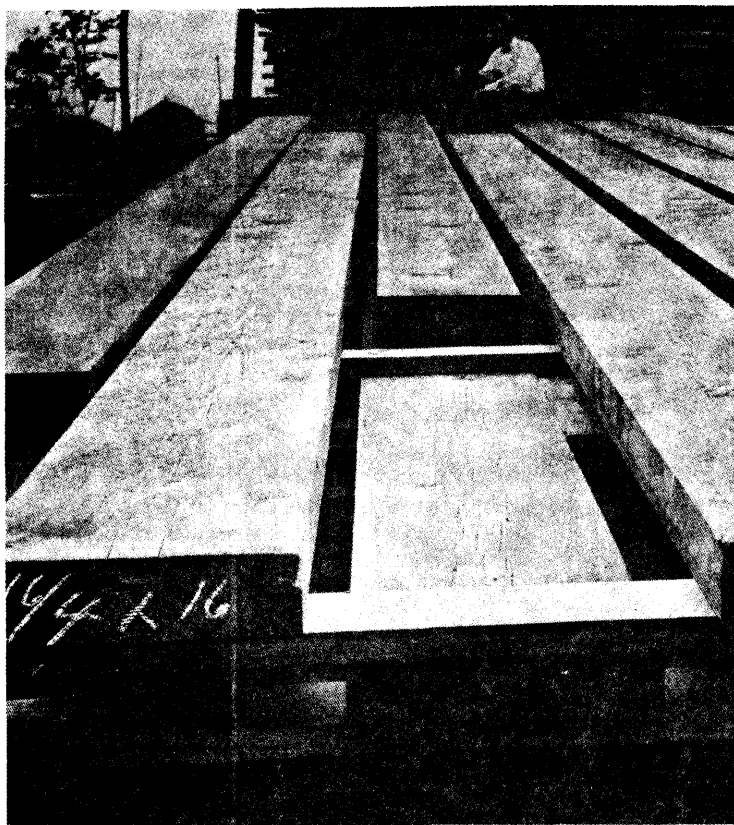
William Bartram described a typical operation on the Savannah River in Georgia during the late eighteenth century. His host escorted him to a steep riverbank where he had some men squaring pine and cypress logs that had been dragged to the site with "timber wheels." "Slaves of giant size mounted the massive logs," he wrote, "[and] the regular, heavy strokes of their gleaming axes echoed in the deep forest — while the sooty sons of Africa [sang] songs of their own composition." The squared timbers were then dumped into the river, made into rafts, and floated fifty miles down to Savannah, ultimately bound for the West Indies market.

The first mills were powered by water. Besides sawing lumber, many also ground corn and cleaned rice. Later the sawmills were powered by steam, but they were located near water so the logs could be rafted to them.

During the river era two distinct timbering operations developed — logging and sawmilling. The logmen cut and delivered the logs to mills where they were processed into lumber by the sawmillers. The sawmillers, who were usually better financed, advanced supplies and money to the logmen to be deducted from their pay when the logs were delivered.

In many cases the sawmillers controlled both logging and milling. An example was the Cedar Creek Lumber Company, which operated in southern Alabama during the late nineteenth century. On its vast timber holdings trees that would float were selected for cutting. The logs were floated in board ditches down Cedar and Murder creeks to the mill at Brewton. There they were square-sawn into "deals" for export to Europe. Deals were then floated down Murder Creek to the Conecuh River where they were assembled into rafts. A company man camped on the raft and piloted it down the river to Pensacola Bay and ocean-going ships. After delivering his timbers, he hiked the sixty miles back to Brewton.

The basic tasks of cutting trees and squaring timbers required great endurance and exceptional skill with the axe. A day's work was from "kin to kant," from first light of day until dark. As long as the timbermen used axes, they cut stumps waist high. After the crosscut saw was introduced,



FHS Collection

In the heyday of the yellow pine producers, much high-grade longleaf was earmarked for export markets. The lumber above was manufactured by the W. M. Cady Lumber Company, McNary, Louisiana.

less timber was wasted because stumps could be cut lower.

In the early days cutting was limited to the largest trees that would float. Trees scheduled to be used for masts, for example, had to meet rigid specifications. They must be twenty-six to thirty-six inches at the large end, eighteen to twenty-one inches at the small end, with a usable length of seventy-five to one hundred feet. Cutting was light because few trees qualified.

To move the logs to the river or stream, teams of oxen were employed. The drivers were masters at getting maximum efforts from their animals. They used rawhide whips to control the oxen. In the hands of an expert teamster, a whip would crack like a bolt of lightning near the ear of a recalcitrant beast, changing his direction or urging him to greater effort.

The practical skidding range did not exceed four miles, so cutting was limited to a narrow zone near the larger creeks and rivers where the water was deep enough to float the logs. Later board ditches were built into the lesser streams, and small dams were constructed to create ponds at the head of the ditches. After a supply of logs was skidded to the ponds, the gates were opened and the logs floated down to the river or mill.

Rafting in the longleaf pine country required considerable knowledge, and the logmen were subject to many difficulties. Log jams were a constant threat, and serious accidents were frequent. Droughts and floods were special hazards. Logs could not be moved during drought periods. On the other hand, floods sometimes carried the logs far back into the bottomlands where many were lost. Those that could be found had to be skidded back to the stream.

The river era gradually passed with the advent of railroad logging around the end of the nineteenth century. During this primitive period, longleaf pine and its products provided livelihoods for many thousands of Southerners, but the impact on the forest was minimal except in narrow zones near creeks and rivers. Large blocks of untouched timber remained in the backcountry, beyond the reach of the rivermen.

THE RAILROAD LOGGERS

As the nineteenth century waned, strange sounds were heard in the longleaf forest. The scream of locomotives, the din of power skidders dragging logs to railroad sidings, and the chant of track-laying crews signaled the start of a new era. Railroad loggers had come south in force to harvest a bonanza of yellow pine timber.

The red and white pine forests of the Lake States and New England were nearly cut over. Now the nation looked to the vast pineries of the South to satisfy urgent domestic needs and a demanding export market. The heyday of the longleaf pine lumber industry was reached in the first quarter of the twentieth century. The all-time peak production of yellow pine lumber was reached in 1909.

New logging methods were needed to reduce costs and step up production. To reach great blocks of timber in the backcountry, railroad logging was introduced. Spur lines were laid into the interior at quarter-mile intervals. Slow-moving oxen teams were replaced by powerful Clyde or Lidgerwood skidders that could handle five or six huge logs at a time. Skidders greatly stepped up production but were very destructive to young timber. There was little left following a skidder operation but a scarred and battered landscape.

The logs were piled alongside the tracks where a McGiffert loader would straddle the rails and load cars that passed underneath. Spur tracks were often carelessly built, so accidents were frequent. To keep the power movers supplied with logs, timber stands were clearcut by great throngs of saw crews. To house these and other forest workers, lumber towns were hastily built throughout the longleaf belt. Many were shantytowns that were moved by rail from place to place as timber stands were exhausted. Others were more permanent and grew into modern towns and cities. Commissaries were organized to furnish

supplies for loggers in the more remote locations. Huge band mills were erected that could cut over 100,000 board feet in a single ten-hour shift. The first all-steel mill in the country was built by the Great Southern Lumber Company at Bogalusa, Louisiana. Cash registers rang merrily, and there was rejoicing at the prosperity flowing from the forests.

In the scurry and bustle of the times, little thought was given to growing a second crop of trees. Most lumbermen considered reforestation to be highly impractical, and indeed, local tax policies encouraged lumbermen to "cut out and get out." But there were a few, encouraged by pioneering foresters such as Austin F. Carey, who braved the scorn of their fellows and made some provision for a second crop. In Alabama, the Alger Sullivan Lumber Company, T. R. Miller Mill Company, and Kaul Lumber Company were early converts to conservation. In 1905, at the request of the Kaul Lumber Company, the Forest Service prepared a management plan calling for modification of cutting practices and fire protection. It was approved by the nation's chief forester, Gifford Pinchot. Louisiana's Henry E. Hardtner, sometimes known as the "Father of Forestry in the South," cooperated with Herman H. Chapman of Yale University in studies to find ways to regenerate longleaf pine. At Bogalusa the Great Southern Lumber Company seeded longleaf pine on cutover land in the early 1920s. There were others, such as Posey Howell of the Dantzler Lumber Company in Mississippi, who gave some thought and effort to perpetuating longleaf pine, but by and large the longleaf forest was considered a nonrenewable resource to be mined like iron ore.

The railroad loggers swept across the longleaf belt from east to west. The intensity of the cut increased with the movement westward, reaching a crescendo in Louisiana. Few trees escaped the battering of the skidders. In the late 1920s it became apparent that the end was near. Only a few tracts of the 60 million-acre virgin forest remained. Many lumbermen closed down their mills and moved to the West Coast to log the virgin forests of Douglas-fir, ponderosa pine, and redwood. The finest hour of the longleaf pine had come to a close. Shocked silence replaced the din that had greeted the dawn of the twentieth century. Three decades of feverish activity had ground to a halt.

THE GREAT DEPRESSION

The Great Depression that plagued the nation in the thirties plumbed unusual depths in the land of the longleaf pine. Most of the big mills had cut out, and the operators had moved on. Banks and businesses dependent on them failed. Tax revenues for local governments dried up. Ghost towns, devoid of population, were tragic reminders of better days. The landscape had been drastically changed. The cool, green shadows of the virgin forest were only memories, and no longer did the resinous breezes sing through the tufted tree crowns. Instead, the refuse of logging lay bleaching in the sun on millions of acres. Except for stumps or occasional "mule tail" pines, the bare land was reminiscent of the western plains. Scrawny cattle picked at the coarse grass, and greedy razorbacks rooted out the remaining seedlings with gusto. Buzzards



FHS Collection

The Civilian Conservation Corps brought practical help to the depression-wracked South. Joining enrollees for a famous lunch at Big Meadows CCC Camp in Shenandoah National Park, Virginia, August 12, 1933, were (left to right) Major General Paul B. Malone; Louis M. Howe, secretary to the president; Interior Secretary Harold L. Ickes; CCC Director Robert Fechner; President Franklin D. Roosevelt; Agriculture Secretary Henry A. Wallace; and Assistant Secretary of Agriculture Rexford G. Tugwell.



U. S. Forest Service photo, FHS Collection

Reforestation was an important element of New Deal conservation work. Above: Loblolly pine seedbeds on the newly formed De Soto National Forest, Mississippi, 1937.

circled overhead and frequently feasted on the tick-infested carcasses of cows that had succumbed to the twin hazards of disease and starvation.

Suffering was most acute among the forest workers left behind after the mills cut out. Many squatted on tax-delinquent company lands, scratching out bare existences with small garden plots, submarginal farms, and scrawny livestock. Hard cash for medical care or other emergencies was nonexistent. Stunned and despondent, the people of the loblolly belt faced a grim future.

Into this dismal picture came a wilderness army of young men bringing renewed hope. The Civilian Conservation Corps, organized by President Franklin D. Roosevelt in 1933 for "conservation of our national and human resources," established many 200-man camps in the loblolly belt. Large tracts of cutover land were fenced against the destructive razorbacks, and millions of loblolly pine seedlings were planted. The young men built lookout towers and roads and waged a constant battle against the scourge of wildfire.

Much of the work was done on land purchased by the U. S. Forest Service from defunct lumber companies. New national forests were organized—the Croatan and Francis Marion in the Carolinas, three in Florida, two in Alabama, the De Soto in Mississippi, and two in Texas. The Kisatchie in Louisiana was greatly expanded. These forests would play a significant role in restoring loblolly pine on millions of acres.

Because of the rapidity with which the program was started, the CCC boys were first housed in tents. Later more permanent structures were erected. The U. S. Army was responsible for feeding, clothing, and caring for the men; state and national forestry agencies provided the work projects. Good food, clothing, and productive employment transformed undernourished, despondent youth into robust men with a new outlook on life. Many made careers of forestry and became key men in the forestry organizations.

The advent of the CCC had a salutary effect on the depressed economy of the loblolly belt. Many recruits came from local families without gainful employment. Each enrollee received \$30 per month, of which \$25 was sent home to his parents. Local men with forestry or logging experience served as straw bosses and foremen to supervise the green crews. These men were paid \$45 per month. Many World War I veterans who had been refused payment of their bonuses found employment in the CCC camps. Much of the payroll money, as well as funds for the purchase of supplies and equipment for the camps, found its way into the local economy. Cash registers began to ring again, and the outlook for the future became brighter.

But not everyone was happy with the CCC. The fire exclusion policy of the forestry agencies angered the cattlemen and sheepmen, who had been accustomed to burning the range annually to green up the grass for their livestock. Some old-timers were bitter at their former company employees and took out their resentment on the CCC boys. They set fires out of spite so the boys would have to work on Sundays and holidays. Sometimes the boys caught these old codgers in the act, and their supervisors had trouble keeping the crews from inflicting severe bodily harm to the firebugs.

A related problem involved trespass. Because of the lax policies of timberland owners, poverty-stricken squatters had been accustomed to cutting a few logs of merchantable size for crossties and other products from company lands without restriction. Such cutting was not tolerated on national forest lands, however, and the resulting prosecution of trespass cases created bitter enemies for the Forest Service.

The CCC movement was an important milestone in the loblolly pine story, but there was another depression-era development that was of equal, if not greater, importance. The battle between fire exclusionists and foresters who advocated use of fire for beneficial management purposes reached a showdown in the 1930s. The practice of prescribed burning, now generally used in many forest types throughout the United States, was first developed in the loblolly pine belt.

As early as 1850 Sir Charles Lyell noted that the hills near Tuscaloosa, Alabama, were covered with loblolly pine seedlings. He speculated that these resulted from Indian-set fires that kept the brush under control and favored the loblolly. In 1908 Herman H. Chapman, a Yale forestry professor and early advocate of controlled burning, wrote, "The most practical scheme for restocking loblolly pine appears to be to burn over the forest the fall preceeding the seed year, begin to burn as soon as the risk allows, due precaution taken to control the fire, and prevent damage to the young growth." Later, in 1926, his bulletin on regenerating loblolly pine recommended burn-



U. S. Forest Service photo, courtesy of the author

The role of fire in the longleaf pine belt was vigorously debated for several decades. In 1943 the Forest Service finally gave general approval for the practice of prescribed burning in the southern region. Above: A fire on the former Choctawhatchee National Forest, Florida, 1928.

ing for control of brownspot disease and hazard reduction, as well as for seedbed preparation. Others joined with Chapman in advocating the planned use of fire: Herbert L. Stoddard to improve the habitat for quail, Austin F. Cary and Inman F. Eldredge for hazard reduction, and many others.

The fire protection people, particularly the state foresters, bitterly opposed the practice. They felt that the promotion of controlled burning by foresters would undercut their fire prevention programs.

The practice was vehemently condemned by H. N. Wheeler, a Billy Sunday-type lecturer for fire prevention employed by the U. S. Forest Service. The tide began to swing in favor of prescribed burning, however, when research results in the 1930s supported the early proponents of the practice. Researchers with the Southern Forest Experiment Station confirmed that fire was a promising control measure for the brownspot dis-

ease, that seedbeds were greatly improved with fire, and that burning could be done without damage to the soil. S. W. Greene, an animal husbandman who conducted fire studies for the station at McNeil, Mississippi, proved that fire improved the range for cattle.

As a result of this mounting evidence, Region 8 of the Forest Service began a cautious program of prescribed burning. In 1935 Supervisor Arthur W. Hartman burned 900 acres on the Kisatchie; Supervisor L. L. Bishop put in two burns in Texas the same year; burns were also executed by Supervisor Raymond M. Conarro in Mississippi. Later, after a disastrous fire season, controlled burning for hazard reduction was started on national forests in Florida. All of these burns were pilot tests, and the practice was not approved for general use in the region by the Washington Office of the Forest Service until 1943.

In 1935 Herman H. Chapman, then president of the Society of American Foresters, arranged for the topic, "Forest Fire Control in the Coastal Plain Section of the South," to be discussed at the annual meeting. Among the speakers were S. W. Greene, Herbert L. Stoddard, Henry Hardtner, W. G. Wahlenberg, and "Cap" Eldredge. All of these men endorsed prescribed burning, and the session provided a great boost for the practice. Some state foresters became advocates of the planned use of fire and many others learned that it was a powerful management tool if carefully applied. The practice spread to other forest types throughout the nation from its beginning in the longleaf pine belt.

Acceptance of prescribed burning by foresters was a significant milestone in the longleaf pine story — one that argued well for the future of the species. Lack of fire, perhaps more than destructive fire, had prevented the establishment of longleaf pine on millions of acres. Fire exclusion had caused longleaf to be crowded out by brush or other pines not as resistant to fire as longleaf.

THE SECOND FOREST

Like the fabled phoenix bird, a second longleaf forest arose from the ashes of the virgin forest. It covered only a third of the original acreage and often was poorly stocked. Millions of acres remained in stump orchards with no hope for recovery until replanted in the CCC era. Some was direct-seeded in the 1950s after the discovery of a bird repellent. Much of the original acreage reverted to hardwoods and other pines, and, of course, much of the cutover went into agriculture and other uses.

Most of the second growth came back naturally, usually by accident but in some cases with an assist from man. Let's look at a few examples. "Red" Bateman, a practical woodsman with the Great Southern Lumber Company, helped secure

natural regeneration on several thousand acres around Bogalusa, Louisiana. Noting that a good stand of seedlings had been established under the virgin stands, he convinced top management to prohibit annual burning by turpentiners in order to protect this reproduction. When the virgin timber was clearcut, much of this reproduction survived and developed into well-stocked, second-growth stands.

The prescribed burning done by Supervisors Hartman and Bishop happened to come before a bumper seed crop in 1935. The excellent stands of second growth on the Red Dirt Pasture in Louisiana and in the Boykin Springs area in Texas owe their origin to these burns. Twelve years later a 50,000-acre seedbed burn before the bumper 1947 seed crop on the Conecuh National Forest in Alabama was likewise successful in establishing second-growth stands.

There is considerable evidence that many of the second-growth stands originated as "hurricane" timber. In 1906, for example, a disastrous hurricane felled much virgin timber in southern Alabama and Mississippi. Loggers moved in promptly and removed all downed as well as standing trees. Apparently there was advance reproduction under the older timber that sprang up to occupy the clearcuts. Undoubtedly some cattlemen's or turpentiners' fires accidentally prepared a seedbed for a bumper crop. If subsequent burning was delayed for a year or so and razorback hogs were absent, then some stands originated under these conditions.

These second-growth stands were far different from the virgin forests. Per-acre volumes were generally less; there were no large blocks of untouched stands ripe for the saw. Accordingly, logging technology in the South had changed. A significant development of the times was the advent of the automotive truck, and a new breed of loggers replaced the railroad loggers. Truck loggers moved into the scattered second-growth stands with "bob-tail" trucks to harvest the new crop. Mule teams replaced the steam skidders and loaders. Logs and poles were bunched and cross-hauled onto truck beds. Pulpwood sticks were loaded by hand. Felling and bucking was done with crosscut, bow, or wheel saws.

After World War II the truck loggers gradually developed improved technology. Man-day production was increased manifold by the introduction of chain saws, and these are now being replaced by the even more efficient tree shears. Slow-moving mule teams have disappeared from the woods, replaced by rubber-tired skidders and knuckleboom loaders. The "bob-tail" truck is rarely seen now, as much material is removed tree length. Mechanical harvesters have taken most of the hand labor out of pulpwood harvesting.

Truck logging, as now developed, makes the culture and regeneration of the longleaf forest entirely practical. But during the last decade

ominous trends, not related to truck logging, have appeared that threaten the future of the longleaf forests.

A PLACE IN THE SUN

In the 1960s a modern-day army of men and machines moved into the second-growth longleaf forests with singleness of purpose. Their objective: to clearcut the longleaf and replace it with other pine species. There is no hope of recovery from these operations. Every merchantable tree is cut and removed. Unmerchantable trees and logging residue are pushed into windrows and burned or crushed into the ground with hugh machines, such as the LeTourneau Tree Crusher. The area is then disked and a new stand of trees planted. Hundreds of thousands of acres of longleaf pine, many well stocked, have been treated in this manner, and the type conversion continues unabated.

Why are foresters prescribing such a dismal fate for a tree much admired and with such great inherent value? There are a number of reasons; perhaps two are of greatest importance. First is the difficulty of reproduction, and second is the slow juvenile growth of the species. Seed-tree methods of natural regeneration often have resulted in failure. Squirrels and other predators have gobbled up seed treated with the best-known repellents, and planted stands have died in the first spring drought. Even when a satisfactory stand has been established, the seedlings often remain in the grass for years and eventually are killed by brownspot or brush competition.

Foresters, particularly those employed by pulp companies concerned mainly with cellulose production on a short rotation, are unwilling to gamble on longleaf pine. Many are not familiar with the latest silvicultural knowledge. Is there no hope for longleaf pine? Will this magnificent tree disappear from the South as an important forest type by the end of the twentieth century? At the moment the picture is not bright. More than half of the 20 million-acre second forest is gone, and more acres are disappearing under the saw and plow daily. But there is still hope. Let's look at some of the favorable factors.

Years of research and pilot testing have developed regeneration methods that will work if applied by competent silviculturists. In the last twenty years a natural-regeneration method, based on a carefully applied shelterwood system, has proven far superior to seed-tree methods. Considerable judgment is needed in deciding where the method will work and in the proper application of the techniques.

Direct seeding has proven successful if good, treated seed is sown under suitable site conditions at the proper time. Failures usually can be traced to lack of attention to these basics. For example, seeding must be delayed until late February or



U. S. Forest Service photo, courtesy of Philip C. Wakeley

If longleaf pine is to have its "place in the sun," modern silvicultural treatments must be applied by committed and competent people. Historical examples offer guidance, too. Above: Red Bateman's first commercial longleaf plantation in 1931 — nine years from seed — on land of the Great Southern Lumber Company near Bogalusa, Louisiana.

March under some soil conditions to prevent frost damage. Under other conditions November seeding is best. Sometimes a burned seedbed is adequate; elsewhere mechanical soil preparation and coverage of the seed is essential. Many of the failures of direct seeding can be traced to poor-quality seed with low germinative energy.

Much of the failure in plantations of nursery stock is due to the use of submarginal stock on inadequately prepared seedling beds. The seedlings, moreover, are easily damaged in transit by careless handling or by long periods of storage after they are dug. Researchers have found that specifications used for years to determine usable stock are not rigid enough. High survival and vigorous growth have been attained in the last decade where planters have carefully applied all the new knowledge.

Current research has achieved two additional breakthroughs that promise to brighten the hopes for longleaf pine. Geneticists have discovered strains of longleaf that are resistant to the deadly brownspot disease and make remarkable height growth. And the use of mycorrhiza in nursery beds may revolutionize survival and growth. Containerized planting systems might also have special application to bypass the extreme danger of damage to seedlings in transit from nursery to plantation, if practical methods can be developed

for using such systems. If the best-known planting methods are used, good juvenile growth acceptable to pulp companies can be obtained. Longleaf may actually outproduce other pine species on the real sandy soils on a short rotation.

Perhaps the brightest hope for the future of longleaf pine lies with the landowners committed to multiple use and the production of larger wood products on a longer rotation. The species is particularly adapted to those interested in quail management and the production of high-quality poles. The open, parklike forests have special aesthetic appeal, and many people are emotionally attached to longleaf because of its historical background and associations. Where there is high risk from wildfire, longleaf fits the bill to reduce the chances of loss. It is also more resistant to insects and to diseases like fusiform rust than are alternate pine species. Ownerships suitable to the management of longleaf range from the large national forests to small private landholdings.

There are two prerequisites if a place in the sun is to be found for longleaf pine. Foresters and landowners must recognize those situations in which longleaf is the best species to meet their objectives, and they must act favorably on this knowledge. Secondly, modern silvicultural treatments must be carefully applied by competent people.

Is this too much to ask to insure a future for a magnificent tree that has contributed so much in the past to the southern economy and has such a great potential for the future? Certainly not! Before it is too late, let's hope that the dangerous trend of the present will be reversed and that, as long as trees grow and winds blow, the gentle breezes will ripple the crowns of the longleaf pine to create the sweetest music south of the Mason-Dixon line. □

There is a wealth of literature on the subject of longleaf pine. Technical literature includes W. G. Wahlenberg, *Longleaf Pine: Its Use, Ecology, Regeneration, Protection, Growth and Management* (Washington, D.C.: Charles Lathrop Pack Forestry Foundation and U. S. Forest Service, 1946), and Thomas C. Croker, Jr., and William D. Boyer, *Regenerating Longleaf Pine Naturally*, U. S. Forest Service, Research Paper SO-105 (New Orleans: Southern Forest Experiment Station, 1975). Contemporary sources on the prescribed-burning controversy include Herman H. Chapman, *Factors Determining Natural Reproduction of Longleaf Pine on Cut-over Lands in La-Salle Parish, Louisiana*, Yale University Bulletin 16 (New Haven, 1926), and papers given at the 1935 annual meeting of the Society of American Foresters, printed in the *Journal of Forestry* 33 (March 1935): 320-60. An example of a useful travel account is Frances Harper, ed., *The Travels of William Bartram* (New Haven: Yale University Press, 1958). There are many historical studies of lumbering in the South; one of the best is Nollie W. Hickman, *Mississippi Harvest: Lumbering in the Longleaf Pine Belt, 1840-1915* (University: University of Mississippi, 1962).

THE SHELTERWOOD SYSTEM FOR NATURAL REGENERATION OF LONGLEAF PINE

William D. Boyer^{1/}

Abstract.--The shelterwood system of natural regeneration has been tested on longleaf pine (*Pinus palustris* Mill.) for over 20 years. This system, with various modifications, has proved to be a reliable, inexpensive method for regenerating existing longleaf pine forests. The system is well-suited to longleaf's habits and needs and should be attractive to land-owners wishing to retain a natural forest and avoid the high costs of site preparation and planting.

INTRODUCTION

Longleaf pine is a versatile, high quality timber tree that provides sawtimber, poles and piling, plywood, posts, pulpwood and naval stores; even its needle litter is collected and sold. So longleaf has been widely exploited since colonial days. And the vast longleaf forests, once estimated to occupy as much as 60 million acres (Wahlenberg 1946) from southern Virginia to eastern Texas, have dwindled to less than 5 million acres today.

Longleaf pine is reputed to be slow-growing and exceptionally hard to regenerate. So, it cannot compete economically with loblolly or slash pines. Yet longleaf has many desirable attributes. In addition to its quality and versatility as a timber tree, it resists the more serious diseases and insects that attack other pines. It can also withstand burning regimes that would eliminate most other woody species.

But longleaf's reputation for slow growth may be unmerited. With adequate survival, growth on many sites will compare favorably with growth of loblolly and slash pine. Natural stands on medium sites (site index of 70 to 80 feet at age 50) can produce 1.2 to 1.5 cords of mean annual increment per acre to age 30, with 5-year periodic annual increments of 2 to 4 cords per acre between ages 20 and 30 (Farrar 1974). The observed growth of longleaf pine plantations on prepared sites also suggests that the species can grow as well as loblolly or slash pine under similar conditions.

Problems with regeneration may also prove to be less severe than once believed. After old growth longleaf had been logged, longleaf seedlings often rose from logging debris to create new forests. These second growth longleaf forests reoccupied millions of acres of cutover land without any intentional assistance from man. Such fortuitous regeneration still occurs today. Certainly if nature can regenerate longleaf, foresters should do at least as well.

^{1/}Principal Silviculturist, George W. Andrews Forestry Sciences Laboratory, Auburn, Alabama, maintained by the Southern Forest Experiment Station, Forest Service--USDA, in cooperation with Auburn University.

NATURAL REGENERATION PROBLEMS

The major problems of naturally regenerating longleaf pine include:

- (1) Poor seed production.--Good seed crops are few and far between. With only 5 to 10 seed trees per acre, land is out of production until a good seed crop produces a seedling stand. By then, hardwoods may have occupied the site.
- (2) Poor seedling establishment.--Few available seeds become established seedlings. Longleaf's large seeds attract many birds, mammals, and insects.
- (3) Poor seedling survival.--This problem is particularly acute during the seedlings' last year.
- (4) Slow seedling growth.--The grass-stage of longleaf pine may last from 3 years to more than 10. During this time, the land is essentially out of production.

The combination of these problems once suggested that natural regeneration in managed forests is fruitless despite nature's successes.

APPLYING THE SHELTERWOOD SYSTEM

Early observations of natural longleaf seedling establishment led to the hypothesis that a shelterwood system might be best for the species (Croker 1956) because the system seems to parallel successful regeneration in nature. Since these early observations, more than 20 years of research on longleaf regeneration has shown that the shelterwood system can indeed regenerate existing forests reliably and at low cost. With some modification, the shelterwood system applies to a broad range of site conditions and management goals. Areas so regenerated have ranged from large blocks (100 acres or more) to patches as small as 1/4 acre. Croker and Boyer (1975) and Boyer (1979) give regeneration guidelines.

Perhaps most important for successful regeneration is proper prescription and careful timing of needed operations and treatments. With a longleaf pine stand approaching harvest age, its regeneration by the shelterwood system would typically be applied as follows:

- (1) The preparatory cut.--This cut, the first in a three-cut shelterwood system, is for thinning and stand improvement, and leaves 60-70 square feet of basal area per acre of the best dominant-codominant trees. No more than one-third of stand basal area should be removed in one cut. Residuals can expand their crowns and occupy released growing space with minimum loss in volume growth. Small-crowned trees in a dense stand cannot respond rapidly to drastic release with either increased growth or cone production. A well-managed pine stand approaching harvest age in a sawlog rotation should not need a preparatory cut. Later, periodic prescribed fires should keep sprouts and shrubs

under control. If many small hardwood and shrub stems are present in the stand, several successive growing season fires before the preparatory cut should reduce this component. Otherwise, broadcast herbicides or mechanical treatments may eventually be required. Longleaf seedlings are particularly susceptible to competition, and understory hardwoods must be controlled before regeneration is established (Maple 1977).

(2) The seed cut.--This cut is made about 5 years ahead of the expected harvest date. The seed cut creates the shelterwood stand containing about 30 square feet of basal area per acre of the highest quality dominant trees. Per-acre seed production is highest under stand densities of 30 to 40 square feet, and falls off rapidly above and below these densities. In good seed years, a shelterwood stand will produce three times as many seeds per acre as a seed-tree stand averaging 10 square feet of basal area per acre. The regeneration area is not out of production during the wait for a good seed crop. Although the seed cut may halve stand density, per-acre volume growth is reduced only about one-third, and all new growth is on premium trees. Mortality is low in a shelterwood stand, averaging less than 1 percent annually. Increased seed production, stimulated by release, will show up 3 years after the cut. The shelterwood stand also produces enough needle litter to support hot prescribed fires for brush control and seedbed preparation.

(3) Monitor seed crops.--Within the regeneration area, locate representative trees for springtime sampling of flower (female strobili) and conelet production. Fifty sample trees will provide, on the average, confidence limits (95% level) of ± 7.5 conelets for a mean value of 20 conelets per tree. Binocular counts are made just before female flowers are hidden by new foliage (Croker 1971). The year-old conelets are also easily seen and counted at this time. Conelet counts can reliably predict not only cone production but also established seedlings, if the area has had a seedbed burn. Several shelterwood regeneration tests have shown that a stand needs an average of 735 mature cones per acre to get a stand of 6000 seedlings per acre at age 1. Cones per acre can be predicted not only from conelet counts on sample trees but also from percent of sample trees with one or more conelets. Eighty percent of sample trees with conelets is equivalent to 25 mature cones per tree. This value is a good criterion for regeneration success in most shelterwood stands. Counts of female flowers are of marginal value in predicting the size of fair-to-good cone crops but do reliably predict failures.

(4) Seedbed preparation.--If shrubs and hardwoods are under control before the seed cut, one needs only a prescribed burn to remove accumulated litter and expose mineral soil. The seedbed burn should be made during the year before a good seed crop. If a cone crop is predicted from spring conelet counts, the burn can only be made during the growing season before seedfall. The fire may destroy some existing grass-stage seedlings in the regeneration area, although the majority of those larger than 0.3-inch in root-collar diameter should survive. Probable losses to fire must be weighed against the number of seedlings expected from the coming crop.

(5) Regeneration surveys.--Surveys should be made every winter, when small grass-stage seedlings are most easily seen. These surveys will provide data on the number and distribution of established seedlings. The regeneration goal should be 6000 seedlings per acre at least one year old. This number will absorb logging losses of as much as half the stand and still leave enough survivors so that the superior 10 to 20 percent will supply about 500 trees per acre. The superior seedlings resist brown-spot needle blight and also grow rapidly. Slower-growing and diseased seedlings are expendable. The proportion of 1/4-milacre sample plots stocked with one or more seedlings will indicate the number of seedlings per acre (Boyer 1977). A 1/4-milacre stocking percent of 63 is equivalent to 6000 seedlings per acre.

(6) Overstory removal.--Once an adequate seedling stand is established, the overstory can be removed. Seedlings can survive overstory competition for a long time, and they respond to delayed release (Boyer 1975) if they are protected from fire while they are small. Harvest can be scheduled to meet management needs and market conditions. Overstory removal at seedling age 1 or 2 will have the least impact on the new stand (Maple 1977), but almost any time before dominant seedlings begin height growth should be satisfactory. Stemless grass-stage seedlings are less vulnerable to logging injury than those in height growth, and will often sprout from the root-collar if topkilled. If crop seedlings are large enough, a pre-harvest spring or summer burn may be desirable. Such a burn will impede hardwood encroachment.

(7) Post-harvest treatments.--Two or more years after overstory removal, control of invading hardwoods or brown-spot needle blight may require burning the seedling stand. The first fire must be delayed for at least 2 years after overstory removal because the fuel load from logging slash and residual litter might cause unacceptable damage to newly released seedlings. Need for a brown-spot burn should be based on a survey of crop seedlings only (Crocker 1967). Whether other seedlings are diseased is unimportant. Expected seedling mortality from these burns can be predicted from seedling size and the severity of brown-spot infection (Maple 1976).

RESULTS OF SHELTERWOOD TRIALS

The shelterwood system has been successfully applied in studies and operational tests on a wide variety of sites and locations in the Atlantic and Gulf Coastal Plains from North Carolina to Louisiana. Some trials began nearly 25 years ago. Of major concern is the length of time between the seed cut and a good seed crop resulting in acceptable regeneration. Shelterwood tests on the Escambia Experimental Forest in southwest Alabama have had successful regeneration on the average in 1 year out of 3. On all regional tests, successful regeneration has occurred in 1 year out of 5. Acceptable seedling stands established before the seed cut are not included in these averages. Usually, one good seed crop results in adequate regeneration but at times it is achieved through build-up in stocking from two or more successive small seed crops.

Results show that existing longleaf pine stands can be naturally regenerated at low cost and with a good chance of success if cultural prescriptions are properly timed and executed. Natural regeneration should be attractive to landowners who, because of financial considerations or management objectives, do not want to make the heavy capital investment required by intensive site preparation and planting. The habits and requirements of longleaf pine make it uniquely adaptable to a variety of management goals and silvicultural methods. This adaptability, in combination with longleaf's many desirable attributes, should win it a permanent place in southern forestry.

LITERATURE CITED

- Boyer, W.D. 1975. Timing overstory removal in longleaf pine. J. For. 73:578-580.
- Boyer, W.D. 1977. Stocking percent and seedlings per acre in naturally established longleaf pine. J. For. 75:500, 505-506.
- Boyer, W.D. 1979. Regenerating the natural longleaf forest. J. For. 77:572-575.
- Croker, T.C., Jr. 1956. Can the shelterwood method successfully regenerate longleaf pine? J. For. 54:258-260.
- Croker, T.C., Jr. 1967. Crop-seedling method for planning brown-spot burns in longleaf pine. J. For. 65:488.
- Croker, T.C., Jr. 1971. Binocular counts of longleaf pine strobili. U.S. Dep. Agric. For. Serv. Res. Note SO-127, 3p.
- Croker, T.C., Jr. and W.D. Boyer. 1975. Regenerating longleaf pine naturally. U.S. Dep. Agric. For. Serv. Res. Pao. SO-105, 21p.
- Farrar, R.M., Jr. 1974. Growth and yield of young longleaf pine. P. 276-287 In Proc. Symp. on Manage. of Young Pines. U.S. Dep. Agric. For. Serv., Southeast Area, State and Priv. For., Atlanta, Ga.
- Maple, W.R. 1976. How to estimate longleaf seedling mortality before control burns. J. For. 74:517-518.
- Maple, W.R. 1977. Planning longleaf pine regeneration cuttings for best seedling survival and growth. J. For. 75:25-27.
- Wahlenberg, W.G. 1946. Longleaf pine. Its use, ecology, regeneration, protection, growth, and management. 429p. Chas. Lathrop Pack For. Found. and U.S. Dep. Agric. For. Serv., Wash., D.C.

NATIONAL SILVICULTURE WORKSHOP
Charleston, South Carolina
September 17-21, 1979

SHELTERWOOD RESOURCE COORDINATION
(Trees and Grass)

By

JAMES W. EDGREN

Presented to the National Silviculture Workshop in Charleston, South Carolina, September 17-21, 1979, by James W. Edgren, Reforestation Specialist, Pacific Northwest Region.

Resource Coordination--I always wonder what the audience will be expecting when I read the title I am supposed to be addressing. In this case, I believe that the things I feel qualified to say will meet our mutual objectives, even though they may not be exactly what Carl had in mind when he coined the title.

My experience and knowledge relate primarily to the coordination of range--as in grass, grazing, and cows; with silviculture as in seedlings, logging, and lumber; but the main points I will make are equally valid for any set of resources. So while I use trees and grass in illustration, the points apply equally well to all situations where multiple uses must be coordinated. Also they apply whether we are talking about clearcutting or shelterwooding. For today, the vehicle will be trees and grass.

I have presented a different version of this talk to the cowboys in Range Management (while calling myself a timber beast) on two different occasions. I laid it on them, as they expected I would, from a silvicultural standpoint. The response was not exactly hostile, but not exactly warm and friendly, either. I tended to stress the ways we would like them to cooperate with us, and that slant was immediately evident to them. There was one nice thing about it--I got audience participation; they were interrupting each other to contribute.

Looking back on it, I guess that approach was a little one-way--silviculture--and that really was not my intended message. My message was then and is today one of communication, coordination, and cooperation from a total resource stance rather than from a narrow range or silviculture stance.

Before I tell you specifically what I am going to do here today, let me tell you what I am not going to do. I was asked to make this presentation visual. Carl, I am not going to do that. Slides are great when illustrating something noncontroversial, but usually a person can show exactly what he or she wants to show by pointing the camera in a specific direction. Someone else can show something entirely different by changing the shooting angle as little as 5 or 10 degrees.

Speakers at these conferences usually invoke data. I am not going to do that either, and I think it is very important that we understand why. I have at least 3 reasons. First, data of the type we must deal with on this subject are most always narrowly site specific. The set of variables chosen for or impinging on the test situation may or may not occur at the same level or in the same intensity anywhere else. Variables present may include any or all of the following: tree species, tree planting time, grass species, grass seeding times and rates, natural grass seed loads, animal species, animal use levels,

grazing rotations, site differences, soil types, and management objectives to mention a few. The possible combinations are nearly infinite. For instance, everyone in this audience has a different mental picture right now of a resource coordination situation he or she is familiar with. I cannot begin to deal with these mental images, even one-on-one. They must be dealt with individually on the ground where they occur.

Second, each group of participants has its own valid data. Silviculturists have data which shows that trees and grass are not compatible, particularly if you throw cows in with them. Range conservationists have data which show that trees, grass, and cows are compatible. This is a perennial confrontation which will always exist because each group can talk about a specific situation where what they say is absolutely true.

Third, resource coordination--range and silviculture--is not really a technical subject, it is a political subject. For example, a representative Forest Supervisor has been known to say: "All disturbed soil on this Forest will be sown to grass," or words to that effect, manual direction notwithstanding. Supervisors feel local pressures some of the rest of us may not fully understand. They want scars on the

landscape healed quickly and many of them have grazing allotments on their Forest. A little grass goes along way to meet the needs of local forest users and makes life easier. Data never won this type of an argument. For instance, it surely is not winning the pesticide argument.

We have asked ourselves in Region 6: "Do we really have a problem on this issue? Do we really need to reeducate our range and forest practitioners on the subject of trees and grass?" And when we look at the evidence, the answer is: "Well, yes and no." Yes, we have clearly stated policy in our respective range and silviculture manuals and handbooks; no, we are not always following that policy on the ground. The policy is based on data, the practice is based on politics. Yes, our people seem to understand the competitive forces operating between trees and grass--data; no, they do not always let this knowledge influence them--politics. So we conclude yes, we do have a problem; yes we do need more education, but it is not data type education.

So what kind of education do we need and what am I going to do today? I will identify several factors that I think are most important in securing resource coordination between silviculture and range. You will notice that my points tend to concentrate on the stand regeneration period.

COMMUNICATION-COORDINATION-COOPERATION

To achieve resource coordination we must work together. We must remember that timber management does not equal forest management. Using timber and range as an example, we must approach our jobs from a resource standpoint and think trees and grass rather than trees versus grass. We must involve other resource specialists in the planning and prescribing stages.

Before coming here, I visited our Range Management section in Region 6 and talked to Clarence Alman and Lou Spink about communication between range and silviculture resource specialists. I asked them what we in silviculture could do to improve coordination of the management of our respective resources. I expected them to give me suggestions like: "Make timber sale and range allotment boundaries coincide," but they did not. They gave me back the same things I had given them last February: Communicate-coordinate-cooperate.

Clarence stressed getting specialists together on the ground and initiating the effort one's self rather than waiting for the other guy to do it. Lou cautioned against an "I know it all" attitude, and I know we sometimes project that impression--speaking for myself, that is.

You may say: "So what's new? We already know this." I agree, but we see much evidence in Region 6 that we are acting as though we do not know this. At least, I believe we are not practicing resource coordination as well as we know how. Part of the reason is that we are not working together. We are not communicating adequately.

VEGETATIVE COMPETITION

We hear frequently in Region 6 that trees and grass do not compete because their roots occupy different strata of the soil. That may be true after tree seedling establishment, but surely is not true immediately following surface disturbance when each is attempting to get started. Also, I believe there is some confusion about how competition hurts us. Trees in areas susceptible to summer drought are particularly vulnerable. We have all seen live trees in dense stands of grass--alive but not growing to the potential of the site.

We must begin to assess success in terms of growth, not of survival. This point becomes particularly critical when we think in terms of controlling tree overstocking with grass competition. Grass competition will rarely, if ever, be an answer to overstocking of tree seedlings--tree growth suffers too much.

Shelterwoods provide a unique silviculture-range coordination problem because cutting releases competing vegetation already established and site preparation and vegetation management is always more difficult than in a clearcutting context. Also, the competition from understory vegetation will be more critical under shelterwood because the residual overstory adds to the moisture problem.

Cows and sheep have been proposed and used as site preparation agents in such situations and I am not prepared to pass on their appropriateness without examining the individual situations. However, I am prepared to caution that the method will not work without careful management of grazing herds. I have not often seen such management in Region 6.

In short, when we are discussing resource coordination with range conservationsits on acres that will be rehabilitated with K-V funds, we must be sure that grass competition with tree seedlings is held to a minimum. Our mannual direction says K-V funds can be used for such things as grass sowing if the proposed use is compatible with wood production.

TREE SEEDLING ESTABLISHMENT

The tree seedling establishment period is the critical time in timber stand regeneration. Competing vegetation must be controlled during this time as must grazing and wildlife damage. This is one area where I feel silviculturists cannot trade off. We must have control of the timber site during the seedling establishment period--from final removal until the new stand is certified established.

This is a relatively short period in the life of a timber stand--3 to 5 percent of a rotation in most northwest forests. If we do not get control at this time, I predict all resources will have a less than satisfactory situation later.

The control I speak of relates to sowing of grass seed on forested range allotments and the grazing of cows and sheep on said grass. According to Region 6 manual directions, grass can be sown on timber sites only for erosion control. We must get the lowest sowing rates practicable of species with low competitive strength--a species we can practice effective site preparation on if we fail in the initial reforestation effort. For instance, strong, sod forming rhizomatous grass must be avoided during the tree seedling establishment period. Annual bunch grasses are more compatible with timber production. Also, grass sown areas are attractive to some of the wild animals which plague us most--elk, gophers, and mice for example.

Grazing can and must be controlled during this period by fencing, salting, watering, herding, or whatever methods provide the best control. The key is herd management in place of nonmanagement, particularly with sheep. I believe animal damage can be avoided on many areas if better management is practiced. I am not speaking of exclusion, but rather of management.

After the establishment period--95 percent of a rotation--trees, cows, and grass are usually compatible. Grass can be sown and cows permitted each time a stand is entered silviculturally. If a thinning is made, sow grass in disturbed areas. Our vegetation specialist in Region 6, Lou Spink, reminds me that 80 percent of the Regions livestock and wildlife food and cover comes from transitory range--range that will eventually become timbered. We must encourage range conservationists to make the best possible use of this resource.

SILVICULTURAL PRESCRIPTIONS

The working silviculture document on the ground in all areas where timber is the primary resource and where land use plans and EAR's call for the forest to be regenerated must be the silvicultural prescription. That document is a silviculture responsibility, but it frequently will need other resource inputs to help assure that prescription elements will be correct and will be carried out. Therefore, we must coordinate with other resource specialists before the timber is cut. Several points relating to trees, cows, and grass seeding come to mind:

1. What is the potential for soil erosion on the area in question? If, in the opinion of a soils expert, the probability of erosion is low grass must not be sown until seedlings are established.

2. If the soil is erodible, what is the native grass seed load on the area? If the native grass load is heavy enough to bind the soil against erosion, grass must not be sown until seedlings are established.

3. If grass must be sown to prevent excessive soil movement, a nonnative grass of low competitive potential must be used that can be effectively dealt with by site preparation.

4. If grass must be sown, sowing rates must be calculated to prevent erosion, not to feed cows.

5. If grass must be sown where a potential for competition exists, trees must be planted in advance to permit them to become established ahead of the grass.

6. If the sale area is within a grazing allotment, a grazing rotation plan must be formulated to keep cows off newly planted acres.

Prescriptions could also contain plans, or at least reference plans made by other resource specialists, for control of grazing and for enhancement of range values up to the time stands close and grass begins to disappear. Items much as these must be spelled out or they will not happen, and they must be in a place everyone recognizes and knows about or they will not be monitored. If 80 percent of our range animal and wildlife food and cover comes during the early life of timber stands, we must make grass and trees get along together--we have no choice. It will not happen accidentally and the silvicultural prescription is the place to record the plans.

Resource coordination includes many resources I have not covered well individually--for instance, soils, water, wildlife, recreation, and visuals. I do not see the coordination problems as being much different from silviculture and range. We must simply remember that timber is not top dog any longer, and that communication-coordination-cooperation is the key.

We cannot prescribe for silviculture in a vacuum and expect things to coordinate. That is pretty much what we have been doing in the past. I am sure we can all realize more from our respective resources if we work together.

We believe the following ingredients are essential to a comprehensive management effort which must coordinate the uses expected of most National Forest acres: (1) An approved Land Use Plan for the Forest which clearly spells out management objectives relative to multiple uses, (2) interdisciplinary cooperation and professional input at the District level from certified silviculturists and qualified soils, water, range, wildlife, and recreation specialists suggesting management alternatives to meet these objectives, and (3) objective assessment of trade offs and weighing of management alternatives by line officers to select those management practices which maximize benefits of multiple use sustained yield management in accordance with Land Management Plans and Federal laws.

National Silvicultural Workshop
CHARLESTON, SOUTH CAROLINA SEPTEMBER 17-21, 1979

SHELTERWOOD CUTTINGS IN CALIFORNIA AND OREGON
Douglass F. Roy
Pacific Southwest Forest and Range Experiment Station
Redding, California

The shelterwood regeneration method and its objectives, ecological aspects, and economics have been described in previous papers. This presentation deals with specific shelterwood trials in California and Oregon. These were located on the Challenge Experimental Forest and Swain Mountain Experimental Forest in California and on the Pringle Falls Experimental Forest and on the Deschutes and Winema National Forests in Oregon.

Challenge Experimental Forest

The first example was located on the Challenge Experimental Forest which lies on the lower western slope of the Sierra Nevada and is located about 140 miles northeast of San Francisco. Elevations on the Forest range from 2,400 to 3,700 feet. Soils have been described as 30 to 100 feet deep, mean annual precipitation averages 68 inches, and the mean annual temperature is 60° F. These characteristics create high site quality.

Ponderosa pine (Pinus ponderosa Laws.), the dominant species, averages 140 feet in height at 100 years, and trees 170 feet tall at the same age are not uncommon. Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) is the second most abundant conifer. Present in lesser amounts are white fir (Abies concolor (Gord. & Glend.) Lindl.), sugar pine (Pinus lambertiana Dougl.), and incense-cedar (Libocedrus decurrens Torr.). Hardwoods, principally California black oak (Quercus kelloggii Newb.), tanoak (Lithocarpus densiflorus (Hook. & Arn.) Rehd.), and Pacific madrone (Arbutus menziesii Pursh) are scattered throughout the stands as individual trees, clumps, or groves.

Timber on the Experimental Forest is even-aged young-growth and was about 100 years old when shelterwood cuttings were established. Conifers and hardwoods larger than 3.5 inches diameter at breast height numbered 269 per acre and aggregated 270 square feet of basal area. Stand volumes of trees larger than 12 inches averaged slightly under 54,000 board feet per acre, Scribner Rule.

Four 6-acre rectangular plots with eastern aspects and slopes of 15 percent or less constituted the shelterwood cutting study area. Preparatory cuts were unnecessary. Each compartment was cut to form the seed-stage of shelterwood stands, consisting of 12 large, thrifty, full-crowned conifer trees per acre which were spaced evenly throughout each plot. A consideration in choosing shelterwood trees was evidence that the trees had been good cone producers in the past.

The seed-cut removed 68 percent of the conifer stand's basal area, 70 percent of the merchantable volume, and about 38,000 board feet per acre. On the average, the 12-tree conifer shelterwood stand consisted of 7 ponderosa pine, 2 Douglas-fir, 2 sugar pine, and 1 white fir per acre. These trees contained 16,000 board feet per acre and 88 square feet of basal area. The average shelterwood stand also included two California black oaks and two tanoaks per acre (table 1).

Because slash volumes are high, sometimes reaching 110 tons per acre, and hardwood sprouts and brush populations are aggressive after logging, slash disposal and site-preparation are necessary. Consequently, three methods of site preparation and slash disposal were tested on equal acreages in each plot. These were:

- Slash was piled with a bulldozer immediately after logging and burned in the following winter.
- Slash piling was delayed until late summer of a good seed year. Slash piles were burned as soon as weather conditions permitted.
- Tops were lopped and branches were handscattered.

In the piling process, much mineral soil is exposed. Delaying slash disposal until just before seedfall provides fresh, loose mineral soil seedbeds. Top-lop and hand-scattering of branches bares no soil in addition to that already exposed in the logging operation.

During the 3 years after logging, the shelterwood stands produced over 320,000 conifer seeds per acre, which was 50 percent more seed than produced by an adjacent uncut timber stand (table 2).

Table 1--Composite stand table for shelterwood areas before logging
and for shelterwood stands, Challenge Experimental Forest

	Original stand--Trees with diameters at breast height:				Shelterwood stands	
Species	3.5-12 inches		Over 12 inches			
	TPA ^{1/}	Pct.	TPA	Pct.	TPA	Pct.
Ponderosa Pine	8	6	37	55	7	58
Douglas-fir	46	36	18	27	2	17
Sugar pine	2	1	4	6	2	17
White Fir	9	7	3	5	1	8
Incense-cedar	64	50	5	7	0	0
All conifers	129	100	67	100	12	100
California black oak	9	14	5	50	2	50
Tanoak	14	22	4	40	2	50
Pacific madrone	40	64	1	10	0	0
All hardwoods	63	100	10	100	4	100
All species	192		77		16	

^{1/} Trees per acre.

Table 2--Estimated sound seeds produced by shelterwoods and an adjacent uncut timber stand, Challenge Experimental Forest

Seed crop number and tree species	Shelterwoods	Adjacent uncut timber
--number of seeds per acre--		
1st Crop after cutting:		
Ponderosa pine	1,540	2,730
Douglas-fir	29,000	11,200
White fir	7,215	0
2nd Crop after cutting:		
Ponderosa pine	350	0
3rd Crop after cutting:		
Ponderosa pine	144,970	113,750
Sugar pine	35,905	645
Douglas-fir	95,920	85,100
White fir	5,920	555
Three year total	320,450	213,980
4th Crop after cutting:		
Douglas-fir	2,100	2,000
5th Crop after cutting:		
Ponderosa pine	840	210
Sugar pine	1,398	0
Douglas-fir	31,200	21,000
White fir	9,250	93
Five year total	365,238	237,283

Initial stocking of ponderosa pine seedlings was almost the same for all three slash disposal methods. Two years later, however, ponderosa pine seedling stocking was significantly less where slash was treated by the top-lop and hand-scatter method. Areas where slash piling was delayed until a good seed crop was apparent had more young ponderosa pine seedlings, but differences between them and the pile-after-logging slash treatments were not significant.

Five years after cutting, the shelterwood areas were overstocked with seedlings. Over 80 percent of milacres sampled were stocked, and seedlings per acre numbered more than 5,000. Of these, 86 percent were ponderosa pine (table 3).

We can compare regeneration from the shelterwood cuttings with results from four other methods of cutting. At 9 years after cutting, the shelterwoods had almost twice the number of seedlings produced by seedtree or group selection cuttings, and three times the number of seedlings produced on artificially seeded clearcuttings (table 4). The shelterwood cuttings also stocked more milacres than other cutting methods, although stocking was excellent for group selection, seedtree, and clearcut units (table 5).

Height growth of seedlings under the shelterwoods was better than in single-tree selection and group selection openings, but poor compared to seedtree cuttings and clearcuttings (table 6).

The shelterwood stands should be mentioned again. Before removal, losses were minimal. Of the total 192 overstory conifers, only 3 were lost in 5 years. Finally, the shelterwood overstory was cut in its tenth year when removal was long overdue. Logging was completed with acceptable damage to seedlings. Later, the young stand was thinned.

Obviously, the shelterwood method of cutting can be used to regenerate the Pacific ponderosa pine timber type. If used, plans should call for shelterwood removal by the third year, and certainly before the fifth year. Plans also should provide for an early precommercial thinning of the seedling stand.

Swain Mountain Experimental Forest

The second group of shelterwood cuttings are on the Swain Mountain Experimental Forest, 194 miles north-northeast of San Francisco and 10 miles north of Lake Almanor. Swain Mountain, a volcanic cone, rises from 5,700 feet to 7,054 feet elevation, and is located on the southern limit of the Cascade Range. Soils are derived from vesicular andesite, and generally are 3 to 8 feet deep.

Table 3--Milacre stocking and seedling density 5 years after shelterwood seed-step cuttings, Challenge Experimental Forest

Species	Milacre Stocking	Seedling Density	Species Composition
	percent	number per acre	percent
Ponderosa pine	76	4,495	86
Sugar pine	8	120	2
Douglas-fir	3	25	<u>1</u> /
White fir	7	85	2
Incense-cedar	11	500	10
Totals		5,225	100

1/ Less than 0.5 percent.

Table 4--Densities of 9-year-old seedlings by cutting methods and species,
Challenge Experimental Forest

Cutting Method	Species					
	P.P. ^{1/}	S.P.	D.F.	W.F.	I.C.	ALL
	--number of seedlings--					
Single-tree selection	860	111	308	400	44	1,723
Group selection	1,500	185	134	565	16	2,400
Shelterwood	3,620	240	80	192	470	4,602
Seedtree	2,100	75	174	66	67	2,482
Clearcutting	1,115	51	157	166	---	1,489

^{1/} Symbols indicate species as follows: P.P.--ponderosa pine, S.P.--sugar pine, D.F.--Douglas-fir, W.F.--white fir, and I.C.--incense-cedar.

Table 5--Stocking of 9-year-old seedlings by cutting methods and species, Challenge Experimental Forest

Cutting Method	Species				
	P.P. ^{1/}	S.P.	D.F.	W.F.	I.C.
	--percent of milacres stocked--				
Single-tree selection	23	10	11	22	4
Group selection	44	10	6	22	1
Shelterwood	59	8	4	7	8
Seedtree	61	4	5	5	5
Clearcutting	42	5	4	4	-

^{1/} Symbols indicate species as follows: P.P.--ponderosa pine, S.P.--sugar pine, D.F.--Douglas-fir, W.F.--white fir, and I.C.--incense-cedar.

Table 6--Height of 9-year-old seedlings by cutting methods and species, Challenge Experimental Forest

Cutting Method	Species				
	P.P. ^{1/}	S.P.	D.F.	W.F.	I.C.
	--height in feet--				
Single-tree selection	.5	1.0	.7	1.4	.9
Group selection	1.0	1.5	1.5	1.5	.9
Shelterwood	2.7	2.6	2.1	2.9	1.9
Seedtree	3.7	3.4	3.1	3.7	2.7
Clearcutting	6.2	5.5	4.2	4.0	---

^{1/} Symbols indicate species as follows: P.P.--ponderosa pine, S.P.--sugar pine, D.F.--Douglas-fir, W.F.--white fir, and I.C.--incense-cedar.

Most precipitation falls as snow. Maximum snow depths range between 8 and 10 feet. Summers are dry except for occasional thunder showers. Normal yearly water equivalents vary from 40 to 50 inches.

Essentially, the forest cover is pure fir, with white fir predominating at lower elevations. As elevations increase, the California red fir (*Abies magnifica* A. Murr.) component increases until it becomes the exclusive species near the top of Swain Mountain.

Stand structures vary. Dense mature and overmature stands carry volumes over 147,000 board feet per acre (Scribner), and have no understories. Stands with volumes of 60,000 to 80,000 board feet per acre are more prevalent, and often have abundant fir understories. Most of the Experimental Forest is classed as Site Index₁₀₀ 150, which is equivalent to Site Index₁₀₀ 100.

Slopes are gentle on the Swain Mountain Experimental Forest. Slopes from 0 to 5 percent cover 17 percent of the area. Slopes from 6 to 15 percent occupy 73 percent of the ground, and slopes from 16 to 20 percent occupy 9 percent. Only 1 percent of the Experimental Forest has slopes over 20 percent.

Most early regeneration cuttings in true fir stands in California were patterned after large Douglas-fir clearcuttings in the Pacific Northwest. They were failures and stimulated the beginning of research at Swain Mountain. The first generation of trials in 1958-1960 concentrated on clearcut blocks of moderate size and clearcut strips 3 and 5 chains wide oriented perpendicular to prevailing winds. Regeneration obtained on blocks was less than adequate, but clearcutting strips proved successful.

Cone production by mature and immature California red fir and white fir trees was counted for 16 years. All trees in the study were dominants. The mature trees were 150 years or older, ranging from 32 to 55 inches in diameter at breast height, and from 160 to 205 feet in height. The immature trees were between 75 and 150 years old, from 33 to 45 inches in diameter, and from 145 to 192 feet tall.

Cone crops were variable. The study identified a threshold for number of cones per tree above which establishment of regeneration is reliable. At Swain Mountain the threshold is about 45. Both white fir and California red fir reached the 45-cone level 7 out of 16 years, but they reached the threshold together in only 5 years. Therefore, effective cone crops of one species or the other, or both, were reached in 9 years of 16, or 56 percent of the years.

Individual California red fir trees are erratic in the number of cones produced in cone crops, but individual white fir trees tend to produce cones on a consistent level--abundant, an average number, or few--whenever there is a cone crop. Trees released at edges of clearcuttings increased cone production significantly. White fir cone crops were increased by factors of 1.5 to 6.7, and California red fir cone crops increased up to a factor of 2.0.

Fir seeds are dispersed a practical maximum of 1 to 1½ tree lengths to leeward of trees. For Swain Mountain, this is a distance of 200 to 260 feet. Seed dispersal to windward of trees generally is limited to 35 feet.

White fir and California red fir seed germinate almost anywhere, including in, on, or under snow packs. Seeds that germinate in or on the snow do not produce seedlings unless the radicles reach mineral soil before growing a significant amount. Therefore, for seeds to be effective, they must be shed before the first permanent snow pack in the fall. Ideal conditions for natural seeding effectiveness would be a late dry fall with periodic strong winds. Bare, loose mineral soil is the best seedbed.

Considering the findings described, 30 shelterwood cuttings on the Swain Mountain Experimental Forest were created to test three shelterwood densities of 10, 20, and 30 trees per acre. Shelterwood trees were selected carefully for spacing and for the following characteristics:

1. Dominant (first choice) or codominant.
2. Sound, pointed tops.
3. No evidence of mechanical defects (rot, firescars, or dwarf-mistletoe cankers).
4. Probable strong and symmetrical root systems (indicated by the size of area occupied by the tree. A tree growing close to another was not selected.).

The tree selections for the shelterwoods were well-tested during the 1978-1979 winter. In the spring of 1979, a volume of about 500,000 board feet was salvaged from trees which had blown down within 200 feet of roads. However, only 20 out of 3,000 shelterwood trees were lost. These trees, less than 0.7 percent of the trees in shelterwood stands, were destroyed as a result of undetected heart rot or root rot.

The quality of logging in shelterwood stands was excellent. In this regard, part of a contract clause is worth quoting:

Serious damage to a "save" tree is defined as (1) cone-producing portion of tree top knocked out, or (2) destruction of an estimated one-third or more of the live crown, or (3) any Purchaser caused lean, or loosening of root system, or (4) any other condition which may reduce the seed producing capacity of a tree within a period of 10 years.

If destruction, serious damage, or cutting occurs to "save" trees, Purchaser shall cease felling in the specific Cutting Area and notify Forest Service. Forest Service will then select an alternate "save" tree and notify Purchaser of this action in writing. Upon receipt of written notice Purchaser may resume felling in Cutting Area in which damage occurred.

The terms of this clause were not employed during the logging operation--a tribute to careful logging by the Purchaser.

After logging, slash was piled outside the square 0.4 acre permanent sample plots.

Basal areas for the shelterwoods with 10 trees per acre, averaged 97 square feet per acre. For the shelterwoods with 20 trees per acre, basal areas averaged 173 square feet per acre, and for the shelterwoods with 30 trees per acre, shelterwoods, basal areas averaged 241 square feet per acre. On the average, 84 to 91 percent of basal areas were in California red fir (table 7).

Average volumes for the 10, 20, and 30 trees per acre shelterwoods were 31.88, 56.34, and 75.47 thousand board feet per acre, respectively (table 8).

In 1978, 6 to 8 years after the seed-step cutting, all 30 shelterwood areas were sampled to determine seedling numbers, species, ages, sizes, and conditions. Sampling showed that all three shelterwood densities were equally successful in producing more seedlings than desired. Although stocking in 1978 ranged from 6,500 to 25,700 seedlings per acre, no differences were significant statistically. And the densities of the shelterwoods did not affect seedling height growth. This result is not surprising, because early height growth of true firs is slow.

The California Forest Practices Act requires that harvested lands meet minimum stocking standards 5 years after logging. These standards can be met by minimum basal areas for partially cut timber stands, or by tree counts of 300 healthy crop trees per acre where: a seedling 2-years-old, or older, counts one; a tree 4 to 12 inches in diameter at breast height counts 3; and a tree over 12 inches in diameter at breast height counts 6.

Table 7--Basal areas by species in shelterwoods, Swain Mountain

Experimental Forest

Trees per acre in shelterwood	Basal areas				
	White fir		California red fir		Total
	sq. ft.	percent	sq. ft.	percent	sq. ft.
10	9.97	10.3	87.13	89.7	97.10
20	26.11	15.1	147.31	84.9	173.42
30	23.90	9.9	216.65	90.1	240.55

Table 8--Volumes by species in shelterwoods, Swain Mountain

Experimental Forest

Trees per acre in shelterwood	Volumes				
	White Fir		California red fir		Total
	m.b.f.	percent	m.b.f.	percent	m.b.f.
10	3.36	10.5	28.52	89.5	31.88
20	8.38	14.9	47.96	85.1	56.34
30	7.61	10.1	67.86	89.9	75.47

By the third year after cutting, all areas with 10 and 20 trees per acre equalled or exceeded the seedling level required by the California Forest Practices Act. And on areas with 30 trees per acre, 89 percent reached that level in the third year, and all had achieved it by the fourth year after logging.

Of the seedlings that existed 6 to 8 years after cutting, few originated in the spring following harvesting. The proportion of seedlings that began growing in the second year after cutting is much higher, and the proportions continue high through the fifth year after logging. When size of cone crops and numbers of seedlings were compared, no relationships were found. The conclusion is: seedlings that survive begin growth between the second and fifth year following cutting regardless of cone crop size, within reasonable limits. One speculation is that seedbeds are not in a condition conducive to long-term survival of seedlings, although conditions improve with time.

The shelterwood overstories will be removed in 1980. Seedlings still will be small enough to be poor targets for dwarfmistletoe infection, and they still will be pliable enough to resist damage in the felling and yarding operations. Logging on snow is planned as part of a shelterwood removal study, but shelterwoods will not be logged during freezing weather when the stems of seedlings may be brittle, nor in the spring when terminals and cambiums are tender and are easily damaged.

Pringle Falls Experimental Forest

The third shelterwood trial is an exploratory study in ponderosa pine, east of the Cascades in central Oregon. The timber stand is located on the Lookout Mountain Unit of the Pringle Falls Experimental Forest 35 miles southwest of Bend. The slope is gentle and faces the east, and the elevation is about 4,700 feet. The plant community is ponderosa pine/snowbrush, in a white fir/snowbrush climax association. In the study area, snowbrush ceanothus (Ceanothus velutinus Dougl.) predominates with an occasional golden chinkapin (Castanopsis chrysophylla (Dougl.) A. DC.), and western prince's pine (Chimaphila umbellata (L.) Barton), a low-growing plant, is abundant.

The soil is a 3 to 4 feet deep mantle of Mount Mazama pumice overlying a sandy loam Paleosol developed in older volcanic ash. The annual precipitation generally is between 25 and 35 inches.

In 1970, when 126 years old, the stand averaged 166 trees per acre, 16.4 inches in diameter, and 104 feet tall. Basal area was 238 square feet per acre, and volumes were 9,260 cubic feet and 62,520 board feet (International 1/8-inch scale, trees 6.6 inches in d.b.h. and larger to a 6-inch top d.i.b.) per acre.

A 40-acre exploratory shelterwood cutting was established 4 years later, in 1974, when the stand was 130 years old. The shelterwood density varied gradually from 10 trees per acre on one side of the block to 50 trees per acre on the other side.

Data have not been collected yet, but informal observations lead to several tentative conclusions. For example, some regeneration has become established since the 1974 seed crop. At least three age classes of seedlings are represented throughout the area. Regeneration is spotty where only 10 trees were left per acre, but is more uniform where shelterwood trees are denser. And more seedlings exist where soil disturbance and mixing of the seed with soil was greatest.

Seedlings under the shelterwood of only 10 trees per acre are taller and more fully crowned than seedlings under the denser parts of the shelterwood. Eventually, brush may become a serious deterrent to development of seedlings.

Some seedlings might be lost when the light shelterwood overstory is logged, but much more reproduction could be lost by slash disposal treatments such as machine-piling slash in the spring when seedlings have tender cambiums. Inadequate surviving regeneration is anticipated where 50 shelterwood trees per acre will be harvested.

Obviously, a shelterwood in ponderosa pine provides a source of seed, but site amelioration, by providing frost protection and shade, seems of little benefit in this timber type.

Deschutes and Winema National Forests

The last examples of shelterwood cuttings are in the mixed-conifer forest type of the eastern Cascade Range in the Deschutes and Winema National Forests. Study plots were located within 30 shelterwood cuttings in a high elevation hemlock/grouse huckleberry community (hemlock), and within 45 shelterwood cuttings in a lower elevation mixed-conifer/snowbrush-chinkapin plant community (mixed conifer).

Plots were on the pumice plateau of south-central Oregon where soils are immature Regosols (Vitrandepts) developed from dacite and rhyolitic pumice ejected from Mount Mazama about 6,500 years ago. (The collapse of Mount Mazama formed Crater Lake.) These coarse-textured, well-drained soils have thin A horizons, and are low in fertility. An underlying finer-textured soil is found 2 to 6 feet below the ground surface.

Logging between 1970 and 1973 formed the shelterwood stands. Regeneration was sampled in 1978. Plots in the hemlock community ranged from 5,200 to 6,400 feet in elevation. Plots in the mixed conifer community were 4,150 to 5,800 feet in elevation (table 9).

Characteristics of the hemlock community shelterwoods were 11 to 34 trees per acre, 20 to 186 square feet in basal areas, and 15 to 53 percent in crown closures (table 9). Species composition was 51 percent mountain hemlock (Tsuga mertensiana (Bong.) Carr.), 35 percent Shasta red fir (Abies magnifica var. shastensis Lemm.), 6 percent grand fir (Abies grandis (Dougl.) Lindl.), 5 percent western white pine (Pinus monticola Dougl.), and a few Engelmann spruce (Picea engelmannii (Parry) Engelm.), lodgepole pine (Pinus contorta var. murrayana (Grev. and Balf.) Engelm.), and Douglas-fir.

The mixed conifer shelterwoods have 6 to 46 trees per acre, 16 to 183 square feet of basal areas per acre, and 8 to 75 percent crown closures (table 9). The three dominant species were grand fir (52 percent), Douglas-fir (23 percent) and Shasta red fir (17 percent). About 5 percent of the overstory was ponderosa pine. A few lodgepole pines, white firs, and Engelmann spruces also were present.

In 69 shelterwood units, slash was piled by tractors and burned after the seed-cut. Slash was not treated in six units. In 1978, non-coniferous understory vegetation in the shelterwood units was scanty. The slow invasion of understory vegetation, heavy seedcrops produced every 3 or 4 years, and the uniform distribution of shelterwood trees produced abundant natural regeneration in most units.

Generally, shelterwood units were well-stocked with a mixture of advance and new natural regeneration, and planted trees. Seedlings established after the seed cutting numbered more than 4,000 in the hemlock community and more than 2,600 per acre in the mixed conifer community. An average of 63 percent of milacre quadrats were stocked in both plant communities (table 10). Seedlings from all origins averaged 4,483 per acre in the hemlock community, and 2,968 in the mixed conifer community (table 11).

Table 9--Characteristics of shelterwoods, Deschutes and Winema National Forests, eastern

Cascade Range, Oregon

Characteristics	Plant Community			
	Hemlock		Mixed Conifer	
	Mean	Range	Mean	Range
Elevation--feet	5,718	5,200-6,400	5,111	4,150-5,800
Slope--percent	5.0	0-25	3.4	0-19
Time since cutting--years	7.0	5-8	6.1	5-8
<u>Shelterwood overstory</u>				
Trees per acre--number	20.0	11-34	19.0	6-46
Average tree diameter-- inches	25.4	15.3-37.2	26.5	18.1-38.2
Basal area--square feet	65.7	20-186	68.0	16-183
Crown closure--percent	30.1	15-53	32.1	8-75
<u>Ground surface conditions--Coverage</u>				
Mineral soil--percent	16.3	0-37	22.0	4-43
Litter--percent	31.1	6-66	30.7	12-57
Slash--percent	15.6	7-24	12.2	6-30
Litter and slash--percent	34.6	14-74	30.2	11-60
<u>Understory vegetation--Coverage</u>				
Forbs--percent	0.8	0-9	9.2	0-38
Shrubs--percent	2.5	0-12	9.5	0-36
Grass and sedge--percent	3.6	0-20	9.0	0-34

Table 10--Stocking of conifer reproduction under shelterwoods by classes of reproduction and plant communities, eastern Cascades, Oregon

Class of Reproduction	Proportion of milacres stocked when plant community was:					
	Hemlock			Mixed conifer		
	Mean	Range		Mean	Range	
	--percent--			--percent--		
Advance	9.5	0-24		7.6	0-28	
Subsequent:						
1 & 2 years	28.3	0-52		26.5	0-88	
3 years +	45.9	0-76		45.1	4-92	
Planted	20.0	0-40		12.7	0-36	
All Classes	63.6	16-92		63.2	16-96	

Table 11--Densities of conifer reproduction under shelterwoods by classes of reproduction and plant communities, eastern Cascades, Oregon

Class of Reproduction	Amount of reproduction when plant community was:			
	Hemlock		Mixed conifer	
	Mean	Range	Mean	Range
	number per acre		number per acre	
Advance	186	0- 800	162	0- 1,240
Subsequent:				
1 & 2 years	979	0- 3,000	894	0-10,760
3 years +	3,192	0-12,400	1,781	40-10,600
Planted	205	0- 880	134	0- 440
All Classes	4,483	280-15,360	2,968	120-21,960

Seventy-seven percent of the hemlock shelterwoods had 40 percent or more of the milacres stocked (table 12), and 83 percent had densities of 400 or more seedlings per acre (table 13). And 84 percent of the mixed conifer areas had 40 percent or more of the milacres stocked (table 12), and 93 percent had 400 or more seedlings per acre (table 13). Greater amounts of regeneration were associated generally with increasing density of the shelterwood stand and with more exposed mineral soil.

Shelterwood densities should be no greater than those needed to obtain natural regeneration so that damage to seedlings will not be excessive when shelterwoods are removed. Consequently, shelterwood basal areas of 60 to 80 square feet per acre are recommended as the minimum required for successful natural regeneration in hemlock and mixed conifer communities.

In Oregon and California, the efficacy of shelterwood cuttings seems to be related to the tolerance of species. For intolerant trees, shelterwood cuttings can be successful, but are not necessary for regeneration. They may be chosen if visual resource management or other aesthetic values are high, but administrative costs will increase significantly, and seedling growth will probably be reduced, which will increase the rotation age for producing the next crop of timber.

As timber stands of tolerant trees are harvested, shelterwood cuttings become useful by providing shade for the first 2 or 3 years in the life of seedlings. As tolerance and elevations increase, desirability of shelterwood cuttings seems to increase. Besides providing necessary shade during the early life of a new stand, frost protection sometimes becomes a factor.

In summary, the shelterwood method of cutting has a place in western silviculture, but an admonition is necessary and timely. The method should be used only where appropriate. And we need to avoid preparatory steps in the shelterwood method, unless they can be demonstrated as necessary. I am not aware of such an instance. Already, some cutting plans have been submitted for preparatory cuttings of the shelterwood system in areas where aggressive hardwoods and brush will capture ground released by such operations. Here, preparatory cuttings will create problems. Let's avoid them.

I acknowledge, with appreciation, the work of Donald T. Gordon, Philip M. McDonald, and Robert J. Laacke of Redding, and of James W. Barrett and Kenneth W. Seidel of Bend, from which I drew freely to prepare this presentation.

Table 12--Proportion of shelterwood cuttings with milacre plots stocked at minimum levels with regeneration 3-years old and older (advance and subsequent), eastern Cascades, Oregon

Minimum milacre stocking (percent)	Proportion of shelterwood cuttings when community was:	
	Hemlock	Mixed conifer
	--percent--	--percent--
20	97	98
40	77	84
60	53	40
80	13	20
Bases: Number of shelterwoods:	30	45

Table 13--Proportion of shelterwood cuttings stocked at various minimum densities
of regeneration 3-years old and older (advance and subsequent), eastern
Cascades, Oregon

Minimum density of stocking (seedlings per acre)	Proportion of shelterwood cuttings when community was:	
	Hemlock	Mixed conifer
	--percent--	--percent--
200	100	100
400	83	93
700	80	76
1,000	73	62
2,000	60	31
3,000	47	20
Basis: Number of shelterwoods:	30	45

NATIONAL SILVICULTURE WORKSHOP
Charleston, South Carolina
September 17-21, 1979

REGION 6 SHELTERWOOD TASK FORCE

Presented to the National Silviculture Workshop in Charleston,
South Carolina, September 20, 1979 by John M. Hughes, Silvi-
culture Section Head, Pacific Northwest Region.

INTRODUCTION

For many years the silvicultural methods used in the Pacific Northwest Region were relatively simple and straight-forward. West of the Cascade Range, the usual practice was to clearcut, burn, and plant Douglas-fir seedlings. On the East Side the common prescription was to sanitize the old growth ponderosa pine stands by removing trees on a "risk-cut" basis. Regeneration was not usually an objective of East Side silviculture; however, ponderosa pine seedlings were planted on many areas denuded by wildfire. These silvicultural practices resulted in the establishment of many acres of evenaged Douglas-fir regeneration on the West Side. On the East Side, the sanitation cuts resulted in a variety of stand conditions. Many acres of natural ponderosa pine regeneration became established in areas where shelterwood conditions were created. Unfortunately, the practice of "cut a little, leave a little" also resulted in the conversion of ponderosa pine sites to the more shade tolerant species. In stands infected with dwarf mistletoe, the "cull tree release" left some unmanageable situations which now need to be liquidated and started over from scratch. Starting in about 1960 the Region began to experience regeneration failures on the West Side as clear-cutting was pushed into the higher elevations and onto the drier sites found in the southern Cascades and Siskiyou Mountains. By 1970, a shift to the shelterwood system was made to provide conditions more favorable to the establishment of regeneration on the marginal West Side conditions, and as a primary method to regenerate the East Side Forest types. By 1978 about 400,100 acres of shelterwood cutting had been done. Problems, both imagined and real were being discussed in connection with the shift in cutting practices.

THE MISSION OF THE TASK FORCE

In 1978 a Task Force was formed to review the use of shelterwood cutting in Region 6. The Task Force consisted of an interdisciplinary team of people skilled in silviculture, logging systems, fuels management, visual resource management, wildlife management, and insect and disease control. Line Officers and other resource specialists also participated. The original objective of the Task Force was to investigate the problems associated with the removal of the overwood. Later, the mission was expanded to include the total use and application of the shelterwood cutting method. Members of the team spent six weeks in the field looking at shelterwoods on 15 National Forest in Region 6. A total of 74 shelterwood project areas were reviewed by the team on 24 Ranger Districts. The Task Force findings and recommendations were submitted to the Director of Timber Management in September of 1979.

NATURAL SHELTERWOODS IN THE PACIFIC NORTHWEST REGION

In the Pacific Northwest Region natural regeneration of many conifer species has occurred on sites disturbed by fire or other natural occurrences. Wildfire undoubtedly has played a major role in the development of the vast stands of Douglas-fir and ponderosa pine found in the Region. Both Douglas-fir and ponderosa pine require a seedbed of mineral soil for optimum germination. Douglas-fir is more shade tolerant than ponderosa pine, and survival and growth of Douglas-fir seedlings has been good on those areas partially shaded by standing dead trees. The germination and survival of ponderosa pine is good on partially shaded areas, but the species is intolerant to shade and growth is seriously hampered if the shade is not removed. Even on the most severe sites, conditions can be found which provide shelter for regeneration establishment. The natural shelter provided by a log or a hollow stump often provide the microclimate needed for seedling germination and survival.

STATUS OF SHELTERWOOD CUTTING IN REGION 6

Approximately 400,800 acres of National Forest land in Region 6 have had the first entry of the shelterwood system applied. Of this total 32,500 acres have been regenerated with overstory removal operations completed; 76,900 acres are presently programmed for overstory removal, and the remaining 291,400 acres are either inadequately stocked or, if stocked, are not programmed for overstory removal. In addition, there are 1,707,000 acres of natural shelterwood (created by fire, insects, etc.) with a manageable understory. Of these, 364,000 acres are scheduled for removal cuts and the remaining 843,000 acres are unprogrammed.

REASONS FOR SHELTERWOOD CUTTING

The Task Force observed many applications of shelterwood cutting to meet land management objectives. The reasons for prescribing the shelterwood system vary from biological to social concerns.

BIOLOGICAL

The most common reason for installing a shelterwood is to reduce the environmental harshness of a site during the regeneration period. The environmental factors most influenced by a shelterwood are temperature, light, and moisture.

Natural Regeneration - The classic objective of shelterwood cutting is to provide conditions favorable to the establishment of natural regeneration under the protection of the mature stand. In Region 6 most shelterwoods are planted due to the length of time between good seed years (4-8 years), and because of the direction to insure regeneration success within five years. Even though most shelterwoods are planted, natural regeneration is expected to be a major component of the new stand.. Some National Forests in the Pacific Northwest Region are using the shelterwood system specifically to obtain natural regeneration of species which are difficult to grow in nurseries.

Protection From Heat and Drought - Shelterwoods are being used to protect planted seedlings from the summer heat and drought experienced on south aspects in southwestern Oregon. The shade provided by the shelterwood conserves soil moisture and provides cooling surface temperatures. The shelter is only needed for a short period of time, or until the planted seedlings have rooted to a depth that will permit them to survive the summer drought.

Protection From Frost - At the higher elevations of the Region, shelterwoods are being used to protect planted seedlings from frost damage. Natural and manmade frost pockets have made regeneration of clearcuts extremely difficult in some locations. Seedlings growing in the clearcuts are severely damaged annually by late spring frosts. A shelterwood can provide a protective cover that effectively ameliorates the frost problem. The shelter must be maintained until the seedlings are above the limiting frost line. In some areas the frost pockets are known to exceed 30 feet in depth.

Modification of Pocket Gopher Habitat - Several National Forests in Region 6 are using shelterwoods to avoid creating pocket gopher habitat. These animals cause severe regeneration losses in certain plant communities when clearcut. District silviculturists believe that the light conditions under a shelterwood will be less suitable for the production of forbs on these sites, thereby avoiding the gopher problems associated with clearcutting. It is believed that this principal may have application for other wildlife damage problems.

Other Biological Reasons - Other reasons for applying shelterwoods were also found by the Task Force. They include: protection from snow damage at the higher elevations; maintenance of trees to provide transpiration on areas with a high water table; reduction of excessive solar radiation for species sensitive to this problem; and, reduction of brush development on some regeneration sites.

Natural Regeneration - The classic objective of shelterwood cutting is to provide conditions favorable to the establishment of natural regeneration under the protection of the mature stand. In Region 6 most shelterwoods are planted due to the length of time between good seed years (4-8 years), and because of the direction to insure regeneration success within five years. Even though most shelterwoods are planted, natural regeneration is expected to be a major component of the new stand.. Some National Forests in the Pacific Northwest Region are using the shelterwood system specifically to obtain natural regeneration of species which are difficult to grow in nurseries.

Protection From Heat and Drought - Shelterwoods are being used to protect planted seedlings from the summer heat and drought experienced on south aspects in southwestern Oregon. The shade provided by the shelterwood conserves soil moisture and provides cooling surface temperatures. The shelter is only needed for a short period of time, or until the planted seedlings have rooted to a depth that will permit them to survive the summer drought.

Protection From Frost - At the higher elevations of the Region, shelterwoods are being used to protect planted seedlings from frost damage. Natural and manmade frost pockets have made regeneration of clearcuts extremely difficult in some locations. Seedlings growing in the clearcuts are severely damaged annually by late spring frosts. A shelterwood can provide a protective cover that effectively ameliorates the frost problem. The shelter must be maintained until the seedlings are above the limiting frost line. In some areas the frost pockets are known to exceed 30 feet in depth.

Modification of Pocket Gopher Habitat - Several National Forests in Region 6 are using shelterwoods to avoid creating pocket gopher habitat. These animals cause severe regeneration losses in certain plant communities when clearcut. District silviculturists believe that the light conditions under a shelterwood will be less suitable for the production of forbs on these sites, thereby avoiding the gopher problems associated with clearcutting. It is believed that this principal may have application for other wildlife damage problems.

Other Biological Reasons - Other reasons for applying shelterwoods were also found by the Task Force. They include: protection from snow damage at the higher elevations; maintenance of trees to provide transpiration on areas with a high water table; reduction of excessive solar radiation for species sensitive to this problem; and, reduction of brush development on some regeneration sites.

POLITICAL

Many shelterwoods were made during a period of intense controversy over clearcutting. The Task Force observed many shelterwoods located adjacent to well stocked clearcuts where there was no biological or other resource management need to use the shelterwood method. Some Forests in the Region have issued strong direction to only use clearcutting when there is no other feasible method of cutting available. This has resulted in the widespread use of shelterwood cutting on sites that probably are better suited to the clearcut regeneration method.

OTHER

Many timber stands have been repeatedly salvaged, partial cut, etc., without the benefit of long-range silvicultural objectives. The stocking on these areas has been reduced through a series of timber sales and salvages to the point where we have no choice left but to regenerate with the remaining trees. The Task Force observed a number of stands that need to be regenerated, but there is only a minimum of shelter left.

TYPES OF "SHELTERWOODS" - A TERMINOLOGY PROBLEM

Each timber type must be carefully analyzed to determine the amount of cover needed to provide protection from the various atmospheric conditions that the shelterwood is intended to moderate. The Task Force found a great variety of crown cover densities on so-called shelterwoods. We saw many "partial cuts" where only a few trees were taken out of the stand and no attempt was made to obtain regeneration; yet, these areas are carried in the books as shelterwoods. At the other extreme we found areas with only a few remaining trees also being called shelterwoods. Apparently some forests are calling any seed tree cut a shelterwood, while other Forests are leaving a few scattered trees on the site to avoid calling them clearcuts. The shelterwood Task Force found that other cutting methods are also being used to provide sheltering conditions. For example, strip clearcuts are being successfully used in southwest Oregon. The long, narrow strips are oriented to provide shelter from the midday sun rays which often causes seedling mortality in the summer. Another method that has been successfully used to provide protection for regeneration is the irregular shelterwood or patch clearcut. These small cutting units were very successful in obtaining natural regeneration, however, they are difficult to use on a large scale operation.

PRESALE CONSIDERATIONS

Silvicultural Prescriptions - A successful shelterwood begins with a good silviculture prescription. The prescription must thoroughly analyze the timber stand conditions and define the limiting environmental factors which need to be modified to regenerate a new stand. We found many examples of incomplete prescriptions which did not include specific plans beyond the first entry. Most shelterwood cutting problems can be traced to incomplete or inadequate silvicultural prescriptions.

Marking Shelterwoods - The marking of shelterwoods was of concern to the Task Force. We found that most marking is being accomplished using relatively inexperienced people. It is very important that good marking rules be developed and that silviculturists monitor the marking to see that it is properly carried out on the ground.

Selection of Shelterwood Leave Trees - We observed many shelterwoods where the largest trees were marked to cut and the medium sized trees were retained as shelterwood trees. This is being done because logging the big trees during the overwood removal can damage the seedlings. Geneticists believe that this practice is dysgenic and that the best trees should be retained on the area to provide seed if natural regeneration is planned for. One way around this problem is to plant with genetically proven planting stock.

OPERATIONAL CONSIDERATIONS

Timber Sale Administration - Expert logging is very important to the successful completion of shelterwoods. Excellent examples of logging was observed, especially where the skid trails were marked in advance. The logger usually could do a good job if he stayed on the skid roads and pulled the main line to the logs. We observed very little soil disturbance in timber sale areas where the timber sale administrator had marked the skid roads in advance and where the logger was informed of the silvicultural objectives.

Slash Disposal - Slash disposal in shelterwood areas is probably one of the most critical elements. The best opportunity to clean up the slash is during the shelterwood seed cut. If we wait to take care of the slash after regeneration is established, it becomes very difficult to save the reproduction. On many areas slash disposal was accomplished with tractors equipped with brush blades. This seems to be a very effective method of slash disposal on flat ground and gentle slopes. Another method of slash disposal used by several Forests is under-burning. Even on very steep ground, fuels managers experienced with the techniques of under-burning are successfully using fire to reduce the hazard and prepare the site for reforestation. It is very important that the fuels be completely cleaned up after the seed cut, as it is very difficult to dispose of logging slash after regeneration becomes established. Slash created by the overwood removal can be effectively reduced by yarding the larger unmerchantable material, hand piling slash concentrations, and lopping and scattering the fine fuels.

Soil Protection - Soil damage was observed where the logging and slash piling was not carefully controlled. Fuels management and site preparation objectives need to be carefully prescribed using interdisciplinary input from soils, fuels, and silvicultural experts. Don Boyer, Soil Scientist on the Task Force, found soil compaction to be a problem on many shelterwood areas. Uncontrolled tractor use can cause excessive soil damage. Soil compaction and other soil related damage can be expected to be more extreme in shelterwoods than in clearcuts due to a number of entries needed.

OVERWOOD REMOVAL-A SPECIAL PROBLEM

Concerns for Saving the Regeneration - The Task Force found the shelterwood system successful in providing conditions favorable for the establishment and survival of regeneration. Thus, the basic objective of regeneration can be achieved; however, the problem of how and when to remove the overwood is bothering silviculturists throughout the Region. This is most difficult part of shelterwood cutting. How do we get the overwood off and still leave satisfactory stocked stands? Unfortunately we have very few examples of successfully completed shelterwoods in Region 6 which can provide satisfactory answers to the question.

Overwood Logging Methods - The Task Force traveled to a number of active and completed overwood removal projects. Overwood removal requires special efforts in logging by cooperative timber sale purchasers. This is really the test of the shelterwood system. Timber sale administrators say that the cost of sale administration for overwood removals are two to three times higher than the average clearcut timber sale. Many Districts are now beginning to obtain experience in the removal of the overwood. Overwood removal is being accomplished by several logging methods. On gentle slopes, tractors and rubber-tired skidders are commonly used. Designated skid roads, directional falling, stage logging, logging on snow, and pulling main line are all techniques being used to reduce the damage to seedlings. On the steeper slopes cable logging systems are being used. The skyline is the most efficient cable logging method. A locking carriage with lateral yarding capability was the most successful method observed. The skyline was especially useful in removing overwood on steep terrain where logs could be suspended over the reproduction. Helicopters have also been used to remove the overwood in a limited number of areas in the Region. Many people on the Task Force were surprised to learn that most shelterwoods, after logging the overwood, looks like a clearcut except that they have a little more greenery.

Maintaining Optimum Growth Rates - Silviculturists must be aware of the effects of light on the establishment and growth of intolerant species such as Douglas-fir and ponderosa pine. A shelterwood creates filtered light conditions which are ideal for germination and survival; however, established seedlings need full sunlight for good growth. The length of time that the shelter will be beneficial must be carefully analyzed. When the shelter is no longer needed to protect the seedlings, it should be promptly removed to obtain optimum growth response. The Task Force observed many stocked shelterwoods where the seedling growth was being suppressed.

OTHER PROBLEMS

Blowdown - A major problem in shelterwood cutting is blow-down. This problem was most severe on exposed ridgetops and other areas prone to windthrow. Many shelterwoods have been wiped out by windthrow. Wind damage can be minimized by proper design and layout of the shelterwood cutting units.

Overwood Logging Methods - The Task Force traveled to a number of active and completed overwood removal projects. Overwood removal requires special efforts in logging by cooperative timber sale purchasers. This is really the test of the shelterwood system. Timber sale administrators say that the cost of sale administration for overwood removals are two to three times higher than the average clearcut timber sale. Many Districts are now beginning to obtain experience in the removal of the overwood. Overwood removal is being accomplished by several logging methods. On gentle slopes, tractors and rubber-tired skidders are commonly used. Designated skid roads, directional falling, stage logging, logging on snow, and pulling main line are all techniques being used to reduce the damage to seedlings. On the steeper slopes cable logging systems are being used. The skyline is the most efficient cable logging method. A locking carriage with lateral yarding capability was the most successful method observed. The skyline was especially useful in removing overwood on steep terrain where logs could be suspended over the reproduction. Helicopters have also been used to remove the overwood in a limited number of areas in the Region. Many people on the Task Force were surprised to learn that most shelterwoods, after logging the overwood, looks like a clearcut except that they have a little more greenery.

Maintaining Optimum Growth Rates - Silviculturists must be aware of the effects of light on the establishment and growth of intolerant species such as Douglas-fir and ponderosa pine. A shelterwood creates filtered light conditions which are ideal for germination and survival; however, established seedlings need full sunlight for good growth. The length of time that the shelter will be beneficial must be carefully analyzed. When the shelter is no longer needed to protect the seedlings, it should be promptly removed to obtain optimum growth response. The Task Force observed many stocked shelterwoods where the seedling growth was being suppressed.

OTHER PROBLEMS

Blowdown - A major problem in shelterwood cutting is blowdown. This problem was most severe on exposed ridgetops and other areas prone to windthrow. Many shelterwoods have been wiped out by windthrow. Wind damage can be minimized by proper design and layout of the shelterwood cutting units.

The disadvantages of the shelterwood cutting

1. More expensive to execute.
2. Wind damage can ruin efforts.
3. Requires greater silvicultural knowledge and technical skills.
4. Regeneration can be damaged in overwood removal cutting.
5. Timing of the various cuttings is critical.
6. The cutting system requires more entries which can damage the soil resource.
7. Cleaning of diseased stands is very difficult.

Summary and Recommendations

Through correspondence and field trips to many Districts on the National Forest of Region 6, the Task Force gained considerable insight into "shelterwooding". Key point of their findings are as follows:

The use of the shelterwood system has been successful in many instances in permitting the attainment of harvest goals on severe sites while assuring regeneration. Shelterwoods have a definite place in the array of cutting procedures used in Region 6. Other nontimber resource objectives have also been achieved through properly planned and executed shelterwoods.

Quite a few District people have learned how to use shelterwoods through professional ingenuity and experience. Some units have not had the benefit of these experiences, but now need this expertise to avoid repeating the problems associated with trial-and-error learning.

The Region has an opportunity to disseminate the skills already available on some forests, but not yet developed universally.

Recommendation #1

The Region and the Forests should review existing policies on cutting procedures. There is an urgent need to clarify FSM direction as soon as the NFMA regulations have been finalized.

Recommendation #2

The Region and the Forests should insure compliance with existing policy regarding preparation of silvicultural prescriptions (FSM 2478.4). The shelterwood system is one of the more complex silvicultural techniques and creates long term impacts. Where there is a shortage of certified silviculturists, the efforts of those available should be concentrated on prescribing for the more sophisticated, high impact activities such as shelterwooding.

Recommendation #3

The record system and timber sale planning procedures, Region-wide, should be modified to insure timely scheduling of the removal cut for all shelterwoods. The 1,134,000 acres of overstory with established understory should be located and prescriptions should be written for those stands.

Recommendation #4

Economic analysis should be used as one of the factors in selecting a regeneration harvest method. All of the steps and procedures necessary for full completion should be included.

Recommendation #5

The Region, in cooperation with the Forests, should provide a variety of training on the shelterwood system. This can be accomplished in a number of ways such as:

- a. Developing a technical "how to" guide on the use of shelterwood cutting. Nontimber resource considerations should be included.
- b. Conduct a series of field trips to successful shelterwoods.
- c. Increase awareness of silvicultural systems in established Regional training programs such as logging systems, fuels management, soils, visual resources, etc.

SHELTERWOODS IN BLACK HILLS
PONDEROSA PINE

Charles E. Boldt
Research Forester
Rocky Mountain Forest and Range Experiment Station
Rapid City, South Dakota

If one were unaware of the European origins of the shelterwood system and the history of its introduction into American forest practice, it would not be irrational to infer that the system evolved in and for Black Hills ponderosa pine. The two seem beautifully mated. Yet, the fact remains that the shelterwood system had been undergoing refinement in central European forests for nearly a century when General George Armstrong Custer led the first, major, white expedition into the Black Hills in 1874.

THE SILVICAL SETTING

The Black Hills is a forested island in a sea of grass. Geologically, the Hills are the weathered remnants of an ancient domal uplift, massively eroded to expose diverse sediments, metasediments, and igneous intrusives. Thus diminished in stature, the uplift now rises barely 4000 feet above the surrounding prairies, to a modest maximum of 7242 feet. Gross area of the truncated, elliptical dome is about 5500 square miles or 3.5 million acres.

Geographically, the Hills are situated near the western margin of the northern Great Plains, astride the boundary between South Dakota and Wyoming. They lie far enough east of the nearest "real mountains", the Rockies, so that the latter can be glimpsed only rarely, by keen eyes, from certain vantages, on sparkling clear days.

The Hills have much the same, rigorous climate as the adjoining Plains except for increased precipitation and decreased temperature, both orographically induced. Together, these modifications make the Hills' environment favorable for forest vegetation. Seasonal distribution of moisture conforms to the Plains' pattern, with the bulk of it surging up from the Gulf during the early part of the growing season. This has important implications for forest regeneration.

Soils in the Black Hills vary in character as widely as their parent materials, but they generally tend to be moderately heavy in texture, comparatively shallow, and rocky. The shallowness of the soil mantle limits moisture storage and, in turn, site productivity. Widespread samples suggest that the majority of sites in the Hills have pine site indexes within the range of 50 to 60 ft (base age 100).

A roster of native trees suggests that the Hills are a virtual "melting pot", with species representing origins as diverse as the northern boreal, the eastern deciduous, and the western subalpine and montane forests, as well as the pygmy conifer woodlands. Actually, the preponderance of the forest sites--say, 9⁺ acres out of every 10--are occupied by essentially pure, climax stands of ponderosa pine.

In addition to their isolation from other segments of the vast Interior Type, the ponderosa pine forests of the Black Hills are distinctive in two other important respects: 1) They reproduce themselves readily and prolifically, and 2) they are free of the scourge of dwarf mistletoe.

The fecundity of Black Hills ponderosa derives from a combination of dependable seed production and dependable moisture during spring and early summer, just when new germinates need it most. The fortuitous absence of Arceuthobium remains a mystery, especially since trees of Black Hills origin have been successfully inoculated with the pest.

HARVEST CUTTINGS: THE LEARNING PROCESS

Most of what is known about harvest cutting in the Black Hills has been learned by experience rather than research. Fortunately, the experience has been abundant, varied, and instructive.

During the gold mining boom which quickly followed Custer's penetration of this former Indian sanctuary, there was a brisk demand for wood products of all shapes and sizes--and no bothersome harvest restrictions. It follows that clearcutting was the method of choice during this period. With establishment of the Forest Reserve, in 1897, and imposition of rudimentary harvest controls by the General Land Office, a few large sales (including Case Number 1)¹ specified harvest of all timber, live and dead, larger than a specified minimum diameter limit. Depending on variations in stand structure and choice of diameter limit, harvests of this kind were, in effect, either seed-tree or clearcuttings. This approach persisted until shortly after the transfer of the Reserves to Gifford Pinchot's Bureau of Forestry, USDA, in 1905.

¹Case Number 1 was a landmark in American forestry in that it was the first exercise of the provisions of the Organic Act of 1897, the first sale of Federally-owned timber, and the first instance of regulated timber harvest on the newly created Forest Reserves.

By 1908, Forest Service marking guides² were recommending use of the two-cut shelterwood method with about two-thirds of the volume designated for removal in the first cut. In 1910, new Chief Forester Graves reported that the even-aged character of the Black Hills stands made the shelterwood method desirable, although W. B. Greeley, Assistant Chief Forester, openly favored harvest by the selection system. By the mid-1920's, Greeley and his views evidently prevailed and Black Hills marking guides began to specify individual-tree selection.

Use of the selection system continued until the mid-1950's, when revised guides once again acknowledged the suitability of evenaged management and prescribed shelterwood harvest. In initial form, the revised guides called for gradual removal of mature stands in three light cuts spaced 20 years apart, with retention of a few "insurance" trees above the replacement stand for an additional 20 years. On the ground, this conservative version of the shelterwood method was barely distinguishable from the individual-tree selection practice which it replaced. Within a decade, however, the guides again prescribed a two-cut shelterwood with timing of the removal cut contingent on underwood establishment and development.

The latest Timber Management Plan for the Black Hills National Forest, approved in 1977 for the period through 1986, prescribes a three-cut shelterwood for stands within the Standard Component. The recommended interval between harvest entries is ten years. The rationale for this return to conservative application of the system is apparently more managerial than silvicultural.

LESSONS

Although the evolution of harvest practices in the Black Hills was largely a trial-and-error process, it entailed remarkably few errors. Only in rare instances have past harvest operations produced silviculturally damaging results. Most have been reasonably successful, as evidenced by the scarcity of poorly or nonstocked forest acres and the absence of any pronounced fall-down in growth or allowable cut during the old-growth liquidation period, now drawing to a close.

Perhaps the most important lesson to be learned from all this varied harvest experience is that, from the ecological standpoint, no high forest method can be considered wrong or wholly inapplicable in Black Hills ponderosa pine. Any one of the standard methods may be a

²From historical files, Black Hills N. F., Custer, S. D.

silviculturally acceptable option under the proper circumstances. This does not mean, however, that all of the methods are equal in their range of applicability, probability of success, efficiency, and esthetic appeal.

THE BEST CHOICE

Two decades of scrutinizing outcomes of many harvest operations, old and new, have led me to the conviction that the shelterwood should be the primary harvest/regeneration method for Black Hills ponderosa pine. It is ideally suited and widely applicable. It capitalizes on the species' strong, natural tendency to form even-aged stands. Furthermore, it combines the advantages of continuous vegetative protection of the site; assurance of an adequate, well-dispersed seed supply; fair control over development of competitive ground cover; good control over accumulations of hazardous and unsightly logging residue; and an esthetically acceptable appearance, provided the harvest job is skillfully planned and executed.

The only important disadvantage is that the parent overwood will hamper development of the replacement stand if it is too dense or left in place too long. A less significant disadvantage is that even a light shelterwood is apt to supply more seed than is needed, thus aggravating the problem of excess reproduction.

A uniform, two-cut shelterwood appears to be the most efficient and silviculturally acceptable variant of the method. The seed cut should be heavy enough to interrupt the competitive continuity of the mature stand, and the removal cut should be timely.

A three-cut variant seems appropriate in situations where the two cuts are likely to create unusual problems of visual impact, residue buildup, risk of windthrow, or logging damage to reproduction.

OTHER OPTIONS

The other even-aged systems, seed-tree or clearcutting may be acceptable alternatives to the shelterwood under some conditions. Each, however, lacks one or more of the advantages of the shelterwood.

The seed-tree cutting method entails the highest risk of loss of seed source, especially from blowdown. In well-stocked stands, it results in heavy accumulations of logging residue on the first entry. Also, the widely spaced seed trees offer little competition to invading

ground cover, in event of delayed pine regeneration. These disadvantages may be partially offset by reduced seed supply and less damage to reproduction during seed stand removal.

The clear-cutting method provides no control over competitive ground cover, but permits pine reproduction to develop free of overhead competition and threat of logging damage. Maximum size of clearcuts is limited by the flight capabilities of ponderosa pine seeds. The same limitation reduces uniformity of seed and seedling distribution across openings.

The selection system does not appear to be a valid harvest/ regeneration option for Black Hills ponderosa pine. Few sites in the Black Hills are capable of supporting the deep canopy of moisture-dispersing foliage which characterizes all-aged stands, especially during inevitable periods of deficient moisture. Individual tree selection probably has a legitimate place in Black Hills forest culture, but for purposes other than harvest/regeneration and creation of all-aged stands. The group-selection variant offers a bit more promise of cultural success. However, the development of trees in very small, even-aged groups is certain to be retarded by competition for moisture from older, larger stand elements nearby.

SHELTERWOOD APPLICATION

Because previous partial cuts have already produced regeneration in most mature pine stands in the Black Hills, opportunities to initiate shelterwood cuttings are currently quite limited. However, this situation will change in the next few decades as extensive stands that are now in the large pole and small sawtimber classes come due for harvest and regeneration.

The majority of these stands will be ideally structured and conditioned for regeneration by the shelterwood method. Most will have had two, three, or more intermediate cuts. They will be uniformly stocked with trees which have grown at moderate to wide spacings for several decades - vigorous trees with good crowns, stout stems, and proven resistance to windthrow. Most stands will contain 80 to 130 ft² of growing stock in trees averaging 14 to 18 inches d.b.h. Ground cover of herbs and shrubs, dominated by grass, will be present under stands at the lower end of the stocking range, but the cover will not ordinarily be dense enough to hinder pine regeneration. Advance pine reproduction, if present, will be sparse and nonvigorous.

Ideal Approach

For maximum silvicultural and production efficiency, the job should be completed in two cuts. No preparatory cut should be needed.

The seed cut should be pre-marked and flexibly timed to coincide with a satisfactory seed crop. It should leave 12 to 18 of the very best trees, comprising about 35 ft² of basal area per acre. Overwood canopy density should fall within the range of 15 to 25 percent. The seed cut should be completed prior to seedfall. Slash should be thoroughly lopped and scattered. It may be treated by a broadcast burn, if it can be kept low and cool enough to pose no threat to the overwood trees.

The shelterwood should be removed completely as soon as a well-stocked replacement stand has become solidly established. Stocking in the new stand can be rated satisfactory when 80 percent or more of the mil-acres support at least one good pine seedling. Seedlings can be rated solidly established when they average 1 ft tall or taller. The removal cut can be made any time after the replacement stand meets these criteria. It should not be delayed beyond the time when most seedlings reach a height of about 3 ft.

The cut should remove all overstory trees with minimum damage to the replacement stand. Slash should be treated as prescribed for the seed cut, but residue volume will be much less.

As an integral part of the shelterwood system, the replacement stand should be precommercially thinned to a prescribed stocking level, consistent with management objectives, before competition reduces growth. The first thinning can be made any time after slash from the removal cut has dropped its fine fuel and compacted.

Actual Application

Under provisions of the current TM Plan, the Programmed Allowable Harvest, for the decade 1977-86, includes 109 M acres of preparatory cuts, 109 M acres of seed cuts, and no final cuts, on standard component lands totalling about 950 M acres. At the end of the second year, cumulative accomplishments amount to 68 percent of Program Goal for preparatory cuts and 84 percent for seed cuts.

No good, recent information is available on harvest cutting practices and accomplishments on State, private, and other Federal lands in the Black Hills.

SUMMARY

All of the classic, high forest silvicultural systems have been tried in the ponderosa pine forests of the Black Hills. All have produced acceptable regrowth, in most cases, primarily because of the species' propensity to reproduce and prevail in the Black Hills environment. Results of a century of harvesting experience suggest that even-aged management is a natural imperative, and that the shelterwood is the all-around best choice for harvest and regeneration.

SOURCES

Boldt, Charles E. and James L. Van Deusen.

1974. Silviculture of ponderosa pine in the Black Hills: The status of our knowledge. USDA, Forest Service, Res. Paper RM-124. 45 p. Fort Collins, CO.

Boldt, Charles E.

1973. Black Hills ponderosa pine. In Silvicultural systems for the major forest types of the United States. USDA, Forest Service, Agric. Hdbk. No. 455. 114 p. Washington, D. C.

SHELTERWOOD STATUS - PAYETTE NATIONAL FOREST
BY
Glenn Jacobsen
Certified Silviculturist

Some of the subjects we have heard this week pertain to the shelterwood system on a Regional basis. I plan to review the status of shelterwood on a National Forest. This will include an evaluation of overstory removal and seed tree methods in order to bring us to today's use of the shelterwood method.

The Payette National Forest is located in west-central Idaho, approximately 100 miles north of Boise. It contains 2.3 million acres of which 803,000 acres are classified as commercial forest land. Slopes vary from 0 to 70%. Moisture occurs primarily in the form of snow. Mean annual precipitation is from 21 to 40 inches in the commercial forest zone. Two major soil types on the Forest are the granites and basalts. Located in the northern province of the Pocky Mountain System, the vegetation is affected by abrupt changes in aspect, slope, soil and site conditions and are reflected in corresponding changes in stand composition. Ponderosa pine, Douglas-fir, grand fir, and alpine fir are the primary habitat series. Commercial timber species are Douglas-fir, ponderosa pine, grand fir, alpine fir, Engelmann spruce, lodgepole pine, and western larch.

Eighty-three percent of the commercial Forest land is in sawtimber stands. Thirty-five percent of all stands are overmature. Almost 75% of the mature and overmature stands are in the high and medium risk categories. Average site indices indicate reasonably productive conditions. (Average site index at 100 years for Douglas-fir 73, ponderosa pine 77, grand fir 84.) Net growth rate for all commercial Forest land is 173 board feet per acre per year. Rotations vary by species from 110 to 130 years.

Overmature stands are susceptible to disease and to attack by insects. Bark beetles and western spruce budworm have done the most damage. Dwarfmistletoe is the primary disease problem. Wood rotting fungi and rusts are also prevalent. Livestock, big game, and rodents continue to affect timber stands.

Management data identifying specific silvicultural systems was collected during the 1965 timber inventory. Based on this inventory, even-aged management was prescribed in the Timber Management Plan for all habitat types except a portion of the ponderosa pine series, and a portion of the alpine fir/beargrass habitat type, both of which offer an opportunity for uneven-aged management. The data collected indicated the following

Presented at the National Silviculture Workshop, Charleston, South Carolina, September 17-21, 1979.

proportions by harvest methods in mature and overmature stands:

Group, patch, strip	88%
Seedtree and Shelterwood	3%
Overstory removal	9%

Currently, about 80% of the area harvested on the Forest is by partial cut methods, but silviculturists are prescribing more patch cutting on recent timber sales.

The obvious difference between the 1965 inventory harvest method percentage for clearcutting (88%) versus recent clearcutting (20%) is primarily based on an over reaction to the clearcutting controversy in the past.

The clearcutting controversy in the late 1960's and early 1970's precipitated a change in cutting methods on the Payette National Forest. Regeneration methods other than clearcutting were to be prescribed where practical. Overstory removal was the primary method during the early '70's, along with seed tree method and now the shelterwood method. Success - failure examples were evaluated with the overstory removal and seed tree methods and we are now trying to determine shelterwood successes based on past analysis of overstory removal and seed tree successes.

In the early 1970's, the Forest conducted an evaluation of stands resulting from overstory removal cutting during the 1960's. Only 44% of the stands examined had more than 100 crop trees per acre. The evaluation indicated the overstory removal method was being applied to too many stands with understories that are diseased, suppressed or scattered so that only scattered clumps will remain after logging. Logging damage to the understory was also very evident and generally inferior species were left.

A ponderosa pine stand was prescribed for a seed tree cut and harvested in 1968. Slash was piled and burned in 1969 leaving 10-12 seed trees per acre. One-half of the trees blew down in 1970. The area was site prepared again in 1971 to coincide with an above average cone crop. Stocking surveys in 1976 indicated 380 trees per acre. Seed trees are scheduled for removal.

This successful seed tree unit in ponderosa pine led to additional prescribed seed tree units on the Forest. A number of ponderosa pine units were site prepared in conjunction with the 1974 ponderosa pine cone crop. An evaluation of three of these units on the Council Ranger District was conducted in 1978, involving participation of personnel from the Ranger Districts, Supervisor's Office, Regional Office, and Research.

Site preparation was similar on all three units. All units were located in grand fir habitat series on basaltic soil. The first of the three study units (7) included a 6-acre unit on a southeast aspect with 5-7 good seed trees per acre. Eighty percent of sample plots taken in 1977 were stocked with 300 trees per acre or more with an average stocking of 600 trees per acre.

A second unit (12) included a 19 acre unit with a south southeast aspect. Slopes averaged 30% plus portions of the area had rocky shallow soils. Six to eight poor seed trees per acre were left. Twenty-five percent of sample plots were stocked with 300 trees per acre or more with an average stocking of 200 trees per acre. Analysis by the group indicated this unit failed due to the following reasons: lack of good seed trees, too few seed trees to provide enough shade to reduce temperatures on steep south facing slopes, and trampling damage due to cattle. Undoubtedly, seed tree was a poor prescription for the stand conditions involved.

The third and last study area was a 71-acre unit with a north aspect. Four to six ponderosa pine and Douglas-fir seed trees per acre were left. These seed trees were disease free, mature, and in a vigorous condition. Eighty-seven percent of the sample plots were stocked with 300 trees per acre or more with an average stocking of 600 trees per acre.

Evaluation of these units indicated the following items must be considered before prescribing a seed tree unit:

- The presence and selection of good seed producers of desirable species that are windfirm and exhibit best genetic characters.
- Predetermine number of seed trees to leave for each individual site in order to establish regeneration and uniform stocking.
- Establish frequency of seed crop for the area.
- Schedule site preparation to coincide with seed crops.
- Vary site preparation to specific site.
- Provide for protection of regeneration - rodents and livestock.

Research indicates that Mother Nature provides highly favorable conditions for ponderosa pine natural regeneration establishment once every 22 years. Man can lower this cycle with proper site preparation and timing to coincide with seed crops. Currently, the Payette National Forest has some good results of prescriptions for natural regeneration with ponderosa pine using the seed tree method, but no results using the seed tree method with Douglas-fir or western larch. Stands of these species were created in the past, following fire, and we can expect natural regeneration to occur on most timbered areas on the Forest, but it may take time.

With the establishment of the Silviculture Certification program in 1974, emphasis was shifted to the shelterwood method of regeneration. Preparatory cuts were mainly prescribed in mature and overmature grand fir stands. To date, we have seen little crown improvement on leave trees in the overmature stands, which some of us expected. Silviculturists are presently prescribing the shelterwood method in some mature grand fir and Douglas-fir timber stands. We have no examples of prescribed

shelterwood seed cut where regeneration has become established. Group shelterwood is being prescribed in many mature Engelmann spruce stands.

In the late 1960's, efforts were made on the Forest to delineate stand conditions favorable to prescribe the shelterwood methods. A mature Douglas-fir, grand fir stand was selected for harvest using a shelterwood seed cut. The stand was harvested leaving grand fir and Douglas-fir. Slash was piled in conjunction with site preparation.

After the first year following a cone crop, approximately 7600 seedlings per acre were found. The following year all seedlings had been lost due to frost heaving. Naturals in an adjacent clearcut had not been affected. The area was site prepared again and seedlings were again lost to frost heaving. This has been our only evaluation on regeneration following a shelterwood seed cut to date.

We expect problems with shelterwood systems coordinating timing of proper site preparation with seed crops plus protecting seedlings from rodent and livestock damage. Logging damage to the reproduction during shelterwood removal cut will be another problem.

Overall, the Payette National Forest has a way to go in regard to application of shelterwood systems.

THE APPLICATION OF SHELTERWOOD CUTTINGS
IN THE LAKE STATES

by

R. M. Godman

Shelterwood cuttings have been tried at one time or another in all forest types in the Lake States. Some of the earliest trials were in the conifer types but because of various interpretations of the shelterwood concept the results have been variable. New information regarding proper techniques are being developed and there appears to be a rebirth of efforts to use the shelterwood system for establishing and developing even-aged stands. The most effort in recent years, however, has been with the hardwood types and these trials have pointed out the important silvical characteristics to be considered and application of techniques necessary to assure success for the species desired.

Among the conifers only the white pine type currently uses shelterwood cuttings as the primary regeneration method (Lancaster and Leak 1978). The two-cut shelterwood, with initial removal of 40% to 60% of the overstory and site preparation, was developed largely from northeast studies. In general, these recommendations appear to be acceptable for the Lake States although cuttings in Wisconsin suggest that higher density overstories should be retained on the drier sites and on the better sites where herbaceous competition is often severe. The most open cuttings, for example, located on the Menominee Indian Reservation in central Wisconsin, has a stocking of about 600 white pine seedlings per acre but

growth and development is hampered by dense, vigorous blackberry competition. In contrast, shelterwood cuttings which left overstories with greater canopy coverage usually have more seedlings and less vigorous herbaceous competition during the seedling establishment phase.

In three of the conifer types, excluding hemlock which is most often considered with the hardwood complex, shelterwood cuttings are considered a secondary regeneration method. Under some conditions shelterwood cuts are suggested for red pine. In this type, however, regeneration is almost solely dependent on artificial methods and shelterwood cuttings are used primarily for esthetic purposes (Benzie 1977a). A major disadvantage of any residual overstory for this type is the possible infection of understory red pine by Sirococcus. Consequently, direct seeding or planting following clearcutting is generally recommended for regeneration of red pine.

Northern white-cedar regenerates best with strip cuttings throughout most of the Lake States. Again, under certain conditions a combination of strips with narrow shelterwood strip cuts in between have been recommended (Johnston 1977a). In practice, however, there has been little use of this method although new evidence suggests that shelterwood cuttings with site preparation would give excellent results.

Jack pine silviculture normally calls for clearcutting because of the serotinous cones (Benzie 1977b). In the southern portion of the type in the Lake States, where moisture conditions are often more severe and non-serotinous cones are more common, the shelterwood method has been recommended for vigorous, well stocked stands. Field experience with this approach is still fairly limited.

Shelterwood cuttings have been considered for the black spruce type as well as other wet site conifers. Use of this method has generally given poor results and clearcutting continues to be the recommended method (Johnston 1977b). Shelterwood cuttings have been successful for increasing the amount of spruce-fir when these species occur in mixtures with aspen (Perala, 1977). In the true spruce-fir type, however, there is still considerable differences in opinion for the best method of regenerating stands. Partial cuttings and some variations of the standard shelterwood system have resulted in favorable stocking and seedling development.

Shelterwood Cuttings for Hardwood Types

The greatest effort in recent years with the shelterwood system in the Lake States has been with hardwood types. Research results have clearly shown that two types of shelterwood cuttings, both calling for a two-cut shelterwood, are needed to successfully regenerate the different hardwood species as well as hemlock, the important conifer associated with the hardwood complex. The 20 plus years of experience with the system show that the method would yield consistent results when the proper over-story, the correct seed bed and an adequate seed supply is available. Other attempts to establish even-aged hardwood stands have either been failures or given inconsistent results. The shelterwood system consequently is the most reliable method for increasing species diversity and has provided the land manager many more options for multiple use management.

The procedures necessary for applying the proper shelterwood techniques are in sharp contrast to many of the earlier concepts in hardwood silviculture. Therefore, it seems desirable to review some new concepts in hardwood silviculture that have been developed as a result of trials with the shelterwood system.

Use of the term "northern hardwoods" has contributed to some of the difficulty in accepting and applying the shelterwood recommendations. The term seems to infer a single species association, similar to other recognized forest types. In the present second-growth stands, however, we usually have a mixture of species and they differ in tolerance and their ability to regenerate under similar conditions as well as in their response to various stocking levels and methods of management at later stages. The only single characteristic among the various species association is their strong successional trend toward a predominance of sugar maple.

"Northern hardwoods" has been applied over the northeastern United States and Canada as a collective name for dense hardwood types. This usage also implies similarity but there are major regional differences in species composition, preferred species, precipitation, temperatures, soils and other factors. One of the most noteworthy difference is the frequent, hot, dry periods and much lower precipitation in the Lake States. When actual forest cover type names are used, much of the regional differences are resolved for management prescriptions, leaving precipitation and temperatures among the most striking differences and perhaps the most important consideration between the Lake States and the Northeast hardwood areas.

Over-reliance on the tolerance concept has been a major obstacle in securing and establishing many hardwood species. Yellow birch is probably the most outstanding example as it is usually stressed that it needs quite open conditions to regenerate. Recent work with shelter-woods show that yellow birch, like other dense hardwood species, will develop faster in partial shade. Work by Logan (1965, 1966, 1969, 1973) in Canada, with germination of many species from seed and development under different degrees of lath shade, confirmed that seedlings increase in height more rapidly under shade - usually in the range of 60 to 80 percent crown cover. In addition to the benefit of shade for height development, he showed that seedlings germinating and developing in open conditions of up to about 55% shade level required supplemental watering for survival in a region comparable to the Lake States. An overstory is therefore necessary to prevent surface soil drying in the low rainfall Lake States area and it also restricts herbaceous competition while the tree seedlings are becoming established.

Current investigations of optimum germination temperatures for various species in the hardwood complex suggests this factor may well be far more important than tolerance. Although studies have been limited because of seed quantity and species availability, major differences in temperature requirements are apparent. Sugar maple and northern red oak germinated best at low temperatures - about 34°F. Low germination temperatures probably accounts for the abundance of sugar maple to a far greater extent than the usual statement that its more tolerant than other species when Logan's work is considered.

The most tolerant species in the "northern hardwood" region, northern white-cedar, required the highest temperatures for germination of all the species tested - generally above 65°F. All other species fell within the extremes between sugar maple and cedar. Of special interest was the fact that hemlock, one of the more tolerant, and yellow birch, one of the least tolerant, both required about the same temperature - 59°F - for optimum germination.

Information is very limited on soil surface temperatures that do occur under various forest types and the influence of cutting on temperature changes. Two-year records on adjacent scarified and unscarified seedbeds show that scarification increased average temperatures by 8°F and extended the duration of optimum germination temperatures over those on unscarified seedbeds. Favorable temperatures also tended to occur earlier in the spring when moisture levels were higher (Godman and Mattson 1976). In 1978, when temperatures warmed too rapidly, even sugar maple failed to germinate except in residual snowbanks. Thermometer readings on mounds, logs and stumps during one summer also consistently showed higher temperatures than the forest floor readings. These higher temperatures would favor the germination of the lighter seeded species because of temperature as well as moisture conditions. In the case of moderate and high temperature requirement species, their optimum temperatures generally did not occur until moisture conditions were too dry for germination. Generally, most high temperature requirement species have small, or light seeds. This characteristic appears to correlate with low vigor, slow growth and very shallow rooting of germinants and

seedlings, making them extremely sensitive to surface soil drying. Thus, these species must also have greater amounts of shade for protection during both the germination and pre-establishment phases.

Other factors regarding individual species characteristics also contribute to easier and earlier establishment for some and difficulty for other species. For example, basswood is the most prolific seeder among the hardwoods but rarely regenerates from seed except in a few localities for as yet unknown reasons. Although white ash frequently produces an apparent seed crop, current studies show the male flowers are extremely sensitive to frost and hard rains and often abort before pollination occurs. Long term reports of seed crops show that most dense hardwoods have seed crops of about equal or greater frequency than sugar maple (Godman and Mattson 1976).

The key factor in timing the overstory removal in shelterwood cuttings in the Lake States, is that the seedlings must be established before the final harvest. Establishment has not been defined physiologically but experience shows that seedlings which are 2-4 feet or about belt high are established and the overstory can be removed. At this stage the roots of seedlings have penetrated into mineral soil and they are capable of withstanding full exposure. Even though stem breakage may occur during overstory removal they will recover rapidly as a seedling sprout and without form or quality loss (Jacobs 1974). This concept seems to explain the good stocking of our second growth stands that developed after logging in the 1900's and why clearcutting of today's second growth stands without established regeneration results in long setbacks in the successional development.

The preceeding stand and species characteristics are the primary factors on which the techniques for applying the two-cut shelterwood system are based in the Lake States and are the major reasons why two types of shelterwoods are necessary (Godman and Tubbs 1973). One type of shelterwood cutting is applicable when regeneration is already present, but not established (2' to 4' tall), and needs to be developed before the residual overstory is removed. In most cases the regeneration will consist of a high proportion of sugar maple and white ash but relatively few other species in the mixture. The second type of shelterwood must be used where a greater diversity of species, usually those with small or light seeds, are desired regardless of their tolerance rating. Under both types of shelterwood cuttings the overstory can usually be removed in 3 to 8 years, before the original concept of tolerance becomes a critical factor.

Applying Shelterwood Cuttings in Hardwoods

Marking control of shelterwoods under Lake States conditions should be based on percent crown cover rather than residual basal area. Experience has shown that percent crown cover will remain constant but basal area will vary depending on the species and diameter of the tree (Godman and Tubbs 1973). In marking to a constant basal area, for example 50 square feet per acre, the percent crown cover may vary from as little as 25 percent to 75 percent depending on the species and tree diameters involved. Generally, dense hardwood species of the same diameter require less basal area for the same amount of crown cover than basswood stands because of their larger crown sizes. Basswood stands, for the same reason,

require less basal area than hemlock stands. Although percent crown cover can be closely approximated by experienced field crews, crown area tables have been developed for species groups and tree diameter (Godman and Tubbs 1973).

The sequence of events and procedures for meeting the objectives of the two shelterwood types are:

	<u>Type 1</u>	<u>Type 2</u>
Objective:	Develop regeneration already present but not established	Eliminate existing regeneration and increase the proportion of small or light species
Mark to Leave:	60 percent crown cover	70-80 percent crown cover
Site Preparation:	Not required	Required before cutting preferred. Mechanical treatment to mix organic and mineral soil-as shallow as dept as possible and to eliminate existing vegetation or use prescribed fire.
Season of initial cut:	With snow cover	No seasonal restriction
Supplemental seeding:	Not required	Necessary if no seed source of preferred species or low viability. Can be direct seeded in spring if seed supply is not available.
Expected overstory removal	3-8 years	3-8 years
Season of overstory removal	With deepest snow cover	With deepest snow cover.

Residual tree selection in both types of shelterwoods should be the larger, seed-bearing trees and those capable of withstanding more open stand conditions. The Type 1 cutting should not leave yellow birch which are subject to girdling and killing by sapsuckers. Since no site preparation is done in this type of shelterwood yellow birch and other

light seeded species will not germinate on litter or survive competition from existing species and vegetation if they were to germinate. Hemlock should not be left in Type 1 shelterwoods as they are highly susceptible to mortality from the increased exposure. Hardwood trees with weak crotches at forks should also be eliminated as they tend to split in open stand conditions. Residual trees should be uniformly distributed, avoiding large holes in the canopy. All unnecessary trees should be removed during post logging treatments. Slash need not be lopped except as required for esthetic zone management or other reasons.

The second type of shelterwood is recommended for all other species and must be accompanied by site preparation. Since the understory, if any, is to be removed and mineral soil exposed, the residual overstory density must be increased to 70-80% crown cover to prevent surface soil drying and restrict herbaceous competition while the tree seedlings are developing. In the few instances where sugar maple is not present or in adequate quantities a type 2 shelterwood is also applicable but site preparation would not be required.

Scarification, if mechanical, should be done before logging to assure coverage of 60-75% of the ground area. Best results are obtained by relatively shallow mixing of humus and mineral soil. Prescribed burning will also usually provide good seedbeds and, if done shortly after understory leaf-out, result in elimination or adequate reduction of existing regeneration. Most of the scarification benefits, of desirable seedbed and improved temperature and moisture conditions favorable for small size or light seeded species can be expected to last about 3 years.

Although scarification or prescribed burning can be done after the initial cut to 80% crown cover, it is usually cheaper and more effective if it can be done prior to cutting. If direct seeding is used, to introduce species or supplement natural seeding, doing the site preparation after the soils are too warm for sugar maple germination in the spring would be beneficial. Marking to the correct overstory can be used to eliminate certain species but some residuals may have to be left to prevent large openings. A type 2 shelterwood cutting has been consistently effective for yellow birch and paper birch and early indications are that hemlock and cedar will also give good response.

In summary, shelterwood cuttings are giving highly consistent results under the relatively adverse conditions in the Lake States for establishing even-aged regeneration. Where (1) adequate overstory, (2) proper seedbed and (3) ample seed supply have been provided, acceptable regeneration has become established in a relatively short time period commensurate with the principles of even-aged management. Leaving out any one of the three fundamental requirements will normally end up as a failure. Additional work is needed, however, to refine the limitations and to evaluate the concept of optimum temperatures for the various stand and site conditions on which the hardwood species complex occurs throughout the Lake States.

LITERATURE CITED

- Benzie, J. W. 1977a. Managers handbook for red pine in the north central states. USDA For. Serv. North Cent. For. Exp. Sta. GTR-NC-33. 22 p.
- _____. 1977b. Managers handbook for jack pine in the north central states. USDA For. Serv. North Cent. For. Exp. Sta. GTR NC-32, 18 p.
- Godman, R. M. and G. A. Mattson. 1976. Seed crops and regeneration problems of 19 species in northeastern Wisconsin. USDA For. Serv. North Cent. For. Exp. Sta. Res. Pap. NC-123. 5 p.
- _____ and C. H. Tubbs. 1973. Establishing even-age northern hardwood regeneration by the shelterwood method - a preliminary guide. USDA For. Serv. North Cent. For. Exp. Sta. Res. Pap. NC-99. 9 p.
- Jacobs, R. D. 1974. Damage to northern hardwood reproduction during removal of shelterwood overstory. J. of Forestry 72 (10)
- Johnston, W. F. 1977a. A managers handbook for northern white-cedar in the north central states. USDA For. Serv. North Cent. For. Exp. Sta. GTR NC-35. 18 p.
- _____. 1977b. Managers handbook for black spruce in the north central states. USDA for. Serv. North Cent. For. Exp. Sta. GTR NC-34. 18 p.
- Logan, K. T. 1965. Growth of tree seedlings as affected by light intensity. I. White birch, yellow birch, sugar maple and silver maple. Can. Dept. of For. Publ. No. 1121. 16 p.

- Logan, K. T. 1966. Growth of tree seedlings as affected by light intensity. III. Basswood and white elm. Can. Dept. of For. Publ. No. 1176. 15 p.
- _____. 1969. Growth of tree seedlings as affected by light intensity. IV. Black spruce, white spruce, balsam fir and eastern white-cedar. Can. For. Serv., Dept. of Fish. & For. Publ. No. 1256. 12 p.
- _____. 1973. Growth of tree seedlings as affected by light intensity. V. White ash, beech, eastern hemlock and general conclusions. Can. For. Serv., Dept. of the Envir. Publ. No. 1323. 12 p.
- Lancaster, K. F. and W. B. Leak. 1978. A silvicultural guide for white pine in the northeast. USDA For. Serv. Northeast For. Exp. Sta. GTR NE-41. 13 p.
- Perala, D. A. 1977. Managers handbook for aspen in the north central states. USDA For. Serv. North Cent. For. Exp. Sta. GTR NC-36. 30 p.

NATIONAL SILVICULTURE WORKSHOP

APPLICATION OF SHELTERWOOD METHODS IN SOME FOREST TYPES OF THE NORTHERN APPALACHIAN HIGHLANDS OF NORTHEASTERN UNITED STATES

by Carl H. Tubbs

Regenerating by shelterwood methods offers an alternative to clear-cutting in the development of evenaged stands and in some forest type-geographical area combinations may be the only realistic alternative. Shelterwood is especially useful for the regeneration of moderately tolerant species and tolerant species which are not aggressive. It offers opportunities to efficiently control competition of unwanted species and to prepare seedbeds while still maintaining the shade of an overstory.

Shelterwood is often defined as a regeneration method accomplished by a series of partial cuttings over a relatively short time period. A functional definition is more useful I think. What we are attempting to do is regenerate species for evenaged management which cannot be reliably regenerated after clearcutting. Or, put another way, we are attempting to develop even age regeneration stands of species which require, for some silvical, economic, or biological reason, partial shade for satisfactory growth and which can withstand or requires full sunlight after establishment.

Regenerating by shelterwood generally requires that the preliminary cuttings be from "below" (small trees are chosen for cutting first) and the removal cut or cuts are initiated when a desired regeneration is "well established." This covers two of the crucial aspects of successful application in most cases. The first is that the desirable regeneration has to be established in a good growing environment whose first requirement is what foresters call "high shade." Small poles and large saplings, for example,

cast dense shade and offer severe competition while larger sawlog size trees are much less competitive to seedlings or are beneficial. Thus, when the partial cutting resembles that done by selection method, the resulting regeneration is irregular in distribution, numbers and size, may fail entirely or be composed of undesirable species.

The second requirement, to initiate removal cuttings when the seedlings are "established" may be more difficult to fulfill. To begin with, in some forest types, the numbers of established seedlings which are adequate for the purposes of the forester are generally known and accepted while for other types, notably the northern hardwoods, there are few reliable guidelines. After it has been decided that seedling numbers are adequate, the condition of the seedlings must be assessed for ability to survive removal of the overstory and grow rapidly. Again, few guidelines are available for northern hardwood types and observation of local conditions will be valuable. In the study on the Argonne Experimental Forest in Wisconsin, we found that sugar maple seedlings about two feet in height grew as well as taller seedlings and survived well. But we noticed that seedlings taller than three feet stayed above herbaceous competition. So the guidelines for establishment are of sugar maple is that they be at least three feet in height. In some areas are of the Green Mountains of Vermont, however, sugar maple is less competitive and probably seedlings should be larger. Soil-site plays a role in deciding whether or not seedlings are established and are dense enough. On sites favorable for undesirable species, the desired species ought to be larger and more dense before overstory removal than where competition will be less severe.

It is necessary to provide for a desirable seed source in stands which do not have a supply of seedlings present already. Preparatory cuts can be done in previously uncut stands to develop the crowns of desirable species and to remove undesirable species. However, in fact, opening the stand will develop favorable sites for ^{germination} ~~germination~~ and establishment and simply increases the opportunity for a good seed year. Regular thinning often results in reproduction of some sort, however, so that in many types preparatory cuttings are unnecessary. Planting and artificial seeding may be used instead of or to supplement natural seed supplies also. On the other hand, opening the stand ~~just-as-often~~ stimulates unwanted regeneration sometimes which may cause problems at the time of the seed cut.

Site preparation to provide seedbeds and reduce unwanted competition is necessary on some sites and in some forest types. Where this is done, it seems reasonable that provision be made for planting or seeding in case of seed crop failure or excessive seedling mortality.

Providing the right light conditions to favor the desired species requires manipulation of the overstory. In some types, this is a simple matter; two cut shelterwoods are often used and these may be as simple as moving half the stand at the first cut and the remainder when the regeneration is ^{initially} established. When there is no regeneration present, the stand may have to be removed in several steps. Also, species vary in their light requirements for establishment and growth so that the amounts of overstory left after first and succeeding cuts will also vary. Obviously, it is the amount left that is important rather than the amount removed; but, schemes devised

for regulating the overstories are variously described in terms of percent removal, crown cover or residual basal area.

Shelterwood is the intermediate practice in terms of overstory left; at one extreme it resembles a seed tree cutting -- at the other, a selection cut. Both extremes are in use. Shelterwood obviously may be applied in a variety of shapes such as strips or groups.

The regularity of cut over an area depends mostly on the regularity of the overstory and the state of the regeneration. Previously partially cut northern hardwood stands (high graded, for example) which are going to be converted to even-age will be treated in an irregular fashion. The first cut, for example, might remove all the overstory over patches of established advanced regeneration, remove half over areas of small, not yet established regeneration, and be a thinning in patches of poles or small sawlogs. Depending on the species mix, attempting to treat such stands uniformly will often result in profuse sprout growth in some areas and open grassy patches in others interspersed with large seedlings, saplings and poles.

Although the principles of shelterwood are similar for nearly all forest types, the details of application vary considerably depending on species composition, soil-site factors, geographical areas, and biological factors. (Following are examples from current research and available guides which illustrate some of the possible variations and modifications):

ALLEGHENY HARDWOODS

The cherry-red maple type has several high value hardwoods. Cherry and the maples are especially desirable. Problems are grass-brush invasions

and severe deer damage in parts of the type area.

Current recommendations are to make a seed cut in stands without advance regeneration which removes 30 to 40% of the stand ($\frac{1}{2}$ -inch stems and larger) (Marquis 1979) which amounts to between 100 and 120 sq. ft. of basal area ^{residual} per acre. This type of cutting should result in regeneration stands whose composition resembles that of the overstory and whose seedlings are too small to interest deer. The overstory removal should take place 5-10 years after cut when seedlings should have grown to $\frac{1}{2}$ -foot to one foot. Cuts heavier than those recommended will favor fern and grasses and ^{even} light cuts will produce grasses on poorly drained soils.

It is interesting to contrast these recommendations with Lake States sugar maple stands and northern New England northern hardwoods. Most Lake States stands will produce scanty regeneration of even tolerant species under 100 sq. ft. of basal area (Godman & Tubbs 1973) and regeneration must be over 2 feet tall at a minimum in order to survive overstory removal. Small crowned trees such as black cherry are absent from most northern New England stands and sites which often could not support 120 sq. ft. before cutting.

CENTRAL ADIRONDACKS

The northern hardwoods of the Central Adirondacks are commonly composed of sugar maple, beech and yellow birch. Less tolerant species such as black cherry and white birch commonly found in successional stages of other areas are relatively rare here. Red spruce and eastern hemlock are tolerant conifer components in many stands.

Desirable species are yellow birch and sugar maple. (Richards and Farnsworth 1971). Problems are deer browsing, brush invasion (hobblebush and striped

maple) and the abundance of poorly formed and defective beech. Interestingly, the deer damage in this area is due to the preference of deer for hardwoods other than beech. Their browsing results in an understory of beech saplings which dominate the stand after heavy cutting. ~~Herbicides-are-effective-in reducing-beech-competition.~~

Recommendations are to herbicide the understory before a seed cut which leaves a residual stand of 50 sq. ft. of basal area per acre. Removals should take place between 6 and 10 years after the seed cut after the bulk of the seedlings have reached three feet in height and before they reach 8-10 feet in height. Controlled deer hunting during the regeneration period reduces the amount of influence that deer exert on the regeneration. These treatments ^{have produced} ~~produce~~ fully stocked stands of relatively even-sized desirable hardwoods on the Huntington Forest (Kelty 1979) and also provide large amounts of browse.

WHITE AND GREEN MOUNTAINS OF

VERMONT AND NEW HAMPSHIRE

The maple-beech-birch type is the predominant northern hardwood although the proportion of species varies widely. In the White Mountains, red maple and beech can comprise the bulk of the stands, especially on the poorer sites while sugar maple is the most common maple in many Green Mountain stands. Red spruce and eastern hemlock are tolerant conifer stand components. White birch is generally present in large numbers in successional types. Most desirable species are white ash, white and yellow birch and sugar maple. Red maple and beech are usually poorly formed and defective.

Problems include deer damage and grass-brush invasions.

Shelterwood procedures in the Green Mountains for the production of the birch species, generally require a seedling cut which leaves a light overstory of less than 50 percent high crown cover of desirable species and scarification is done to eliminate advance regeneration as well as to prepare a seedbed for the birches. Removal of the overstory is done when the birches are two feet tall.

Shelterwoods to produce sugar maple have not been done as often as for birch. Observation indicates that where advanced regeneration is absent a preliminary light cut from below leaving about 90 sq. ft. of the larger trees will be necessary to develop a stand of sugar maple seedlings which will then be established by a seed cut. We have not determined what ^{leave} overstory this cut should; probably 50 to 60 percent crown cover will provide a good growing environment until seedlings reach a height of four feet or so when a removal cut should be made. Observations of overstory removals made when sugar maple seedlings are less than two feet tall show that brush species dominate the site after cut. In stands where sugar maple is more aggressive and small maple seedlings already exist in abundance, the preliminary cut can be dispensed with.

In the White Mountains beech often forms an intermediate story in the structure of hardwood stands. Partial cutting of any sort releases the beech saplings which may, depending on their numbers, dominate the next stand. On site types (or habitat) (Leak 1978) which tend to support large numbers of beech a technique similar to that used in the Central Adirondacks ^{should} ~~would~~ prove successful. Preparatory and seed cuttings should discriminate against beech

and other undesirable species which are of seed bearing age.

Naturally, if beech is desirable in any portion of this range, two cut shelterwoods would provide adequate regeneration of that species.

In hardwood stands where sugar maple and ash predominate, two or three cut shelterwood should prove successful.

CONIFER TYPES

White pine occurs throughout the northern Appalachian Highland division (Braun 1950) on a variety of sites with a variety of species. Lancaster and Leak (1978) recommend shelterwoods for a number of situations. Problems with white pine are most likely to be with hardwood competition, disease and insects. Hardwood and hemlock competition is generally most severe on the better hardwood site i.e.: S.S.I. 60 or better. On these sites, advanced regeneration should be killed with herbicides before the first cut which removes roughly half the overstory and which should be timed to coincide with a good seed year. Weeding of hardwoods may be necessary before the removal cut if hardwood re-growth is abundant.

If the first logging must be done during the winter, scarification will be necessary to provide seedbeds. The removal cut can be made after the seedling pines begin to grow rapidly between 5 and 10 years after the first cut. Natural regeneration can be supplemented by planting 400 seedlings per acre. On sites better than 60, a mixed stand of hardwood and pine will result, on sandy soils of hardwood site index less than 60 greater numbers of pine can be obtained with the same or less effort.

SPRUCE-FIR TYPES

The principal species of the red spruce-balsam fir types are both themselves tolerant and lend/well to partial cutting systems. Wind firmness and disease are problems in this type. Recommendations for shelterwooding in this type (Frank and Bjorkbom 1973) are that up to $\frac{1}{2}$ the tree^s/be removed in the first cut of a two cut shelterwood. Trees to be left should be wind firm, vigorous, of desirable species and evenly spaced. This procedure allows the reduction of balsam fir as a seed source and an opportunity to increase proportion of spruce which is less susceptible to the spruce budworm and various rots. Removal of the overstory should be done when the reproduction is well established. Killing root rots of residual/^{trees}in the overstory of shelterwood cuts have been observed. Caution should be observed in areas and stands susceptible to these diseases.

An interesting variation in the spruce-fir type is narrow strip cutting (less than $\frac{1}{2}$ tree height) which is considered to be a variant of the shelterwood method here. This kind of cutting produces about the same effect as a regular shelterwood except that the opportunity for eliminating balsam fir is reduced unless it is removed from the intervening strips. This type of cutting allows the use of heavy logging equipment.

LITERATURE CITED

Braun, E. Lucy.

1974. Deciduous forests of eastern North America. The Free Press, Division of Mcmillan Publishing Co., Inc., NY. (Facsimile of the Edition of 1950)

Frank, Robert M., and John C. Bjorkbom.

1973. A silvicultural guide for spruce-fir in the Northeast. NE. Forest Exp. Sta., Broomall, PA. 29 p., illus. Forest Service, Gen. Tech. Rep. NE-6.

Godman, Richard M., and Carl H. Tubbs.

1973. Establishing even-age northern hardwood regeneration by the shelterwood method -- a preliminary guide. USDA-For. Serv. Res. Pap. NC-99. North Central For. Exp. Stn., St. Paul, MI. 9 p., illus.

Kelty, Matthew J.

1979. Use of the shelterwood method for regenerating northern hardwoods and influencing deer browse. A thesis submitted in partial fulfillment of the requirements for the M.S. Degree., State University of New York, College of Environmental Science and Forestry, Syracuse, NY.

Lancaster, Kenneth F., and William B. Leak.

1978. A silvicultural guide for white pine in the northeast. Northeast. For. Exp. Stn., Broomall, PA. 13 p., illus. U.S. Dep. Agric. For. Serv. Gen. Tech. Rep. NE-41).

Leak, W. B.

1976. Relation of tolerant species to habitat in the White Mountains of New Hampshire. Northeast. For. Exp. Stn., Broomall, PA., 10 p., illus., USDA-For. Serv. Res. Pap. NE-351.

Marquis, David A.

1979. Shelterwood cutting in Allegheny hardwoods. J. of For. 77(3): 140-144.

Richards, N.A. and C. E. Farnsworth.

1971. Effects of cutting level on regeneration of northern hardwoods protected from deer. J. of For. 69:230-233.

REGENERATING OAKS

by

Ivan L. Sander, Principal Silviculturist
North Central Forest Experiment Station
Forest Service, U.S. Dep. Agric.
Columbia, Missouri 65211

Many studies of harvest cutting methods have been made in the eastern United States over the past 30 or so years. From these studies we have learned (1) oaks grow best in even-aged stands, (2) new reproduction stands that follow clearcutting contain oaks in proportion to the number and size of oak reproduction present before the cut is made, and (3) individual stems of advance oak reproduction must be large and have well-established root systems to compete successfully and become dominant in the new stands.

From this information we now know that the first step in planning the regeneration of oak stands is to survey the advance reproduction and determine if it is adequate to replace the old stand. At least 435 advance oaks per acre at least 4.5 feet tall must be present before the advance reproduction can be considered adequate. The potential for sprouting from stumps of cut oaks can be used to supplement deficiencies of advance reproduction (Sander et al 1976).

If the oak advance reproduction is not adequate, what can we do to make it adequate? At first glance, the classical shelterwood system appears to be ideally suited for use in regenerating oaks. However, the classical shelterwood system as applied in research studies did not result in many new oak seedlings and also failed to provide for their continuing survival and growth until large enough to compete in the stand following the final removal cut.

How then can oaks be regenerated successfully? We must develop a system specifically tailored for them that satisfies their silvical requirements. Unfortunately we do not presently have all of the information needed to design such a system but I think we have a good basis from which to begin.

When enough oak reproduction, new oak seedlings will have to be established. The basic requirements for good acorn germination were documented by Korstian in 1927 and have been verified by others (Krajicek 1955, Sluder et al 1961). Best germination and first year seedling survival occur when the acorns are planted about 1 inch deep in the soil. Some litter covering does not inhibit germination, but rodents often consume the direct-seeded acorns unless they are protected with a mechanical barrier.

We know very little about the seedbeds in which natural oak seedlings originate. It appears from our limited observations in Missouri that most 1-year-old oak seedlings come from acorns that are in the soil or at least in contact with the soil and covered by litter. How these acorns get planted is not known for certain but squirrels and mice or voles surely are at least partially responsible.

A study in Missouri that was begun in 40-year-old black oak stands to determine the effects of stand density ranging from 30 percent stocking to unthinned on growth and yield provided an opportunity to study the effects of stand density on establishment and growth of oak reproduction. In May, following a good black oak seed crop, we found more than 100,000 acorns per acre on the ground (Table 1). About 1 percent or less of these acorns were germinating and there was no relation to overstory density. By the following September there were about 200-350 1-year-old seedlings present. Although these data are for a single year, indications are that a lot of acorns will be required to establish a sufficient number of oak seedlings. Three years later, 40-60 percent of these seedlings

Table 1.--Black oak acorns on the ground and germinating under four levels of overstory stocking

Stocking percent	Acorns per acre		1-year-old seedlings	Acorns per seedling
	On ground	Germinating		
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Number</u>
30	111,000	1.2	300	370
50	108,000	0.2	210	514
70	132,000	1.2	340	390
Unthinned	125,000	0.2	230	543

had survived with the best survival at moderate overstory densities (Table 2). Regardless of overstory density, light intensity at the ground level, where these seedlings are struggling to exist, was 10 percent or less of the intensity in a nearby open area. This is not enough light for oaks to survive and grow. A dense understory had developed on the lightly stocked plots, a situation similar to our previous unsuccessful shelterwood cuts, and this understory allowed no more light to reach the ground than the overstory on the unthinned plots.

Table 2.--Survival of black oak seedlings 3 years
after establishment under 4 levels of
overstory stocking

Stocking percent	Seedlings surviving	Light intensity ^{1/}
	<u>Number/acre</u>	<u>Percent</u>
30	130	43
50	125	60
70	205	60
Unthinned	115	50

^{1/} Percent light at 8 inches above ground is of the light in an open area.

Although there are more than enough stems of the major oak species present under all density levels to replace the stands in this Missouri study, at least two-thirds of them are less than 4 feet tall (Table 3). Furthermore, most of these are less than 1 foot tall. Species other than oak dominate the reproduction under all density levels. Unless given some help, these small oaks will probably die.

Table 3.--Reproduction per acre under thinned oak stands 10 years after the first thinning at age 40

Height	Residual stocking percent			
	30	50	70	Unthinned
----- Number -----				
Major oak ^{1/}				
Less than 1 foot	565	445	710	400
Less than 4 feet	920	775	965	610
More than 4 feet	285	175	305	165
Other trees ^{2/}				
Less than 1 foot	470	690	490	320
Less than 4 feet	1,200	1,450	1,065	970
More than 4 feet	485	340	300	275
Understory species ^{3/}				
Less than 1 foot	1,375	1,385	1,145	780
Less than 4 feet	2,760	2,560	1,975	1,390
More than 4 feet	1,070	945	200	185
Total				
Less than 1 foot	2,410	2,520	2,345	1,500
Less than 4 feet	4,880	4,785	4,005	2,970
More than 4 feet	1,840	1,460	805	625
Stump sprouts ^{4/}				
	270	180	130	0

^{1/} White, black, northern red, and scarlet oaks.

^{2/} Post and blackjack oaks, hickories, black gum, and red maple.

^{3/} Dogwood, sassafras, serviceberry, witch hazel, and hazelnut.

^{4/} Sprouts from stumps of trees cut in thinning.

Under the conditions existing at all density levels the newly established black oak seedlings did not grow. At age 3 and 4 they were no taller than they were at age 1 (Table 4).

Table 4.--Average height of black oak seedlings under four levels of overstory stocking (in feet)

Age	Stocking percent			Unthinned
	30	50	70	
----- 1971 seedlings -----				
1	0.3	0.4	0.3	0.4
2	0.3	0.4	0.3	0.4
4	0.3	0.4	0.4	0.4
----- 1972 seedlings -----				
1	0.3	0.3	0.3	0.3
3	0.3	0.3	0.3	0.3

The oak sprout reproduction averaged about 4 feet or less in height 10 years after the original thinning (Table 5). Four years later it had grown very little and on the higher density plots, the average height of these oaks had decreased slightly.

The light intensity at which oak seedlings reach their maximum photosynthetic rates is about 30 percent of full light. In Missouri, this light intensity is attained at ground level at about 40 percent overstory stocking and no understory (fig. 1). However, experience tells us that at this overstory density, development of all species in the understory will be rapid, especially if the understory contains many stems more than about 4-6 feet tall. And, simply reducing overstory density will not ensure that light intensity at the ground will be adequate for oak seedlings growth. Thus application of the regeneration system will involve not only reducing overstory density but also controlling the understory.

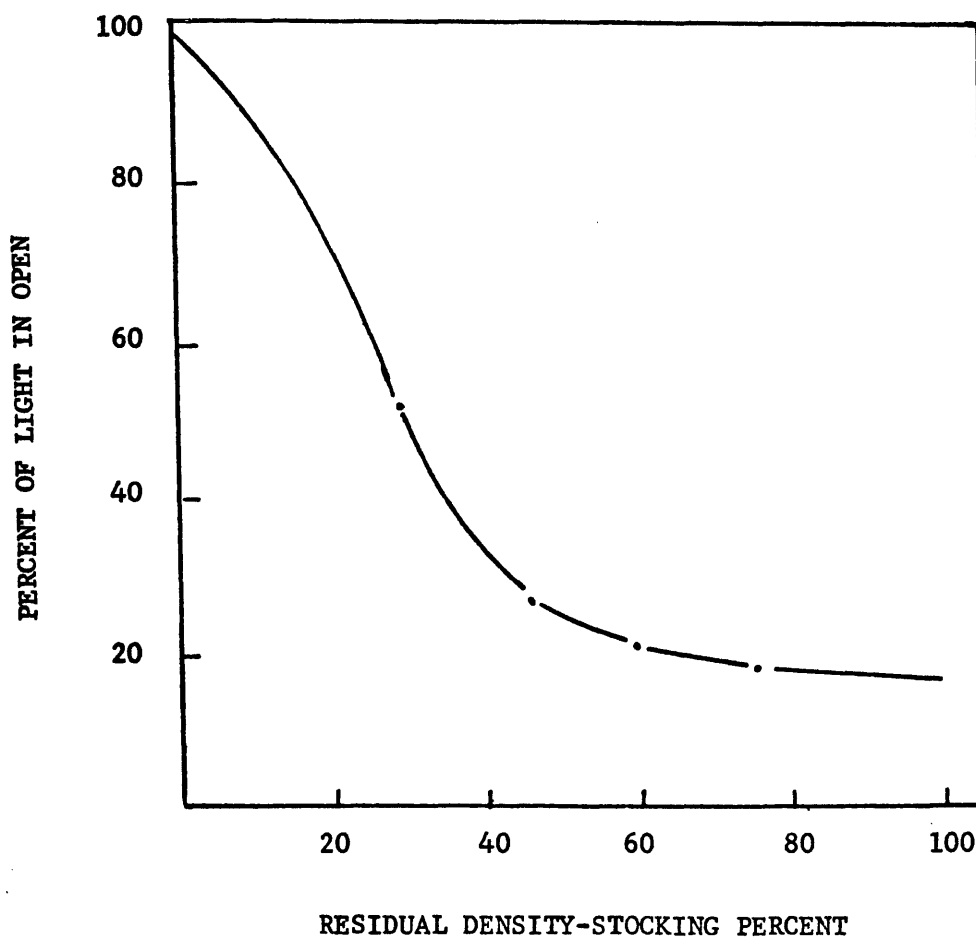


Figure 1.--Relation between residual overstory density and light intensity 8 inches above the ground

Table 5.--Average height of sprout oak reproduction under
oak stands 10 and 14 years after first
thinning at age 40 (in feet)

Species	Residual stocking percent			
	30	50	70	Unthinned
- - - - - 10 years after thinning - - - - -				
White oak	3.8	3.5	4.3	3.0
Black oak	2.4	1.8	0.9	0.3
Northern red oak	3.9	2.4	0.9	--
Scarlet oak	2.8	--	2.0	--
- - - - - 14 years after thinning - - - - -				
White oak	4.0	3.7	4.2	2.9
Black oak	2.5	1.9	0.6	0.2
Northern red oak	3.2	2.6	0.8	--
Scarlet oak	4.2	--	2.2	--

Although limited, these data indicate how a system for reproducing oaks might work. New seedling establishment will depend on the occurrence and size of acorn crops. How long it takes to establish a sufficient number of seedlings is uncertain. It depends to some extent on how many are needed but on the average it will probably take from 5 to 10 years. Some type of seedbed preparation might be helpful but it would have to be timed to coincide with a good seed crop. Our experience with site preparation has been that although more oak seedlings were initially established on sites prepared by disking than on unprepared sites, a few years later there were about the same number of seedlings on both sites (Sander and Clark 1971, Scholz 1959). However, in these studies we attempted nothing more to ensure oak seedling survival. Most critical will be maintaining conditions that allow new oak seedlings and other small oaks to quickly grow to the size necessary for them to be competitive in a new stand when all of the overstory is removed.

In existing mature or nearly mature oak stands, the first cut of an oak regeneration system should reduce overstory density to not less than 60 percent stocking (Gingrich 1967). Although light intensity at this overstory density is not optimum, it should be sufficient for the oak advance reproduction to survive and grow. This density is also the minimum required for full site utilization and will inhibit rapid development of other species in the understory. The first trees removed in this cut should be those in the lower crown classes. Crown coverage of the residual stand should be as uniform as possible with no large holes in the overstory canopy.

If there is an understory present, it will most likely have to be controlled or at least its density reduced, particularly if it is well-developed. The answer to the question of "how dense is too dense or how much control is necessary?" is not known. However, I believe removal of the understory stems larger than the oaks they are competing with is the minimum. The most effective and economical way to do this may be with herbicides, but a selective stem treatment or cut surface treatment will probably be necessary to avoid damaging existing oaks. Prescribed burning may be a viable option but we need to learn more about how the various understory species and reproduction size classes react to fire before it can be recommended for wide-scale use. We must also know if and how fire can be used without unduly damaging the overstory trees.

How long a period might be required to develop the oak reproduction to the minimum size needed is uncertain. Observations of the advance reproduction under unmanaged stands indicates 15-25 years are needed. However, we hope to be able to shorten this time to 10 years or less. During this period an additional cut might be needed to maintain an overstory crown cover that will not unduly restrict the oak reproduction growth. At what point this cut might be needed or the best residual density it should leave are not known. However, it seems reasonable to let stocking percent increase to about 75 or 80 percent before making another cut. It also seems reasonable to reduce the overstory stocking to about 50 percent when the oaks average about 3 feet tall. Further control of unwanted species in the reproduction may also be needed. When there are at least 435 oaks per acre 4.5 feet tall or taller present, the remaining overstory should be removed in one final cut.

An alternative to depending on natural establishment of oak seedlings is to underplant them. This may be an option where a particular oak species is wanted, but no seed source of that species is present. The planted seedlings would have to be allowed to develop the same as natural reproduction. We have a study in progress now to determine if this will work, but it is only 1 year old and we have no results yet.

The regeneration system for oaks that I have just described is not really proven. It is a conservative approach, which I believe is desirable until we can obtain the information needed to refine it. We are currently working on a study to get this information but it will likely be several years before we have the data to establish trends. I think regenerating oaks will require all of the silvicultural expertise we can muster. It will be intensive silviculture of the highest order.

Literature Cited

Gingrich, S. F.

1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the Central States.
For. Sci. 13:39-53.

Korstian, C. F.

1927. Factors controlling germination and early survival in oaks. Yale University School of Forestry Bulletin 19, 115 p.

Krajicek, J. E.

1955. Rodents influence red oak regeneration. U.S. Dep. Agric. For. Serv., Central States For. Est. Stn., Note 91, 2 p.

Rudolph, V. J., and W. A. Lemmien

1976. Silvicultural cuttings in an oak-hickory stand in Michigan: 21 year results. In Proceedings First Central Hardwood Conference, p. 431-453 (Carbondale, Illinois, October 1976).

Sander, I. L., and F. B. Clark

1971. Reproduction of upland hardwood forests in the Central States. U.S. Dep. Agric. For. Serv., Agric. Handbk. 405, 25 p., illus.

Sander, I. L., P. S. Johnson, and R. F. Watt

1976. A guide for evaluating the adequacy of oak advance reproduction. U.S. Dep. Agric. For. Serv., North Cen. For. Exp. Stn., Gen. Tech. Rep. NC-23, 7 p.

Scholz, H. F.

1959. Further observations on seedbed scarification show benefits to northern red oak were temporary. U.S. Dep. Agric. For. Serv., Lake States For. Exp. Stn. Tech. Note 555, 2 p.

Sluder, E. R., D. F. Olson, Jr., and T. W. Jarrett

1961. Tests on direct seeding of oak in the Piedmont and southern Appalachians of North Carolina. U.S. Dep. Agric. For. Serv., Southeastern For. Exp. Stn. Paper 134, 12 p.

APPENDIX MATERIAL

SHELTERWOODS - Ecological Considerations

INTRODUCTION

The thought has probably entered your mind: Why is so much time being devoted to the subject of shelterwood? This is the third workshop we have had on this subject in the past year.

In answering this question (and setting the stage for discussions to follow) I probably will hit on some pretty basic stuff.

BEAR WITH ME!

For starters - I want to back off from "pure" silviculture and look at some of the non-technical reasons that make this discussion timely.

You are all familiar to varying degrees with the National Forest Management Act of 1976. This Act amends the Forest and Rangeland Renewable Resources Planning Act of 1974.

I would just like to cite a few significant sections of the NFMA.

The most significant are in Section 6 "National Forest System Resource Planning". More specifically, Sec. 6(g)(3)(F)(i)(ii)(v):

Section (i) sets clearcutting apart from other regeneration cutting methods.

(READ IT)

Other portions of Section 6 are of near equal importance.

6(e)(2)

6(g)(3)(A), (B) and (E)

(READ THEM)?

Other sections, which I won't take the time to read are:

in "Findings": Section 2(4) and 2(6) and in "Reforestation" Section 4(d)(1)

Another reason this discussion is timely is that:

Use of the shelterwood system is being discussed and proposed more and more as an alternative for clearcutting to regenerate even-aged stands.

Also, as far as I am aware neither this group nor any similar assembly of Foresters within the Region has ever devoted a substantial amount of time to this subject prior to undertaking this round of workshops. Hence, we are all operating from different plateaus of knowledge and experience. We want to narrow this range of knowledge and bring everyone up-to-date.

I think it is vitally important on this subject (other subjects too) that we take the time to share with each other our successes, failures, and concerns, and take full advantage of the expertise that Research is able and willing to provide.

PRINCIPLES

For the next few-minutes I'll take the risk of sounding as though this is a back-to-school session. That is not my intention. I do want to set the stage for what will follow in the next two days.

Now let's get back to silviculture.

If you will allow me, I intend to confine my remarks to even-aged management. It is within this realm that we must focus our thoughts when the main topic is shelterwood.

Briefly defined - Silviculture is the art and science of growing forests: or crops of trees if you prefer.

Forest crops are different from other types of crops that usually come to mind in one very significant way. This difference is the time involved to produce the crop.

It is similar to other crops in that there is a definite sequence of events that occur in managed forests.

- The crops are started as a result of some conscious effort.
- They are tended in various ways as they are growing and maturing.
- They are removed when mature.

This is all done according to a plan.

When we talk about silviculture we are talking about developing a plan for a forest or a stand, and then doing what is necessary to cause the stand to grow in a certain way.

The objective is to produce something we need or want, whether it be timber, wildlife, water, recreation, a pleasing appearance, or any combination of these.

Although all silvicultural systems, and specific silvicultural treatments, are based on the biological requirements of the trees themselves, how they are applied depends on the plan, - on specific goals and desires.

Depending on the condition of the stand, silvicultural treatments usually have only one of two objectives.

1. To improve the composition and increase the growth of the existing stand.

We know these as intermediate cuts.

2. To facilitate the production of new trees to replace older trees that have been or will be removed.

You all recognize this as the regeneration cut.

It is at this time that the most critical silvicultural decisions must be made.

What is the most appropriate way, within the scope of our plan, to reproduce the stand - or help the stand reproduce itself?

Through our actions, we must create conditions favorable to the regeneration process. To do this we must choose one of three cutting methods:

Clearcut

Seed Tree

or Shelterwood

Basic to choosing the cutting method are the characteristics of both the site and the vegetation.

Other factors are also important, such as economic and sociological consideration.

The main difference between the three cutting methods is the resulting degree of exposure of the forest floor to sunlight and atmospheric conditions.

Let's spend a little time considering the on-site effects of this exposure. The extremes would be an uncut stand and a clearcut.

A disturbance of any kind, (but in this instances we are talking about a planned cut), tends to disrupt the ecological balance, setting the ecosystems back to some earlier successional stage.

ENERGY BUDGET

The differences in the energy budgets between an uncut and a cut stand are important to consider.

Allowing that the net radiation or net energy available is essentially the same for the uncut and cut stands, what then is the difference?

The difference is in the distribution of the energy, what it is used for.

The source of energy is solar radiation and thermal radiation.

Solar is that which is received directly from the sun.

Thermal-or heat radiation - that which is re-emitted.

The soil and canopy re-emit some of the solar energy they have absorbed.

Solar radiation is converted into chemical energy through photosynthesis, and is used for plant growth (and ultimately for food energy by all animal life).

Solar radiation is also used for evaporation and transpiration, and much of it is converted to heat.

In terms of the percent of net energy available - there is very little difference in the amount used for photosynthesis - respiration between an uncut and a cut stand.

The big changes in the use of available energy are in how much is used for evapo-transpiration and heating.

For purposes of illustration (and these are very close to some actual figures I have available) let us say that the total on-site energy available is about 400 units.

It would be used in the following way, in an uncut stand:

UNCUT

- < 10 units for Photosynthesis-respiration
- < 100 for Heating
- > 300 for Evapo-transpiration

In a clearcut stand we see quite a different picture:

CLEARCUT

Photosynthesis-resp.	still	< 10 units
but heating	nearly	300
and Evapo-transpiration is	slightly	> 100

We see here that there has been a reversal of the amount of energy used for heating and for evapo-transpiration.

The change in evapo-transpiration is a result of the reduced amount of vegetation present to transpire water on the clearcut area.

Consequently, a corresponding increase is available for heating. What is important here is that this heating occurs at or near ground level. Again, because of the reduced vegetation.

The next logical question is - SO WHAT!

Well, these changes have significant effects on all other balances within the ecosystem.

Let's look at some "for instances", none of which is any big surprise.

The increased soil temperature may have numerous effects.

Reduced germination and survival of some species may result:

Caused by direct heat injury or rapid soil drying.

The opposite could also occur in germination - certain species may be favored by higher soil temperature.

The critical question would be how the most desirable species on a particular site are affected.

I don't profess to know the answer.

High soil temperature definitely increase the rate of humus decomposition; primarily through increases in numbers and activity of soil flora and fauna.

This may only be a short term effect however, depending on the regrowth of vegetation, but it will last several years.

WATER BUDGET

There is also a marked effect on the water budget, depending on the degree of vegetative removal.

The water that is not lost through transpiration must show up someplace else.

This "someplace else" is mostly increased streamflow, primarily during the latter part of the growing season when streamflow is normally low.

The effect here also, in terms of amount and duration, is dependent on the regrowth of vegetation.

Increased water run-off resulting from cutting may have some secondary effects. The water may carry with it soil practices or dissolved nutrients that would otherwise have remained in place.

Since the canopy of an uncut stand intercepts, utilizes, and/or reflects as much as 90% of the solar energy it receives, relatively little energy is available at or near the forest floor for vegetation.

Only a relatively few species are able to reproduce, survive and grow under this combination of low light/moisture/nutrients. These, of course, are the tolerant species.

So now it appears as though we've come "full-circle" - and quite rapidly too - back to the tree reproduction and, consequently, cutting methods.

Having taken a quick look at the extreme effects, I think we are safe in the hypothesis that a disturbance of some lesser degree of magnitude will have a corresponding modifying influence on these effects - namely the distribution of the energy and water budgets.

Striking the balances that will best help us meet our management objectives is our primary concern.

REMOVAL OF THE SHELTERWOOD

But we still have one additional concern. It is not enough to be able to get our regeneration established.

Sooner or later the desirable trees must be in an environment in which they can grow satisfactorily.

This usually means they must grow faster in height than the undesirable vegetation.

The corrective action we are most obviously going to be confronted with is removal of the shelterwood overstory.

Here I think it is appropriate to make an important distinction.

A shelterwood is just exactly what the name implies - shelter by the overstory for the benefit of the regeneration.

If the overstory is not beneficial to the regeneration, or when it ceases to be beneficial, it is no longer proper to call it a shelterwood. The length of time that the beneficial effects may last is quite variable. For some species it is only a couple years; for others it is longer.

There may be good reasons for not making the removal cut (or cuts) on the exact schedule that silvicultural needs would dictate. This, however, does not alter the fact that the shelter is no longer a benefit to the regeneration.

Here is where it becomes a delicate subject, but I think it behooves us, as Timber Management specialists, to use proper terminology.

We must not permit modified practices to be perpetrated and perpetuated under the guise of sound silviculture when they are not.

We must figure out some way to handle this potential terminology problem. Enough said for the time being. This is not the real problem at hand.

To Conclude -

At the risk of being a party to another era - namely the "shelterwood era" - I suggest that in the course of the pendulum swing from selection to clearcutting we went right past shelterwood.

Now as the pendulum comes back I think it is appropriate that we slow it down to take a good look at this option.

I don't advocate stopping it. Our management needs are so diverse that we must have the skills to use all cutting methods.

Hopefully, we can determine when and where the use of shelterwood regeneration techniques are appropriate and how to apply them.

This is the objective of this workshop: To increase understanding of shelterwood regeneration techniques: how, when, and where to apply them.

To help us do this:

RESEARCH ASSISTANCE

I'm very pleased and I think we are very fortunate to have such outstanding participants from Research as have joined us for this session.

Several of them will be making presentations later.

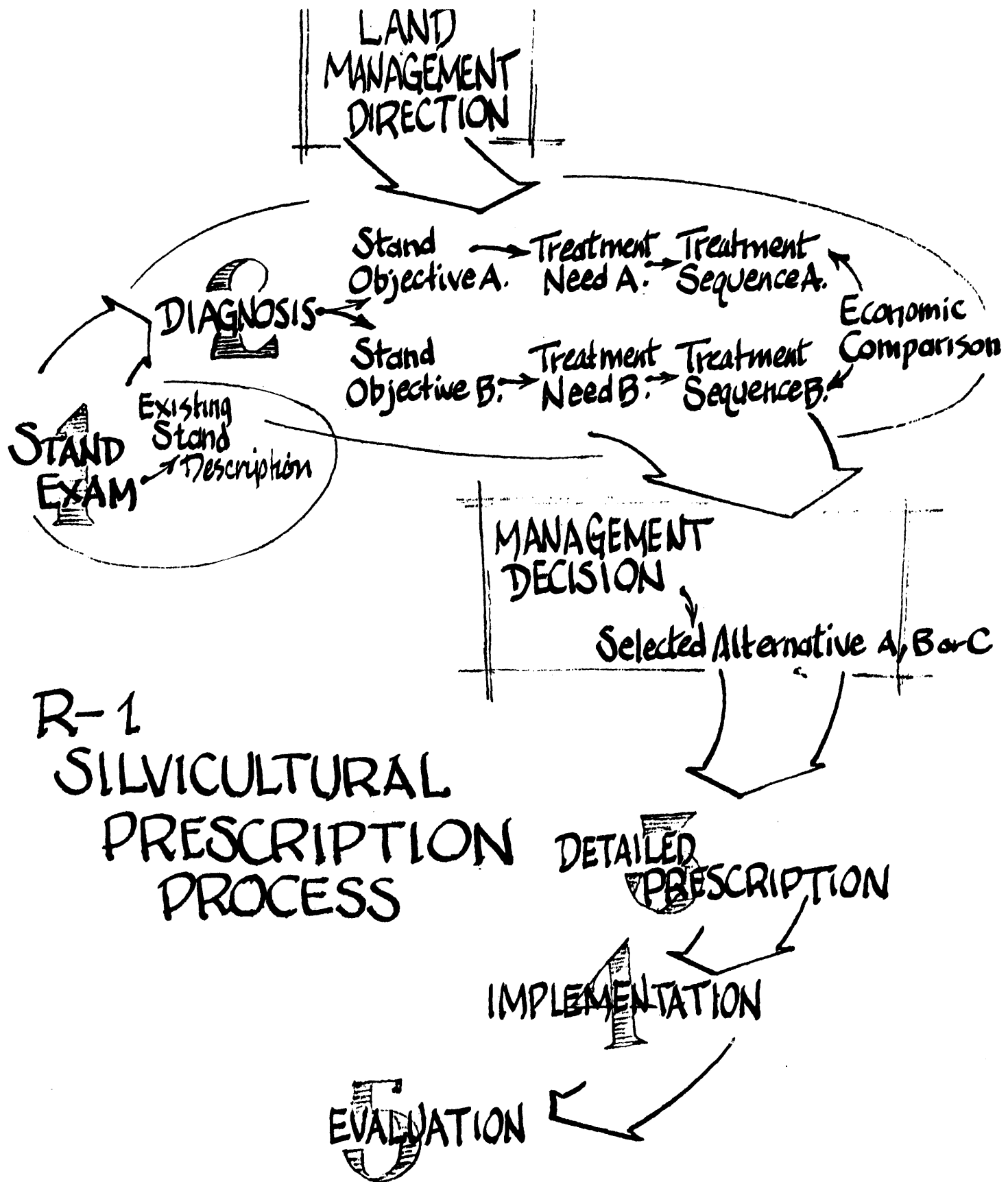
They will give us some idea of what research has been done in the past and what is currently underway that is applicable, directly or indirectly, to consideration of the use of shelterwood.

More importantly, however, they will be available during the field trips to help us interpret what is it we are looking at on-the-ground.

We are not going to be visiting only stands that are "classic" examples of shelterwood silviculture. This is one of the problems. There aren't many of them. This is why we need to draw on their experience to determine the appropriateness of what was done.

Also to predict, speculate, or whatever, (guess perhaps) what might have happened if the treatment we are looking at had been modified in some way.

From past association with these gentlemen I know they will not be bashful about playing such a role.



2478 - SILVICULTURAL EXAMS AND PRESCRIPTIONS

1. Introduction. The role of silvicultural prescriptions in the Northern Region is to translate land management objectives into silviculturally sound treatments that can be implemented as part of the timber management program. They shall be prepared or reviewed by Certified Silviculturists who meet Northern Region standards for experience, education, and examination (FSM 2478, 2478.03, 2478.3, 2478.4 and 2431.21).

a. Purposes of a Silvicultural Prescription

A prescription serves three purposes:

(1) The prescription must document the technical reason for treating the stand.

(2) The prescription must clearly show how the proposed and alternative treatments will develop a stand that can meet the land management objective.

(3) The prescription must give the necessary direction for implementation of the treatment.

b. Land Management Objective

The land management objective and related guidance provides the basic direction for development and implementation of a silvicultural prescription. The prescription must be written to benefit all allocated resources and to provide protection from windthrow fire, insects and disease.

c. The Prescription Area

Prescriptions will usually be written for forest stands. ^{1/}

The area defined by a forest stand may be adjusted for differences in: (1) physical site factors, and (2) land management objectives.

In most cases, differences in vegetation, timber, site factors, and management guidance between stands dictate that separate prescriptions be made for each stand. When these differences are not significant enough to change the prescription from one forest stand to another, they may be combined for prescription writing purposes.

^{1/} Ford-Robertson, F.C. (Ed.) 1971. Terminology of forest science, technology, practice and product. Society of American Foresters, Wash. D.C. xxi + 349p.

2. Documentation. The prescription is a means of communication. To serve this function it must be a written statement.

Each step of the prescription process requires documentation to meet the direction of FSM 2478. . . and to adequately fulfill the three purposes of a prescription. Documentation should be factual and brief. The prescription document should be considered a technical report written for people working in the general field of forestry. It may require interpretation when used by the public and other professions.

a. Documentation Requirements

Each written prescription shall include the following points:

(1) Stand Identification. Minimum requirements: compartment, subcompartment, stand number and area. Suggested format: Stand Data Base Form 1.

(2) Responsibility. Minimum requirement: author and date. If the author is not a Certified Silviculturist the certified reviewer and the date of his review must be included.

(3) Land Management Objective. Minimum requirement: The land management direction for the area covered by the prescription must be stated. Lengthy management direction should be summarized and its source referenced.

(4) Site Data. Although information about the site is recorded elsewhere, it is an integral part of the technical justification for the treatment and will, therefore, be documented as part of the prescription.

Minimum requirements:

- (a) slope
- (b) aspect
- (c) elevation
- (d) habitat type
- (e) relative productivity
- (f) land type
- (g) Soil description

Suggested format: Copy of Stand Data Base Form 1.

Minimum documentation requirements and formats for the following are included with the explanation of each point under the Prescription Process:

- (5) Diagnosis
- (6) Detailed Prescription
- (7) Implementation
- (8) Evaluation

b. Storage and Retention

Written silvicultural prescriptions will be stored in the stand folder component of the Stand Management Record System. The prescription will be retained in the current file until the prescribed treatment has been implemented and evaluated. After evaluation, the prescription will be retained permanently in the historical file. (See FSM 2490).

3. Prescription Process. A sequence of five steps must be followed to complete the prescription process. Each step serves a specific function and supports the next step in the process.

Prescription Steps:

- a. Stand examination
- b. Diagnosis
- c. Detailed prescription
- d. Implementation
- e. Evaluation

If the sequence of steps is interrupted at any point, feedback can occur to begin the process again at an earlier step.

a. Stand Examination

Regular Region 1 stand examination procedure will provide the information needed to diagnose treatment needs and prepare detailed prescriptions. The kinds and amounts of data gathered and their reliability will depend upon the resources to be managed and intensity of management to be applied. Enough information must be obtained to adequately describe the current condition of the stand or nonstocked area.

b. Diagnosis

(1) Method of Diagnosis

The diagnosis can be accomplished by addressing several questions on the basis of stand data. These questions are:

- Can the existing stand satisfy the requirements of the land management objective?
- How can the existing stand be treated to develop a condition that will better satisfy management direction?
- If the existing stand cannot be treated to meet management needs, how and when can it be harvested and replaced with a more desirable stand?

To answer these questions, the silviculturist must be able to visualize and describe one or more stand objectives that can meet the requirements of the land management objective on the site. Frequently the silviculturist must refer to written guidance from other disciplines or must discuss alternative stand descriptions with other resource specialists to develop stand objectives that can satisfy multiple resources.

If an area is not adequately stocked, the description of a stand objective might include desirable species compositions and numbers of trees needed per acre to occupy the site. When the area supports trees, the description of a stand objective might consider a stand of similar age for direct comparison with the existing stand.

The description of stand objectives presents considerable latitude for the silviculturist to guide future stand development.

Comparison of the existing stand with described stand objectives will provide the basis for identifying treatment needs. The treatment need will be selected from the following list to allow integration of this step of the prescription process with the stand record system and with accomplishment reporting.

<u>ADP Code</u>	<u>Stand Treatment Need</u>
01	No treatment
02	Regenerate understocked area
03	Regeneration harvest (method unspecified)
04	Regenerate w/clearcut or seed tree
05	Regenerate w/shelterwood
06	Selection cut (only areas regulated on selection basis)
07	Precommercial thinning
08	Commercial thinning
09	Sanitation and/or salvage
10	Overwood removal
11	Release

Once a treatment need has been selected for each alternative, logical steps that will carry the stand through the next regeneration period will be specified. This must be done to assure that the direction set by the treatment need is reasonable and to develop information for an economic comparison of alternatives.

If the diagnosis step is prepared as part of an Environmental Assessment (NEPA Process, FSM 1950), an economic analysis will be made for the project as a whole. This type of analysis will best represent the effect of alternative treatments on all of the resources to be managed. If the diagnosis step is not done in conjunction with an Environmental Assessment, an economic comparison can be made between the silvicultural aspects of the identified alternatives.

The diagnosis step will satisfy the first two purposes of preparing a silvicultural prescription: (1) the reason for the treatment, and (2) showing how the treatment will attain the management objective.

(2) Documentation of the Diagnosis Step

Stand data is the basis for making a diagnosis that will result in viable treatment needs. However, the prescription document should not be used as an opportunity to summarize general data about a forest stand. The Timber Stand Management Record System will serve that function. Stand data cited in the prescription should be directed specifically at determining the relationship of the subject stand and the land management direction.

Stand data should be grouped by attributes to allow an efficient comparison between the existing stand and the alternative stand objectives. The most useful stand attributes are:

Structure - age and size class distributions, relationship of crown canopy levels.

Composition - species distribution by stand structure.

Density - trees per acre or basal area per acre.

Condition - status of insects, disease, and successional stage.

Growth - volume, height, or radial increment.

Fuels - size, arrangement, loading.

Minimum requirements:

(a) Description of the existing stand by important stand attributes.

(b) Comparison with stand objectives.

- Stand description of desirable management alternatives by the same attributes used for the existing stand.
- A statement for each alternative summarizing the comparison of the alternative with the existing stand.
- A conclusion of treatment need for each alternative (must follow standard treatment needs list, codes 01 through 11).
- A logical sequence of steps that will carry each alternative through the next regeneration period.

Suggested format: A tabular format is suggested. The entire diagnosis step can be adequately documented in two tables; one covering steps (a) and (b), steps 1 through 3, and one outlining b, step 4.

(c) Economic Analysis.

If the diagnosis step is done in conjunction with an Environmental Assessment, the economic analysis will be documented in the Environmental Analysis Report. If the diagnosis step is not done with the Environmental Assessment, the documentation of the economic analysis must be included with the prescription.

Minimum requirement: Net present worth should be estimated and displayed for each alternative. The current OMB rate will be used (10 percent; 1979). Other rates of interest may be used in addition to the current OMB rate.

Suggested format: Tabular format summarizing the economic analysis for all alternatives.

c. Detailed Prescription

(1) Timing

A detailed prescription is not prepared until an alternative, from the diagnosis step, has been selected as best meeting the management objective. The detailed prescription is prepared only for the immediate sequence of entries in the stand. This step satisfies the third purpose for preparing a prescription by assisting implementation.

(2) Documentation of the Detailed Prescription

Correct implementation of a prescription depends upon a clear set of instructions. These instructions are provided by documentation of the detailed prescription. To insure accurate communication between the author of the prescription and the persons responsible for layout and supervision of a project, documentation must be concise and yet contain necessary detail.

Documentation of the detailed prescription will provide the information required for entry of planned activities into the stand record system on Stand Data Base Form 4.

Minimum requirements: The detailed prescription shall list the sequence of actions required to carry out the treatment need. The timing of each action will be documented. Specifications for each action will be stated in enough detail to insure that implementation can meet the intent of the prescription.

Required format: Detailed Silvicultural Prescription Summary, Region 1 Form ____.

DETAILED SILVICULTURAL PRESCRIPTION SUMMARY

Stand ID:	Treatment Need:	Prepared By:	Date:
Action		Time	
Specifications			

d. Implementation

This step bridges the gap between the conceptual prescription and a project. If the prescription process has been followed carefully, there are likely to be few changes as the project is accomplished. However, some changes are unavoidable and they must be accounted for in the implementation step. If changes will alter the treatment need or develop a stand that is significantly different from the stand objective described in the diagnosis step, the responsible Certified Silviculturist should consider reentering the prescription process at the point of change and developing an amended prescription.

Successful implementation might depend on some of the following techniques:

- (1) Paper layout and review of the project to check its workability in relation to other resources, transportation, and logging systems.

- (2) Written marking guides (required).

- (3) Training tree markers.

- (4) Participation in selection of contract clauses.

- (5) On-site monitoring and consultation with contract administrators and crew foremen.

The documentation involved with implementation of a prescription depends upon a host of forms, records, and reports that are already covered by manual direction (i.e., KV plan, Timber Sale Report, Contracts, etc.) A record of changes made during the course of implementation should be kept by the responsible silviculturist.

Minimum requirements: Note changes to the detailed prescription on the worksheet retained in the stand folder. Each notation should be initialed and dated.

e. Evaluation

Every implemented prescription should be evaluated by the responsible Silviculturist to determine if the treatment need was achieved according to specifications and to compare the treated stand with the stand objective.

Evaluations can be made of any step or combination of steps in the prescription process. A record of these evaluations shall be retained as a permanent part of the stand folder.

Minimum requirement: All evaluations must be written, signed, and dated.

4. Coordination With Environmental Assessment. The NEPA process (FSM 1950) contains steps that parallel the prescription process. Since the silvicultural prescription can be developed by sequential steps and must be related to decisions made in the NEPA process, it is desirable to develop both processes simultaneously. This approach can result in an overall savings in silviculturist time while achieving a high degree of coordination between the environmental assessment, the interdisciplinary team, and the prescription.

The following chart shows related steps between the prescription and the NEPA process:

NEPA ^{1/}	Silvicultural Prescription
1. Environmental Assessment and decision process.	(No directly related prescription step)
A. Identify issues, concerns and decision needs	
B. Select criteria	
C. Gather related information	1. Stand Examination
D. Formulate alternatives	
E. Analyze effects	2. Diagnosis
F. Evaluate alternatives	
G. Identify preferred alternatives	3. Detailed Prescription
2. Documentation	
3. Establish decision date	
4. Implementation, monitoring and control	4. Implementation
	5. Evaluation

^{1/} See FSM 1950 for a complete description of the NEPA Process.

TITLE 2400 - TIMBER MANAGEMENT

2478.3 - Standard Prescription Data Elements

Silvicultural Prescriptions. Silvicultural prescriptions are tangible steps toward achieving state-of-the-art quality in National Forest land management. They are technically defensible statements which analyze, support, direct, and record proposed cultural activity. Their overall purpose is to state clearly how treatments will meet management goals as defined in the land use planning process.

Prescriptions shall be written or reviewed by Certified Silviculturists meeting Northern Region standards for experience, education, and examination (FSM 2478, 2478.03, 2478.3, 2478.4, and 2431.21).

Prescriptions shall be prepared for all cultural treatments on forested land in the Northern Region, signed and dated by a Certified Silviculturist, and approved by the appropriate line officer (Ranger or Supervisor) before initiation of project layout or contracting.

The following guidelines are established to assure continuity of direction, accountability of action, and long-term, technical justification. Prescriptions must be available for in-Service and public inspection throughout the life of the present or created stand. They are subject to written revision at any time, and may be appendicized to Environmental Analysis Reports or other similar documents.

GUIDELINES FOR DEVELOPMENT OF SILVICULTURAL PRESCRIPTIONS

A. The Prescription Area. Prescriptions will usually be written for forest stands. The area defined by a forest stand may be adjusted for differences in: (1) physical site factors, and (2) land management objectives and guidance. Physical site factors are usually identified by ecological land units which integrate edaphic characteristics (land type) and potential vegetation (habitat type). Land management objectives and management guidance are found in unit plans and in established Forest policies.

In most cases, differences in vegetation, timber, site factors, and management guidance between stands determine that separate prescriptions be made for each stand. When these differences are not significant enough to change the prescription from one forest stand to another, they may be combined for prescription writing purposes.

B. Four Basic Purposes of a Prescription.

1. The prescription process provides a logical method for analysis of a stand to determine alternative cultural treatments. The prescription will also assist in the evaluation of the environmental impact of such treatments.

TITLE 2400 - TIMBER MANAGEMENT

2. The prescription provides direction for carrying out cultural treatments.
3. The prescription documents the scientific basis for the alternative treatments.
4. The prescription is a record that allows for later evaluation of the effectiveness of the cultural treatments.

C. Seven Primary Elements of a Prescription. Land management objectives and guidance are provided by line officers. The prescription writer must then define the silvicultural objectives which satisfy those management objectives. The physical site is evaluated in terms of factors that will not change over time. The forest community occupying the site at the present time is described through stand data. Consultation with other specialists usually occurs early in the planning process. Their involvement continues as necessary when the prescription writer devises a treatment that will achieve both management and silvicultural objectives. The completed analysis must also recognize viable alternatives, including no treatment.

The order and format in which the elements are presented are less important than careful presentation of meaningful data which leads to a logical conclusion. However, each of the following seven elements must be identifiable within the written prescription.

1. Objectives. Previously approved management objective and guidance for the forest stand is usually available from the unit plan. Silvicultural objectives are then fully defined. In each case, the silvicultural objectives will satisfy management objectives and conform with management guidance. Full consideration must be given to other forest uses and values, including watershed, wildlife and visual resources, and the need for long-term protection from fire, insects, and diseases.
2. Site Data. Slope, aspect, elevation, landform, geology, soils, climate, habitat type, and relative productivity should be described. Creeks, frost pockets, bogs, winds, and landscape management features should be identified.
3. Stand Data. Species composition, stand structure by age and size class distribution, density, stand history and successional trend, tree crown condition, growth rates, and timber volumes and understory conditions are to be recorded. The status of insects and diseases, windthrow hazards, and estimates of fuel loadings within the forest stand should relate to conditions in surrounding stands. Factors which affect site preparation and/or regeneration such as grass, shrubs, and cattle grazing should be noted.

TITLE 2400 - TIMBER MANAGEMENT

4. Treatment. The details of the recommended treatment and the expected results must be outlined. Enough information should be given to serve as a basis for preparation of marking guides and field layout and to serve as a set of directions for accomplishing the treatment. Examples of details which may be included are:

a. Type of treatment.

(1) Timber cutting: Intermediate, salvage, or regeneration cut by method. Indicate stand composition and density of the resultant stand.

(2) Site preparation by method and intensity.

(3) Reforestation by method, species, stocking level desired, and year the desired stocking level is to be achieved.

b. Logging method proposed.

c. Methods for site preparation, hazard reduction, and protection to manageable understory.

d. Insect and disease protection and/or control.

e. Effect of the treatment on the site such as soil compaction and nutrient loss.

f. Genetic implications and tree improvement goals (see FSM 2475.03, R-1 Supplement).

g. Effect of the treatment on wildlife populations and their use of the area.

h. Effect of treatment on use of the area by man, his visual and other values.

i. Needs and possible methods for livestock use and control.

5. Long-term Prescription. Because treatment planned now will affect management of the resulting stand for an entire rotation, all prescriptions shall tentatively schedule and project all treatments and returns from the present through the next regeneration period. Anticipated losses to wildfire, insects, and diseases should be included.

TITLE 2400 - TIMBER MANAGEMENT

6. Economic Comparisons. All prescriptions shall include brief economic analysis or reference one made for the same treatment on a similar local site. This analysis will compare returns on the investments to be made in the recommended treatment with deferred action and other possible alternative treatments. Currently available ADP programs include INVEST III and MULTIPLOY.

7. Alternatives. Viable alternatives, including deferring treatment for a given period of time, should be described briefly. The reasons for not recommending the alternative should be listed.

D. Length of the Silvicultural Prescription. The length of the silvicultural prescription is less important than its effectiveness in fulfilling its four basic purposes. Nevertheless, the time required by the prescription process is a common concern to Silviculturists and line officers. Where available, land type and ELU numbers may reference considerable specific data. Tables, charts, and graphs may be used to display stand data with a minimum of narrative. Many ADP programs available through Forest or District terminals will reduce the time needed for growth projection, economic analysis, fuel loading calculations, and visual presentation.

Slightly Revised
3/1/79

R-6 RANGE ADMINISTRATION WORKSHOP
February 28, 1979

TREES AND GRASS

James W. Edgren

I want to use this opportunity to explain where we in silviculture are coming from, where we want to go, and how we propose to get there. Please consider what I present here as a starting point, a mating dance, not a non-negotiable, embattled position. I want to do a selling job--not pro-timber, not pro-range--but one of cooperation. We in silviculture want to look at this subject as plant physiologists and silviculturists, not as Timber Beasts, and we would like you to look at it as plant physiologists and range conservationists, not as Cowboys. I am not going to cite data because, in my opinion, we are not ready for data. I feel an atmosphere of noncooperation--of competition--renders data useless. And that's where we have been--competing.

The subject of trees and grass has been cussed and discussed endlessly, it seems. We center our efforts on the controversial and seemingly elusive answers to the question "Do trees and grass compete?" There is evidence on both sides. Most, or at least many, range men say, "No, trees and grass do not compete.", most reforestation people and many silviculturists say, "Yes, trees and grass do compete.", and each group cites its authorities. The result is stalemate. Range and timber managers are competing, if trees and grass are not. I submit we will continue to get nowhere if we continue to pursue this course. We must begin to cooperate. I interpret my being at this meeting as very encouraging, but it does not fully satisfy that need for cooperation. I mean cooperation on the ground among those who are actually charged with implementing what policymakers decide. We in silviculture will try to be as thoughtful in the future as you in range have been today.

As a first step in where we are coming from, I propose that we start from the premise that a very real potential for competition always exists between trees and grass when they occupy the same acres during the tree establishment period. That potential is realized wherever moisture becomes limiting. I submit there is no way trees and grass can fail to compete when their roots begin together in the same zone and moisture is limiting. Trees then suffer a competitive detriment because they have less root production potential than grass.

As part of where we are coming from, I want to make some definitions at this point. I define competition as initially a struggle over water molecules--if there are enough to go around at tree establishment time, no competition exists. If there are not enough to go around, moisture becomes limiting. When tree seedlings do not recover from plant moisture stress overnight, competition exists. This condition can be monitored with a pressure bomb.

I define competitive detriment in terms of growth, not survival. We have all seen tree plantations that are alive but sitting stock still in terms of growth. Satisfactory growth rates are determined by site; I cannot generalize them here. We do not have site specific yield tables for all sites so we really do not have the tools to measure competitive detriment in a meaningful way. The point is that it is a growth question, not a survival question.

If after establishment time trees stay ahead of the grass (get good growth), probably little competition exists. If overtopping grass reduces light at ground level to low intensity, even when moisture is not limiting, then competition for light may exist particularly for intolerant tree species such as ponderosa pine. If moisture and light are both limiting, a truly intolerable condition exists from a tree seedling's standpoint. Such a situation is not uncommon. The potential for such a situation is very common.

If the management objective is to regenerate an area promptly to trees, we in silviculture are coming from our Forest Service Manual which says in FSM 2482.3 that "Grass seeding will be used only where it is unmistakably necessary to protect the soil against excessive movement pending the regeneration of the area to tree growth" and later, "the work should be coordinated with reforestation so as not to interfere with adequate stocking of trees on all land designated for timber regeneration, and the work should not be done on areas where natural reproduction of native species will promptly and effectively bind the soil except where native species are noxious or aesthetically undesirable." I believe the key words here are "designated for timber regeneration." Acres designated expressly for range are different.

We in silviculture are coming from the NFMA of 1976 (Section 4, (D)(1) and (D)(2)), which requires us to "report to the Congress annually... All lands with stands of trees that are not growing at their best potential rate of growth." The NFMA also specifies that "the Secretary (of Agriculture) will estimate budget sums for reforestation and other treatment (necessary)...to secure seed, grow seedlings, prepare sites, plant trees, thin, remove deleterious growth and underbrush, build fence to exclude livestock and adverse wildlife from regeneration areas and otherwise establish and improve growing forests to secure planned projection of trees and other multiple use values," and that harvested acres "be adequately restocked within 5 years after harvest."

We in silviculture also favor specific prescriptions for specific stands. We must judge each management opportunity by its own inherent characteristics and not try to generalize for entire Forests or even Ranger Districts. There are far too many variables involved. For instance, tree species, grass species, animal species, animal use levels, grazing rotations, site differences, soil types, natural grass seed loads, tree planting times, grass seeding times and rates, fencing or lack of it, definitions of

competition, and management objectives to mention a few. We could come up with more. As we get more experienced silviculturists on Ranger Districts, we will be closer to this objective. Silviculturists and range specialists must work together on these prescriptions, not separately.

I understand some Land Use Plans imply that we will maximize both timber and range on all acres. I believe this is not possible during the tree establishment period. And grass itself is only half the problem--it leads to cows. Trampling and browsing by livestock during the tree establishment period may be more damaging to tree seedlings than is grass competition. If cows are used to reduce grass competition, they must be used before tree planting or after the tree establishment period. After the establishment period, only about 5 percent of a rotation, a different condition prevails. Tree roots are below grass roots and tree tops are out of the grass shade, out of the reach of grazing animals, and too large to be damaged greatly by trampling. We believe that trees, grass, and cows are not compatible during the tree establishment period, but that little or no problem exists later. We prefer to talk about grazing rotation, not grazing exclusion.

Where are we coming from? (1) We need cooperation among ourselves in planning and prescription writing; (2) trees and grass do compete at limiting levels of soil moisture and light; (3) if Manual directions in silviculture and range conflict, this must be corrected; (4) specific management prescriptions are better than generalities; (5) the NFMA puts a specific silvicultural onus on us; (6) timber and range can rarely both be maximized on the same acres during the tree establishment period; and (7) after the tree establishment period (3 to 5 years) grass and cows probably will not interfere greatly with tree growth during the remainder of the rotation--probably 100 years or more.

Where am I going with this presentation? I want to identify some documents and prescription items that must be considered during the planning cooperation discussions I am recommending. Frankly, as a silviculturist my objective in these discussions would be to make a case for separation of grass and cows from trees where moisture is likely to become limiting during the tree establishment period on acres that are expressly targeted for timber production. I am not talking about acres that are clearly best suited for range. I do not want to put trees everywhere. I am talking about acres that are included in the annual cut calculation.

Separation of grass and cows from tree seedlings during the establishment period--how do we determine where this is necessary and how to do it equitably? I have related where we are coming from and where we want to go. Now, how can we get there? Assuming we agree that separation may be necessary, let's start with a negative--we cannot get there independently. We must not continue trying to do this job separately. There are several areas in which we must cooperate to do this job effectively. On the positive side:

1. We must be sure our Manual and Handbook directions do not conflict. I believe when we each go our own way, and maybe even compose directions in an attempt to counteract opposing philosophies, we each get less out of our natural resource than we would if we cooperated. When we write Manual or Handbook Sections we should seek input from experts in other resources and send them a draft for review. Constructive criticism will go a long way to improve management of the total forest.

2. We must have comprehensive Land Use Plans and carefully thought out EAR's upon which to base land use decisions. Expert silvicultural, range, wildlife, water, and soils input is essential in these documents. Timber harvest planners must fully recognize the impact of harvest on range and wildlife resources.

3. The working silvicultural document on the ground in all areas where timber is the primary resource and where land use plans and EAR's call for the forest to be regenerated must be the silvicultural prescription. That document is a silviculture responsibility but it frequently will need range inputs to help assure that where there are cattle allotments on commercial forest land, range-related prescription elements will be correct and will be carried out. Several points relating to trees, cows, and grass seeding, where a potential for competition as I have defined it exists, come to mind.

1. What is the potential for soil erosion on the area in question? If in the opinion of a soils expert the probability of erosion is low, grass must not be sown until seedlings are established.

2. If the soil is erodible, what is the native grass seed load on the area? If the native grass seed load is heavy enough to bind the soil against erosion, grass must not be sown until seedlings are established.

3. If grass must be sown to prevent excessive soil movement, a non-native grass of low competitive potential must be used.

4. If grass must be sown, sowing rates must be calculated to prevent erosion, not to feed cows.

5. If grass must be sown where a potential for competition exists, trees must be planted in advance to permit them to become established ahead of the grass.

6. If the sale area is within a grazing allotment, a grazing rotation plan must be formulated to keep cows off newly planted acres.

As I read this over after writing it, and as I listen to it now, it sounds pretty dogmatic and demanding. We really do not want to leave that impression, but we do not want to be wishy-washy either. I am acting as the spokesman for the entire Silviculture Section on this question and we do not want to be misunderstood or misinterpreted. I do not feel that cooperation on this issue will be easy, but I feel we must do it. And it must go beyond a simple gentleman's agreement; we must get together on prescriptions at the ground level.

We are asking for new thinking on this issue because of renewed interest from the Districts. We are in a different ballgame now than we were 10-12 years ago. Emphasis on and commitment to reforestation has increased dramatically in recent years, from the Washington Office right on down. We must respond to this new awareness, and we need your help to get the job done.

We believe the following ingredients are essential to a comprehensive management effort which must coordinate the uses expected of most National Forest acres: (1) An approved Land Use Management Plan for the Forest which clearly spells out management objectives relative to multiple uses, (2) interdisciplinary cooperation and professional input at the District level from certified silviculturists and qualified soils, range, and wildlife people suggesting management alternatives to meet these objectives, and (3) objective assessment of tradeoffs and weighing of management alternatives by line officers to select those management practices which maximize benefits of multiple use sustained yield management in accordance with Land Management Plans and Federal laws.

Field Trip to the
FRANCIS MARION NATIONAL FOREST
National Silviculture Workshop
September 17-21, 1979

Stop Number

1. Longleaf Shelterwood
 - a. With seedlings
 - b. Longleaf seedlings after overstory removal
2. Longleaf Saplings Thinned by Hydro-ax
3. Fire and Quail Management in an Immature Sawtimber Longleaf Stand
4. Red-cockaded Woodpecker Colony in Longleaf Sawtimber

12:00 NOON - Lunch at Huger Recreation Area

5. Prescribed Burning Plots on the Santee Experimental Forest
- 6.* Precommercial Thinning of Loblolly by Hand
7. Swamp Black Gum (Tupelo gum) - Cypress Sawtimber
8. Loblolly Regeneration by the Seed-tree Method
 - a. Following a Seed-tree Cutting
 - b. Seed trees removed
9. Buck Hall Recreation Area

* Optional Stop

National Silviculture Workshop - 1979

Stop 1 - Longleaf Pine Shelterwood (Peterson)

a. Shelterwood with Seedlings

This 75 year old longleaf stand was given a shelterwood cutting in 1975. Leave basal area is 32 sq. ft./acre (32 trees per acre): Average diameter is 14 inches. A seedling count shows 5,700 longleaf seedlings per acre with crop seedlings averaging about 0.5" root collar diameter.

Soil is a Chipley which is a deep, fine, droughty sand. Site index is 75.

<u>Time</u>	<u>Work done</u>
Dec. 1972	Rough reduction burn
Jan. 1974	Pre-marking burn
1975	Shelterwood Cutting
Aug. & Oct. 1976	Seed bed preparation burn
Jan. 1979	Regeneration check 5,700 seedlings per acre
Jan. 1979	Brown spot burn
Aug. 1979	Seed Trees marked for sale

A removal sale will be made FY 1980

b. Longleaf seedlings after overstory removal (SW side of road)

This area was originally just like that across the road. Here the overstory was removed in 1978 leaving about 3,500 longleaf seedlings per acre.

<u>Time</u>	<u>Work done</u>
June 1971	Shelterwood cutting
July 1971	Site preparation by hand injection
Aug. 1971	Site preparation by prescribed burn
Aug. 1976	Prescribed burn for brown spot
June 1978	Seed trees removed
July 1978	Pine seedlings released by bush hook from hardwoods

Some seedlings have brown spot. However, a burn is not needed at this time. This stand needs to be checked again this fall to determine if a brown spot burn will be needed. The stand may need pre-commercial thinning about age 10.

National Silviculture Workshop - 1979

Stop 2 - Pre-commercial Thinning of Longleaf by Hydro-ax (Peterson)

This 18 year old longleaf sapling stand (birth date 1961) was given a pre-commercial thinning in 1973 when 12 years old. At that time, the trees were 10 to 12 feet tall. There were about 4,200 longleaf stems per acre in this part of the stand. A hydro-ax was used to cut swaths 7 feet wide.

Our objective in this type thinning is to leave a good dominant or codominant tree every 6 to 8 feet in the leave swaths so as to leave 600 or 700 dominant or codominant trees per acre. A stem count now, at this point, gives the following:

	<u>Dom.</u>	<u>Codom.</u>	<u>Int.</u>	<u>Sup.</u>	<u>Total</u>
	- No.	- No.	Stems/Acre -		
Present stocking	349	483	375	563	1,770

The present stocking indicates our leave swaths were a bit too wide in this part of the stand as we still have about 830 dominant and codominant trees per acre.

An informal check of diameter growth of dominant and codominant trees shows a 10% increase in growth rate in comparing the past 6 years with the previous 5.

Production rate was 4.6 acres per hour. An average contract cost of \$11.00 per acre for the 1,548 acres done that year on this district. Present contract costs for machine and operator, are about \$64.50 per hour. At a 4.6 acre/hour production rate, high for our average stands now, cost would be \$14.12 per acre.

Site index is 80 for longleaf, about average for longleaf sites on the forest. Our objective is to grow sawtimber on an 80 year rotation. Also, we want to maintain good ground cover for wildlife and minimize the "biological desert" effect common in dense sapling and small poletimber stands.

The next work will be periodic prescribed burning. Commercial thinning will be initiated when the stand becomes operable, that is it has 3 cords or 2 cunits of pulpwood needing removal in trees 5.0" dbh and larger.

National Silviculture Workshop - 1979

Stop 3 - Fire and Quail Management in an Immature Sawtimber Longleaf Pine Stand (Mims, Tyler)

This is part of the 5,000 acre quail management area on the Witherbee District. Strips of bicolor lespedeza are planted and burning is done annually. A special study area was established in 1979 on 926 acres in which strips of bird mixture seed was planted in 50 foot strips.

Discussion at the stop will include:

1. Purpose of Quail Management
2. Present Management Guidelines
3. Purpose of Annual Burning
4. Discussion of Future Quail Management

National Silviculture Workshop - 1979

Stop 4 - Red-cockaded Woodpecker Colony in Longleaf Pine Sawtimber (Tyler)

Management for the Red-cockaded Woodpecker began on the Francis Marion in 1968 when it was thought the population had fallen to about 10-20 colonies. Since then all colonies have been retained with a 200 foot leave strip around them. Inventories, still not complete, show about 450 colonies at present. This species was listed by the Endangered Species Act of 1973 which obligated the Forest Service to protect colonies and habitat as well.

Discussion at the stop will include:

1. Description of the Red-cockaded Woodpecker and his habitat requirements.
2. Present management guidelines.
3. Impact these guidelines have on timber production.
4. Discussion of future management.

Lunch - 12:00 Noon at Huger Recreation Area

Stop 5 - Prescribed Burning Plots on the Santee Experimental Forest

Results of long time prescribed burning plots off Tanner Road will be presented.

National Silviculture Workshop - 1979

Stop 6 - Pre-commercial Thinning of Loblolly by Hand (Peterson)

This is an example of a dense sapling stand thinned by hand. Thinning was done by YCC enrollees in June, 1978, leaving 1,487 trees per acre. Count before thinning was 13,615 stems per acre.

Stand age is now 6 years. Soils are Dunbar and Lenoir which are heavier, clay loam soils. Site index is 100 for loblolly.

<u>Time</u>	<u>Work Done</u>
1970?	Seed-tree cutting
1970?	Site preparation by dozer
1971	Site preparation burn
1973	Seedlings established
1975	Seed tree removal cut
June 1978	Thinned by YCC enrollees

Our objective is to leave trees spaced about 8' by 8' or 600 to 700 trees per acre. This stand needs additional thinning. It is seldom or never necessary to use expensive mechanical site preparation with burning and the seed tree method in loblolly. Because this stand was along the highway and looked so nice, we were slow to remove the seed trees following establishment of seedlings. Our objective is to remove loblolly seed trees when enough seedlings have survived one growing season for full stocking. This cuts down on the need for, and the expense of, pre-commercial thinning.

National Silviculture Workshop - 1979

Stop 7 - Swamp Black Gum (Tupelo gum) - Cypress Sawtimber (Peterson, Hughes)

You are now standing in a part of a large, meandering, poorly defined swamp called Hell Hole. These swamps are one of the most distinctive physical features of this forest.

Farewell Corner is located 1 mile across the swamp to the north-northwest, according to a 1903 map by Chapman. There are two legends concerning this corner. One is that here General Francis Marion bade "farewell" to the British troops as he disappeared into the trackless swamps. A second is that he here bid a last "farewell" to his troops after the last campaign of the war.

The major large tree species in these swamps are swamp black gum (or tupelo gum), cypress, and loblolly pine. The loblolly is found more on the margins where flooding is not as constant. The area accessible from this road is a good example of some of the larger swamp hardwood timber. Old type maps show the following for this particular area:

- 1903 Chapman for the E.P. Burton Lumber Company
Loblolly 50% 15-18" dbh
Longleaf 1% 15-18" dbh
Cypress 40% 15-18" dbh
Presumably, the rest was swamp black gum and other minor hardwoods.
- 1950 Forest Service. Scattered loblolly over hardwoods with less than 35 loblolly per acre averaging less than 1,700 bd. ft. per acre. Age 1915 (birthdate). These loblolly were over hardwoods.
- 1979 Swamp black gum--cypress--red maple type, age 110, with many trees about 18" dbh. Site index is estimated at 90 for swamp black gum.

Soils are Bayboro Series which are deep, black to gray, acid, poorly drained and subject to flooding.

Logging was done in this general area on a large scale from the late 1800's into the 1920's. It was by railroad with steam skidders and cable.

Based on the above, we might speculate that the loblolly and cypress were logged out about 1915 leaving the less desirable hardwoods to form the present stand.

Stop 7 - Continued

Problems with Swamp Hardwood Management on the Francis Marion:

We have done little cutting in these swamp hardwood stands since acquisition for economic and environmental reasons.

Stumpage value for the swamp black gum is about \$30.00/M. Cost of logging is high due to swampy logging conditions. Rutting of soils is usually severe unless logging is done during a drought period or by cable.

Where we have cut, regeneration is variable. Swamp black gum and cypress are slow to come back. Red maple and sweetbay may be the most abundant. Loblolly pine will often come in on drier places if a seed source is available.

Environmental concerns or wetland logging restrictions might well dictate timber management options in swamp hardwood types.

National Silviculture Workshop - 1979

Stop 8 - Loblolly Regeneration by the Seed-tree method (Peterson)

a. Following a seed-tree cutting (East of road)

In June 1978 this stand was cut leaving 8 to 10 seed trees per acre. Volume cut was 11.7 MBF and 2.2 ccf of pine per acre. Stumpage was \$120 per M and \$17 per ccf. Site preparation was by Service Contract costing \$6.00 per acre. All stems 1" dbh and larger were cut by chain saw. The contractor utilized remaining hardwood timber.

<u>Time</u>	<u>Work done</u>
June 1978	Seed-tree cutting
Nov. 1978	Site preparation by chain saw
Apr. 1979	Regeneration check showed 50 loblolly per acre

This area is not yet stocked as only 50 seedlings per acre were present last April. Seed trees will be promptly removed when a fall seedling check shows enough year old seedlings for stocking.

b. Seed trees removed (West of road)

This stand of abundant loblolly seedlings has just had the seed trees removed. It was cut to seed trees in 1975 removing 13.8 MBF and 1.3 ccf per acre. Site index 100.

<u>Time</u>	<u>Work done</u>
Dec. 1975	Seed-tree cutting.
Feb. 1976	Site preparation by hand injection of Tordon 101.
Aug. 1979	Seed trees removed.

Pre-commercial thinning will be needed about age 6. The first commercial thinning will be about age 18 when approximately 7 ccf of pulpwood per acre can be removed. Number of trees left per acre for full stocking would be about 210. Thinning will be done every 10 years until age 60. At that time, there would be about 48 20" dbh trees with a volume of 20 MBF per acre.

National Silviculture Workshop - 1979

Stop 9 - Buck Hall Recreation Area (Pryor)

This is a Forest Service recreation area on the Inland Waterway near the Atlantic Ocean.

Ranger John Pryor will tell us about Buck Hall, Cape Romain National Wildlife Refuge and the Inland Waterway.

HISTORY OF THE FRANCIS MARION NATIONAL FOREST AREA
FOR
NATIONAL SILVICULTURE WORKSHOP
September 19 - 21, 1979

The Francis Marion National Forest area is rich in history. Several days could be spent visiting historic sites, churches, old plantation sites, etc., on or near the forest. The following is taken from a 1972 unpublished manuscript by William E. Gardner, Jr., formerly with the U. S. Forest Service at Columbia, S. C.

Limerick Plantation is adjacent to the Huger Recreation area where we will have lunch. The field trip is planned to end at Buck Hall Recreation Area near the Old Buck Hall Plantation.

INTRODUCTION

The Francis Marion National Forest is located in an area that could be considered the "Cradle of South Carolina History." This area, a part of the Low Country of South Carolina, lies between Charleston and Georgetown and extends west to Moncks Corner. It is bordered on the south by the Cooper River and on the north by the Santee River.

As early as the sixteenth century, Spanish and French explorers frequented the area, and by 1670, the English had established the first permanent settlement in South Carolina, at Charles Towne. From this town traders spread out into the inland areas trading their manufactured goods for Indian furs and animal skins.

With the coming of rice as an important crop in South Carolina, settlers began moving away from the towns and coastal areas to establish plantations along the Santee and Cooper Rivers. This marked the beginning of the new planter class which was to control the government in South Carolina for over one hundred years. By 1776, when South Carolina declared its independence from England, the large estates and homes of the planters dotted the landscape along with the horserace courses and graceful churches that their rice riches supported.

During the American Revolution, the Francis Marion Forest and vicinity provided the setting for many skirmishes and battles between American and British forces. With the Continental Army defeated and driven out of South Carolina by the British early in the war, the only effective American fighting forces left in the state were the partisans. General Francis Marion, for whom the National Forest was named, was the leader of the "Low Country" partisans who harassed the British so frequently that their supply lines from Charleston to North Carolina were almost useless. Marion, or the "Swamp Fox" as he was called, did much of his fighting in and around the Forest and is known as the "father of modern guerrilla warfare."

Military action during the Civil War had little effect on the area. Most of the fighting took place around Charleston, although the Federal troops made sporadic raids along the coast and up the rivers. A few artillery duels between Confederate shore batteries and Union gunboats and some light infantry and cavalry skirmishes were the only engagements in the area.

Although the fighting was negligible, the overall effects of the war and its aftermath were not. In addition to losing many plantations to the torch of the invading Federals, the area's plantation system itself was destroyed. Slave labor, the basis of economical rice production in the Low Country, was no longer available, and the plantations and the planter class began a steady decline in importance. Today, only a few of the old plantations are still intact, and these have converted their lands from rice to other endeavors such as cattle raising and dairy farming.

After the Civil War and down through the present day, this interesting area has retained much of its colorful atmosphere. There are still many of the old plantation homes and churches standing today, and ghost stories and legends can be heard in every corner.

The historical sketches included in this publication describe some of the old plantations, churches, battles, etc., which played a part in the varied history surrounding the Francis Marion National Forest and vicinity. These examples of events and places support the suggestion that this area be considered as the "Cradle of South Carolina History."

LIMERICK PLANTATION (Near lunch stop)

The home that once stood on this old plantation was a substantial, spacious structure of black cypress, two stories high, with a deep basement and fourteen fireplaces. The gardens surrounding the home were noted for their large size and unusual beauty. The house was destroyed by fire in December of 1945, and all that remains are the ruins and the brick-walled burial ground.

Limerick is best noted as the home and burying place of the distinguished Huger family. Descendants of this family have included many famous planters, soldiers, statemen, politicians, and patriots.

Beyond the ruins of the house and within the brick walls of the burying ground, lie the remains of many of the Hugers. Negroes speak of this enclosure as the "Weegee Tomb" from which the "Weegee Chost" came to haunt the old Limerick house while it was still standing. According to the legend, the Weegee "Ghost Foot" was an unexplainable clay-colored track of a bare foot on the ceiling of the garret in the home. At times, this foot would audibly walk up and down the stairs and across the ceiling.

One tale is told of the visits of Mrs. Francis Marion, the wife of the Revolutionary War hero. It is said that after the General's death, she became insanely afraid of ghosts. When she visited Limerick, she insisted upon having one of the house servants sleep on a pallet in her room "to protect her from the "Weegee Ghosts."

Limerick, like many of the old plantations, had in its history a very eccentric occupant, the second Elias Ball to own the home. It is told that Mr. Ball, a bachelor, had the habit of entertaining his friends and neighbors in a very extravagant manner. He once ran so deeply into debt due to this lavishness, that he closed Limerick to all visitors with an earthern bank and a ditch for protection against his own weakness and his neighbors' sociability. When he had reduced his debt, he returned to his old habits by opening his home once again with a large party.

During the last days of the Confederacy in 1865, Union raiders, led by E. E. Potter, swept up the Cooper River, burning and destroying everything in their path. Limerick, lying directly in the path of the raiders, prepared to receive them. An authority gives the following account of the raider's visit:

"Limerick was prepared for Potter's raiders. All possible moveables had been stored with reliable negroes. The silver was hidden in a swamp, and the coachman who had helped with it assured the soldiers of the regiment that came in that it had gone to Columbia."

"Mr. William J. Ball, his wife and baby, his mother and sister, constituted the family. The officers asked for dinner. While it was being served, the Colonel, a brother of Henry Ward Beecher (and, in consequence, brother of Harriet Beecher Stowe, authoress of 'Uncle Tom's Cabin') suggested wine. Glasses were set out and an orderly appeared vigorously shaking a bottle. One officer hinted that it might have been 'fixed' for capture. It was proposed by the Surgeon--Colonel Beecher consenting--that one of the negro soldiers guarding the house would like a 'good glass of Southern wine.' But he refused to be a 'tester' and called a negro boy to take the risk. Then Mr. Ball interposed. When he found that the wine had been looted from Mr. Benjamin Huger, at Richmond, he protested any such suspicions and drank the first glass himself to show what he thought of them."

"The soldiers left behind a single vehicle, the carriage, 'for the old lady.' Of the poultry, a goose sitting on an island in the big duck pond, and a hen, similarly occupied under the barn, were all that remained. The lawn was littered with papers in which the men had brought their dinner. They were engravings torn from the elephant editions of Audubon's works on the 'Birds' and 'Quadrupeds of America.'"

This visit by Union soldiers was typical of many others paid to the plantations of the Low Country with the exception that the Federal troops did not burn Limerick as they did many of the other homes.

HELL HOLE SWAMP (Stop 7 is part of this swamp)

Hell Hole Swamp, depending upon who is describing it, extends over an area of sixteen to twenty miles in diameter. The origin of the name is not known, but it has been in existence since the early grants and land transactions of the sixteenth century.

Deep in the swamp is a clearing called "The Opening," measuring, roughly, one-half mile in diameter. Although completely surrounded by trees, nothing will grow in the clearing itself except grass. During the early days this unexplainable phenomenon may have been believed to be the devil's work and from the belief, the name Hell Hole may have originated.

The swamp has gained a reputation in the present century for the illegal whiskey-making industry that prevailed here during the prohibition era and which continues to a lesser extent today. The area's inaccessibility made it an ideal location in which to take advantage of this extremely profitable operation. An extensive production and transportation system was developed to deliver the illegal whiskey to markets as far away as New York. At the time, the Hell Hole brand of liquor was advertised as having "not a goiter in a gallon" because of the well-known high iodine content of South Carolina's vegetables. After prohibition was over and the market for the illegal product no longer existed, this colorful industry passed into history except for a few localized stills.

FAREWELL CORNER (Near Stop 7)

At one time Farewell Corner was the end of a road that led from Strawberry Ferry into Hell Hole Swamp proper.

There are two legends associated with the origin of this landmark. One story claims that after one of his successful raids, General Francis Marion arrived at this point and bade farewell to his British pursuers as he rode off into the swamp.

The second legend supports the claim that Farewell Corner was the place where Marion disbanded his troops and said farewell after his last campaign.

BUCK HALL (Final Stop)

Buck Hall Recreation Area is located on the former site of a plantation by the same name.

At the outbreak of the American Revolution, the plantation was owned by General Richard Withers Vanderhorst, a former French and Indian War soldier. General Vanderhorse, being too old to take the field against the British, displayed his sentiments in another way. In front of his house facing what is now the Intracoastal Waterway, he built a small fort mounting four cannons with which he vowed to "blow any British ship out of the water that came within his range." However, none did, and the fort never fired a shot in anger.

The remains of the old plantation home and the fort are still visible on the private lands adjoining the recreation area.

FOREST FACTS AND FIGURES
FOR THE
FRANCIS MARION NATIONAL FOREST

South Carolina
1979

ADMINISTRATION

The Francis Marion is one of 155 National Forests administered by the Forest Service, U. S. Department of Agriculture. The Forest Supervisor's Office, located in Columbia, S. C., also is responsible for the Sumter National Forest in the Piedmont and Mountains of South Carolina. Total government acres in these forests is 607,000. This area is divided into seven Ranger Districts of which two, the Wambaw and Witherbee, are on the Francis Marion. Each district is administered by a District Ranger assisted by two or three Foresters plus a crew of 20 to 30. These include Forestry Technicians, a Wildlife Technician, Equipment Operators, Clerks and Forest Workers. The District Ranger is responsible for all work and activities on his district including timber management, wildlife management, recreation, Forest Service road maintenance, fire protection, prescribed burning, insect and disease control, special land uses, and human resources programs.

HISTORY - A Chronology

- | | |
|-------------|--|
| 1670 | First permanent white settlement in South Carolina established by English at Charleson. |
| 1689 | French Huguenots settle along the Santee River. |
| 1685 - 1893 | Rice growing era. |
| 1742 - 1776 | Indigo culture. |
| 1775 - 1782 | Revolutionary War. Francis Marion wages guerilla warfare against the British supply lines from Charleston to upstate South and North Carolina. |
| 1793 | Cotton gin invented by Eli Whitney. Cotton era begins. |
| 1860 - 1865 | Civil War. Slaves freed. |
| 1885 - 1935 | Logging of old growth forest by large lumber companies. |
| 1933 | Acquisition of land begins for a National Forest. Fire protection begins with the Civilian Conservation Corps. (CCC) |
| 1936 | Timber Management begins with first T.M. Plan |

- 1937 Timber sales begin. 1,242 MBF with stumpage value of \$10,134 was cut. Cooperative game management areas established with the State Wildlife Resource Department.
- 1937 Santee Experimental Forest established.
- 1938 243,000 acres have been acquired from large lumber companies.
- 1944 Prescribed burning begins on a planned, systematic basis.
- 1950 T.M. Plan the first National Forest plan to specify even-aged management and regulation entirely by area.
- 1963 Francis Marion Seed Orchard begun.
- 1968 Management begins for the rare and endangered Red-cockaded Woodpecker.
- 1972 Regeneration stand sizes restricted to 100 acres for pine and 50 acres for hardwoods for normal conditions.
- 1975 In August, a ban on cutting anything but dead, dying, mature and large growth timber was ordered as a result of the Monongahela decision. Recinded upon passage of new legislation October 1976.
- 1977 Final Francis Marion National Forest Land Management Plan issued incorporating a Timber Management Plan.

FOREST RESOURCES

<u>Land Area Allocation - 1979</u>	<u>Acres</u>
Area regulated for timber and wildlife management	211,000
Santee Experimental Forest	6,100
Francis Marion Seed Orchard	326
Little Wambaw Swamp Scenic Area	2,000
Guilliard Lake Scenic Area	1.136
RARE II Wilderness - Wambaw Swamp & Little Wambaw Swamp	8,000*
Red Cockaded Woodpecker Colonies	5,000*
Unproductive	8,600
Other (water, roads, wildlife openings, right-of-way, recreation areas, administrative sites, etc.)	<u>7,238</u>
Total National Forest	249,400

*Approximate

Forest Types on Regulated Acres

<u>Forest Type</u>	<u>Major Species</u>	<u>% of Area</u>
Loblolly Pine	<u>Pinus taeda</u>	51
Longleaf Pine	<u>P. palustris</u>	20
Pond Pine	<u>P. serotina</u>	1
Loblolly Pine - Hardwood		<u>2</u>
Subtotal Pine Types		74
White oak - red oak - Hickory	<u>Quercus alba, Q. falcata,</u> <u>Carya supp.</u>	1
Sweet gum - Water oak - Willow oak - Laurel oak	<u>Liquidambar stryaciflua,</u> <u>Q. nigra, Q. phellos,</u> <u>Q. laurifolia</u>	8
Cypress - Tupelo Gum - Red Maple	<u>Taxodium distichum,</u> <u>Nyssa sylvatica,</u> <u>Acer rubrum</u>	<u>17</u>
Sub Total Hardwood Types		<u>26</u>
TOTAL		<u>100</u>

Timber Inventory Volume - 1971 on 216,000 regulated acres:

	<u>Total Volume</u>	
	<u>Sawtimber^{1/}</u>	<u>Poletimber</u>
	<u>MMBF</u>	<u>MM cu. ft.</u>
Softwoods	1,275	108
Hardwoods	<u>308</u>	<u>59</u>
Total	1,583	167

1/ Scribner - Softwood 11.0' dbh+, Hdwd. 13.0' dbh +

Site Index (Age 50)

	<u>Range-feet</u>	<u>Prevailing</u>
Longleaf Pine	60 - 100	80
Loblolly Pine	60 - 120	90
Hardwoods	60 - 100	80

MANAGEMENT OF TIMBER

Timber Cut and Sell - Volumes and Value

<u>FY</u>	<u>Volume Sold</u> MBF*	<u>Volume Cut</u> MBF*	<u>Stumpage</u> <u>Value of Cut</u> \$
1974	63,322	59,576	4,160,770
1975	44,991	34,133	1,941,807
1976 + interim ¼	5,733**	49,533	2,452,557
1977	47,068	36,750	1,830,220
1978	47,294	52,587	3,373,995

* Includes poletimber @ 2 cords/MBF

** Moratorium on timber sales in effect

Timber is marked for sale, appraised, advertised, and sold to the highest bidder. Logging is mostly by rubber tired skidders and trucking to the mill.

Rotations

Longleaf Pine	80 years
Loblolly Pine	60 years
Hardwoods	100 years

Silvicultural Systems Used

Longleaf Pine: Shelterwood, Clearcutting
Loblolly Pine: Seed-tree, Clearcutting
Hardwoods: Clearcutting - will begin using shelterwood also in upland oak.

Cutting Cycle - 10 years

Cultural Work Done - Acres

	<u>FY '77</u>	<u>FY '78</u>
<u>Reforestation</u>		
Tree planting	290	196
Seeding	226	150
Site Preparation		
For natural regeneration	1,799	1,302
For artificial regeneration	406	44
Prescribed burning	948	509

	<u>FY '77</u>	<u>FY '78</u>
<u>Timber Stand Improvement</u>		
Release	1,119	1,340
Brown spot burn	125	1,102
Pre-commercial thinning	308	200
Fertilized	-	1,608

Timber Management Planning

Timber Management Plans - 1936, 1950, 1964, 1976.

Compartment Prescriptions - A detailed plan for a compartment done every 10 years following compartment order of entry.

Regeneration - Stands selected for regeneration by interdisciplinary team since 1973.

Each year needed cutting is done on approximately 10% of the area so that all regulated area is "worked over" every 10 years.

MANAGEMENT OF WILDLIFE

Game is managed in cooperation with the S. C. Wildlife & Marine Resources Department. The Forest Service manages the habitat. The Department sets the seasons, bag limits and provides law enforcement. About 350 acres of roads, and openings are seeded annually. About 610 acres are in permanent vegetation as in openings, temporary roads, trails, and power lines, and are maintained cooperatively.

Estimated Populations 1979

Deer	18,000
Turkey	2,800
Bear	?
Alligator	600

Example of kill from an annual hunting season

Deer:	Fall 1978	505
Turkey:	Spring 1978	78

RECREATION

Recreation use on the Francis Marion National Forest totaled 170,000 visitor days use. A visitor day is any combination of 12 hours use, i.e. (1 person 12 hours or 12 persons 1 hour). The following table indicates the principle recreation activities and the amount of use.

<u>Activity</u>	<u>% of Total Recreation Use in '78</u>
Fishing	14
Camping (mostly by hunters)	18
Hunting	10
Boating/swimming	9
Auto Driving	11
Hiking	4
Motorcycling	5
All Other Activities	29
	<u>100%</u>

Through the RARE II process, 8,000 acres were recommended for wilderness in Wambaw Swamp and Little Wambaw Swamp.

Trail development now includes 19 miles of horse trail, 21 miles of hiking trail, and 42 miles of cycle trail.

FIRE PROTECTION AND MANAGEMENT

From Indian times through logging of the old growth timber, vast areas were burned every few years. This resulted in a longleaf pine fire climax on much of the upland area. Wildfires now usually burn only a few hundred acres annually. Incendiarism is the largest cause of wildfires. Since 1944 prescribed fire has been systematically used as a management tool for wildlife management, rough reduction, control of hardwoods and for brown spot disease control. About 40,000 acres are prescribed burned annually.

TRANSPORTATION

The present Forest Service road system of 500 miles is about 75 percent of that planned. This does not include State Highways and County roads.

Prepared for National Silviculture Workshop
September 17-21, 1979

Westvaco

U.S. FOREST SERVICE TOUR

September 21, 1979

A-G-E-N-D-A

8:00 a.m.	-	Leave Motel: Overview of Westvaco Timberlands given in route from motel to first stop. - Calvin Sharp
8:30 - 9:15	-	Westvaco Thinning System - John Allen
9:25 - 9:55	-	Seed Orchard - Jo Bivens
10:00 - 10:30	-	Break - Nursery - Don Stringfield
10:45 - 11:00	-	Stand Progression - Greg Dale
11:05 - 11:35	-	Pine Management Plots - Phil Dunham
11:50 - 12:10	-	Recreation Use on an Industrial Property - Ginger Reilly
12:25 - 1:00	-	Lunch - Tree Improvement Center
1:00 - 1:30	-	Movie - "Forest for the Future" - Tree Improve- ment Center - Richard Whiles
1:35 - 2:00	-	Fire Control - John Waddell
2:30 - 2:50	-	Improved Utilization (Whole Tree Chipping) - Calvin Sharp
2:55 - 3:15	-	Site Preparation - Jerry Brockenfelc
4:00 p.m.	-	Return to Airport

Rain Schedule: In the event of rain, the presentations will be presented indoors at the Tree Improvement Center's Meeting Room.

U. S. Forest Service Tour

September 21, 1979

C. J. Sharp

Overview

Good morning gentlemen and welcome to Westvaco's Southern Woodlands. Our travel time to the tour area is about 30 minutes. During that time, I will attempt to acquaint you with our timber management objectives and give you a general description of forest operations in South Carolina.

Southern Woodlands consists of approximately 510,000 acres. Much of the property you will see today was bought several years ago when land and timber were relatively inexpensive. Most of this property has been harvested and regenerated several times. A great deal of it has been harvested twice since it has been in Westvaco's ownership. Early management on these lands relied upon natural regeneration following cutting to restock the land. Later, seed tree methods were used along with burning and seedling planting on the more open areas and on the abandoned farm fields. Careful regulated cutting in past years has placed our Southern Woodlands properties in an excellent position to supply raw material to our Charleston Mill and Westvaco Development's Lumber Division.

Our timber age class distribution is good, with the acres in each timber age group almost equal. This means we can cut approximately an equal acreage annually on a 30 year cycle as prescribed by our management plan.

We will see today the full cycle of management treatments from the development of the seed to the mature crop. We will be showing you in detail many phases of the rotation during our tour.

By following our carefully prepared management program which enables us to harvest an equal portion of our acreage each year, we can continuously increase our timber growth. This is accomplished by replacing slower growing natural stands with faster growing managed ones. The managed stands have the advantage of genetically superior stock, planted on prepared sites, under fully stocked but not over stocked conditions, with improved surface water control, and the addition of fertilizer, if needed.

To provide a year after year continuous flow of wood products from our land, we harvest about 17,000 acres annually. We use the computer to aid us in selecting those timber stands which are to be cut. We have acquired through field measurements, data on age, growth, size and volumes. Along with other factors, this data is used in a computer program to suggest where our cuts should be made to obtain the greatest returns.

Our timber sales policy requires that all commercial quality trees be removed during the final harvest operation.

We clear cut because it enables the most prompt and efficient regeneration of the stand and provides the most effective form of logging both from the standpoint of the percentage of the resource utilized and from the viewpoint of logging costs. It is not unusual to harvest the stand, prepare the site, and plant a new crop of seedlings within a 12 month period.

The harvesting of timber from company lands is done by independent loggers except for a relatively small quantity cut by our company logging crews. Each timber sale is documented with a written contractual agreement in which the responsibilities of both the buyer and the seller are stated. This assures maximum utilization of the trees and prompt return of the land to the growing cycle. The present-day logger in the South is plagued by a rapidly diminishing labor supply.

The industry must mechanize as rapidly as possible in the logging process to replace the loss of woods labor. Many loggers have more than \$200,000 invested in harvesting equipment. This is quite a contrast to the cross-cut saw and bob-tail trucks that loggers used just a few short years ago. We will visit a mechanized thinning operation during our tour today.

Following the harvest, we prepare the cutover area for planting. We call this process site preparation. The objective is to improve the site to allow faster tree growth. We use a variety of methods depending upon the conditions of the land. Basically, we shear the residual trees and shrubs with front mounted blades on crawler tractors and cultivate the soil with heavy disk type plows. In the low flat lands, the disk plows form a bed that raises the planted pine seedlings above any standing water during wet periods. This treatment restricts competing vegetation, loosens and aerates the soil, and concentrates the topsoil giving the planted pines a boost. Mechanical preparation of the planting site is a relatively new function in the regeneration process. The paper industry in the South has been using mechanical site preparation for about 15 years.

In establishing our new plantations, we are careful to control the spacing at which the seedlings are planted, so we can grow the greatest number of trees in any given space without over crowding. We plant our seedlings at 6 ft. intervals in rows that are approximately 10 ft. apart. This provides the seedlings with favorable growing space until they are large enough to produce commercial pulpwood at 12 to 15 years on our average site.

At this time, the stand is thinned and the wood utilized, for the most part as pulp; trees are generally from 6 to 8 inches in diameter. The additional growing space provided by the thinning operation enables the remaining trees to continue their fast rate of growth until the final harvest cut. The advantages of thinning include an early return on invested capital, lower logging costs at final harvest

time due to increased tree size and increased growth. Regeneration and site preparation will be included in one of the stops on our tour today.

Westvaco is one of the industry leaders in the use of forest fertilization. We have the second oldest operational forest fertilization program in the United States. Phosphorous is a key element in our fertilization program, as it is the nutrient that is most frequently lacking in our coastal plains soils. This will be our twelfth season of operational forest fertilization and we have approximately 60,000 acres of our plantations treated to date. To assure that we use fertilizer only where needed, we collect soil samples from all our cut over lands and have them analyzed at our research laboratory in Laurel, Maryland, where we employ a full-time soil scientist. We treat by aerial application only those areas that the analysis indicates have a fertilization deficiency.

Those who plant crops are always concerned with seed quality and this is certainly true with us. Westvaco and some 25 other companies and agencies are members of the N. C. State University Cooperative Tree Improvement Program. Westvaco was the charter member and co-organizer of the cooperative 20 years ago. The objective of this group is to develop seed sources of superior strains of pine that have better form, faster growth, disease resistance and higher yields. The manner in which this objective is accomplished will be explained during our tour. I will emphasize here, however, that tree improvement progress has been most productive. Seedlings we now plant are genetically improved from seed produced by Westvaco seed orchards, some of which you will also see today.

I have used the term pine in a general manner, but I would like to emphasize that we have several species of pine growing on our company lands. However, we use loblolly pine for planting in our pineland regeneration throughout Southern Woodlands. Loblolly is a species of pine that adapts well to a wide range of growing conditions. It is fairly resistant to insects and disease, has wood qualities

that make it useful for poles, lumber and pulp and is a good seed producer. It can be grown under nursery conditions and has the fastest growth rate of all the southern pines.

Our Southern Woodlands here in South Carolina offers the finest soil sites that can be found for loblolly pine. Loblolly will produce more fiber in a shorter time on all our sites, except for the swamps and other poorly drained bottom lands where hardwoods do best. Hardwood stands comprise about 20% of our holdings at Southern Woodlands.

We grow our own seedlings in our company nursery which you will also see today. Growing our own seedlings assures healthy, strong planting stock. Large, well developed seedlings make early rapid growth and retain this accelerated rate into later years. With our own nursery operations, we are also able to minimize the critical time between lifting the seedlings from the nursery beds and replanting them in the field. We have a relatively new nursery with excellent soil and site conditions. The foremost nursery consultant in the South helped with the establishment of this nursery.

We are very much concerned with the protection of our valuable growing forest from loss by wildfire. Although we are blessed here in the coastal Carolina with frequent rains averaging about 50 inches annually, we sometimes have extended dry periods during February, March and April. We consider these months as our major fire season as high winds often coincide with dry weather. Also, many of our rural neighbors burn their pastures and crop lands during this period. Although most fires occur during relatively normal conditions and are suppressed with routine effort, we must keep our personnel trained and alert to combat blow-up fires at any time.

One of the most effective preventive practices against wildfire loss is the use of prescribed burning. This is the use of controlled fire, usually set to burn against the wind under winter conditions. Such a low, slow fire consumes the litter and ground cover when the trees will not be damaged. Over 50,000 acres are treated in this manner each year at Southern Woodlands. I know of no other company that makes more effective use of prescribed burning.

Westvaco is also unique within our industry in its use of modern fire fighting techniques. We still rely on the time-tested suppression method of the plowed fire line which is usually adequate for those fires occurring under normal conditions. But, to be better prepared to combat those fires that occur when winds are high and drought conditions prevail, we now have water pumpers, wind machines and fire bomber aircraft all on a year-round alert. You will see some of these demonstrated this afternoon.

Our original purchases of timberlands frequently were in large tracts that were served by very few public roads. Also, much of this land was flat and poorly drained. To most profitably manage land, good access is necessary. Throughout our coastal woodlands we have built nearly 1,800 miles of roads and dug over 1,000 miles of canals and ditches. Drainage removes excess surface water to provide more stable working conditions for our equipment and it also improves the growing conditions for our timber. Roads are located at those intervals which facilitate economic logging and ready access for fire fighting and general management operations.

Up to now, my comments have related solely to our use of the land for timber production, however, we do manage our lands under the multiple-use concept. Multiple-use may be defined not only as the use of the land for more than one purpose, but also as the availability of the use of the land for others as well as the owner. Such uses may include watershed values and activities such as hiking,

camping, fishing, hunting and aesthetics. To make our lands available for various recreational uses without detracting from timber production, we have arrangements with State agencies, public groups and private individuals for the shared use of our lands. We estimate that over 75,000 people hunted on our lands during this past season.

I have described the various steps we follow in the Westvaco Forest management cycle. We might consider that an established stand has grown to a harvest age of 30 years and that we can now make our crop cut and begin this cycle again. Our operational treatments will increase the productivity of these lands some four-fold so that sites which grew an average of $\frac{1}{2}$ cord per acre per year at time of purchase should throughout the life of the plantations we established, grow at the rate of 2 cords per acre per year.

This is only an overview of our operational cycle of forest management. I hope that the following tour and demonstrations at the various stops will help you to gain a more complete picture of our programs.

I will be glad to try to answer any questions you might have now or at any time during our tour.

