

United States
Department of
Agriculture

Forest
Service

Timber
Management
Washington, D.C.



PROCEEDINGS OF THE NATIONAL SILVICULTURE WORKSHOP

HARDWOOD MANAGEMENT

Roanoke, Virginia
June 1-5, 1981

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Acknowledgement

This year's National Silviculture Workshop was held in Roanoke, Virginia and the Monongahela National Forest. The purpose of the meeting were to discuss current silvicultural issues affecting all Regions and to review in detail the state-of-the-art application of hardwood management in the United States. These proceedings include the presentations of individuals on the program.

Co-hosts of the meeting and field tour were the Jefferson National Forest and Monongahela National Forest staffs. To these persons and to all who made presentations and participated during the session, NFS Silviculture extends our thanks.

Silviculture Group
Timber Management Staff
Washington, DC

PROCEEDINGS OF THE
NATIONAL SILVICULTURE
Workshop
Roanoke, Virginia
June 1-5, 1981

Theme: Hardwood Management

Division of Timber Management
USDA-Forest Service
Washington, DC

TABLE OF CONTENTS

	<u>Page</u>
Workshop Agenda	<u>1</u>
Register of Attendees	5
<u>Presentations - National Topics</u>	
Robert Gillespie	Purpose of Meeting 7
	TSI-Reforestation Action Plan
	Resource Program and Assessment (RPA)-Budgets
Dan Cramsey	K-V Activity Reviews 11
	Reforestation Trust Fund
Dick Miller	Tree Improvement Activity Reviews 22
Dennis Hamel	Update on 2,4,5-T and 2,4-D 25
	Forest Pest Management
Carl Puuri	Silviculturist Certification 36
<u>Technical Session</u>	
F. Bryan Clark	Hardwoods in Perspective 39
John Erickson	Breakthroughs in Hardwood Product Development 44
Nelson Loftus	The Eastern Hardwood Program 51
Lloyd Casey	Northeastern Area Hardwood Initiative 57
H. Clay Smith	Hardwood Silvicultural Systems 66
Bob Marquis	Modification of Silvicultural Systems for Special Objectives 77
Martin Dale	Hardwood Growth and Yield Simulators 88
Charles E. McGee	Managing Low Value Hardwood Stands 98
Robert D. Williams	Hardwood Tree Planting 108

		<u>Page</u>
Gayne G. Erdmann	Tending Young Northern Hardwood Stands	124
R. M. Godman	Production of Quality Hardwoods	151
Stephen G. Boyce	Biologic Diversity and its Use in Silviculture	163
Paul A. Schrauder	Problems Associated with Early Hardwood Management in the Appalachians	182
H. Clay Smith	Managing Central Appalachian Hardwood Stands	185
Donald E. Beck	Origin, Development and Management of Mixed Hardwood Stands-Southern Appalachians	196
David A. Marquis	Even-Age Development and Management of Mixed Hardwood Stands: Allegheney Hardwoods	213
James L. McConnell	Hardwood Tree Improvement	227
Paul S. Debald	Estimating Timber Values: A Guide to Treatment	237
David R. Houston	Some Dieback and Decline Diseases of Northeastern Forest Trees: Forest Management Considerations	248
Walter Knapp and Tom Turpin	Managing Red Alder on The Siuslaw National Forest	266
Warren Bacon	Visual Resource Management	274
Arnold Schulz	Wildlife and Endangered Species	291

Appendix

Field Tour Itinerary

1981 NATIONAL SILVICULTURE WORKSHOP
ROANOKE, VIRGINIA
June 1 - 5

CHAIRMAN: Robert E. Gillespie/Carl R. Puuri

PURPOSE OF MEETING: Discuss current silvicultural issues affecting all Regions. Review and discuss aspects of hardwood management including projections of future needs, improving quality and yields through sound silvicultural treatment.

June 1 (Indoors)

1 p.m.	Call to Order	
	Introduction of Participants	Robert Gillespie, WO
	Welcome	R-9
	House Rules and Announcements	R-9
	Purpose of Meeting	Robert Gillespie, WO
	Silvicultural Challenges	Norman Gould, WO

National News Related to Silviculture

1:45 p.m.	TSI & Reforestation Action Plan	Robert Gillespie
	RPA; Budgets	Robert Gillespie
2:15 p.m.	K-V Activity Reviews	Dan Cramsey
2:30 p.m.	Reforestation Trust Fund	Ken Myers
2:45 p.m.	BREAK	
3 p.m.	Tree Improvement Activity Reviews	Dick Miller
	Action Plans - Nursery Capacity Study	Dick Miller
3:30 p.m.	EPA - 2,4,5,-T Hearings 2,4-D Status	Dennis Hamel
	Pesticide Direction-IPM	Dennis Hamel
4 p.m.	Silviculturist Certification	Carl Puuri
4:30 p.m.	Open Discussion	
5 p.m.	Break for Day	

Technical SessionJune 2 (Indoors)

8 a.m.	<u>Hardwoods in Perspective</u> An overview of the resource and its importance.	F. Bryan Clark RES, WO
8:30 a.m.	<u>Breakthroughs in Hardwood Product Development</u> (Kraft and Corrugated Paper Breakthroughs) 20-50 years into the future! Silvicultural and Research Implications	John Erickson FPER, WO
9 a.m.	<u>The Eastern Hardwood Program</u> Improved use and management of eastern hardwoods: a research, development, and application plan.	Nelson Loftus, TMR NA and SA Representatives, S&PF
9:45 a.m.	BREAK	
10 a.m.	<u>Hardwood Silviculture and Management Systems (Panel)</u> Normal Silvicultural Systems Modification for Special Objectives	Bob Phares, NE (Panel Moderator) Clay Smith, NE David Marquis, NE
11:15 a.m.	<u>Hardwood Growth and Yield Projections</u> State-of-the-Art	Martin Dale, NE
12 noon	LUNCH	
1 p.m.	<u>Hardwood Silvicultural Practices (Panel)</u> Low Quality Hardwoods Hardwood Planting Tending Young Hardwood Stands (Stocking Levels) Production of Quality Hardwoods	Gene McGee, SO Bob Williams, NC Gus Erdmann, NC Dick Godman, NC
2:30 p.m.	<u>Biological Diversity and Its Use</u>	Stephen Boyce, NE
3 p.m.	BREAK	

3:15 p.m.	<u>Even Aged Development and Management of Mixed Hardwood Stands (Panel)</u>	Dan Cramsey, TM (Panel Moderator)
	Central Hardwoods	Clay Smith, NE
	Southern Appalachians Hardwoods	Don Beck, SE
	Allegheny Hardwoods	David Marquis, NE
4:30 p.m.	<u>Hardwood Tree Improvement</u>	Jim McConnell, R-8
5 p.m.	BREAK for day	

June 3 (Indoors a.m.)

8 a.m.	<u>Estimating Timber Stand Values: A Guide to Treatment</u>	Paul DeBald, NE
8:45 a.m.	<u>Ecological Aspects of Dieback and Declines in Hardwoods</u>	David Houston, NE
9:45 a.m.	BREAK	
10 a.m.	<u>Management of Red Alder with Conifers</u>	Walter Knapp, R-6 Tom Turpin, R-6
10:30 a.m.	<u>Hardwood Silviculture for Other Resources - Visual Resource Management</u>	Warren Bacon, WO (R)
	Wildlife and Endangered Species	Arnold Schultz, R-9
12 noon	LUNCH	
1:15 p.m.	Load Bus	
	Travel to Monongahela National Forest	Monongahela National Forest Staff
	Discussion stops enroute	
5 p.m.	Arrive Snowshoe Lodge	

June 4 (Field Tour)

7:30 a.m.	Fernow Experimental	Fernow Experiment Forest
- 5: p.m.	Forest and Monongahela	and Monongahela National
	National Forest selected	Forest Staff
	stops to observe and discuss	
	hardwood silviculture	
7 p.m.	<u>Banquet</u> - "Slides and discussion	Bob Gillespie, TM
	quality hardwood Management in	Bobby Kitchens, R-8
	France"	Dan Sims, NA
7:30 a.m.	Load Bus	
12 noon	Arrive Roanoke. (End of Workshop)	

1981 National Silviculture Workshop
Roanoke, Virginia
June 1-5, 1981

Attendees

<u>Regions</u>		<u>Location</u>
Jack Bennett	Director, TM	R-1
Bob Naumann	Silviculture, TM	R-1
Milo Larson	Silviculture, TM	R-2
Dick Bassett	Silviculture, TM	R-3
Truman Puchbauer	Timber Staff (Boise N.F.)	R-4
William Beaufait	Silviculture, TM	R-5
Chuck Timberman	Klamath N.F.	R-5
*Walt Knapp	Silviculture, TM,	R-6
*Tom Turpin	Silviculture, (Siuslaw N.F.)	R-6
*Warren Bacon	Recreation	R-6
Bill Hughes	Recreation	R-8
Malcolm Edwards	Wildlife	R-8
Tom Hoots	Jefferson N.F.	R-8
Bob Brooks	George Washington N.F.	R-8
Jim Lunsford	Plans, TM	R-8
Robert Kitchens	Silviculture TM	R-8
*Jim McConnell	Silviculture, TM	R-8
*Ken Shalda	Timber Staff (Monongahela N.F.)	R-9
*Arnold Schultz	Wildlife Biologist (Monongahela N.F.)	R-9
Paul Schrauder	Jefferson N.F.	R-8
Robert Colona	Jefferson N.F.	R-8
George Freeland	Jefferson N.F.	R-8
Patricia Clark	Jefferson N.F.	R-8
Ed Leonard	Jefferson N.F.	R-8
<u>Washington Office</u>		
A. P. Mustian	TM	WO
*John Erickson	FPER	WO
*F. Bryan Clark	R	WO
Wayne Millen	PA	WO
*Norman Gould	TM	WO
Hugh C. Black	WL/F	WO
*Dennis Hamel	S&P	WO
Dan Schroeder	TM	WO (Fort Collins)
Lloyd Olson	TM	WO
*Nelson Loftus	TMR	WO
*Bob Gillespie	TM	WO
*Dan Cramsey	TM	WO
*Dick Miller	TM	WO
*Carl Puuri	TM	WO

S&P Areas

*Lloyd Casey	NA
*Dan Sims	SA

Research

*Robert Phares	NE
*David Marquis	NE
*Clay Smith	NE
*Paul Debal	NE
Doug Powell	NE
*Martin Dale	NE
*Stephen Boyce	NE
*David Houston	NE
Doug Phillips	SE
*Gene McGee	SO
*Donald Beck	SE
*Gus Erdmann	NC
*Bob Williams	NC
*Dick Godman	NC

Other

Otis Hall	VPI, School of Forestry
David W. Smith	VPI, School of Forestry
John Hosner	VPI, School of Forestry

*On Program

Purpose of Meeting

During 1978, a Forest Service steering group was established to develop a program on "Management and Use of Eastern Hardwoods." The stimulus for this program was an investment package proposal presented jointly by Region 9, Northeastern Forest Experiment Station, and Northeastern Area. Identification of a number of ongoing activities in the various field units was made to promote and improve hardwood management and utilization. Associate Chief Resler then recommended that a total east-wide effort be made.

During January 1980, a 3-day meeting was held to develop a research, development and application program for Eastern Hardwoods. The purpose was to plan a document for a Forest Service, industry, and States program. Also, develop a basis for FY 1981 budget for Eastern Hardwood Research Project. The National Forest System (NFS) was anxious to participate in the Eastern Hardwoods initiative. We had also planned and put together a workshop and meeting proposal for NFS. We decided our workshop theme for 1980 would or should augment the Eastern Hardwoods initiative and cover hardwood management including projections of needs, improving quality and yield through sound silvicultures.

As you know, this is the workshop that was planned and organized and postponed from last fall. I do not want to steal any more thunder from our speakers. If you have looked at the program carefully, you will see that it follows the theme of the workshop and thus the purpose of our meeting.

Several people have asked about the scheduled Sales-Silviculture workshop planned for this September in the Black Hills. Although official notice has not gone out, that workshop has been delayed also. We will not hold the workshop in the Black Hills this fall.

We have proposed in the Timber Management Division a joint Silviculture, Sales, and Plans conference for April 5-9, 1982, to be held in Seattle, Washington. This has not been approved as yet. But there would be a short joint session of all groups and then technical sessions for each group at the end of the week. Our silviculture theme will emphasize the use of economics in investments in the management of the timber resource. We would hope to take advantage of the field location around Seattle to visit Weyerhaeuser Company operations, and other silviculture operations around Mount St. Helens and the Mt. Baker-Snoqualmie National Forest.

We have also requested a Nursery Management Information System Workshop and a Genetic Workshop on Breeding for Disease Resistant Trees for next fiscal year. Again, we have no approval for these sessions as yet, either.

TSI - Reforestation Action Plan

Last year a Progress Report was prepared on the Action Plan of July 6, 1978, on Evaluation of Reforestation and TSI. This was submitted to the Chief with a revised plan of Action dates. The report and revised dates were approved by the Chief on May 12, 1980, and was sent to the Regions by letter of April 23, 1980. Another progress report is due to be submitted to the Chief as of September 30, 1981. I will not review the entire plan. Over half of the Action items were completed as of the last report and many more have been completed as of this date. Some items of significant progress or no great progress are noted.

1. Item A-6 Direction (10) Update of 2470 Manual to reflect major new direction:

FSM 2470 and 2471 has been drafted and sent to you for comment.

FSM 2478 Certification is out in ID #69.

FSM 2472 and 2476 Reforestation and TSI are in the process of revision.

FSM 2475 TI is in the process of minor revision.

FSM 2478 Examination and Prescription out in ID #69.

Hopefully, all will be in draft form this fiscal year.

A2 - Standards

Stocking level standards have been drafted and sent out for comment. We are on schedule for this Action item.

A3 - Benefit Cost Analysis

We are still way behind schedule on this Action item. John Sessions was to help, but got tied up with LMP and RPA and then left. Art Briggs has not had time to work on this yet. Hopefully, we will cover this more fully next April in Seattle.

B1 - Budget Execution (7)

Schedule Activity Reviews of representative Regions to determine if funds are being spent as planned and make recommendations for improvement.

Weldon Cook was to work on this and was transferred to F&AM. Therefore, this action has not been scheduled and will be delayed even longer.

B4 - Coordination (7)

Train other functional specialists in fundamentals of silvicultural systems, cultural operations, and timber production requirements. The Regions were to prepare a training program during FY 1981, implemented during 1982 and an evaluation made during 1983.

I have no idea how this is going but only one Region had started as of last year.

C1 - Evaluation (7)

Require each Region to make an Activity Review of Reforestation and TSI and forward a copy to the Chief by end of FY 1981.

Need I say, we do not have many copies in the Washington Office. Therefore, I assume these have not been completed yet.

In summary, I might add that those of you who have not looked at the April 1980 letter recently should drag it out, because another progress report will be made.

by Robert E. Gillespie

Resources Program and Assessment (RPA) - Budgets

When this first was put on the Program, I was going to say how disappointed I was with the reforestation TSI levels in the RPA. In my opinion, they are way too low in total. But now I see we have only one Staff Director here and no Deputies, so I am talking to the wrong audience. I guess I expect for you to pass the word on to your bosses.

So I will talk budget. I have to talk in generalities and on a national basis so if the shoe fits you can squirm a little and, if it does not you can relax.

Even though I believe the RPA levels are too low for our needs, every year we run in to the same problem: We can not reach our RPA Goal. We hear this from a number of Regions. Typically, it comes after the budget has gone to Congress and even after the Appropriations Act has been passed. Something is wrong somewhere. Let's forget K-V for the present and only talk appropriated targets and programs. Every Region reports annually on their "needs" acres with appropriated funds. The Washington Office budget people put together program levels based on RPA levels as submitted by the Regions. We do look over these targets by Regions to see if they look reasonable. We do have contacts, questions, etc. with you timber people in the Regions.

My big question is: Do you timber people have contact and communications with your counterparts on the Forests and do you work with and talk to your budget coordinators in the Region? When your needs reports say you have the acres to work on, the targets and budget is set, and then the Region says they do not have the acres to work on. It does not make sense. It is also embarrassing to the Forest Service to say we really could not do the program we said we could. Enough said except to emphasize--get involved in the early stages and budget planning process. It is much easier than after the axe has fallen and you try to reduce targets or scratch for programs.

K-V ACTIVITY REVIEW AND OTHER TOPICS

D. E. CRAMSEY

In the short time provided, let us briefly look at where we are on three topics: (1) the National Activity Review of the Knutson-Vandenberg (K-V) Program; (2) the Reforestation Trust Fund; and (3) the Administrative Studies on Alternatives to Herbicides.

NATIONAL ACTIVITY REVIEW OF THE K-V PROGRAM

The National Activity Review of the K-V Program is about 60 percent completed with two of six Regions remaining to be reviewed. These should be completed by the close of fiscal year (FY) 1981. Let's review the objectives, actions and findings to date, and plans for completion.

The K-V Act as amended in 1976 authorized the use of funds for "protecting and improving the future productivity of the renewable resources of the forest land on such sale area, including sale area improvement operations, maintenance and construction, reforestation, and wildlife habitat management." This was in addition to previous authorization under the original Act. The Chief established an interdisciplinary work group of field personnel to develop and recommend policy and direction to implement the amended Act. Interim direction was placed in Forest Service Manual (FSM) 2477 in November 1977. After a year of compliance with the Interim Directive (ID), the Regions and affected divisions were requested to review the directive and recommend revised policy and direction. The FSM 2477 ID was amended with final policy and direction in June 1979.

During the ensuing 3 years that the field units had to implement the amended K-V Act, there were many questions as to the authority for kinds of projects, location of projects on sale area, program planning process, and reporting of accomplishments. Discussions with field personnel indicated that generally there was inadequate recognition or use of the new authority. Direction was needed on how, when, and where the authority could be useful in protecting and improving the future productivity of renewable resources on timber sale areas.

A National Activity Review of the K-V program was approved to determine: (1) if management direction was adequate and complied with and (2) whether strengthening was needed at the national, Regional, and Forest levels. Also, the Chief would encourage full use of the authority, but within the constraints of fiscal integrity.

The review would focus on management activities that are formulated and implemented with the use of K-V funds and include review of:

1. National, Regional, and Forest policies and direction.
2. Field compliance with item 1.

3. SAI plan development and review for selected Forests and Districts.

4. Fiscal controls and integrity on collections and expenditures.

5. Program planning and budgeting process and reporting of accomplishments.

6. Quality control at Regional and Forest levels.

7. Field concerns of the program.

The review was conducted by a Washington Office and Regional interfunctional team, including a Regional Liaison Officer. The review team first analyzed Washington Office direction including the FSM. All staff involved with the use of K-V were asked to update Manual direction, then Regional direction, and budgeting data were reviewed.

The next phase was to visit selected Regions and discuss problems and concerns and field review use of K-V funds (the items listed above).

Four (Regions 1, 5, 6, and 8) of the six Regions selected for review have been completed and Action Plans written. Here are some of the major actions to be completed.

Chief's Responsibility

1. Consolidate Forest Service Manual instructions on collecting and expending K-V funds.

2. Establish standard terms and definitions to be used in K-V program direction including permanent facilities, improvements, and maintenance.

3. Complete policy direction for each functional unit involved with the K-V program.

4. Provide FSM direction to clarify that sale area improvement plans (including revisions) or all projects funded with K-V funds be supported by the following:

a. Stated objectives (purpose of projects).

b. Economic and environmental analysis.

c. Coordination Statement (projects should conform to stated land or resource objectives).

d. Plans for maintenance of K-V improvements and the impacts on environment, other resource programs, and funding.

e. Cost breakdown to support collections.

5. Coordinate with the Regional Foresters to provide procedures for obtaining necessary funds to correct adverse resource impacts associated with timber sales. These include resource problems that do not qualify for K-V funds or that existed prior to the timber sale. Include direction for obtaining appropriate funds to supplement K-V to accomplish coordinated resource projects.

6. Clarify legal and policy constraints on the use of K-V funds including those imposed by the K-V Act and amendment and the appropriations act. This will include clarifying the use of K-V funding for permanent facilities and improvements, for planning, and for studies.

7. Review and revise, if needed, policy concerning adjustments of K-V targets, limitations on adjusting K-V plans, use of K-V for tree improvement, regeneration cost added to base rates, reporting functional K-V accomplishments, and restrictions on collecting K-V, (Example: volume and acceleration restrictions).

8. Review and amend instructions for program planning and budgeting to include use of K-V for all functional purposes and identifying K-V funding with benefiting resource.

9. Provide direction for monitoring K-V work to meet the intent of the National Forest Management Act.

10. Provide technology transfer on the use of K-V funds.

11. Review and revise instructions on annual K-V fund review required by the K-V Act.

Regional Forester Responsibility

1. Provide training in developing Sale Area Improvement (SAI) plans and Environmental Analysis (EA) for interdisciplinary team members and develop monitoring procedures to ensure all resource input into these plans.

2. Evaluate present data systems and adopt procedures to handle current programing of K-V activities.

3. Give priority in allocation of appropriated funds for the preparation of SAI plans.

4. Develop procedure to identify and select timber sales to evaluate resource opportunities for K-V funding.

5. Provide direction for resource inventories and specialist involvement to develop SAI plans and EA.

6. Develop Regional guidelines for priority for use of K-V funds and projects approved for use.

The Activity Review in Regions 4 and 10 will be completed this fiscal year. Some of the Chief's action items will be started this year and most completed by the end of fiscal year 1982.

REFORESTATION TRUST FUND

This topic refer to the trust funds authorized in Section 303 Reforestation Trust Fund of Title III-Reforestation, Public Law 96-451, Recreational Boating Safety and Facilities Improvement Act (RBSFIA) of 1980. This Act amended the Federal Boat Safety Act of 1971, (Public Law 92-75, 85 Stat 213) and was signed on October 14, 1980.

Public Law 96-451 established a Reforestation Trust Fund and authorized the Secretary of the Treasury to transfer to the fund an amount equal to the sum of the tariffs received in the treasury from the imports of softwood lumber and other such products, not to exceed \$30 million in a fiscal year, for each fiscal year from October 1, 1979, to September 30, 1985. The Secretary of the Treasury has the responsibility to invest the funds, except for the amount needed for current withdrawals, in interest-bearing obligations of the United States or in obligations guaranteed in principal and interest by the United States.

The Secretary will report to Congress each year on the status of the Trust Fund and after September 30, 1985, will transfer the balance to the general fund of the treasury.

For each fiscal year, from fiscal year 1981 through fiscal year 1985, Section 303, part (d) authorizes the appropriation to the Secretary of Agriculture from the Trust Funds of an amount equal to "the sum estimated by the Secretary of Agriculture for the fiscal year under section 3(d)(2). . . to be necessary for Reforestation and other treatment of acreage, as set forth in the report (RPA) transmitted by the Secretary to the Congress" that exceeds the sums of the amounts appropriated that year for work authorized in Section 3(d)(3) plus administrative costs of the reforestation program. Section 3(d)(3) authorizes the appropriation of funds for reforestation and other treatment up to \$200 million annually for this work.

The provision of Section 303 were originally part of Senate Bill S.100 sponsored by Senator Bob Packwood (Oregon) in January 1979 and later became an amendment to H. R. 4310. Originally, the legislation specified tree planting for backlog areas only, but this language was replaced with a broader reference.

In April 1981, the USDA Office of General Counsel (OGC) rendered us the opinion that the language and purpose of the RBSFIA appropriations authorization covered funding needed for reforestation and related activities enumerated in RPA Section 3(d)(2). They stated that "The

authorization in Section 303(d)(1) of RBSFIA expressly relates to an identifiable portion of the Secretary of Agriculture's estimate under Section 3(d)(2) of RPA (i.e. the amount by which this estimate exceeds the \$200,000,000 appropriations authorization of RPA Section 3(d)(2). The Secretary's estimate under RPA Section 3(d)(2) specifically includes:

Moneys needed 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 production of trees and other multiple use values.

Also, ". . . this interpretation of RBSFIA Section 303(d)(1) is consistent with, and supported by, the Conference Report, which indicates that the moneys thereby made available to the Secretary 'would be used to supplement Congressional appropriations for reforestation and timber stock improvement on publicly-owned National Forests . . . ' H. R. Rep. No. 96-1320, 96th Congress 2d. Sess. (1980)".

The actual funding under PL 96-451 would be a supplemental appropriations request after congressional action on the RPA Section 3(d)(3) appropriation.

In FY 1981, activities not funded included 40,000 acres of site preparation for \$6 million and 50,000 acres TSI for \$11 million, a total of \$17 million, RPA report shows \$121.4 million needed in FY 1981 and the FY 1981 appropriation was \$103.8 million, a difference of \$17.6 million.

The status of unfunded work qualifying for the trust funds was included in the Chief's briefing papers on the fiscal year 1982 budget. Under the constraints of the present administration, we may not have the opportunity to utilize this source for a couple of years.

Section 301 amortization of Reforestation Expenditures and Section 302 Investment Credit of Title III- Reforestation provide incentives to small private landowners to increase reforestation on private land. These sections amend the Internal Revenue Code by providing a direct tax deduction for reforestation investments. Section 301 allows reforestation expenditures, up to \$10,000 in any single year, to be amortized over a 7-year period. Reimbursements under a Government cost-sharing program would not qualify for the amortization, unless reported as gross income. Section 302 adds reforestation expenditures to the cost items eligible for the 10 percent-investment credit, limited to \$10,000 per year. Both section start with calendar year 1980.

ADMINISTRATIVE STUDIES ON ALTERNATIVES TO HERBICIDES.

Research supports the theory that vegetation control is necessary in most of the Forest types in the United States to produce the outputs of Forest products desired from our National Forest lands. Much is

known about the effects of competing vegetation on forest trees. Presently, there are studies on the various methods to control competing vegetation, but more information is needed on the cultural and manual methods of control. Much of the public is questioning and attacking the use of herbicides, claiming that chemicals used are not safe, that control of competing vegetation is not needed, and that the Forest Service is not considering alternatives to the use of herbicides. The immediate need is for information comparing manual control with herbicides for site preparation and plantation release. The Washington Office, Timber Management and Timber Management Research staffs, is coordinating with five Regions and five Research Stations on administrative studies to evaluate alternatives to herbicides to answer several specific questions, such as:

1. What is the relative effectiveness of alternative herbicides and manual brush control on tree seedlings survival and growth?
2. How many treatments are needed to obtain satisfactory vegetation control?
3. What does each treatment cost to obtain equivalent effectiveness?

Timber Management and Research staffs at the Regional and Station level respectively have jointly identified the major problem areas and have designed study proposals. These plans have been approved by the Regional Foresters and Station Directors and have been reviewed and approved by the Washington Office, Timber Management and Timber Management Research staffs. Fiscal years 1980 and 1981 funds have been provided to initiate these studies. Since approving these projects, however, several Regions have faced severe travel restrictions and have had to modify some of the work planned for fiscal years 1980 and 1981. Some of the studies were not installed in fiscal year 1980. Here is a summary, by Region, of progress to date:

REGION 1

Study Title: Site Preparation Techniques for Pinegrass and Sedge Communities in the Northern Rocky Mountains.

Managed (Mgt.) Species: Douglas-fir; lodgepole pine, ponderosa pine, western larch.

Controlled Species: Pinegrass, sedgegrass, beargrass

Treatments: Scalps 18 inches, 24 inches, and 30 inches; herbicides at three rates, pre- and post-planting, spring and late summer, low and ultralow volume mixes, on protected and unprotected conifers--include glyphosate (Roundup), Velpar (liquid and dry), atrazine, dalapon, atrazine-dalapon, and control (no treatment).

Status: Study initiated in spring 1979; follow-up 1980; first year data.

Study Title: Techniques for Releasing Suppressed Conifers in Northern Rocky Mountains Shrub-Conifer Communities.

Mgt. Species: Douglas-fir, true fir, lodgepole pine, western larch.

Controlled Species: Alder, willow, redstem, shiny leaf ceanothus.

Treatments: Glyphosate, 2,4-D, Krenite, Garlon, hand-cutting and control.

Status: Five study sites to be selected and treated FY 1981; four sites treated fall 1979 and spring 1980; plots remeasured spring and fall, FY 1981.

Study Title: Alternative techniques for the Prevention of Conifer Suppression by Comparative Vegetation, Northern Rocky Mountains.

Status: To be installed on five different sites.

REGION 5

Study Title: A test of Manual and Chemical Release of Conifer Plantations on National Forest Lands in California.

Mgt. Species: Douglas-fir, ponderosa pine, mixed conifers.

Controlled Species: Manzanita, snowbrush, sierra chinkapin, rabbitbrush, deerbrush, tanoak, madrone.

Treatments: Hand-cutting (one and two times at 2-, 4-, 6-foot radius, and full plot), grubbing, hand spray, helicopter simulation, 2,4-D, glyphosate (one and two times), combination hand and herbicide, and control.

Status: Three study areas installed, fourth to be installed FY 1981, and two under consideration. Herbicide treatments and measurements to be done fall 1981.

REGION 6

Study Title: Comparison of Site Preparation Methods on Coast Range Sites.

Mgt. Species: Douglas-fir

Controlled Species: Red alder, salmonberry.

Treatments: Spot hand clearing; spraying; burning only; slash and burn; spray and burn; spray, burn and seed grass; control. Herbicides include 2,4-D, Tordon 101, glyphosate.

Status: Treatments completed CY 1980. Plots will be remeasured and photos retaken.

Study Title: Manual and Chemical Options for releasing Douglas-fir from Competing Brush in Oregon's Coast Range.

Mgt. Species: Douglas-fir, western hemlock.

Controlled Species: Elderberry, salmonberry.

Treatments: Manual (one, two, and three times), aerial spray using glyphosate and fosamine, manual plus fosamine, and control.

Status: Initial spray and manual treatments done, additional treatments and measurements to be done FY 1981.

Study Title: Environmental Impacts of Manual and Chemical Alternatives for Site Preparation and Conifer Release in Oregon's Coast Range.

Treatments: Samples of vegetation, forest floor and mineral soil analyzed for chemical residues, soil erosion measured in soil erosion boxes, water monitored.

Status: Pre-spray samples taken and post-spray samples initiated (96 samples for 2,4-D and picloran, 80 samples for glyphosate, and 40 samples for fosamine taken as of October 1, 1980). One hundred-forty soil boxes installed.

Other Studies: Similar studies planned for Cascade Range. Region and Station evaluating manpower and travel to determine feasibility.

REGION 8

Study Title: Comparisons of Cultural Treatments for Site Preparation and Pine Release in the Southeast. Four installations represent separate physiographic provinces: Cumberland Plateau, Appalachian Mountains, Coastal Plains, and Piedmont.

Mgt. Species: Loblolly pine.

Controlled Species: Hardwood sprouts-oak, gum, hickory, maple.

Treatments: Hand clearing all woody vegetation over 2 feet in height, injection of all woody stems 2 inches dia. at ground with Tordon 101 or 101R, Velpar gridballs, control.

Status: The release plots and site preparation plots are installed, except for preparation in the Cumberland Plateau. Initial measurements will be made FY 1981.

REGION 9

Study Title: Alternative Means for Release of Lake States Conifers.

Mgt. Species: Red pine, white spruce.

Controlled Species: Aspen, birch, maple, oak.

Treatments: Ground foliar spray with 2,4-D, basal spray with 2,4-D and 2,4DP, manual cutting with axes and clippers, aerial foliar spray and control.

Status: Treatments installed in 1980. Cost data obtained.
Remeasurement of plots and follow-up manual treatments will be done FY 1981.

SILVICULTURAL ADMINISTRATIVE STUDIES

Here is a summary of the Regional responses listing their active Administrative Studies in Silviculture.

<u>Region</u>	<u>Study</u>	<u>Objective for Progress</u>
1	a) A cooperative plan to study tree growth and associated forage production of managed stands in the Northern Region 1969.	Published August 1980 INT-255 Russell Graham; Jonalea Tonn agreement with Intermountain Forest and Range Experiment Station - Pfister to update habitat type classifications in an Interim Directive.
2	None	
3	None	Final report on forestation project on Prescott National Forest submitted FY 1980.
4	a) Comparison of containerized and bare-root ponderosa pine.	Project will be completed 1986, evaluated and reported.
	b) Effect of a liquid organic fertilizer and soil conditioner on establishment of planted Douglas-fir trees (Kozgro).	Study has been evaluated for practical application to improve initial survival and growth.
	c) Planting trails - Boise National Forest survival, growth, site preparation, grazing.	Close after report finished; record establishment, annual growth, survival, grazing effects, etc. Close after report.
	d) Test shelter sowing method-survival, growth, response.	Data recorded annually field application evaluation write report--1981.
	e) Spruce cutting trials; effect of cutting on germination and survival of Engelmann spruce, and alpine fir.	800 plots examined, 5-year schedule; open study--periodic reports.

<u>Region</u>	<u>Study</u>	<u>Objective or Progress</u>
5	a) True Fir regeneration studies. (Pacific Southwest Forest and Range Experiment Station).	Develop tree classification related to risk (death) and vigor (growth).
	b) Rust resistant sugar pine. (Pacific Southwest Forest and Range Experiment Station).	Develop criteria for selection, and evaluate progeny performance.
	c) Releasability of understory trees. (University of California.)	Determine ability of understory to respond and develop.
	d) Forest regeneration in Sierra Nevada brush fields. (University of California).	Determine competition and effectiveness of herbicide.
	e) Forest fertilization.	Determine feasibility and criteria for fertilization.
6	a) Evaluation of fuel--air explosives (FAE) for site preparation.	Determine suitability of FAE for site preparation.
	b) Reforestation systems for coastal environments.	Evaluate regeneration system alternatives on high site forest lands in coast ranges.
	c) Characterization of champion mine race of cronartium ribicola.	Determine changes needed in rust resistance breeding to respond to this new race.
	d) Response to urea and ammonium nitrate by 115-year-old Douglas-fir stand.	Evaluation of responses to fertilization.
	e) Sensitivity analysis of timber RAM inputs on two National Forests.	Evaluate annual harvest calculation results from silvicultural and administrative inputs.
	f) Field performance evaluation on container-grown nursery stock.	Determine if level of investment is warranted.

<u>Region</u>	<u>Study</u>	<u>Objective or Progress</u>
8	a) Carribbean National Forest	- 1
	b) National Forest's in Florida	- 1
	c) Jefferson National Forest	- 6
	d) Ashe Nursery	- 18
	e) Erambert Seed Orchard	- 1
		<u>27</u>
9	a) Site preparation evaluation in northern hardwood, hemlock, and hemlock--yellow birch.	Application of various seedbed preparation methods to obtain desired regeneration and growth.
	b) Cottonwood evaluation in southern Illinois.	Determine which cottonwood clones suitable for southern Illinois bottoms
10	a) The effects of stand density upon growth and yield of hemlock-spruce stands in coastal Alaska.	Develop biological information to aid management of evenaged hemlock-spruce stands.
	b) Alternatives for management of vegetation to establish sitka spruce on cutover sites dominated by salmonberry.	Test effectiveness of alternative methods of hand and chemical site preparation.
	c) Silvicultural value of prescribed burning of logging slash in southeast Alaska.	Measure effects of slash burning on natural regeneration.

NURSERIES AND TREE IMPROVEMENT

Richard G. Miller

It's a real pleasure to have this opportunity to bring everyone up to date on nursery and tree improvement programs.

NURSERY PROGRAMS

Nursery Trainee Program. The nursery trainee program has been underway since 1978. Five people have graduated from the program to date. Four of the graduates have been placed in nursery positions; the fifth person completed his training during April and, as yet, has not been placed in an appropriate nursery position. We encourage all nurseries to consider the graduates of this program when filling vacancies. We expect to continue the program with one or two trainees per year. Regions interested in participating in this program should contact Timber Management, Washington Office.

Nursery Capacity. A major effort to increase nursery capacity and construct suitable facilities is continuing in Regions 5, 6, and 8.

The Chief has approved the closure of Mt. Sopris Nursery in Region 2 and Eveleth Nursery in Region 9. The nurseries should be phased out by 1984 and 1985 respectively.

All Regions are encouraged to work together to meet their stock production needs. If seedlings for a particular area in the Region can be grown better at another Region's nursery, we urge you to make the necessary arrangements and have the particular seedlings grown in the most appropriate nursery.

FA&O. As you know, FA&O funds are extremely limited and consequently only the highest priority projects in each Region are funded. We suggest you review FSM 6514.31b-6 to make sure the project being proposed must, in fact, be constructed with FA&O funds. Some nursery work can be accomplished with 035 funds.

Surplus Stock. Some Regions are still producing large numbers of surplus stock. While we fully understand the reasons for ending up with some surplus trees, OIG and some of our administrative personnel are telling us to sell these surplus trees on the open market. Private nursery managers are directly opposed to our selling these extra seedlings. Those of you who are involved with sowing schedules and nursery production should evaluate nursery factors and monitor tendencies to over-sow in order to hold surplus stock to an absolute minimum. We will have to take a close look at this next year and develop appropriate policy.

A-76. Bob Snoich, Administrative Management, Washington Office, and I are preparing a national review for the nurseries. We are proposing that the nurseries are a necessary government function. The review is

based on data submitted by all Regions. If this review is approved, individual Regions will not have to make special reviews of their nurseries.

Annual Nursery Reports. Approximately half of the nurseries are not providing all of the information specified in FSM 2496.4 in their annual reports. The majority of nurseries need to include only a few additional items. Please see that nursery managers review the Forest Service Manual and include the specified information in their FY 1981 annual report.

Nursery Management Information System (NMIS). One of the more exciting developments for me this year was working with the NMIS. This system is divided into seed and seedling subsystems, and will handle current data and maintain historical information for several nursery operations.

The system was pilot-tested at Lucky Peak, Medford, and Wind River Nurseries between February and May of this year. A review of the pilot test was conducted during the week of May 18 and showed that the basic system was satisfactory. The system will save time and money, and will facilitate and improve our recordkeeping. Several new reports and enhancements were proposed, and many of these suggestions will be included in the system before it is implemented Service-wide.

We expect to create two mini-task forces next fall to develop background information for the inventory and seed collection phases of the system. A 1-day meeting has been proposed in conjunction with the Western Nursery Manager's Meeting at Medford, Oregon, to review the system and to discuss and establish priorities for enhancements.

Six additional nurseries (Albuquerque, Ashe, Coeur d'Alene, Humboldt, Placerville, and Toumey) will be receiving TI 990 microcomputers during July. The TM staff in Fort Collins will send these nurseries a system disc and will arrange for training.

TREE IMPROVEMENT PROGRAMS

Workshops. During March, Gene Namkoong, Southeastern Forest Experiment Station, conducted an outstanding workshop devoted to state-of-the-art strategies in tree improvement. This was the first continuing education-type program we have had for geneticists. Undoubtedly, some changes and improvements in our genetics programs will result.

A genetics workshop dealing with rust-resistant breeding programs has been proposed for July 1982 in Eugene, Oregon. An in-depth discussion and evaluation of these programs are needed.

Activity Reviews. Tree improvement activity reviews have been conducted in Regions 5 and 8 so far this year, and a third review will be conducted in Region 6 during July. Reviews have been proposed for Regions 1 and 9 during FY 1982.

The objectives are to determine how priorities are established for budgeting and selecting program intensity levels; to determine adequacy of staffing, seed source control, and the genetic base; and to determine the effectiveness of cooperatives, cooperation with Research, and integration of genetic principles in land and resource management plans and in total vegetation management.

We found that minor amounts of seed (cones) are being purchased on the open market with little or no knowledge of seed source. This practice does not comply with Forest Service policy. All seed used in Forest Service programs must be accurately identified and meet the standards of a Level I program (FSM 2475.3).

First-generation programs are generally progressing at a satisfactory rate. We do need to develop specific plans for determining how the material for the first generation will be used to create advanced generation breeding programs.

Data handling and analysis is becoming a problem due to the large amount of data being generated. Software needs to be developed to effectively handle the data. We are in the process of surveying the Regions' needs and we will try to develop a system for Service-wide use. It will be desirable to have microcomputers located at major tree improvement facilities.

In closing, my travels in the Regions show that some people still believe that tree improvement is a program that is not really related to silviculture. I must emphasize that nurseries and tree improvement are important parts of silviculture programs. We must produce quality seed of broad genetic base in our tree improvement programs. The seed must be grown in nurseries using state-of-the-art practices to produce high quality planting stock. Silviculturists must establish this stock on sites where it is adapted, and then tend these stands by applying basic genetic principles along with principles of several other important disciplines. A coordinated approach based on sound silvicultural practices is mandatory if we are to meet our timber production and other resource management goals and objectives.

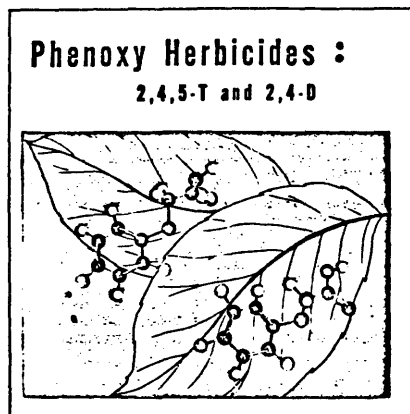
FOREST PEST MANAGEMENT

Thank you. Representing the Washington Office, Forest Pest Management Staff, it is a pleasure for me to attend this National Silviculture Workshop and be able to address you today on some aspects of forest pest management

As requested, my discussion will be confined in bringing you up-to-date on three areas of pest management work.

1. The status of the phenoxy herbicides - 2,4,5-T and 2,4-D.
2. Pesticide-Use Management and Coordination direction, and
3. Forest Pest Management direction in terms of:
 - a. incorporation of the approved FPM charter into the Forest Service Manual system, and
 - b. implementing integrated pest management into forest practice.

Update on 2,4,5-T and 2,4-D



These phenoxy herbicides have been synthesized and used for their unique, selective herbicidal values since the 1940's.

2,4,5-T. The first registration of 2,4,5-T was in 1948. In the ensuing years it was a valuable tool in a variety of situations, including forestry. Since its introduction, 2,4,5-T's toxicity has been studied both intensively and extensively. The general consensus among scientists is that there is no hazard to humans, wildlife, or livestock, when the product is used according to

Paper presented by Dennis R. Hamel, Pesticide Specialist, Washington Office, Forest Pest Management to the National Silviculture Workshop, June 1-5, 1981.

label instructions; and, yet the "battle" continues. It is a battle sparked by the controversy of an unpopular war in Vietnam.

Phenoxy herbicides were widely used since 1948 with little attention given to their toxicity until a mixture of 2,4-D and 2,4,5-T, known as Agent Orange, was used as a defoliant in the jungles of Vietnam. However, a unique set of circumstances occurred early in the 1970's which have affected the status of 2,4,5-T today. For example, studies by the National Cancer Institute revealed that 2,4,5-T used in the study of teratology resulted in some birth defects in certain strains of laboratory mice. It was later determined that the 2,4,5-T used in the study contained an unusually high level (28 ppm) of a contaminant called 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD or dioxin). This finding was the impetus for discontinuing the use of Agent Orange as a wartime defoliant.

Soon after this military ban, USDA, USDI, and HEW issued a joint statement cancelling certain uses of 2,4,5-T. In 1974, a National Academy of Science committee issued a report which indicated that there was no conclusive evidence of association between exposure to herbicides and birth defects in humans in South Vietnam. Despite this comprehensive study, reports continued to appear in the news that a possible relationship might exist between exposure to 2,4,5-T and human birth defects. Several TV programs on the subject have been shown worldwide.

Many of you are aware that also during this time, opponents to 2,4,5-T were attempting legislative bans such as the use of temporary restraining orders and court injunctions which have been effective against the Forest Service.

As the U.S. Environmental Protection Agency (EPA) matured and the amended Federal Insecticide, Fungicide and Rodenticide Act was implemented, a procedure was formulated for reviewing pesticides to determine if they should continue to be registered. This process is known as the Rebuttable Presumption Against Registration or RPAR process. An RPAR was issued on 2,4,5-T in April of 1978. However, before the process of evaluating the risks and benefits was completed, EPA issued an emergency suspension on 2,4,5-T on March 1, 1979. The basis for the EPA suspension was the purported incidence of abnormal levels of spontaneous abortions near the forest community of Alsea, Oregon. Subsequently, weaknesses in the Alsea Study have been pointed out and include:

1. Incomplete and inaccurate data on 2,4,5-T use.
2. Failure to take into account differences in characteristics between the study area and the rural and urban control areas.
3. Failure to take into account the differences in medical attention practices in the different areas.

4. Lack of a demonstrable level of exposure to 2,4,5-T, and

5. The hospitalized spontaneous abortion index for the study area showed no increase for the second 3-year period over the first period even though EPA reports a threefold increase in spraying for the second period.

Despite these discrepancies, the study has been quoted often during the 2,4,5-T cancellation proceedings initiated by EPA early in 1980. However, about two-thirds of the way through the proceedings being conducted before an administrative law judge, on March 20, 1981, EPA and DOW agreed to suspend the hearings and discuss settlement. We are in that settlement discussion process at present and due to the confidential nature of certain aspects of these discussions, we are not at liberty to bring you up-to-date any further.

2,4-D. The other phenoxy herbicide embroiled in controversy is 2,4-D and although under fire it has retained its registration status in tact in the United States. EPA in a January 23, 1981 fact sheet has concluded that "The agency feels there is no justification for regulatory action to change current uses of 2,4-D products or to prohibit current manufacturing processes..." In Canada a ban on the manufacture and sale of certain butyl esters of 2,4-D has been proposed primarily because of high volatility of the butyl esters and the detected presence of a relatively nontoxic form of dioxin.

Use. Phenoxy herbicide use by the Forest Service has declined in recent years. Of course since the restriction on 2,4,5-T, its use has become non-existent except for some research work on rangelands in the West.

Phenoxy Herbicide Use											
2,4,5-T Use on National Forest Systems Lands											
FY	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	
Pounds:	57402	40501	53220	26022	95540	102720	14597	6938	1210	220	3/
Acres	25777	32100	26424	37436	49357	50463	7105	4254	405	55	
1/ Includes small amounts of other herbicides (e.g., 2,4-D) applied in combination with 2,4,5-T.											
2/ Involved two projects; one of 390 acres on the Lassen National Forest, CA. for conifer release and one of 15 acres for poison plant control research in Utah.											
3/ Represents the final phase of a rangeland research project to control the noxious weed, tall larkspur (<i>Delphinium barbeyi</i>) in Utah.											
2,4-D Use on National Forest System Lands											
FY	1975	1976	1977	1978	1979	1980					
Pounds:	270,826	236,636	213,040	280,949	341,893	216,862					
Acres	130,820	106,385	110,617	126,485	139,274	128,255					
1/ Includes small amounts of other herbicides (e.g. picloram, but not 2,4,5-T) applied in combination with 2,4-D.											

2,4-D use has been more stable, ranging from an average 126 - 139,000 acres treated over the last 3 years. As indicated by excerpts from the 1980 pesticide-use report, 2,4-D and picloram remain the most frequently used herbicides for a wide variety of vegetation management purposes.

PESTICIDE USE REPORT FOR FY 1980			
COMMON NAME	TARGET PEST/ PURPOSE	QUANTITY USED/TREATED	
		POUNDS	UNITS*
2,4-D	Site Preparation	72,393	43,383
	Conifer Release	53,454	29,660
	Conifer Release	20,738	9,108 (A)
	Range Improvement	19,801	12,688 (A)
	Noxious Weed Control	14,880	9,500
	Wildlife Habitat Improvement	7,935	4,338
	Range Improvement	6,400	2,952
	Thinning	4,783	3,474
	Rights-of-way	2,775	1,039
	Fire Protection	864	216 (A)
	Fire Protection	444	392
	Aquatic Weed Control	407	62
	Noxious Weed Control	324	162 (A)
	Rights-of-way	156	36
	General Weed Control	136	151
	Nursery Weed Control	102	13
	Site Preparation	84	42 (A)
	Research	0.1	10 Trees
Picloram	Site Preparation	12,786	34,399
	Noxious Weed Control	8,781	9,173
	Conifer Release	6,166	16,574
	Wildlife Habitat Improvement	3,814	3,099
	Fire Protection	2,737	425
	Thinning	687	2,173
	Range Improvement	410	1,523
	Rights-of-way	356	437
	Rights-of-way	71	36 (A)
	Noxious Weed Control	41	162 (A)

However, three newer herbicides--Fosamine ammonium (Krenite), Glyphosate (Roundup) and Hexazinone (Velpar) are seeing increased use as alternatives to 2,4,5-T.

ALTERNATIVES			
COMMON NAME	TARGET PEST/ PURPOSE	QUANTITY USED/TREATED	
		POUNDS	UNITS*
Fosamine Ammonium	Rights-of-way	3,920	717
	Site Preparation	2,728	676 (A)
	Rights-of-way	1,609	156 (A)
	Noxious Weed Control	43	91
	General Weed Control	40	10
Glyphosate	Conifer Release	6,663	3,204 (A)
	Noxious Weed Control	844	786
	Site Preparation	492	453
	Rights-of-way	470	229
	General Weed Control	384	176
	Research	317.62	165.73
	Site Preparation	256	574 (A)
	Nursery Weed Control	148	53
Hexazinone	Range Improvement	26	27
	Hardwood Release	2,161	1,620
	Site Preparation	1,304	825
	Conifer Release	351	260 (A)
	General Weed Control	50	46
	Rights-of-way	32	17
	Research	2.04	0.69

Pesticide-Use Management and Coordination

Maintaining guidelines for the use of pesticides in forest management is a dynamic challenge.



For the past several years we in FPM have been required to make revisions to Forest Service Manual Chapter 2150 - Pesticide-Use Management and Coordination; 1980-81 are no exceptions. Our staff writers have completed their revision; however, this year the process is taking longer to review than before because of 2 new requirements:

1. Review by the union.

2. Review (60-day) by Office of Management and Budget (OMB) of certain policy items.

Once OMB has completed their reviews, we expect to have the revised manual to the field by the end of the summer.

Major changes in this revision will be:

REVISION OF FSM 2150 PESTICIDE-USE MANAGEMENT AND COORDINATION
MAJOR CHANGES
-PESTICIDE STORAGE, TRANSPORTATION, SPILLS, AND DISPOSAL HANDBOOK
-RESPONSIBILITIES OF PESTICIDE-USE MANAGEMENT COORDINATORS
-REVIEW, CONCURRENCE, AND APPROVAL OF PESTICIDE USES
A) RESCISSION OF ASSISTANT SECRETARY APPROVAL AUTHORITY
B) REGIONAL FORESTER APPROVAL OF 2,4,5-T/SILVEX PROJECTS
-PHENOXY HERBICIDE-USE CRITERIA
-RESTRICTED-USE PESTICIDE APPLICATOR CERTIFICATION PLAN

1. Deletion of large amount of "how-to" information on pesticide storage, transportation, spills and disposal from the manual per se and inclusion of this information in a new Forest Service Handbook which will cover the topics of storage, transportation, spills and disposal in detail.

2. Another major deletion (one which we expect all of you will welcome) is that of rescinding the approval authority of the Assistant Secretary of Agriculture for 2,4,5-T and related herbicide projects. It is Forest Service policy that such decisions should be delegated to the lowest level possible and in this case we have been able to lower the approval authority from the level of the Assistant Secretary to that of the Regional Foresters. This change is also in accord with changes of emphasis on environmental protection between the previous and the present administration. We are also taking this opportunity to delete the specific criteria for the use of 2,4,5-T. We have long argued that it is inappropriate to single out specific pesticides in the Forest Service Manual and we hope that you too will welcome the deletion of the criteria imposed on us during the previous administration.

3. Other changes in FSM 2150 that you should be alerted to are:

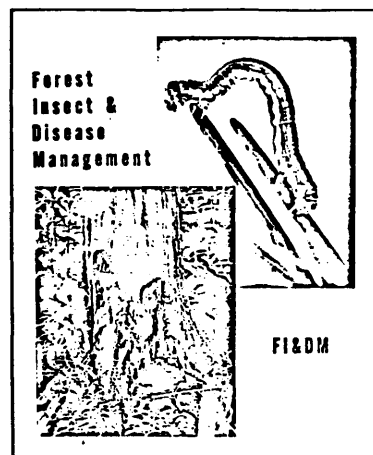
- Clearer definition of the roles and responsibilities of pesticide-use coordinators.

- Specific guidelines for implementing the finally EPA approved Federal Agency plan for certification of restricted-use pesticide applicators.

All in all from where we sit, we expect to continue to be able to use pesticides when and where they are determined to be necessary; however, we do encourage everyone to make appropriate evaluations, document decisions, and conduct post-treatment evaluations to insure we are doing the job we expect pesticides to do for us. As pointed out in recent reviews of pest management programs by The Center for Natural Areas (CNA) and the General Accounting Office (GAO), if we don't accurately document our decisions and their results, we could be faced with further restrictions or losses of the very tools required by our trade.

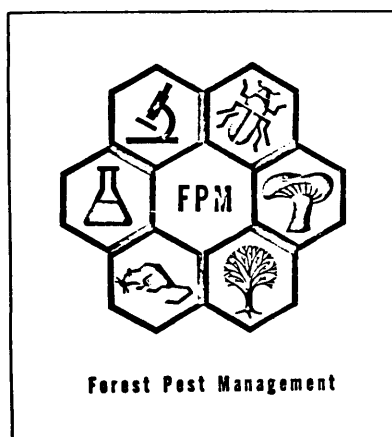
Forest Pest Management

Another Chapter of the Forest Service Manual under revision is FSM 3400 - Forest Insect and Disease Management and while this Chapter and the staff group having responsibility for it has for several years gone by this title or FI&DM, as a result of certain realignments of responsibilities and the development and subsequent approval of a forest pest management charter - FI&DM as a staff group and as a FSM chapter is in the process of becoming FPM or Forest Pest Management.

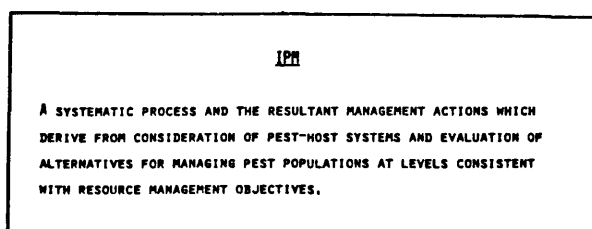


This realignment places emphasis on the FPM staff to encourage integrated pest management in forestry and be responsible for the overall IPM process. While the functional staff groups maintain their responsibility to manage forest resources, taking into

account pest problems, the FPM staff group has a responsibility to encourage IPM as it involves all pests--not only the traditional insects and diseases but also pest vegetation, and animal damage control. They must also encourage research in improving our pest management technology and provide a basis for feedback among all concerned parties.



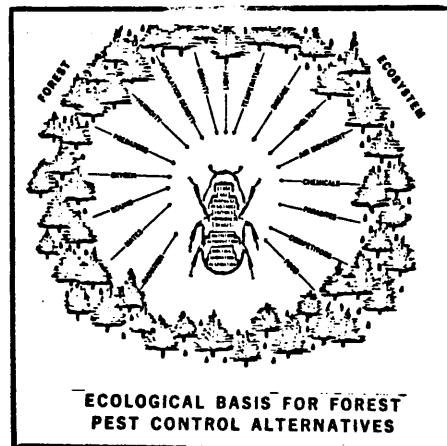
At this point, some may be saying what is integrated pest management or IPM? It is a process which has been described or defined a number of ways but essentially it includes



Now this may seem to be a somewhat bureaucratic set of words but essentially what IPM involves is a careful look at management objectives, pests which can affect those objectives, analyses of the alternatives available to ameliorate the problems created by the pests, and appropriate management action.

One principle important in developing a system for managing pests is that the ecosystem is the management unit and any manipulation of it may result in conditions which will affect

its components, including those organisms that have been designated as pests.



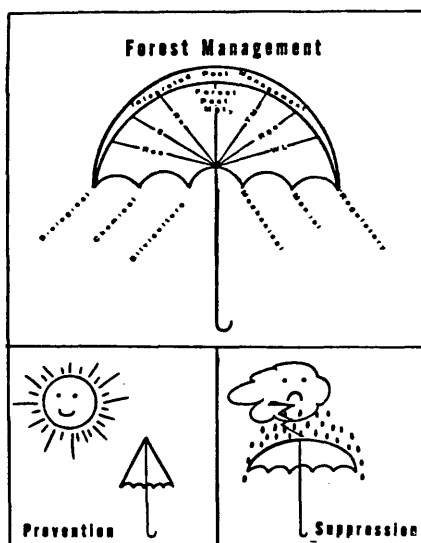
Some of the more significant components of the forest ecosystems which can be manipulated to affect the physical or physiological status of forest pests are indicated in this figure. The manipulation of any one or more of these ecological or physiological factors by man can produce effective ways of managing pests either through prevention or suppression strategies.

For example: We can manipulate such environmental factors as food supply, parasites, predators, chemicals, disease, temperature, and affect such physiological processes as mating and reproduction.

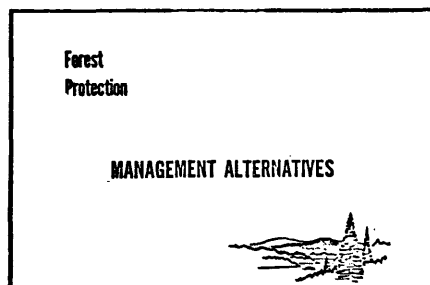
When these alternatives are considered systematically and decisions are made to take management action based upon our management goals and objectives we are in effect practicing IPM.

Taking another look at this, I like to use an "umbrella concept." Overall, this umbrella represents forest management, the job both you and I have responsibility for. However, integrated pest management is in fact an integral part of forest management and I depict it here as the lining of the umbrella. The basic process of incorporating IPM into forest management

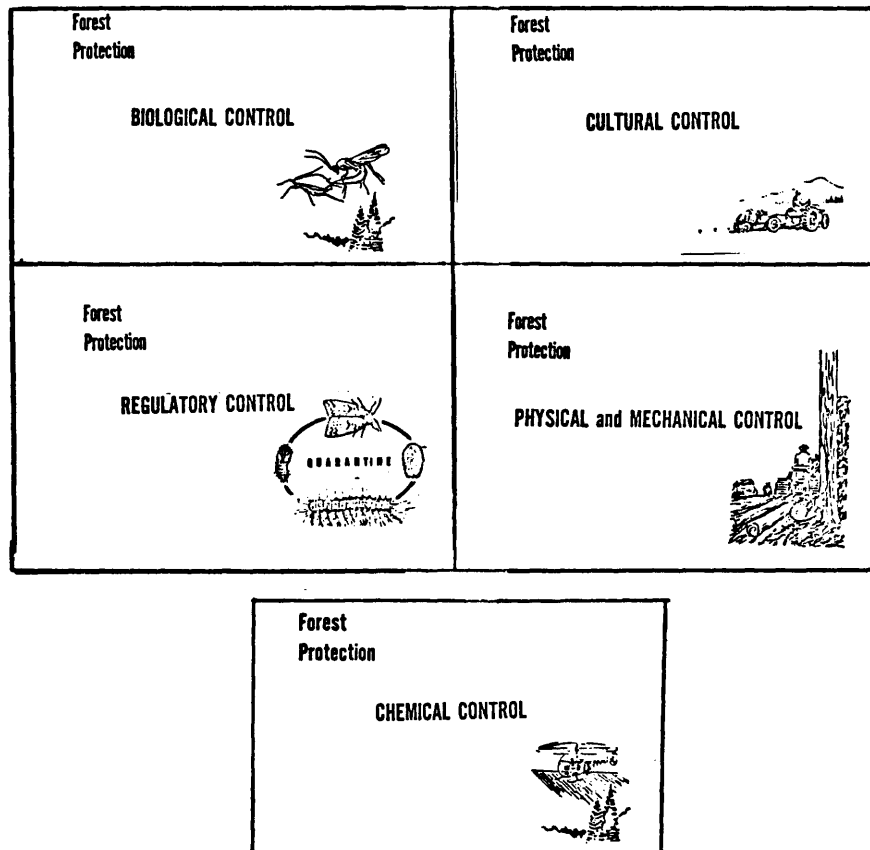
has been charged to the FPM staff; however, they cannot do it alone and must look to all other resource and research staff groups for assistance in managing the forests in an integrated mode.



A variety of tactics are available for managing pest populations. They can be used singly or in combination for effective integrated pest management programs. Included are biological, chemical, silvicultural, mechanical, manual, and regulatory means. When we "make hay while the sun shines" and use these alternatives to reduce the chances of introducing pests through proper forest management, we are practicing the prevention strategy of IPM. However, when we fail to integrate pest management information into resource planning "stormy days" are ahead and direct control or suppression activities must be undertaken to protect resource values threatened by pest populations.



Whether the prevention or suppression strategy is used, the management alternatives are the same. We can use biological, regulatory, physical, mechanical, manual, cultural, and of course, Chemical means to achieve our goals.



While all these illustrations are simplified and somewhat animated, hopefully they will provide you with some insight into the concepts and philosophies we are incorporating into the Forest Service Manual.

Major changes o you can be alerted to are:

REVISION OF FSM 3400
FOREST PEST MANAGEMENT

MAJOR CHANGES

-INTEGRATED PEST MANAGEMENT

- A) CONCEPTS
- B) STRATEGIES
- C) TACTICS
- D) COORDINATION

-EVALUATIONS

- A) ENVIRONMENTAL
- B) BIOLOGICAL
- C) ECONOMIC
- D) LOSS ASSESSMENT

-CONTROL PROJECT SELECTION CRITERIA

- A) BIOLOGICAL EFFECTIVENESS
- B) ENVIRONMENTAL ACCEPTABILITY
- C) ECONOMIC EFFICIENCY

-SPECIAL PROJECTS

- A) LOSS ASSESSMENTS
- B) PILOT PROJECTS
- C) DEMONSTRATION AREAS

-HANDBOOK FOR SPECIFIC FOREST PESTS

- A) THINNING FOR BARK BEETLES
- B) OTHER INSECTS AND DISEASES
- C) ANIMAL DAMAGE CONTROL
- D) PEST VEGETATION

Again, thank you for this opportunity to bring you up-to-date on several aspects of forest pest management.

SILVICULTURIST CERTIFICATION

During the next few minutes, I will give you an update on the status of silviculturist certification in the Forest Service. I'll discuss briefly what has taken place regarding continuing education programs and certification efforts in the Regions in response to the recently established minimum national standards. The minimum national standards for silviculturist certification were approved by the Chief in January of this year and are in the form of an Interim Directive in the Forest Service Manual 2478.

Focus first on the purpose of silviculturist certification and the minimum national standards for certification.

1. Identifies people with a specified level of skill, knowledge, and experience needed to develop sound silvicultural prescriptions on Ranger Districts and National Forests.
2. Provides line officers with employees having a good foundation in natural and social sciences and a specified minimum level of competence to result in sound land management decisions.
3. Provides a means to apply state-of-the-art knowledge to land management projects on National Forest land.
4. Provides line officers with qualified individuals needed to monitor, evaluate, and implement on-the-ground treatment results.

The Chief has directed that all prescription for reforestation, TSI, and harvest activities be personally prepared or approved after field review by a certified silviculturist.

The minimum qualifications for a certified silviculturist are defined in the Interim Directive. These qualifications are defined in terms of knowledge, skills, and abilities required to accomplish the tasks and duties of a silviculturist.

We realize and the Interim Directive recognizes that all Regions are not at this time in compliance with the FSM 2478 direction in several respects:

1. Some Regions certification programs were not up to the level established as the minimum national standards in regard to knowledge, skills, and abilities.
2. We also realized that some Regions needed to improve or bolster their continuing education program and some Regions had to start nearly at ground zero and had to establish a continuing education program. This all takes time, but I'd like to acknowledge some positive steps by Regions in recent months to meet new minimum national standards:

- a. Regions 2, 3, and 4 recognized inadequacies in their education programs. These Regions are now in the final stages of development of what appears to be an excellent 9-week continuing education program utilizing Utah State University, Colorado State University, and Northern Arizona University. Start-up of this combined program is planned for fall of this year.
- b. Region 8 has developed a fine education program utilizing three Universities within the Region.
- c. Region 9 had developed an innovative program in cooperation with four Universities in the Region and one outside the Region.

My casual observations, thus far, of the various education programs is that though no two programs are identical, there are common threads between programs to meet the minimum education standards of the Forest Service Manual 2478. These observations are based only on reviewing course objectives established in the contracts with universities and list of subjects included in the programs.

Each program has some differences also to meet specific needs identified in each Region. Some examples:

Region 9 has identified a need to improve communication skills and are devoting 2 weeks to communications.

Region 8 has an innovative approach to deal with applied silviculture of species. Candidates from the upland or mountain forests go through a different final 3 weeks of the program, than those candidates from Coastal Forests.

Region 6 emphasizes prescription development and have a 2-week module devoted to improving prescription writing skills.

One of the initial reasons for establishing minimum national standards for certification was to create a situation that would help in transferring silviculturists and their certification between Regions. Personally, I don't believe that we can ever reach a point where you can relocate an individual from one Region to another and have him land on his feet and running in another Region, with sufficient background to be fully competent to immediately begin to prescribe at the new location. There will always be a need to gain local knowledge of silvics and silviculture, before the silviculturist can be fully competent to prescribe or direct silvicultural programs after transfer. Regions still have a responsibility to provide experience, training, and education necessary to bring a certified silviculturist from one Region up to speed in a new assignment.

Now that we have established minimum national standards in the Forest Service Manual 2478, and the Regions are responding by upgrading their education and certification programs, the next question in our minds concerning certification is:

WHAT'S NEXT? OR, WHERE DO WE GO FROM HERE?

Three principal areas of needed emphasis in the future are:

1. Ensure that Regions are meeting the minimum national standards for certification. Fine tune the standards to meet the objective of developing silviculturists with an adequate foundation in natural or social science and a specific minimum level of competence to make sound land management decisions.
2. Work to develop more uniformity between Regions in continuing education and certification programs to aid in resolving programs associated with transferring certified silviculturists between Regions.
3. More emphasis and direction is needed in developing sound re-certification programs in Regions.

We will use the Activity Review process to help resolve the concerns. Activity Reviews will be conducted in Regions 5 and 8 in fiscal year 1982. We will review continuing education programs, the certification process, and we will look at the performance of certified silviculturists on-the-ground. As part of the Review team, we will include an individual from an outside Region in an attempt to exchange ideas and information to develop inter-Regional uniformity.

We will also review the re-certification efforts of Regions in order to develop a more uniform and efficient certification program. Additional silviculturist certification activity reviews will follow in subsequent years.

National Silviculture Workshop
Roanoke, Virginia
June 1-5, 1981

F. Bryan Clark
Associate Deputy Chief for Research

Hardwoods in Perspective--An overview of the resource and its importance

The eastern hardwood forest is extensive, covering some 248 million acres of land which is slightly more than half the commercial forest area of the entire country. With net annual growth substantially exceeding removals, the potential for increased utilization is high. However, some of the preferred timber species are in short supply and much of the inventory is either of low quality or too small for conventional use, in species not readily utilized, and primarily controlled by nonindustrial private landowners with little incentive for more than custodial management. The prospect for improved management of this neglected resource is closely tied to our ability to effectively utilize lower value stems and species.

With increasing demands for softwoods, dwindling supplies in the West, and potential increases in the use of hardwoods, it is appropriate at this time to review the character of the eastern hardwood resource.

The Eastern Hardwood Forest Today

The eastern hardwood forests contain about 100 species considered to have commercial value. In the Forest Survey statistics these species are grouped into six major types and the area of commercial forest land is broken down as follows: 44 percent oak-hickory; 14 percent oak-pine; 14 percent maple-beech-birch; 11 percent oak-gum-cypress; 9 percent elm-ash-cottonwood; and 8 percent aspen-birch.

Together oak-hickory and oak-pine are the most extensive types covering 144 million acres or 58 percent of the commercial hardwood area. The oak-hickory type is extremely variable with dominant species ranging from low value post and black jack oaks to the valuable yellow poplar--white oak--northern red oak association. Whether through neglect, exploitive cutting, or successional trends a high percentage of oak-hickory stands are now stocked with a preponderance of low quality residuals. A major deterrent to the management of this type is the lack of markets for low quality materials and our inability to regenerate the preferred species.

The oak-pine type develops mainly in the South and without intervention it usually reverts to oak-hickory. Forest Survey estimates that about 30 million acres now occupied by these hardwood types in the South would be more productive if converted to pines. Technical and economic questions of controlling hardwoods on potential southern pine sites is one of the most critical forestry problems in our time. Without cheap energy and cheap labor the economics of maintaining pine on many sites in the South becomes less attractive. Even so, we are ill prepared to predict what hardwoods would produce under extensive management in the long run. Or as a third alternative, what could be expected from extensive efforts to accept regimes of oak pines.

Maple-beech-birch is one of the most commercially desired types for timber production in the North. Because of the demand for species such as sugar maple, yellow birch, black cherry and basswood, many stands have been repeatedly high graded resulting in an increase in the percentage of red maple, beech and cull trees.

The eastern hardwood forest contains approximately 234 billion cubic feet of growing stock. Although this is a tremendous volume and a valuable resource, the quality and size class distribution are not what they could be. Preferred species such as hard maple, yellow birch, black walnut, black cherry, and select white and red oaks make up only 30 percent of the growing stock. While 48 percent of the total volume is concentrated in trees less than 11 inches in diameter, which limits their current use.

Most of the eastern hardwood timber is relatively small, with 46 percent of the total inventory in trees less than 15 inches in diameter. These trees yield very little clear material and their present use is limited to conventional low grade markets. About 60 percent of the hardwood sawtimber volume--316 billion board feet--is in upland oaks, hickory, beech, and various other species that have limited potential for high-value products. However, most of this timber is considered suitable for the manufacture of railroad ties and pallets. Thus, the supply of larger timber for products where quality and appearance are important is currently limited. The forest is maturing and average tree size is increasing. For example, between 1952 and 1977 the inventory of hardwood growing stock rose 44 percent, going up from 162 billion cubic feet to 234 billion. Sawtimber inventories followed a similar trend, increasing from 402 billion board feet to 536 billion. Increases occurred in all diameters but the bulk was in the 11.0 to 17 inch class. The statistical trend is unquestionable; more large trees are in the future and quality is improving. Paradoxically those in segments of our hardwood industry that rely on large trees as raw material are quick to point out that good, large hardwoods are scarce, and scattered, and high priced. The real opportunity is to accelerate growth of preferred trees with the potential for quality improvement.

Currently we harvest less than half the net annual growth of hardwood growing stock. In 1976, net growth of eastern hardwoods exceeded removals by 4.7 billion cubic feet, or 117 percent. Sawtimber growth was 23.1 billion board feet, or 66 percent above removals. However, sawtimber removals tend to be concentrated on preferred species such as black walnut, black cherry, hard maple, select oaks, and the larger diameter trees. The continuing practice of "cut the best and leave the rest" has contributed to diminishing supplies of preferred species in larger size classes. The problem is how to remove and use large quantities of small low-grade trees.

In 1977, about 75 percent of the commercial hardwood forest land and 73 percent of the hardwood inventory was held by nonindustrial private owners. Many of these holdings include highly productive sites, and most are close to markets for forest products. Nevertheless, few of these owners depend on timber production for primary income and their management is best described as custodial. Yet, private ownerships provide about 80 percent of the hardwood cut. National Forests account for about 14 million acres of the eastern commercial hardwood forest and 8 percent of the growing stock.

Thus, the character of the eastern hardwood resource can be summarized as a vast acreage of forest stands which are low in productivity; dominated by a high proportion of slow growing, small diameter, low quality trees; are predominantly privately owned; occupy over half of the nation's commercial forest land; have limited markets; are managed at low intensity, if at all; and have historically provided little economic incentive for managers.

Yet the eastern hardwood forest is producing substantially more wood than is being harvested. This is attributed in part to the generally small size, low quality and technical properties of hardwoods relative to softwoods especially in the West. Also, domestic production for hardwood lumber, veneer, and plywood has declined due to lack of adequate supplies at reasonable prices. This has resulted in increased dependence on imported veneer and plywood. Some conventional hardwood markets, such as flooring and railroad ties, have vacillated drastically.

The reduction in flooring is attributed to the use of carpeting in residential construction and full recovery to previous levels is doubtful. On the other hand, crosstie production has increased from less than 15 million in the early 1960's to approximately 27 million in 1977. Demand for crossties has been projected to rise to 31.1 million by 1990. Hardwood pulpwood production increased from 215 million cubic feet in 1950 to 1.1 billion cubic feet in 1976.

Shortages of preferred species, continued dependence upon imports, soaring prices, increasing competition for high quality hardwood timber, and dwindling supplies of softwoods in the West sets the stage for improved use and management of the eastern hardwood resource.

Silvicultural Concerns

I have briefly discussed the nature of the resource and its importance, now I would like to add a few personal concerns. Our obsession with volume yield and short rotations has too often detracted from the real issue, increased quality. The quality of hardwoods is improving much too slowly--a trend that practicing foresters can do something about through intermediate cuts if they can remove the poor trees. For most small private ownerships on average and better sites, I believe the best strategy is multiple objectives with large trees of preferred species as the final crop. The opportunities are more pronounced on National Forest lands where demands for other uses are high. The potential for quality improvement and species regulation are better where longer rotations are possible. Longer rotations will enhance the production of high-quality sawtimber and veneer and, at the same time, accommodate the strong demands for other uses such as esthetics, recreation and wildlife. This is my personal opinion for eastern National Forest management direction.

In hardwoods, we usually are not concerned with restocking following harvest, something nearly always fills the opening. My concern is that we continue to accept potluck. But we can always find our favorite stands that somehow has some desirable trees of good quality. We pass up a lot of mediocre stands to contemplate a few good ones. Oak timber is selling at an all-time high, especially in the foreign market, yet we cannot with certainty regenerate these species when advanced reproduction is lacking. Consequently, many of our oak stands are "naturally" regenerated to mixed hardwoods with a high component of less desirable species. A notable exception is the Southern Appalachians where oak stands are being replaced by yellow-poplar. But even in this case we must ask ourselves how much poplar is enough and at what prices?

There are many hardwood stands where poor composition requires a great deal of time or drastic treatment to get them back into production. Unfortunately, we do not have the technology to rehabilitate these stands at modest investments. How long are we going to be satisfied with gradual improvement that occurs without help beyond protection? Fortunately there are many young hardwood stands on good sites with enough desirable species to form excellent stands at harvest. My concern here is that research has not provided the alternatives needed to insure proper stand development. The paradox is that extensive treatments being studied to fit today's economics may or may not produce significant species and/or growth responses in the present stands. On the other hand, research

has provided some excellent principles that must be fully understood by every practicing hardwood silviculturist if we are going to influence future composition. I commended to your careful study a short article in the May 1981 issue of the Journal of Forestry by Dave Marquis, Dave reports on 35-year results in Allegheny hardwood cuttings relating to advance growth and development. His citations are classics for any one in the Northeast. And the value of long term research is very vividly demonstrated.

The potential for the eastern hardwood forest is high. Survey statistics substantiate that there is no physical scarcity of hardwoods, quality is improving--depending upon definition and perspective, and the resource is attracting widespread attention. With more intensive management the hardwood forests have the capacity to produce enough goods and services to meet projected domestic demands and also to meet some of the needs in world markets for fine quality wood and wood products.

Breakthroughs in Hardwood Product Development
John R. Erickson
Director of Forest Products and
Engineering Research

Introduction

I have been asked to predict the effects of technological advances in forest products utilization on forest management in hardwoods in the next 20 to 50 years. Prediction is always difficult and somewhat foolhardy, but it is also a very stimulating exercise.

How does one predict the effect that new techniques will have on hardwood utilization? I chose to begin with the review draft of An Analysis of the Timber Situation in the U.S. 1952-2030 developed under the leadership of Dwight Hair, USDA Forest Service. Further, I attempted to relate how some of the more recent utilization research accomplishments might change these projections. In fact, I have presented an extreme case showing a major shift in the use of hardwoods over softwoods. Technologically, this shift is possible. However, market forces, industry decisions, and land management options will probably preclude reaching my "fearless" projections.

We should first consider the historical trends in the use of hardwood in consumer products. To do so, I would like to look only at roundwood consumption trends since these data relate most closely to utilization, harvesting, and forest management. Harvesting is one of several management practices designed to provide forest-based products and improve forest land productivity. In fact, at present, harvesting is the primary management tool. Final product form and value have a vast influence on the feasibility of harvesting.

As we look to the future, we must consider the past improvements that utilization techniques provided for recovering lower value material. One example is the rather wide-scale use of whole tree chipping. However, there are limitations as to the number of products that can be made with whole tree chips. We must also consider the variety of improved technologies possible for converting smaller or lower value hardwood into products. Needless to say, "conventional forest products" only exist at a point in time. The forest products industry, often described as being conservative, is progressively striving to provide quality products in differing forms to meet consumer demands. Researchers at university, governmental, and industry laboratories are investigating several approaches to improve the recovery of available timber, improve the efficiency of conversion, and develop new products.

Some of the more promising research opportunities to improve the utilization of hardwoods will be discussed in more detail later. First, let's look at the status of roundwood consumption, and the current projection of the role that hardwoods might have in the future.

Presented at the National Silviculture Workshop, Roanoke, Virginia, June 1-5, 1981.

Projections of Roundwood Consumption 1/

Roundwood consumption increased from 11.9 billion cubic feet in 1952 to 13.3 billion cubic feet in 1976 (table 1). During that period, sawlog consumption remained relatively constant, but pulpwood consumption rose from 2.7 billion cubic feet to 4.5 billion cubic feet. Miscellaneous products such as cooperage, poles, piles, etc., decreased as did fuelwood.

Table 1. Summary of U.S. roundwood consumption

	<u>Billion cubic feet</u>							
	<u>1952</u>		<u>1976</u>		<u>2000</u>		<u>2030</u>	
	<u>swd</u>	<u>hwd</u>	<u>swd</u>	<u>hwd</u>	<u>swd</u>	<u>hwd</u>	<u>swd</u>	<u>hwd</u>
Sawlogs	5.0	1.1	5.4	1.0	7.5	1.7	7.5	2.3
Veneer logs	0.2	0.2	1.2	0.3	1.8	0.4	1.9	0.4
Pulpwood	2.3	0.4	3.4	1.1	6.3	2.7	8.3	4.6
Miscellaneous Products	0.3	0.4	0.2	0.1	0.4	0.4	0.5	0.4
Fuelwood	0.5	1.5	0.1	0.5	0.3	1.2	0.5	1.9
	<u>8.3</u>	<u>3.6</u>	<u>10.3</u>	<u>3.0</u>	<u>16.3</u>	<u>6.4</u>	<u>18.7</u>	<u>9.6</u>
	11.9		13.3		22.7		28.3	

The percentage of hardwood consumption declined from 30 percent to 22 percent between 1952 and 1976. It is important to point out, however, that the product mix of hardwood usage has changed. In 1952, hardwoods provided about 25 percent of the pulpwood while in 1976 they provided about 30 percent. The major decrease in the use of hardwoods during the 1952-1976 period was in fuelwood, a decline of 1 billion cubic feet. We all know how the fuelwood situation is now changing and the possible implications on wood demand for the near future.

By the year 2030, the demand for roundwood is predicted to increase greatly from 13.3 to 28.3 billion cubic feet. Hardwoods are expected to supply about 34 percent of the total demand in 2030. The increase in demand for pulpwood will be a major factor in the increased use of hardwoods.

In addition to increased consumption in the United States, there probably will be substantial increases in exports of hardwoods to Europe. The shortfall between timber growth and demand is increasing rapidly in the European countries. Hardwoods from the United States will probably be in as much demand to fill the European needs for fiber as they are now for veneer and solid wood products.

1/ Developed from data derived from Review Draft An Analysis of the Timber Situation in the United States 1952-2030, U.S. Dep. Agric. Forest Serv., 541 p. plus Appendixes, 1980.

Other discussions in the analysis by Hair, et al., relate to current and future supply and demand. For softwoods, the total growth is about equal to the drain, primarily due to the harvest of old growth timber in the West. Presently, the growth of hardwoods is about double removals in the East. In the hardwoods, of course, we are all familiar with the heavy demand on selected species and sizes of timber so this growth-removal relationship may appear more optimistic than it should.

If we look at the 20-to-50-year projections, there is an implied shortfall of both hardwoods and softwoods to supply the products that the consumer desires. However, the supply of hardwoods is substantially better over the next two to three decades than is the supply of softwoods. Thus, utilization schemes to replace softwood products with hardwood products become important to the overall economy in the forest products industry. This strategy, if successful, will have large and favorable impact on the management of our hardwood timber stands.

High value products made from the smaller and lower value hardwoods will permit improved management in hardwood stands. In addition to increasing the use of hardwoods in consumer products, we must also concentrate on greater efficiency to improve final product yield.

The reduction of waste wood (or lower value uses) and maximizing the quantities of the higher value products are the economic keys permitting the expansion of hardwood utilization. I believe that utilization research will allow hardwoods to supply a much greater percentage of our timber supply in 2030 than the projected 34 percent mentioned earlier. Several examples of emerging technologies illustrate the potentials.

Press Dried Paper

Linerboard, used for corrugated containers, is currently the largest single paper market. Linerboard paper is now made almost exclusively from softwood pulp. Of the total annual U.S. pulp production of about 50 million tons, linerboard accounts for 15 million tons or 30 percent.

Press dried paper made from hardwood could replace all of the softwood linerboard now produced resulting in a major relief in softwood demand. The Forest Products Laboratory's press dried paper process has been researched and pilot-tested. The following results illustrate the potential of linerboard from hardwoods: (1) The pulp yields from current tests with oak are 15 percent greater than those of conventional softwood pulp (yields from other species could be higher); (2) the major strength characteristics needed for linerboard are superior; (3) energy requirements for pulping are estimated to be 15 percent less; and (4) chemical consumption is reduced.

You will recall that hardwoods supplied about 25 percent of roundwood consumption for pulp in 1976 and 35 percent in the projections for 2030. If linerboard pulp were to represent 30 percent of the total production in 2030, and if hardwoods were used exclusively, hardwoods could possibly supply 50 to 60 percent of the pulpwood consumption. In addition, we expect that hardwoods will find increased use in products from existing papermaking processes as well as from the new press dried production.

Reconstituted Wood Products

Another emerging product class which should stimulate expanded use of lower grade hardwood is reconstituted wood products. Examples include flakeboard, COM-PLY panels and structural lumber, pallets, utility poles, crossarms, and an array of other products. We are already witnessing industrial implementation of past research results in the production of reconstituted products. The most notable example is the rapid growth in structural particleboard from aspen in the Lake States. This effort will expand to other species.

Many wood properties and processing variables must be considered in selecting species for structural board products. These are the subjects of continuing research. However, there are several practical considerations which provide indications of which species offer the best opportunities. One is the weight per cubic foot of board. If the board is too heavy, the carpenters simply won't use it.

Aspen is a good species for flakeboard production because the board weight is close to the weight of plywood panels. It has a specific gravity of 0.36. Yellow poplar has to be a prime target species for the expansion of structural board products since its specific gravity is about 0.4. Another excellent opportunity is with red alder. Use of these species will be followed by mixtures such as sweetgum and oak. Research is continuing.

COM-PLY panels and lumber products are just beginning to be used. Four plants now produce COM-PLY panel products, which are now made totally from softwoods. In the future, I expect that the core material for COM-PLY products will be made with a high percentage of hardwood. COM-PLY lumber is not commercially available at this time but has been produced in sufficient quantities in the laboratory to be used in several demonstration homes.

These two classes of reconstituted wood products, particleboard and COM-PLY, appear to have the greatest potential for significantly changing the demand on softwood and hardwood resources used in construction. There are other uses, however, that may draw increasingly on the hardwood resources. One is fiberboard core stock which is overlaid by veneer, paper vinyl, or other materials. We already have a substantial industry using these processes. This known technology can be expected to expand proportionately as with the European market where it is in widespread use.

Specialized moulded products will also utilize hardwoods. Examples include moulded pallets, utility poles, and crossarms. Research is underway to support production of all such products. At least one company is licensed for a patented moulded pallet process developed by Michigan Technological University. Also, service tests on moulded utility poles and crossarms are underway at the same university.

It is difficult to predict the impact that these products might have on the increased use of hardwoods. One analysis is to consider the possible replacement of plywood with particleboard and COM-PLY panels. Recall from Table 1 that the consumption of veneer logs was expected to be 2.3 billion cubic feet in 2030, 1.9 of which is supplied from softwoods. Replacement of

25 percent of the plywood with flakeboard and COM-PLY products could save up to 0.3 to 0.4 billion cubic feet of the projected consumption of softwood veneer. Similar projections could be made for sawlogs used for lumber; however, the savings will probably be more modest.

High Quality Hardwood Products from Low Valued Logs

Processes to improve the use of lower value woods for high value hardwood products will not have a large impact on shifting the projected use of hardwoods and softwoods. They are mentioned here because they represent good opportunities for using small hardwood trees.

One such process, now ready for implementation, is the System 6 process developed by the NEFES Princeton Laboratory. This process converts small diameter hardwood (7"-12" diameter) to high value end uses. It requires producing 6' plus bolts, canting, special sawing techniques to form boards which are then dried and glued into standards sized blanks. These blanks are then used to manufacture high value products such as furniture. On a dry weight basis the value of these built-up furniture boards is 75 times greater than conventional wood chips. In the future, it may be possible to use 1 billion board feet of hardwood blanks for furniture and kitchen cabinets.

Fuelwood

In 1976, it was estimated that 0.6 billion cubic feet--or 7.5 million cords--of fuelwood were consumed. Estimates of current fuelwood use by various sources range from 15 to 30 million cords. We do not have a good estimate of the actual amount of fuelwood consumed. Indications are that it is growing rapidly. One indicator is the expansion of free fuelwood permits on National Forests. Another is the increased use of wood for fuel in pulp, paper, and other industries.

Fuelwood "free use" permits on National Forests indicate that the use of wood for fuel has risen from about 0.2 million cords in 1972 to nearly 5 million cords in 1980. In the same time period, the pulp and paper industry has moved from 42 percent to about 48 percent energy self-sufficiency reflecting both energy conservation and increased combustion of residue wood and bark.

Although it is difficult to predict what will happen to fossil fuel bases and prices, I would expect fuelwood consumption to continue to increase into the 1990's and then level off. It seems entirely possible that 100 million cords of wood could be used for fuel. The major part of this will come from hardwoods.

Possible Shift in Hardwood/Softwood Use?

The three technologies--improved papermaking, reconstituted wood products, and fuelwood--can have a major impact on hardwood use. They can also represent opportunities for improved management of hardwoods. If predictions I made previously were to become a fact, there would be a complete reversal in the demands for hardwoods and softwoods (table 2). First, there would be a large increase in total demand, from 28.3 billion cubic feet to 33.9 billion

cubic feet, because of fuelwood demand. Second, hardwoods would make up 54 percent of the demand rather than 34 percent, influenced primarily by pulpwood and fuelwood, and, secondarily, by reconstituted wood products. Regardless of which resources are used to meet future demands, it is obvious that increased levels of management must be applied to more closely approach the potential growth per acre.

Table 2. Comparisons of projections at year 2030.

	<u>from Table 1</u>		<u>With improved technologies</u>	
	<u>Billion cubic feet</u>			
	<u>swd</u>	<u>hwd</u>	<u>swd</u>	<u>hwd</u>
Sawlogs	7.5	2.3	7.5	2.3
Veneer logs	1.9	0.4	1.5	0.4
Pulpwood	8.3	4.6	5.2	7.7
Miscellaneous Products	0.5	0.4	0.5	0.8
Fuelwood	0.5	1.9	1.0	7.0
	<u>18.7</u>	<u>9.6</u>	<u>15.7</u>	<u>18.2</u>
	28.3		33.9	

Conclusion

I have tried to make a case for a much larger use of hardwoods during the next 20 to 50 years than previously projected. Although these predictions are perilous, they are technologically possible. In addition, the increasing demand for fuelwood seems to indicate that overall wood consumption could exceed previous projections.

By far the best opportunity to increase the use of hardwoods and decrease demands for softwoods is in pulp and paper. The new press dried paper process developed at the Forest Products Laboratory could completely change the balance of hardwood and softwood raw material supply for the pulp and paper industry, the largest consumer of roundwood.

Reconstituted wood products could reduce the projected increase in demand for veneer logs and to a lesser extent sawlogs. The primary opportunity is in structural panel and lumber products. However, there are many possibilities for specialized moulded products. Upgrading product output from low quality logs with processes such as System 6 presents tremendous opportunities for utilizing smaller and lower value hardwoods. The high value panel products made from these logs are a good alternative to chips or pulpwood. The value of 1 pound of this panel is 75 times that of the same material made into chips. These product upgrading systems are important because they change the end use value which may support harvesting economics.

Improved pallets and containers will draw on hardwoods in larger quantities. Several other technologies could have been mentioned that will draw on the hardwood resource. Structural lumber will be manufactured using the saw, dry, and rip, and edge, glue, and rip processes developed at the Forest Products Laboratory. The laminated wood I-beam could become a reality. A Forest Service patent on structural particleboard decking used to replace metal panels on industrial buildings is now a reality. There is

little doubt that the demand for hardwoods will increase--it is a matter of how much. This increased demand will provide excellent opportunities to improve hardwood management, and that will be a healthy thing for the economy in both the West and East, the forest industries, and the forests.

National Silviculture Workshop
Roanoke, Virginia
June 1-5, 1981

Nelson S. Loftus, Jr.
Staff Research Silviculturist
Timber Management Research
Washington, D.C.

The Eastern Hardwood Program

Under use of hardwoods and overdependence on softwoods was identified as a major problem in a 1974 Forest Service program to improve hardwood utilization. Although we were partially successful in implementing this program, the resource is still underutilized, and, consequently, management of the eastern hardwood forest remains at a relatively low level. To help develop the potential of this resource, the Forest Service together with the forestry schools under the auspices of the Association of State College and University Forestry Research Organizations (ASCUFRO) is making a concerted effort to accelerate and coordinate research, development, and application of new and existing technology needed to improve the utilization and management of eastern hardwoods.

Planning Process

You may recall that in 1977 the Forest Service and the universities through the Association of State College and University Forestry Research Organizations held a series of working conferences involving research user groups representing industry, States, conservation agencies and organizations, and private owners. In the 1978 reports from the Northeastern, North Central, and Southern Regional conferences, the hardwood resource was identified as needing special research attention. Additional justification for increased research emphasis on hardwood forest management and product utilization is also presented in McLintock's 1979 report, Research Priorities for Eastern Hardwoods. In responding to this need a task force with representatives from the Forest Service, Science and Education Administration, the universities and industry met in January 1980 to set objectives and describe the major program elements. This resulted in the preparation of the Research, Development, and Application Plan for the Improved Use and Management of Eastern Hardwoods. This plan received wide review and Congressional attention and has served the Forest Service as a framework for more detailed planning at the Station, Area, and Regional levels.

Program Objectives

The objectives of the eastern hardwood program are:

- o To develop utilization, harvesting, and marketing technology for low quality surplus hardwoods that will help dampen inflationary costs of building material and energy costs in rural areas.

- o To develop utilization and marketing technology to permit substitution of hardwoods for softwoods.

- o To increase the opportunities to manage hardwood forests on small private ownerships that will result in higher returns, improved stands, and better wildlife habitat.

- o To develop effective low-cost silvicultural methods and treatments to make long range improvements in stocking, species composition, and quality.

- o To improve our understanding of the amount, quality, and availability of the hardwood resource.

- o To develop more effective technology transfer systems that will involve more users faster.

Attainment of these objectives requires the involvement of a large part of the forestry community in the East. It is the primary responsibility of Forest Service and university research to develop the needed new technology. Contributions are also expected from the research and development activities of forest industries. State and Private Forestry, together with Extension, State Divisions of Forestry, forest industries and their respective trade associations, and a number of other organizations have the responsibility of delivering new and existing technology to resource managers, manufacturers, entrepreneurs, and forest owners. State and National Forests, industries, and private owners particularly Tree Farmers, have a key role in using and demonstrating the application of practical technology.

Major Program Elements

Five major program elements were described by the joint task force as focal points for the planning, development, and implementation of the Eastern Hardwood Program. They are: (1) utilization; (2) management; (3) resource status; (4) economics and other resource benefits; and (5) technology transfer. Although the elements are listed in order of priority, highest to lowest, technology transfer transcends all elements and they are all interdependent.

Utilization--Many stands of lower quality and immature hardwoods are unmanaged and underutilized for lack of markets and economic harvest and transportation systems. In the South, there is also a need to utilize low quality hardwoods on sites considered more suitable for the production of pine. Thus, markets must be established and marketing related problems must be solved if the full potential of the eastern hardwood resource is to be realized.

Systems and equipment are available for harvesting and transporting many materials to a processing point for manufacture of products that are competitive in the market place. However, there is a great need for new and improved systems and equipment to handle small logs, logging residues,

and trees from adverse sites such as wetlands and steep terrain which are common to many hardwood forests. As new markets develop, better multiproduct processing systems will be needed to direct each log or bolt into its highest possible value product.

With forecasts of softwood shortages, research needs to develop processes for the use of hardwoods as structural members in light frame construction. Technology is needed to implement the concept of producing high quality hardwood furniture panels from short, smaller diameter logs. The utility and servicability of hardwood flakeboard and composite materials as well as doweled crossties needs to be demonstrated through additional research. Research on problems associated with short hardwood fibers in the production of pulp for paper products needs to be accelerated.

Finally, the use of wood for energy has attracted increasing attention and could be a key factor in making some timber stand improvements profitable. However, technology is needed to predict the quantity of hardwoods stems and residues physically and economically available for energy production.

Management--Although there is no physical scarcity of hardwoods, several priority research problems confront our management of this resource. Hardwood management is complicated by the fact that there are more than 100 commercial species each with its own site requirement, silvicultural characteristics and corresponding cultural requirements, and unique wood properties. With the exception of a few high value species, slow growth discourages long-term management investments for increases in volume yield. However, large economic returns are possible from quality improvement. This is the real opportunity in hardwood management.

A key to improving quality and production of eastern hardwoods lies in the systematic rehabilitation of existing growing stock. New and accelerated research is needed to develop simple effective treatments to rehabilitate intermediate age stands, especially on good sites with an adequate component of good growing stock. Obviously, this will require the development of strong and stable markets for the existing small diameter, low quality trees.

Low-cost, reliable regeneration techniques must be developed to produce new stands with an adequate stocking of desirable species. Furthermore, cultural techniques are needed to insure survival, favorable growth and continued stand development. The need is particularly critical for the oaks which are extremely difficult to regenerate without the presence of advanced reproduction.

Reliable growth and yield information is essential for sound management decisions, yet such information is incomplete. This research is complicated by the large number of species in most mixed stands and the almost infinite variation in stand composition and structure. Research must also develop improved tree grade guides to promote the culture and utilization of each tree for maximum economic return.

Better systems for evaluating and classifying sites as to their relative productivity and potential response to management are needed to identify investment opportunities as well as limitations. Due to past treatments the present condition of many eastern hardwood stands does not adequately reflect site potential and innovative research is needed.

Resource status--Forest survey statistics substantiate the abundance of hardwoods in the East, but concerns about deficiencies in quality and availability for consumptive uses persist. Greater detail is needed about the characteristics of the eastern forest and its ownership to provide insight into questions about availability, operability, accessibility and other limitations on supply and management. New techniques are needed to meet the need for increased inventory sampling intensity and analyses for both timber and nontimber values.

Economics--Research in the economics of marketing, utilization, and management of eastern hardwoods must provide answers to many questions regarding costs, possible financial returns and multiresource trade-offs. For example, what is the economic competitiveness of wood with other fuel resources? What is the economic feasibility of using new hardwood products as replacements for softwood materials? What value increases can be expected from specific alternative management treatments? And, what are the economic trade-offs to be considered in multiresource management?

Much of the eastern hardwood resource is held by nonindustrial private landowners with widely differing and changing ownership objectives. Expanded economics research that recognizes both monetary and intangible returns from forest ownership as well as the role of taxes and tenure in decisionmaking is needed.

Technology Transfer--A great deal of research has been done on hardwoods and there is a considerable effort underway to develop new technology to improve their use and management. In fact, there are a number of promising new products and improved management techniques available that are not being used. A critical element in effecting desired changes in our use and management involves transferring information to the owners, managers, and processors of the timber resource. The assessment of available information, identification of potential users and the delivery of existing and new technology together with supporting assistance from subject area specialists is a vital part of the overall eastern hardwoods program.

Research Program Emphasis

In Research the improved use and management of the eastern hardwood resource is one of our highest priority programs. Our goal in research program development and budget planning is to emphasize the need for funding increases to accelerate both the development of knowledge and the speed with which it is put into use.

In response to our program initiative for fiscal year 1981, Congress approved an increase of \$3.8 million for research related to eastern hardwoods. Of this appropriation, \$1.5 million supported accelerated research on improving regeneration of preferred species, speeding growth and improving quality of existing stands, and determining stand growth rates and yields. Of the \$1.3 million allocated to utilization and engineering research, \$1.1 million is being used to improve the processing and utilization of low value hardwoods, to develop estimates of biomass yield and to investigate the use of wood for energy and \$200 thousand for developing improved harvesting methods. The \$1.0 million allocated to resource evaluation and economics research is supporting the acquisition of information on the location, composition, ownership, and availability of hardwoods and the economic evaluation of stand management and harvesting. Thus, new and accelerated research under the 1981 program increase is being conducted by 35 work units at 20 locations throughout the eastern United States. In addition, at least 10 percent of the increase is being used to fund cooperative research at colleges and universities.

To give some insight into the magnitude of Forest Service research on the improved use and management of hardwoods, the program currently involves approximately 230 scientists in 61 projects at 26 locations. Of the total Forest Service research appropriation for this fiscal year approximately 25 percent or \$31 million, including the program increase, is being directed to hardwoods. These figures include research on insect and disease problems, watershed management, and wildlife habitat as well as utilization, timber management, resource evaluation and economics.

In conclusion, the expected benefits of this program can be summarized as an increased supply of hardwood products which, in the short run, would reduce the demand for softwoods, contribute to the Nation's fiber supply, and provide alternative sources of energy. In the long run, the quality and the quantity of hardwood resource would be increased, through management.

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NORTHEASTERN AREA HARDWOOD INITIATIVE

Lloyd R. Casey

THE HARDWOOD INITIATIVE BEGAN IN THE NORTHEASTERN AREA AS A UTILIZATION PROJECT IN 1978. THE OBJECTIVE WAS TO INCREASE UTILIZATION OF LOW VALUE HARDWOODS.

THIS WAS A NATURAL CONCERN FOR THE NORTHEASTERN AREA IN THAT 46 PERCENT OF THE HARDWOOD GROWING STOCK LIES WITHIN THE AREA AND 52 PERCENT OF THE WOOD USING POPULATION RESIDES WITHIN ITS BOUNDARIES.⁴

EVEN THOUGH THE ANNUAL GROWTH OF HARDWOODS (3,920 MCF) IS UNDER UTILIZED AT THE PRESENT TIME (ONLY 46 PERCENT IS REMOVED EVERY YEAR), THIS REMOVAL PERCENT HAS BEGUN TO ACCELERATE DUE TO SEVERAL FACTORS; NAMELY, (1) THE INCREASED UTILIZATION FOR FUELWOOD, (2) THE DISPROPORTIONATE INCREASES IN SOFTWOOD STUMPAGE PRICES,² (3) THE NEED OF MANUFACTURERS TO FIND RAW MATERIAL IN PROXIMITY TO THEIR PLANTS AND MARKETS IN ORDER TO REDUCE TRANSPORTATION COSTS, AND (4) THE HARDWOOD TIMBERLAND BASE IS SHRINKING DUE TO URBAN SPRAWL, GREENBELT DEVELOPMENT, AND TRANSPORTATION CORRIDOR CONSTRUCTION. IN SOME STATES LESS THAN 20% OF THE FORESTLAND IS OWNED BY FARMERS,¹ THE TRADITIONAL SUPPLIERS OF PRIVATE HARDWOOD STUMPAGE.

BY THE YEAR 2030 IT IS PROJECTED THAT THE DEMAND FOR HARDWOOD WILL EXCEED THE SUPPLY.³ IN ORDER TO MITIGATE THIS SITUATION THE UTILIZATION SECTION OF S&PF PROPOSED A THREE ELEMENT EASTERN HARDWOOD INITIATIVE:

ELEMENT 1 - MARKET DEVELOPMENT

PAST HARVESTING PRACTICES HAVE RESULTED IN HARDWOOD STANDS OF POOR QUALITY AND LOW VIGOR LOCATED THROUGHOUT THE EAST. INADEQUATE MARKETS OR POOR LOGGING PRACTICES WASTES HUNDREDS OF THOUSANDS OF TONS OF DOWNED HARDWOOD RESIDUES. TO ENCOURAGE REMOVAL OF THIS RESIDUE (REQUIRED FOR SOUND HARDWOOD MANAGEMENT PRACTICES), A CONTINUED AND INTENSIFIED EFFORT TO DEVELOP MARKETS FOR THE RESIDUE MUST BE ATTAINED.

TO HELP ENSURE SOUND MANAGEMENT AND FULL UTILIZATION OF THESE TYPES OF STANDS, THE MARKET DEVELOPMENT ELEMENT IS SEGREGATED INTO THREE INDEPENDENT, YET INTERRELATED SUB-ELEMENTS: INDUSTRY DEVELOPMENT, MARKETING, AND BUSINESS MANAGEMENT. THE MANAGEMENT, USE, AND EXTENSIONS OF ALL FOREST RESOURCES ARE DEPENDENT ON MARKET DEVELOPMENT WORK. THIS INITIATIVE WILL NOT ONLY STRIVE TO CREATE NEW MARKETS, BUT WILL CONTINUE TO COORDINATE EXISTING ONES TO HELP ENSURE THAT WOOD PRODUCTS ARE MADE AVAILABLE TO THE CONSUMERS.

ELEMENT 2 - IMPROVED HARDWOOD UTILIZATION

THE PROPER UTILIZATION OF AMERICA'S TIMBER RESOURCES IS ONE OF THE MOST IMPORTANT ENDEAVORS OF STATE AND FEDERAL RESOURCE AGENCIES AND THE FOREST PRODUCTS INDUSTRY. THE ELIMINATION OF WASTE FROM THE TIME TREES ARE HARVESTED UNTIL FINISHED PRODUCTS REACH CONSUMERS IS IMPERATIVE IF THE NATION IS TO MEET ITS NEEDS FOR FOREST PRODUCTS. THESE NEEDS MUST BE MET BY EMPLOYING PRACTICES THAT WILL MAINTAIN A QUALITY ENVIRONMENT. THE RATIONAL UTILIZATION OF TIMBER RESOURCES FOR THE PRODUCTION OF CONSUMER GOODS IS ONE OF THE MOST IMPORTANT OF THE MANY USES OF AMERICA'S FOREST LAND AND IS THE BASIS FOR THE ENTIRE PROFESSION OF FORESTRY.

ELEMENT 3 - WOOD FOR ENERGY

THE NATION CONSUMES 80 QUADRILLION BTU'S (QUADS) OF ENERGY ANNUALLY. WOOD PRESENTLY PROVIDES THE NATION 1.3 QUADS, AND IT HAS BEEN ESTIMATED THAT WOOD COULD CONTRIBUTE AS MUCH AS 5 QUADS TO THE NATIONAL ENERGY REQUIREMENTS. AN ACTIVE STATE/FEDERAL UTILIZATION PROGRAM WILL RESULT IN THE FOLLOWING ENERGY CONSERVATION AND CONVERSION ACTIVITIES:

1. PROMOTE, WHERE FEASIBLE, THE CONSERVATION OF ENERGY THROUGH EXISTING PROGRAM SUCH AS SAWMILL IMPROVEMENT PROGRAM (SIP), IMPROVED HARVESTING PROGRAM (IHP), IMPROVED DRYING PROGRAM (IDP), AND OTHERS. THIS SHALL BE IN THE FORM OF AN ENERGY CONSUMPTION ANALYSIS FOR EACH FIRM.
2. ASSIST IN THE DEVELOPMENT OF CONVERSION OF INDUSTRIAL FIRMS TO THE GENERATION OF POWER USING WOOD AS A SUBSTITUTE FOR, AND AN ALTERNATIVE TO, FOSSIL FUELS.
3. ASSIST THE RESIDENTIAL HOMEOWNER WITH INFORMATION AND TECHNICAL ASSISTANCE ON CONVERSION OF HEATING SYSTEMS FROM FOSSIL FUEL TO WOOD. THIS SHALL INCLUDE EQUIPMENT AS WELL AS THE RESOURCE. THIS PHASE SHALL BE PARTICULARLY APPLICABLE TO URBAN AREAS.

AFTER THE UTILIZATION PROJECT WAS DEVELOPED IT WAS EVIDENT THAT THE HARDWOOD RESOURCE MUST BE MANAGED PROPERLY IN ORDER TO INCREASE THE QUALITY, REDUCE THE ROTATION AGE AND INCREASE THE INCOME OF THE FOREST LANDOWNERS AS AN INCENTIVE TO FOREST MANAGEMENT.

THE HARDWOOD RESOURCE MANAGEMENT SECTION INCLUDES THE FOLLOWING:

(1) HARDWOOD REGENERATION

IT HAS BECOME MORE APPARENT THAT HARDWOOD REGENERATION PRACTICES (NATURAL AND ARTIFICIAL) ARE NOT ALWAYS EFFECTIVE IN OBTAINING DESIRABLE SPECIES WHEN AND WHERE THEY ARE NEEDED. THERE ARE SEVERAL PARTS TO THE PROBLEM: (1) HARDWOOD CUTTING METHODS MUST BE CHOSEN VERY CAREFULLY TO PRODUCE THE DESIRED REPRODUCTION. OAK REGENERATION IS ESPECIALLY DIFFICULT. (2) REFORESTATION OF HARDWOODS REQUIRES MUCH MORE CARE THAN SOFTWOODS. IN GENERAL MOST OF THE HARDWOODS THAT ARE DESIRED FOR REGENERATION NATURALLY APPEAR IN MEDIAN SERAL STAGES OF SUCCESSION, AND REQUIRE MORE MANIPULATION OF THEIR ENVIRONMENT IN ORDER FOR THE REGENERATION TO BE SUCCESSFUL. (3) SEED AVAILABILITY IS SPORADIC AND SUBJECT TO EXTREME SHORTAGES. FOR THE MOST PART, HARDWOOD SEED IS LARGER THAN THAT OF CONIFEROUS SPECIES AND DO NOT STORE WELL FOR LONG PERIODS.

IN ORDER TO COMBAT THESE PROBLEMS, HARDWOOD REGENERATION SPECIALISTS WOULD BE USED TO TRAIN AND UP-DATE FIELD FORESTERS ON RESEARCH RESULTS. RESEARCH IS VERY DYNAMIC IN THIS FIELD AND IT WILL TAKE A BIG UNDERTAKING TO KEEP THE FIELD FORESTERS INFORMED OF THESE RESULTS.

(2) SILVICULTURE

THE "DIAMETER LIMIT" METHOD OF HARVESTING IS THE PREDOMINANT CUTTING SYSTEM USED IN THE NORTHEASTERN AREA. LESS THAN 11 PERCENT OF ALL TIMBER IS SOLD WITH THE ADVICE OF A FORESTER. SINCE THE "DIAMETER LIMIT" ENCOURAGES THE HARVESTING OF THE LARGEST TREES WITHIN A STAND AT ONE TIME REGARDLESS OF AGE, THE NATURAL SELECTION OF THE FITTEST IS OFTEN INTERRUPTED, RAPID GROWING YOUNG TREES MAY BE CUT BEFORE THEY CAN PRODUCE SEED AND DISGENIC SELECTION OCCURS. TIMBER MARKING WITH IMPROVEMENT OF THE SPECIES IN MIND WILL BENEFIT FUTURE STANDS AND MAINTAIN ADAPTABILITY AND DIVERSITY OF GENE POOL RESOURCES.

THE DEMAND CREATED BY THE PUBLIC REQUIRES ADDITIONAL FIELD FORESTERS TO PROVIDE MANAGEMENT SERVICES TO THE WOODLAND OWNERS, AND IN TURN ENCOURAGE ADDITIONAL WORK FOR THE CONSULTANT AND INDUSTRIAL FORESTER. MANY FOREST LANDOWNERS WILL NOT MAKE THE TIMBER AVAILABLE FOR UTILIZATION WITHOUT ASSISTANCE FROM AN UNBIASED GOVERNMENT ADVISOR. SOME STATES WOULD ELECT TO HIRE ADDITIONAL STATE PERSONNEL TO COMPLETE THIS ELEMENT. HOWEVER, MANY STATES WOULD CONTRACT THE JOB TO CONSULTANTS.

IN ADDITION TO THE DIRECT BENEFIT OF ADDITIONAL CUBIC FEET OF WOOD, THE WILDLIFE HABITAT WOULD BE IMPROVED BY THE INCREASED DIVERSITY CREATED FROM THE CUTTING AND THE ADDITIONAL MAST PRODUCED FROM THE TREES GROWING IN ^{the} CROWDED CONDITIONS.

BY PROVIDING AN INCOME FROM THE FOREST, OWNERS WILL BE LESS LIKELY TO GO TO THE EXPENSE OF CLEARING THE FOREST FOR ALTERNATIVE CROP PRODUCTION. SINCE MORE OF THE TIMBER WOULD BE HARVESTED UNDER THE DIRECTION OF A PROFESSIONAL FORESTER, THE EROSION WILL BE REDUCED AND THE QUALITY AND QUANTITY OF WATER PRODUCED FROM THE WATERSHED WILL BE MAINTAINED OR IMPROVED.

(3) MANAGEMENT INCENTIVES

TAXES HAVE BEEN LISTED AS THE SINGLE MOST IMPORTANT DETERRENT TO TIMBER MANAGEMENT. IN SOME AREAS THE REAL ESTATE TAXES AMOUNT TO A SUM LARGER THAN THE POTENTIAL INCOME FROM THE TIMBER. HEIRS OFTEN HAVE TO SELL PROPERTY IN ORDER TO PAY INHERITANCE TAXES.

THIS INITIATIVE WOULD PROVIDE TAX TRAINING TO SERVICE FORESTERS, CONSULTANTS, AND/OR INDUSTRIAL FORESTERS SO IN TURN THEY COULD PROVIDE THE INFORMATION TO THE LANDOWNERS ON THE PRESENT TAX LAWS THROUGH THE FOREST MANAGEMENT PLAN.

MONITORING AND DOCUMENTING DISCRIMINATING TAX LAWS SHOULD PROVIDE BACKGROUND INFORMATION TO FORMULATE MODEL LEGISLATION TO ELIMINATE THIS DETERRENT TO FOREST MANAGEMENT.

HARDWOOD STUMPAGE PRICES FLUCTUATE OFTEN AND WOODLAND OWNERS AS WELL AS FORESTERS CANNOT KEEP UP WITH THEM. OTHER CROPS HAVE PRICE REPORTS EVERY DAY. ALTHOUGH TIMBER PRICES WOULD NOT NEED TO BE REPORTED EVERY DAY, THEY SHOULD BE UPDATED AT LEAST ONCE A MONTH. AN UPDATED REPORTING SYSTEM WOULD PROVIDE INFORMATION TO THE LANDOWNER THROUGH A TELEPHONE RECORDING SYSTEM.

CONCLUSION

THE HARDWOOD INITIATIVE CONTAINS A UTILIZATION PORTION AND A MANAGEMENT PORTION. THE UTILIZATION PORTION INCLUDES THREE MAJOR ELEMENTS: MARKET DEVELOPMENT, IMPROVED HARDWOOD UTILIZATION, AND WOOD FOR ENERGY, EACH CONTAINING SUB-ELEMENTS ALL OF WHICH FOSTER, ENHANCE, AND IMPROVE THE UTILIZATION OF EASTERN HARDWOODS.

THE MANAGEMENT PORTION OF THE HARDWOOD INITIATIVE IS TO STIMULATE THE LANDOWNERS TO MANAGE THEIR HARDWOOD FOREST RESOURCE AND TO INSURE ADEQUATE SUPPLIES OF HIGH QUALITY HARDWOOD MATERIAL BEYOND 2030.

THE ELEMENTS ARE DESIGNED TO REMOVE THOSE OBSTACLES THAT NOW APPEAR TO HINDER HARDWOOD MANAGEMENT NAMELY: (1) TO INFORM THE PUBLIC ON THE USE OF THE TAX LAWS AND TO OBTAIN ~~FOR~~ A MORE EQUITABLE TAXING STRUCTURE FOR TIMBER LAND. (2) TO IMPROVE THE HARDWOOD SPECIES SO THAT THE ROTATION AGE IS REDUCED; (3) MONITOR THE STUMPAGE PRICES AND MAKE THEM AVAILABLE TO THE PUBLIC ON A MORE FREQUENT BASIS; (4) HALTING THE DISGENIC PRACTICE OF TIMBER HARVESTING; AND (5) INCREASING THE PERCENT OF TIMBER THAT IS HARVESTED WITH THE ADVICE AND GUIDANCE OF A PROFESSIONAL FORESTER.

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NORMAL HARDWOOD SILVICULTURAL AND MANAGEMENT

SYSTEMS--Eastern Hardwoods¹

H. Clay Smith²

Abstract--Silvicultural cutting methods used in the eastern hardwoods for the even-age and uneven-age management are discussed. These methods include clearcutting, shelterwood, and seed tree for even-age management and individual tree selection for uneven-age management.

When we discuss the silvicultural systems normally used in managing eastern hardwoods, definitions become a problem. There is certainly no reason to present a major discussion of terminology or personal opinions on definitions here. Instead, I have tried to conform to Society of American Foresters terminology and that of a paper by Gibbs (1978) that was intensively reviewed by the Washington Office staff. However, I have purposely avoided using the terms "management systems" and "silvicultural systems" simultaneously in this discussion.

For even-age management, there are three silvicultural cutting or re-production methods (Society of American Foresters 1971)--clearcutting, shelterwood, and seed tree. There is also one ^{un}even-age silvicultural cutting method--selection. Designation of these various cutting methods within the two management systems does conform to Gibbs (1978).

Of course, there are variations of cutting methods within each management system. One that is obviously omitted is group selection, usually placed in the uneven-age category. Generally, this method is similar to individual tree selection, but the actual application of group selection is controversial. Gibbs (1978) stated that to some, group selection is a re-production method used to insure the presence of the valuable intolerant species in mixtures with tolerant species. Others believe group selection is the answer to the silviculture and management of all species except the very intolerant ones. Research results indicate that clearcuts should be at least 1/2 acre to gain the silvicultural effects of large clearcuts, i.e., establishment and development of a high ratio of intolerant to tolerant species (Smith 1981).

¹Presented at the National Silviculture Workshop, USDA Forest Service, Roanoke, Va., June 1-5, 1981.

²Project Leader, 1103 TM Project, Northeastern Forest Experiment Station, Timber and Watershed Laboratory, Parsons, W. Va.

Gibbs further stated that group selection does not fit the uneven-age management system for sustained yield because to date there is no realistic method of regulating small group selection openings. Also, the details of applying the method to insure adequate stocking and acceptable growth of individual trees have not been developed.

For even-age management, silvicultural reproduction methods are regulated by area and maximum tree size (rotation age). In the eastern hardwoods, desired rotation ages for mixed stands may range from 70 to 80 years to well over 100 years. In some cases, the actual on-the-ground rotation could approach 200 or more years. For uneven-age management, stands are regulated by an expression of volume such as number of trees, basal area, stand structure, or the largest size tree to grow.

Cultural practices can be considered either part of management or part of silviculture. In this paper I have chosen to consider them as a means of regulating the stand for sustained yield.

In even-aged stands, the relation of number of trees to dbh class is typically a bell-shaped curve where size is an indication of tree age. But, size is not always an indication of tree age (Gibbs 1963) because growth rate will differ among species with site conditions and species silvical characteristics and requirements. Often, even-age stand structure curves resemble the reverse J-shaped curve (number trees:dbh class), typical of uneven-aged stands. This can be apparent with mixtures of intolerant and tolerant species and can lead to improper interpretation of the stand situation.

Usually, regeneration in even-aged stands occurs once, at or near harvest. Even-aged stands can be silviculturally treated between regeneration cuts with cleanings, thinning, and other cultural practices to improve quality and provide growth for stand structural development.

NORMAL SILVICULTURAL CUTTING METHODS

Even-age management

Where even-age cutting has been applied, it is often assumed that all trees will be the same age. This can be misleading because tolerant stems too small to be cut may have been in the understory for years. It is important to plan the size, shape, and dispersion of the managed stand to meet multiple-purpose management objectives (U.S. Forest Service 1973). For even-age management, three methods will be discussed--clearcutting, shelterwood, and seed tree cut, and one variation--a deferment or delayed cutting method.

Clearcutting method. Clearcutting is harvesting all the trees in an area in one cut to create a new even-aged stand. The area harvested may be several acres or a patch of a few acres or strips large enough to be mapped or recorded as a separate age class in planning for sustained yield under area regulation. We have been advised by NFS that the minimum acreage for

realistic silvicultural stand treatment is 5 to 10 acres. Clearcutting requires locating the boundaries to fit the landscape and considering measures to improve the appearance of the cutover areas (U.S. Forest Service 1973).

Hardwood regeneration for all even-age practices is obtained primarily through natural seedlings, seedling sprouts, stump sprouts, or root suckers. However, occasionally artificial regeneration techniques are used.

Many variations of clearcutting are widely practiced in eastern hardwood management. Though there are limitations on the size of clearcuts on public lands, clearcutting and the other even-age cutting practices are silviculturally acceptable primarily because of the higher ratio of intolerant to tolerant stems and the diversity of tree species that usually inhabit newly regenerated stands. However, clearcutting can not be recommended as a standard procedure because of such problems as uncertainties in reproducing specific species, competition from understory beech, striped maple, and dogwood, and grass, ferns, or vines inhabiting young stands. Also esthetics and the question of when to cut small unmerchantable stems concern silviculturists and economists.

Shelterwood method. In the shelterwood method, the mature stand can be removed in a series of two or more cuts, usually within a 20- to 30-year period, depending on the stand rotation age. Ideally, regeneration and establishment of the new stand occur under a partial crown canopy. The final harvest cut removes the partial canopy and permits the new even-aged stand to develop (U.S. Forest Service 1973). Shelterwood is one technique researchers believe will regenerate oaks on good sites; however, this has not been consistently demonstrated in practice.

Throughout the eastern hardwoods, the shelterwood method is commonly recommended for regenerating new stands; however, the details of timing for removing the overstory shelter and the residual density level to retain in the shelter are still being researched. Many shelterwood recommendations contain a statement that details are uncertain and more research is needed.

Seed tree method. The seed tree method involves harvesting nearly all the trees in one cut, leaving a few well-distributed, more desirable trees to seed the area naturally. In eastern hardwoods, seed tree cuts are seldom used because advanced stems are present, viable seeds are stored in the soil duff, and sprouts from cut stumps usually provide abundant regeneration to establish the next stand.

One variation of the seed tree method is called deferment or delayed cutting. It has been used in Europe, particularly in Germany, for managing oak and beech stands (Kostler 1956, Troup 1966). It is similar to leaving seed trees for future growth as discussed by Smith (1962). In practice, deferment resembles a seed tree cut except that ideally the seed trees are not cut until the sawlogs from the newly regenerated stand are removed. Cultural practices such as cleanings and thinnings are done as planned; the deferment trees are ignored in these operations unless there is a silvicultural reason for removing them. A major reason for considering this method is to give the appearance of not clearcutting yet attain the silvicultural benefits of clearcutting. These benefits include regenerating a

greater number of the more valuable intolerant species and maintaining species diversity. Additional reasons for leaving residual trees for a long period include protecting the soil, changing species composition, carrying valuable timber through a poor marketing period, stimulating growth response, and increasing site production by growing two tree crops (veneer and sawlog) on the same site (Troup 1966).

The deferment trees will normally be at least 160 to 200 years of age before they are removed. Of course, they must be species that are long-lived, wind-firm, and relatively free of insects, disease, and defects. No doubt epicormic branching will also be a problem. Oaks, sugar maple, and beech should be good deferment trees, but species such as yellow-poplar and particularly black cherry are questionable.

Uneven-age management

Selection method. For uneven-age management, I will discuss the selection method. The objective of this selection method is to maintain a specified number of trees in each diameter class, in contrast to other "selection methods" where factors such as tree quality or spacing are emphasized and the number of trees left in each dbh class fluctuates. In application, the desired diameter distribution must be appropriate to the species under management. Also, the diameter distribution is a goal based on the number of residual trees. To determine the number of residual trees, one needs to know the desirable residual basal area, largest trees to grow, and an expression of the reverse J-shape curve called "q" or quotient (Meyer 1952).

Thus, the selection method is a planned periodic, economic removal of individual trees with the overall goal of attaining and maintaining a given number of trees per acre in each diameter class in the stand. Trees are harvested singly or in small groups, and desirable, tolerant species regenerate either continually or at each harvest cut. Thinning and cultural treatments (though not always considered such) are done simultaneously to promote and maintain stand structure--the movement of trees from one diameter class to the next. This is possible because with the selection method, some trees will be cut throughout a range of diameter classes, not just trees in the larger or mature diameter classes (Trimble and Smith 1976, Smith 1980).

Ideally, in uneven-aged stands, the relation of number of trees to dbh class is the typical reverse J-shape curve. Tree size in uneven-aged stands should indicate age, but to my knowledge, this is not as yet true in any eastern hardwood stands managed by selection. In fact, few stands in the eastern hardwood forest are managed by the selection method, though managers commonly state that they are using selection. In reality, their so-called selection cutting is some form of a partial cut.

Selection should not be confused with high-grading, where only the large trees are cut. Individual tree selection does not mean marking all sawlog trees individually. Also, selection is a partial cut, but not all partial or selective cuts are selection cuts. Roach (1974) states that marking to leave a certain minimum basal area in three broad dbh classes is the *absolute minimum* that can be called selection cutting.

In many cases, the "selection method" forest managers refer to is anything but selection; it is usually either a form of high-grading or an improvement cut. If it is an improvement cut, what are the plans for the second or third entry into the managed stand after all the defective trees have been removed? Good stand inventories are needed for the selection method. If managers decide they cannot afford the inventories, or cannot mark trees to be cut, or want to cut only large trees or defective trees, they should not call it selection. Managers could call the cutting practice high-grading, an improvement cut, or a partial cut, but not selection.

Some managers believe that selection cutting has strict limitations and rigid requirements, difficult and expensive to apply, or that regenerating tolerant species is not a desirable objective. They may be correct. When this belief is followed and the forest property is to be managed for sustained yield, then the only choice is even-age management (Roach 1974). In reality, only a few commercial tolerant to intermediate species are well adapted to selection: sugar maple, beech, red maple, white oak, and hickories, for example. The managers must decide whether the value and utility of these species warrants the loss of the intolerant to intermediate species such as black cherry, yellow-poplar, basswood, yellow birch, and oaks.

USE OF SILVICULTURAL CUTTING METHODS

The eastern hardwood forests contain a variety of commercial species, often 20 or more different species on a few acres. Sites and stand conditions due to previous uses also differ widely. As Marquis (1977) stated, the diversity is even greater in lesser vegetation and among the animal population inhabiting the forests. Differences in species growth rates, site characteristics, and values add to the complexity of managing the eastern hardwood forests. Species such as those in the oak family are extremely valuable for wildlife, timber products, and recreation. Black walnut, black cherry, and white ash are consistently the most valuable hardwoods available for timber production in the eastern hardwood forest.

Silviculturists realize that cutting trees is a major means of managing the forest. Also, when forests are managed for the various disciplines and a forest alteration is needed, some type of cutting or tree removal is usually done. Cutting or removing trees is an accepted procedure in forestry, but problems arise from the degree of cut and the way the environment is altered.

Depending on the management objectives of the forest owner, there can be several choices of silvicultural methods. Timber markets fluctuate and public interests in recreation, esthetics, wildlife, and other values of the forest influence the choice of silvicultural method. In many situations, the nontimber values strongly influence these choices. Also, biological factors influence the use of silvicultural methods, including species reproduction and silvical requirements, wildlife, insects and disease, climate, and fire as related to stand and site characteristics.

Silvicultural methods have been recommended for major forest types in certain situations (U.S. Forest Service 1973).

North Central Types

Northern hardwoods. For the Lake States, northern hardwood type, the selection method is recommended on well-drained sites for continuing production of high quality veneer and sawlog products of shade-tolerant species such as sugar maple. If regeneration of the light-requiring valuable species such as yellow birch is the management objective, then an even-age method is suggested (Tubbs and Godman 1973).

Sugar maple is a dominant species in northern hardwood forests on poorly drained sites in the Lake States. Other species include hemlock, yellow birch, black ash, American elm, and red maple. Tubbs and Godman (1973) conclude that regeneration following a complete clearcutting is unpredictable, as the grass-shrub-herb stages can last for decades. They recommend the selection method to manage for the tolerant species and the shelterwood method ^{for} more intolerant species.

Aspen. Brinkman (1973) concluded that the major cutting practice used to regenerate aspen in the Lake States is complete clearcutting, although modifications of it are almost as successful. Aspen cannot reproduce under its own shade, so the selection method cannot be used.

Oak-hickory. In the oak-hickory type there are numerous oak and hickory species as well as a wide range of associate species. Watt, Brinkman, and Roach (1973) concluded that oaks can be reproduced and grown in even-aged stands. The selection method is not suitable for managing oaks. When adequate oak-hickory advance regeneration is present, clearcutting can be used to regenerate the new stand. The ratio of intolerant to tolerant species will increase and the higher the site quality the greater the species diversity will be. Shelterwood has no advantage over clearcutting where advanced oak-hickory regeneration is adequate. If advance regeneration is inadequate, then in theory shelterwood should be useful in establishing the oak-hickory regeneration. However, in reality, this theoretical point has not been demonstrated on good oak sites. As Sander (1979) concluded, the successful application of shelterwood to regenerate oaks will require all the silvicultural expertise we can muster. Seed tree cutting is of little value as a reproduction method for the oak-hickories as the heavy seed is poorly distributed.

Northeastern types

Northern hardwoods. In the northeastern types, commercial species in the northern hardwood type include yellow birch, white ash, red maple, paper birch, sugar maple, beech, hemlock, and red spruce. Filip and Leak (1973) state that the silviculture methods suitable for these northern hardwood types vary with species composition, age distribution, site productivity, deer browsing, and management objectives. The selection cutting practice is recommended to increase production of shade-tolerant species--sugar maple,

beech, hemlock, and red spruce. If intermediate or light-demanding species are desired in future stands, then some form of clearcutting is suggested at the final harvest. Shelterwood can probably be used for establishing even-aged northern hardwood stands, but guidelines from experimental cuttings are not available.

Cherry-maple. Another northeast type is cherry-maple, composed of black cherry, red maple, and sugar maple with white ash, yellow birch, sweet birch, beech, and hemlock as common associates. The most valuable species are the intolerant black cherry and white ash. These species can be established and maintained only by some form of even-age silviculture, as the high deer population limits the choices of silvicultural methods in the Allegheny forest. For clearcutting, an abundant understory of advanced seedlings is necessary (Marquis 1973). If advanced seedlings are absent, a costly way to insure reproduction after cutting is to erect fences to exclude deer. A less expensive alternative is to fertilize (Auchmoody 1978). Shelterwood may provide better conditions for seedling establishment and survival than clearcutting, but it has not been used for lack of information on cutting intensities and timing of removal cuts. The high deer population precludes using the selection method in cherry-maple as new stems are severely browsed, killed, and not allowed to develop.

Appalachian hardwoods. For the Appalachian hardwoods, Trimble (1973) suggested that selection can be used, but it discriminates against the more light-demanding species. Shade-tolerant species will dominate the stands. A selection cutting heavy enough to encourage regeneration and development of light-demanding species risks reducing stand growth through understocking and impairing stand quality by high-grading. Shelterwood appears promising for reproducing species that are intolerant to intermediate in shade tolerance, but little research has been done on this method of regeneration in Appalachian hardwoods. Also, current thought is that it is not necessary to retain hardwood seed trees as a seed source in Appalachian stands because hardwoods reproduce from advance regeneration, stump sprouts, root suckers, or seed already stored in the soil duff.

Trimble (1973) stated that clearcutting provides the greatest potential for maximum reproduction of desirable light-demanding Appalachian hardwood species. Though this method is easy to regulate for timber, wildlife, and water yield, compared to selection, sensitive scenic locations and esthetic objections to newly clearcut areas can limit its use.

Southeastern types

Oak-pine. For the southeastern oak-pine type, major oaks include white, northern red, scarlet, black, chestnut, and southern red oak along with associated hardwoods, yellow-poplar and sweetgum (Olson and McAlpine 1973). Pines are largely loblolly, shortleaf, and Virginia. Except on the best sites, the silvicultural objective for timber production in this type is to increase the pine and decrease the hardwood components. Pines are favored over hardwoods because of the greater demand for pine lumber, plywood, and veneer and because pine grows faster and provides better yields on most upland sites. All even-age methods have been used successfully, but the most

effective is clearcutting followed by hardwood control, site preparation, and the planting or direct seeding of pines. When selection is used, oaks and certain other hardwoods are favored over pine and the stand composition will shift to the more shade-tolerant hardwoods such as hickories and most tolerant oaks, especially white oak.

Southern types

Oak-gum-cypress. In the southern oak-gum-cypress type, the choice of silvicultural method in the bottomland forest depends on the composition and density of advanced regeneration, sprouting characteristics of the trees to be cut, and whether the stand is even-aged or uneven-aged (Johnson 1973). Clearcutting provides the best growing conditions for regenerating most species and especially for those intolerant of shade. Shelterwood is used to provide seed for advanced reproduction of suppressed, unwanted, and undesirable understory vegetation. With intolerant species such as yellow-poplar, sycamore, and sweetgum, the overstory usually is removed within 5 years. With tolerant species, release can be delayed much longer. Selection can be applied in the oak-gum-cypress type where mature, suppressed, or damaged trees are removed, but this method is not recommended to reproduce the oak, gum, and cypress.

CONCLUSIONS

In selecting the silvicultural method to use in managing hardwood stands, management objectives must be clearly defined and consideration must be given to timber markets as well as wildlife, water, and other public interests such as recreation and esthetics. In many situations, the nontimber values may dictate silvicultural and management decisions. Also, biological factors should influence the decision, especially a decision that is attainable in the real world.

The decision on which silviculture method to use in any given stand should also be based on management objectives, stand conditions, and the silvical characteristics of the species present or desired. For example, zones with steep slopes, dry sites, a high water table or travel influence may be ideally suited for uneven-age management, especially where there are desirable tolerant species. Even-age management is excellent for increasing intolerant species and can be used to harvest overmature, diseased, or insect-inhabited stands (Gibbs 1978). Sometimes because of previous stand practices, an even-age silvicultural method allows the manager to start over. The silvical characteristics of the desired species are of major importance and determine the type of management system. For example, intolerant black cherry can only be regenerated by an even-age method; using individual tree selection would result in the eventual loss of the black cherry in the overstory stand.

Managers must be knowledgeable of the attributes and alternatives of silvicultural practices applied to a specific stand. Now, more than ever,

the public is aware that forestry plays a significant role in our society. We must continue to improve and progress in our manipulation of the environment or be prepared for the consequences.

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HARDWOOD SILVICULTURE AND MANAGEMENT SYSTEMS:

MODIFICATION FOR SPECIAL OBJECTIVES^{1/}

David A. Marquis^{2/}

Abstract--There are numerous modifications to traditional silvicultural techniques that can be used to improve their suitability for nontimber resources. Rotation length and stand structure goals can be set to provide more large trees and alter the distribution of size classes for wildlife or esthetics. Esthetic shelterwood, retention of residuals, and two-age management cutting can be used to reduce the visual impact of regeneration openings. Opening size, shape, and distribution can be altered to favor water yield, esthetics, or certain wildlife species.

^{1/}Presented at the annual Silviculture Workshop, USDA Forest Service, Roanoke, Va. June 1-5, 1981.

^{2/}Principal research silviculturist, USDA Forest Service, Northeastern Forest Experiment Station, Warren Pa.

INTRODUCTION

Clay Smith has described and defined the traditional silvicultural systems as they are applied in eastern hardwoods. These systems have developed primarily to meet timber management objectives. My task is to describe modifications to these traditional systems that can be used to improve their suitability for other resource objectives.

I have selected a few practices that appear to be useful for nontimber resources. I'll try to describe each technique and its effect on the target resource, as well as mention the major trade-offs involved.

MODIFIED ROTATION LENGTHS

Rotation lengths under even-age silviculture are traditionally set at the point of stand financial maturity to maximize returns from timber production. But rotation length has major effects on nearly all resources; it determines the amount of area regenerated each year (area in openings) and establishes the distribution of stand size and age classes over the forest area. This organization of the vegetative cover affects esthetics, visual and biological diversity, wildlife habitat, water yields, and other resources.

Esthetics and Long Rotations

Many people find forests to be more pleasing and more primeval in appearance if they contain large trees. In eastern hardwoods, this generally means that large sawtimber stands should occupy a significant share of the total area, and some trees 24 to 36 inches dbh should be present.

In addition, many people consider clearcuts and other regeneration openings to be unattractive, so visual objectives are easier met if the proportion of area in these disturbances can be kept to a minimum.

Extending the normal rotation can help in both providing large trees and reducing the area in regeneration openings. For example, in the cherry-maple or Allegheny hardwood type, the economic rotation is usually set at 80 to 90 years. At that age, cherry usually averages about 18 inches dbh, with a few trees as large as 24 to 26 inches. Large sawtimber stands comprise about 16 percent of the total forest area and openings 10 years or younger represent about 11 or 12 percent of the area (table 1).

By lengthening the rotation from 90 to 120 years, average diameter of the cherry is increased to about 22 inches, with a few trees as large as 30 to 32 inches or more. Large sawtimber stands more than double, comprising 38 percent of the total forest area, while regeneration openings are reduced somewhat to about 8 percent of the area (table 1).

Table 1.--Percent of forest area by stand size class for Allegheny hardwoods under two rotation lengths.

Stand size class	Age class	Rotation length	
		90 years	120 years
	<u>Years</u>	<u>Percent</u>	
Seedling	0-10	11	8
Sapling	10-25	17	12
Pole	25-50	28	21
Small sawtimber	50-75	28	21
Large sawtimber	75+	16	38
Total		100	100

Wildlife and Long Rotations

Most species of forest wildlife are adapted to a particular successional stage of the plant community. For example, deer food production is at a maximum during the seedling-sapling stage in the first 10 years after clear-cutting, and the more area in this age class, the more food the area will produce. Short rotations would presumably maximize deer populations. By contrast, gray squirrels depend on overstory mast and den sites found primarily in sawtimber stands, so maximum populations of this species can be expected with very long rotations or selection management (Hassinger et al. 1975).

Many of the effects of rotation length (or stand age class distribution) on wildlife populations have been quantified by Boyce (1977) in several papers on techniques of developing harmonized forest management actions for a variety of benefits.

Considerable care is required in evaluating the effect of rotation length on individual wildlife species. For example, we have estimated the amount of available woody browse and foliage within reach of deer in Allegheny hardwood forests under various rotation lengths (table 2). We found that loss in deer food resulting from a smaller amount of regeneration cutting each year is offset by an increase in production from thinned stands. This occurs because of the large increase in proportion of area in large sawtimber stands, which can be commercially thinned at about 15-year intervals. So, increasing the rotation length from 90 to 120 years does not necessarily produce a negative effect on browsing wildlife species, even though it reduces the area in the productive seedling-size class (Marquis 1981b). Thorough evaluation of the total effect of changes in rotation is necessary before judgment is made.

Table 2.--Deer food production under two rotation lengths
in Allegheny hardwoods.

Size class	Production factor ^{1/}	Rotation length			
		90 years		120 years	
	<u>lb/acre/yr</u>	<u>Acres</u>	<u>lb/yr</u>	<u>Acres</u>	<u>lb/yr</u>
Seedlings	400	110	44,000	80	32,000
Unthinned saplings, poles	90	450	40,500	330	29,700
Thinned sawtimber	200	440	88,000	590	118,000
Total		1,000	172,500	1,000	179,700

^{1/} Based on regressions of foliage dry weight within 5 feet of ground plus dry weight of the terminal 2 inches of each twig within 5 feet of ground, both calculated as a function of seedling size; plus data on average number of seedlings of each size class in Allegheny hardwood stands of each stand size class.

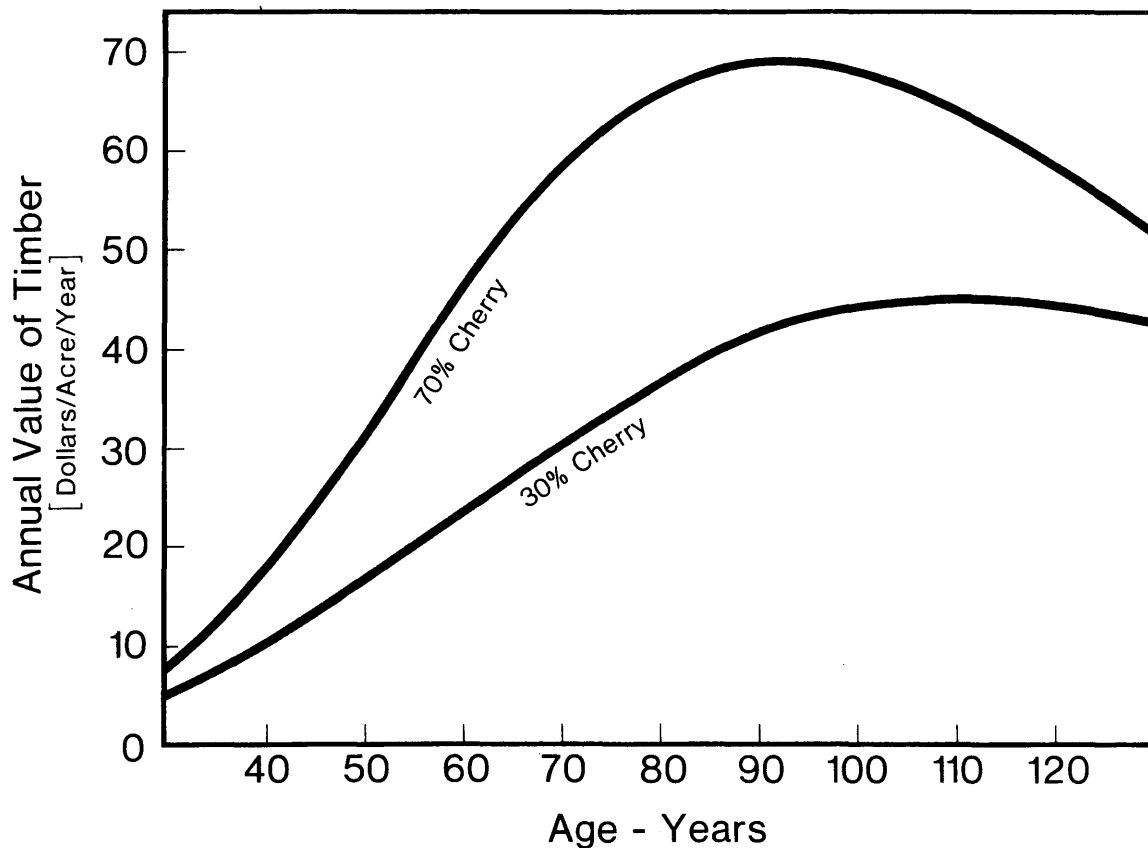
Trade-offs of Long Rotation on Timber

The value of timber production lost from an extended rotation can vary widely. In Allegheny hardwoods, we have found through computer stand growth simulation that all Allegheny hardwood stands do not reach financial maturity in 80 or 90 years. Stands with a high proportion of their volume (70% or more) in black cherry reach peak value per year in 90 years, then decline rapidly. Extending the rotation of such stands to 120 years may result in about a 15 percent loss in timber value (fig. 1).

However, stands with less black cherry and a larger component of maple do not reach peak value until age 110 or later, and values decline only gradually thereafter. This is because slower growing maples require additional time to reach sawtimber size, and overlapping of the several species approach to maturity provides a long time-span over which profitable timber rotations can be set.

I feel sure that there are similar relationships in other hardwood types that contain a mixture of species with widely different tolerance levels and growth rates. In many mixed hardwood stands, the concept of a single rotation age doesn't fit, and there is ample room for adjustments to accommodate other resources. Judicious thinning can also be used to alter the shape of the value production curve and reduce timber losses that might otherwise be associated with the longer rotation.

Figure 1.--Value production for cherry-maple stands of several species compositions.



MODIFIED STAND STRUCTURE

With selection cutting under uneven-age silviculture, there is no rotation length to vary to ensure that the forest contains large trees to meet esthetic objectives. Stand structure goals can be modified to achieve the desired results.

In selecting a stand structure goal under uneven-age management, set three parameters: the residual stocking level, the maximum tree size, and the distribution of size classes (Marquis 1978).

Residual stocking levels should be set at about 60 percent of full stocking, or at some other basal area goal already determined to be appropriate for timber production. Maximum tree size for timber production in eastern hardwoods usually ranges from 18 to 24 inches dbh, depending on species, site quality, and economic considerations. In areas where large trees are desired for esthetics, the maximum tree-size goal should be increased to 30 inches or so.

Distribution of size classes is commonly expressed in terms of the ratio "q" between numbers of trees in successive diameter classes. For example, a "q" of 1.5 (for 2-inch diameter classes) means that there are 1.5 times as many 10-inch trees as there are 12-inch trees, 1.5 times as many 12-inch trees as 14-inch trees, and so on. The lower the "q" ratio, the more large trees there are in proportion to small trees. Ratios of 1.5 to 2.0 are often recommended for timber production in northern hardwoods, but lower "q" ratios (1.3 to 1.5) should be selected where the objective is to provide large trees for esthetics.

Stands managed with the modified structure goals described above will have larger maximum tree sizes, larger average stand diameter, and larger proportions of the basal area in large sawtimber. For example, a northern hardwood stand with a "q" of 1.3 and maximum tree size of 30 inches will contain 26 square feet of basal area per acre in large sawtimber, versus 3 square feet for a similar stand managed with more traditional stand structure goals. It will have 55 square feet of sawtimber total, compared to only 21 square feet in the traditional stand (table 3).

Table 3.--Typical stand structure goals for northern hardwoods.

Dbh class (inches)	Normal structure goal		Modified structure for esthetics	
	Number of trees	Basal area	Number of trees	Basal area
		<u>Sq. ft./acre</u>		<u>Sq. ft./acre</u>
2-6	284	21	48	7
8-12	58	28	36	18
14-20	13	18	19	29
22-30	1	3	8	26
Mean diameter	6.0 inches		10 inches	
Residual stocking	70 sq. ft. B.A.		80 sq. ft. B.A.	
Maximum tree size	24 inches		30 inches	
"q"	1.7		1.3	

The major disadvantage of the modified stand structure goal described above is the added cost of timber stand improvement necessary to remove the many small trees. This cost may be offset to some extent by increased sawtimber production, since the proportion of growing space devoted to sawtimber-size trees is high. However, the effects of various stand structure goals on timber yields have not yet been clearly defined, so trade-offs with timber production are only speculative at present.

The modified stand structure goal described above should substantially improve habitat for late successional species, because overstory mast and larger trees with potential as dens would be markedly increased. There should be little effect on browse production.

MODIFIED REGENERATION CUTTINGS

In areas where timber management goals require the use of even-age silviculture, but where clearcutting and traditional shelterwood cutting is esthetically unacceptable, it is sometimes possible to meet visual goals by modifying the regeneration cutting practices. Esthetic shelterwood cutting, retention of residuals with traditional cuttings, and two-age management cuttings are three possibilities that can achieve this result under proper conditions.

Esthetic Shelterwood

Esthetic shelterwood is a modification of standard shelterwood techniques that requires an additional entry to develop the advance reproduction to sapling-size (10 to 15 feet in height) before the final overstory removal. This large reproduction conceals soil disturbance and logging residue and leaves an opening that has already partially healed. Thus, the unsightly appearance of a fresh clearcut or ordinary shelterwood, as viewed in a foreground situation, is largely avoided (USDA Forest Service 1980).

Esthetic shelterwood cutting might be handled as follows in an even-aged stand approaching rotation age:

Year 0: Make the seed cut of a normal shelterwood sequence, reducing stand density to 50 or 60 percent of full stocking. This will open the canopy moderately to encourage the establishment of seedling regeneration, or to augment any advance regeneration already present.

Year 10: Make the first of two removal cuts, reducing stand density to 30 or 40 percent of full stocking. This will maintain adequate canopy density so that the visual effect of a stand remains, but it also provides adequate light for the advanced seedlings to make moderately fast height growth.

Year 20 or 25: Make the final overstory removal when advance reproduction has reached a height of 10 to 15 feet over most of the area. This will usually require 10 to 15 years additional growth after the previous cut. The final overstory removal will leave a seedling-sapling stand that can be managed in the same manner as any other even-aged stand.

Special Practices for Openings

The visual impact of clearcut openings and openings created after the final removal cut of a shelterwood sequence can be softened considerably by retention of some residual trees in the openings, either in groups or uniformly across the area. The standard practice during final harvest cutting in northern hardwoods is to remove all trees to some minimum size, such as 2 inches dbh. However, it may sometimes be desirable to retain a small number of residual stems in harvest areas for timber, wildlife, or visual purposes. The procedures are similar for clearcuts or final removal cuts of a shelterwood sequence.

Inclusion.--Clumps or islands of trees may be retained in final harvest areas to break up the opening and reduce its apparent size. This is especially effective when viewed from an oblique angle in middleground landscapes. Such inclusions can also benefit wildlife if mast-producing, den, or perch trees are retained, or if the trees are retained along streambanks to avoid stream temperature increase or siltation.

Uniform residuals.--Residual trees may be retained throughout the harvest areas for both visual and timber purposes. The residual trees should be restricted to tolerant species, such as sugar maple and beech, which will withstand the sudden exposure without severe epicormic branching or mortality, and will recover and grow under such conditions. The trees retained should be between 3 and 8 inches dbh, with clear, straight boles. The goal should be to retain between 60 and 100 such trees per acre, uniformly distributed.

This small number of residual trees may serve timber purposes also. Fast-growing, intolerant regeneration will catch up to the residuals by about age 40 to 50, and join with them to form a single crown layer. This is often the only feasible way to grow species of markedly different shade tolerance so that all species mature at the same time. These residuals also make it possible to perform the first commercial thinning at an earlier age than otherwise possible. However, care must be exercised in the selection of trees to retain, and in their number and distribution, so that the desired effects are obtained without interfering with intolerant regeneration (Marquis 1981a).

Two-Age Management

Two-age management cutting (as defined and used here) is a cutting technique and management scheme that falls somewhere between traditional even-age and uneven-age schemes. It is intended to permit maintenance of intolerant species while avoiding complete overstory removal at any time. It is intended for use in areas where regeneration openings made by clear-cutting or any sort of shelterwood cutting will not meet visual quality objectives, but where intolerant species and even-age management using area control are desired.

Two-age management is really a controlled form of diameter limit cutting, but with regulation of residual stand density and definite scheduling of age or size classes. It involves the maintenance of two distinct age classes on all areas at all times. For example, a second-growth, even-aged stand about halfway to rotation age (100 years) might be handled as follows:

Year 0: Harvest about half of the existing 50-year-old stand, reducing density to 40 to 50 percent of full stocking. This leaves a residual stand about half as dense as that left after a normal thinning, and creates an open canopy under which intolerant species will regenerate. The resulting stand will consist of 50-year-old trees and new regeneration in about equal numbers.

Year 50: After 50 years of growth, the two age classes will be 50 and 100 years old. At this time, all of the 100-year-old trees are

cut, and the 50-year-old trees are thinned to one-half of B level stocking as before. A new crop of regeneration is again obtained to replace the 100-year age class that was removed.

Year 100 and beyond: After year 50, repeat cuttings at half-rotation intervals. Thinnings may be applied in both age classes at intermediate times in the above schedule. For example, thinnings at year 35 and again at year 85 will often be desirable to maintain density control and ensure that the intolerants will not be shaded out. Such a thinning could be a combination precommercial operation in the younger age class and commercial thinning in the older age class.

SIZE, SHAPE, AND DISTRIBUTION OF OPENINGS

The size, shape, and distribution of regeneration openings used in a forest area have important effects on nearly all resources. Careful selection of these parameters can, therefore, help in meeting nontimber objectives.

From a silvicultural standpoint, there is little difference in the regeneration to be expected in clearcuts that range from 10 to 100 acres. Marking and logging costs may be lower with larger openings, and large stands are easier to handle in record keeping. For these reasons, large openings tend to be favored for timber management purposes.

In areas where water-yield increases are the goal during the summer low-flow period, large clearcuts have a distinct advantage. The water increases because of the absence of tree roots to take up and transpire water back into the atmosphere. But the perimeter of clearcut openings does not produce water-yield increases of the same magnitude as interior portions, because of the large amount of water withdrawn from the opening by roots of bordering trees (Lull and Reinhart 1966).

This perimeter area represents only 4 percent of the total clearcut acreage if 100-acre openings are used, but it represents 13 percent for 10-acre openings and nearly 40 percent for 1-acre openings (table 4). So, large openings are desirable when water-yield increases are the goal.

Size of opening also affects habitat for many species of wildlife that depend on forest edge for food or cover. Forest edge can be dramatically increased by using a large number of small openings rather than a few large ones. For example, the perimeter of fifty 10-acre openings is 132,000 feet, whereas the perimeter of ten 50-acre openings is only 59,000 feet (table 4).

Visual effects of various sizes, shapes, and distributions of openings have been well documented in the various landscape management handbooks (USDA Forest Service 1980). In general, smaller openings help to reduce the visual impact of recent clearcuts when viewed in the foreground. However, this effect can be offset by the need for a larger number of openings per unit area, which is sometimes less acceptable when viewed in middleground or background. Many very small openings tend to create a pock-marked effect

Table 4.--Size of border zones based on number and size of clearcuts.

Clearcut size (acres)	Number of clearcuts	Total perimeter	Area in ^{1/} border	Percent in border
		<u>Feet</u>	<u>Acres</u>	
.1	5,000	1,320,000	455	91
.25	2,000	834,800	345	69
.5	1,000	590,200	265	53
1	500	417,500	196	39
10	50	131,900	67	13
25	20	83,480	43	9
50	10	59,020	31	6
100	5	41,740	22	4
500	1	18,666	10	2

^{1/} On the basis of a total of 500 acres clearcut.

that is undesirable, and many small openings are sometimes more difficult to blend with the topography than a few larger ones. So, the visual effect of clearcut size depends to a large extent on site characteristics.

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HARDWOOD GROWTH AND YIELD PROJECTIONS:

STATE OF THE ART¹

Martin E. Dale²

INTRODUCTION

Growth and yield projections have historically been an extremely useful tool of foresters. They have played an important role for a variety of objectives, such as regulating the cut, choosing the rotation length, and estimating forest values. In the last two decades, growth and yield modeling methodology has evolved rapidly. Traditional normal yield tables that were constructed from temporary plot data and graphic techniques are being replaced by the highly complex individual-tree models. Over the last 15 to 20 years, the state of the art also has changed rapidly due to a broader spectrum of users with specific objectives, and new areas of application.

We need to trace the evolution in modeling methodology to appreciate this dynamic state of the art. Recent trends provide a good idea of where we are today and of what lies ahead. In this paper I briefly explain how various models are classified, the types of use, and some of the factors that should be considered in choosing a particular model for a specific objective.

FOREST STAND GROWTH MODELS

The basic objective of all stand models is to provide summary information on the state of the forest at some point in time. The amount of detail in these summary tables may vary greatly depending on the model you use and your specific objective. Munro (1974) proposed a useful classification system that is based on the importance of individual trees and inter-tree distance as modeling parameters. His classification system recognizes three types of stand simulation models:

1. Whole stand, distance independent
2. Individual tree, distance dependent
3. Individual tree, distance independent

The chief distinction between whole-stand and individual-tree models seems to be whether or not the identity and characteristics of individual

¹Presented at the National Silviculture Workshop, USDA Forest Service, Roanoke, Va. June 1-5, 1981.

²Principal mensurationist, USDA Forest Service, Northeastern Forest Experiment Station, Delaware, Ohio.

trees are important variables in estimating growth and yield parameters. Both of the individual-tree models require a tree list where identity and certain characteristics of each tree are maintained. Individual-tree, distance dependent models also require a stand map that gives the location of each tree in relation to its neighbors.

Whole-Stand Models

In whole-stand distance independent models, stand characteristics or features are averaged or aggregated to form independent predictive variables such as stand basal area, mean stand diameter, site, and age. The normal yield tables developed in the past are examples of this type of model, though they bear little resemblance to today's whole-stand models.

Incorporating whole-stand models into computer programs usually is relatively easy and economical. They require a minimum of input data, most of which are readily available to managers from stand inventory summaries. The usual input data might include stand age, site, and a measure of stocking such as basal area, and some may require the number of trees per acre. Whole-stand models provide much of the information on stand response that managers can use for decisionmaking, especially those constructed from data from managed stands. Because they are easy and economical to use, and because input data generally are available, management has the opportunity to look at a number of possible treatment options. The GROAK program (Dale 1972) is an example of whole-stand model for upland oak; Beck and Della-Bianca (1972) have provided similar models for thinned yellow-poplar stands. Until the last few years, models of this type probably were the most extensively used --at least in the hardwood timber types.

In recent years, particularly in the South, whole-stand models have been developed that provide much more detailed information on various components of the stand, for example, by species group or by diameter class. These whole-stand models use probability distribution techniques to determine the relative frequency of either basal area or number of trees by diameter class (Lenhart and Clutter 1971; Burkhardt and Strub 1974; Clutter and Allison 1974). A similar model approach for even-aged northern hardwoods was developed by Solomon (1974).

Various probability distributions such as the Weibull, Beta, Gamma, and Johnson Sb can be used in describing the distribution of trees by basal area or by diameter class. The procedure is used to predict the values of the parameters in these theoretical probability distributions as functions of stand characteristics such as age, site, stocking, and average diameter. Since we can predict the number of trees in each diameter class over time, it is fairly easy to compute growth and yield estimates.

These models should be relatively inexpensive to run, since growth is estimated by class or at least distributed to class rather than individual trees. Growth and yield estimates by diameter class provide management with very valuable additional information compared with that obtained with traditional whole-stand models. Both species and size class are important variables in determining tree values for use in economic evaluations. The

principal shortcoming in using this technique appears to be that the actual distribution of trees may not always conform well to the theoretical probability distribution, especially when management options such as thinning are imposed.

Individual-Tree, Distance Dependent Models

Individual-tree distance dependent models require a stand map that gives the location of each tree in relation to its neighbors. Usually, these inter-tree distance measurements along with overlapping crown projection areas and relative tree size are used to develop some type of competition index that is used to modify the growth of a specific tree. At least in theory, the individual-tree distance dependent models should provide the highest resolution and greatest amount of detail. Although there is limited published information that compares one model with another using the same data set, there is some evidence that the distance dependent models may perform slightly better than distance independent models (Ek and Monserud 1979).

These models may have limited utility for field use. Stand maps usually are not available, and the cost of obtaining the field data and running the programs is quite high. However, these models probably were developed primarily for researchers or forest planners. They may be very useful when used in simulation studies to evaluate various silvicultural treatments, develop prescriptions, or select management strategies. An example of this type model is FOREST developed by Ek and Monserud (1974). Dudek and Ek (1980) published a bibliography of individual-tree models. They reported more than 40 distinct models with about an equal split between distance independent and distance dependent types.

Individual Tree, Distance Independent Models

Most individual-tree distance independent models generate about as much detail as distance dependent models but at a lower cost for data collection and processing. These models require a list of individual trees, but stand maps are not needed. Some measure of relative competition usually is built into these models, but it is based on a combination of stand and tree characteristics. For example, stand variables of stocking or mean stand diameter could be used along with individual-tree size, crown ratio, or tree vigor class to develop the competition index.

The STEMS model developed by the North Central Forest Experiment Station (USDA Forest Service 1979) probably is the most widely used example of this type of model in the hardwoods. These models provide a large amount of tree or stand detail and can handle a wide range of forest treatment practices, species mixtures, and size classes.

EVOLUTION OF METHODOLOGY

Graphic Techniques

Normal yield tables and empirical yield tables

Until about 1950, most yield information was published as normal yield tables. Yields by age and site class are expressed in terms of various measures, such as cubic feet, board feet, and basal area. For a given timber type, yield data are based on temporary plots selected from even-aged, undisturbed stands with near maximum stocking. Empirical yield tables are similar to normal yield tables, the chief distinction being that plots of average stocking are selected. Most of the methodology was adapted directly from Europe, where such procedures were used nearly a century ago.

Nearly every forest manager has used these yield tables such as Schnur's (1937) tables for upland oak, and is familiar with their usefulness and their shortcomings. Most of our timber stands simply do not match the tabular stand values; yields are difficult to extrapolate, and the tables do not apply to managed stands. Growth estimates are obtained by the difference in yields from one age class to the next. In other modeling techniques described later, actual growth from permanent plot remeasurements is used to construct growth functions, which are then summed or integrated over time to obtain yields.

Analytical Techniques

Variable density yield tables

A significant departure from graphic techniques was the suggestion of MacKinney et al. (1937) to use least squares multiple regression techniques for fitting yield data. This allowed yields to be expressed as functions of age, site, stand density, or other independent stand variables.

The statistical approach has obvious advantages over graphic techniques. Reliability of the yield equation can be determined, and the results can be duplicated. Also, the yield equation is incorporated into computer programs much easier than the tables. Most of the yield functions over the last 30 years have used similar statistical techniques. In coniferous stands, especially southern pines, there are numerous examples; for hardwood stands, examples of variable density yield equations include those for yellow-poplar (Beck and Della-Bianca 1972; Schlaegel and Kulow 1969) and for upland oak (Dale 1972).

Compatibility of Growth and Yield Equations

Since the late 1940's, considerable data have been accumulated on actual volume growth based on repeated measurement of permanent growth plots such as CFI, Forest Survey, or research plots. During this period, multiple regression techniques were used to fit growth as the dependent variable

rather than yield. It was not until 1962 that the yield estimates were recognized as the integral or summation of the growth rate equation. Buckman (1962) developed a differential expression of the growth rate of red pine stands as a function of age, site, and stocking. This expression of growth rate was integrated over time to provide yield predictions. Since this logical compatibility between growth rate and yield was first demonstrated by Buckman and almost simultaneously by Clutter (1963), most of the recent models present a set of compatible growth and yield equations.

RECENT ANALYTICAL TECHNIQUES

Within the last 15 years or so the state of the art in modeling techniques has changed rapidly. I have mentioned briefly the development of compatible growth and yield models, the two types of individual tree models, and the theoretical diameter distribution approach for providing tree detail for whole stand models. For any of the model types there is a wide range of methodologies and equation forms for fitting data to develop the growth and yield equations. The use of non-linear models and stochastic processes are two techniques I will mention briefly because we will likely see more of these in the future.

Nonlinear Models

We are now seeing a shift from empirical model building using multiple regression techniques to nonlinear models constrained to some degree by biologically based concepts of growth. Certain parameters in nonlinear models can be restricted so that they limit the ultimate size of a tree, the basal area stocking of a stand, or maximum growth rate of a tree or stand. Although nonlinear models often may not fit a given data set as well as multiple linear regression, the parameter values may be easier to interpret biologically. There is also less risk of extrapolating to conditions beyond the range of data where the model parameters are constrained. Many nonlinear models are very flexible and, depending on the parameter values, capable of assuming a variety of possible shapes.

Although many nonlinear mathematical models have been known and suggested for growth modeling for a long time (Pearl and Reed 1920; Richards 1959; Burkhart and Strub 1974; Ek 1974; Hafley and Schreuder 1977; Bailey and Dell 1972), it is only recently that their use has become widespread. Besides the great flexibility and biological appeal, the availability of modern computers and accompanying statistical programs to estimate nonlinear parameters may be partially responsible for this shift in techniques. Techniques also have changed because of demands by users and developers for models that can incorporate biological growth trends. The increasing quantity of actual growth from permanent plots also has contributed to this change.

Stochastic Processes

A number of papers describe techniques for modeling stand dynamics as a Markov chain process (Peden et al. 1973; Bruner and Moser 1973).

The future state of a tree, such as moving from one diameter class to the next or dying during the projection period, is described by the joint probability distribution. Projection equations are used to derive means, variances, and covariances, and the approximate distribution of number of trees by class for any future growth period. Although some of the mathematical theory has been developed and the procedures demonstrated for sample stands, I do not believe many such models are used in the operational sense. They appear to be quite complex mathematically and provide about the same degree of detail as whole-stand models using the diameter distribution technique.

APPLICATION OF GROWTH AND YIELD PREDICTIONS

Objectives and Users

Probably all of the early yield models were developed for a very limited set of timber management objectives, specifically to help regulate the cut, set rotation length, and estimate forest values. Today, we have a greatly expanded set of objectives, and a broad spectrum of potential users. Objectives may range from long-range ecological studies of forest succession on a regional basis over a rotation or longer, to a short-range economic evaluation of a given cultural practice applied to a specific woodlot or timber stand. So there is a need for both long- and short-term projections, and projections that apply to specific individual stands, forests, regions, or to the forest situation nationwide.

The intended use of the information often differs at each level in the organization. For example, information at the national level may be useful in setting agency policy, developing national goals, both long and short range, and developing broad action programs. The forester on the ground may be trying to choose the cultural practice that will best apply to his specific stand in obtaining the best volume or economic response. At the regional level, forest planners may use projections in analytical studies to derive optimal decision rules, develop management guidelines, or update regional inventory statistics. Obviously, the accuracy of estimates and amount of detail required will vary greatly for these different objectives. More precise and detailed estimates usually are required by the field forester for a specific stand.

I believe that growth and yield predictions will soon be recognized as useful or even necessary in nearly every aspect of forest management. I am speaking of forest activities that are used to manipulate the timber cover for other purposes, such as watershed, recreation, or wildlife benefits. Projections of tree growth is certainly one of the needed tools for examining trade-offs between timber and water, or timber and any of the other forest

commodities. Silviculturists are aware of the need and utility of growth projections for timber management activities. But they also need to know the effect of other forest activities on the timber resource.

Choosing a Specific Model

For Eastern hardwoods there usually is little choice in selecting among existing growth and yield models. At the present time, there are simply not many available; for some hardwood types there may be none. Where choices exist, there are a few factors to consider in selecting among models.

1. Objective or intended use
2. Data requirements (input)
3. Level of detail (output)
4. Cost efficiency
5. Accuracy of model estimates
6. Potential loss in relation to error

Because of these factors and the wide range of user objectives, no one model will ever best serve the interests of all users. One probably should select the model that will accomplish the intended task at the least cost. The bibliography by Dudek and Ek (1980) is a good reference for individual tree models. The most recent list of the types of computer growth models available in the United States was compiled in 1980 by Trimble and Shrimmer for the Oak Ridge National Laboratory.³

SPECIAL PROBLEMS OF HARDWOOD STANDS

Complex Ecosystem

Eastern hardwood stands are extremely complex ecosystems and this complexity magnifies the mensurational problems in developing suitable models. There are more than 50 major broad-leaved species plus a large number of minor tree and shrub species, each with its own site requirements and silvical characteristics. Typical stands contain several to many different species or species groups that vary widely in growth rate and quality characteristics.

Product, Quality, and Value

Eastern hardwoods produce many types of specialty products that are related to specific quality characteristics and species. Timber products range from low-value wood fiber for pulp or fuelwood to extremely high-price veneer for paneling or fine furniture. Different grading rules or other criteria of quality may apply because specifications often vary for each type of potential product. For example, white oak may be used for pulp or fuelwood, ties and timbers, factory lumber, bourbon staves, or veneer. Because

³Personal communication with Judy Trimble, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

of this diversity of product and quality characteristics, the relative price differential differs greatly within and between species. If our objective is to evaluate alternative treatments, we must somehow account not only for the response in quantity but also for the potential change in quality, product, and value. It may be that only a few veneer-quality trees per acre of walnut, cherry, or white oak more than exceed the value of all remaining trees.

MODEL COMPONENTS

Conceptually, the components needed to simulate growth and yield over time are quite simple. The three basic components of stand dynamics are (1) survivor volume growth, (2) mortality volume, and (3) ingrowth or regeneration. The status or change of each of these components is controlled by a number of growth factors. The more important ones might include age, species, site quality, structure that may be changed through thinnings, and some measure of stocking or competition. As forest managers we are primarily interested in how and to what degree stand components change when certain growth modifying factors are applied or occur. These growth modifying factors result from both timber management practices and environmental influences. Intermediate stand treatments, site preparation, fertilization, and planting improved genetic stock are examples of timber practices that modify potential growth. Environmental influences that modify growth might include climatic variation, air pollution, or insect and disease attack.

For individual-tree models, the same basic components are computed by summing the change in dimensions or status of each tree in the stand. Volume change of each tree can be computed from changes in tree height, form, and diameter. Individual-tree simulators are more flexible and easier to change if each of the components or subcomponents are described by individual computer subroutines. For example, if better height prediction equations, volume equations, or diameter growth equations are developed later, they can easily be incorporated into the system.

FUTURE TREND FOR HARDWOOD MODELS

I expect to see particular emphasis placed on distance independent individual-tree models in all forest types, especially in the Eastern hardwoods. These models seem to offer the most logical approach for providing the detailed information needed for many objectives. They have the flexibility for handling stands of mixed species, the size and quality class distribution, even or uneven-age conditions, and various types of silvicultural treatment.

Future models probably will be based primarily on various forms of non-linear equations, and model parameters will be estimated using various estimation techniques. It would certainly not be wise in such a rapidly evolving field to adopt one universal model form for all types of application. I expect to see more models to choose from so that we can better match model capability with intended objectives.

Future models will likely provide mechanisms for adjusting model parameters to provide stand specific estimates. Stand inventory data that sample past growth performance could be used to alter model parameters in a manner similar to Stage's (1973) prognosis model.

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MANAGING LOW QUALITY HARDWOOD STANDS

by

Charles E. McGee^{1/}

For many years hardwood managers and researchers have concentrated their silvicultural efforts on good hardwood stands. Low quality hardwood stands, on the other hand, have not received much attention. There have been logical reasons for assigning first priority to good hardwood stands. But every district in the East has some low quality stands, and the aggressive management of these stands offers a great opportunity for improving forest productivity and diversity. This paper reviews management options and suggests an approach for improving low quality hardwood stands.

Identifying the problem is easy -- we all can recognize poor quality stands. Discovering the cause of the low quality is much more difficult. The quality of the site is an important key to management, but the accurate determination of site index from low quality trees is difficult. Because of these and other problems many managers lump their low quality hardwood stands into one management unit and prescribe treatment for them as a group. But if each stand is considered separately, management options can be devised that will produce great improvement while minimizing the chance for costly silvicultural mistakes.

^{1/}Principal Silviculturist at the Sewanee Silviculture Laboratory, maintained at Sewanee, Tennessee, by the Southern Forest Experiment Station, Forest Service--USDA, in cooperation with the University of the South.

Most foresters are reasonably well acquainted with the treatments available for low quality stands. But few will recognize the following shopping list of options. That the list is a facsimile of an old-fashioned dance card is purely coincidental.

1. The hardwood shuffle.
2. The upland two-step.
3. The wallflower syndrome.
4. Cutting in and cutting out.
5. The woodchopper's bawl.

I will describe these options in detail later. First we need to define a low quality stand. Simply put, a low quality stand is one with many culls and poor trees, or with inadequate acceptable growing stock.

Recognizing why a stand is low quality is important. Some stands are poor because of past management practices, some are poor because of repeated fires, and some are poor because of poor site quality. Sometimes these factors combine to produce low quality stands, which without positive action will have very slow rates of improvement.

Many stands are low quality today because of past cutting practices. Signs of recent cutting are usually easy to see, but cuttings carried out 20 years ago or more are hard to recognize. Yet these old cuttings can affect species composition, density, and general health of stands we see today.

Similarly the effects of recent fires are relatively easy to evaluate, but many trees carry scars caused by fires that occurred decades ago. I suspect that most of the culls present today have some sort of fire history.

Some stands are low quality because the site is too poor to grow good hardwood. But most sites given proper care and treatment will grow at least a few good trees. Quite often we make a serious mistake by assuming that a stand is poor because of site quality when, in fact, the site is capable of producing a good stand. Hardwood stands on good sites that have been high-graded and burned several times look like stands grown on poor sites, so we're tempted to lump them all into one management group. Yet site index in these areas can vary 20 points or more - a site-55 cutover stand can look much like a site-70 cutover stand.

So determining site quality of low quality stands is a good way to begin in deciding how to manage that stand. I have been pleased in recent years to see more management decisions on the National Forests based on site index. Unfortunately, proper methods are not always used to determine site index. In some cases only one or two trees have been used to establish site index of large tracts of diverse land. Such determinations are questionable at best and give an impression of preciseness that can lead to serious mistakes. But accurately determining site index from low quality stands is often impossible, because they do not usually reflect true site potential.

Rather than using stunted, overtopped, or culled trees as indicators we should turn to other methods. Many districts now have up-to-date soil maps. Use them. Some areas have access to soil-site studies that will give site index in relation to easily measured soil and site variables. Use these. Recently Glen Smalley (1978, 1979) has developed a forest land evaluation guide based on landform. Smalley's guides are being developed for use independent of existing vegetation and will be especially helpful in low quality stands. One of his guides includes the Bankhead National Forest and another in preparation will cover parts of the Daniel Boone National Forest. Using all these procedures and observing the vigor of understory trees and the presence of indicator species will help the prescription writer to come to an adequate evaluation of site potential.

Okay, now we know we have a low quality stand. We know why it is low quality. And we know the site potential. Let's consider our management options.

We can solve some of our problems with low quality stands by converting to pine -- the hardwood shuffle. A decision to convert to pine should be based on multiple-use needs, economics, and site quality.

Many districts have large areas of adjacent low quality stands. If all these areas are converted to pine, multiple-use objectives may be hard to meet. But if pine conversion areas are properly selected they add much to the forest's diversity.

The cost of conversion and the general economic condition should be major considerations in pine conversion. Costs of \$150 per acre are routine, and \$200 per acre is not unusual. You can reduce costs by using more of the hardwood and killing less. Costs can be greatly lowered if we reduce our standards for success. Most of us are not happy unless we have 90 percent survival of 600-800 planted trees and have most of them free to grow. Perhaps we can spend less money and accept a less uniform plantation or even a pine-hardwood stand.

Site selection is important for successful conversion. I have seen some terrible mistakes where attempts to convert high-site-index land to pine resulted in a new stand of hardwoods. Remember that low quality stands sometimes mask high quality sites. Similarly, money is sometimes wasted when sites too poor to produce a reasonable crop are planted. Each district should know what these limits are.

Almost every low quality hardwood stand is a candidate for the upland two-step. The upland two-step requires an intensive harvest and reasonable control of unmerchantable trees; it results in natural regeneration. Almost every low quality hardwood stand can benefit from a heavy harvest preceded or followed by injecting or lopping of unmerchantable stems. Many of our problems with low quality stands can be solved by the two-step approach. The key to a successful two-step operation is the intensive harvest. A good harvest means few trees left to control.

The results of a regeneration cut will depend mostly on why the stand is low quality. After being clearcut, a high-graded stand on a good site will often produce a broad species mix from stump sprouts, seedlings, and seed. But a low quality stand fully stocked with large trees will rely more on seed and may come back heavily to yellow-poplar, ash, etc., depending on site quality.

The third option for handling low quality stands is the wallflower syndrome -- the low quality stand is ignored. We justify this option by a generous classification of LIM lands, noncommercial zones, squirrel habitat areas, etc. Sometimes we decide that road construction is going to cost more than the timber is worth so we decide to wait another 10 years. The low quality timber grows a bit, but road costs go up so we continue to ignore large acreages of low quality stands. Of course, in some cases doing nothing may be the best management.

The fourth option is cutting in and cutting out. This includes such well-known vices as high-grading and logger's choice. We no longer see the deliberate use of these two procedures on the National Forests. But we do see similar conditions resulting from diameter limit cuts, some deferred removal cuts, occasional "selection" harvests, and other partial cuts. Low quality stands almost beg for some form of partial cut because of the make-up of the stands. Usually the only trees in the stand that can be sold for sawtimber are the best trees. So, if a partial cut is made, the best trees are removed and the poorer trees are left. Occasionally, some form of high-grading may be the best treatment. But when we high-grade a low quality stand we are perpetuating an undesirable situation and postponing the solution to the problem.

The final option has been named the woodchopper's bawl because this option includes those activities likely to squeeze a logger's profit margin. Included are thinnings, improvement cuts, sanitation cuts, and a new untested technique called sparse-stand retention.

Thinnings and improvement cuts are often useful in well stocked good stands. Such practices can be helpful in low quality stands but can be hard to administer; and many so-called improvement cuts become just another high-grading. Prescription writers are now recognizing this problem and usually prescribe instead a complete harvest with either conversion to pine or natural regeneration as the silvicultural goal. These are reasonable options. But there may be another option: the reverse of high-grading -- we can call it sparse-stand retention.

Most low quality hardwood stands have some good trees that are not yet mature and could, in the next 10 to 20 years, increase in size, quality, and value. Usually, the total basal area of these acceptable-growing-stock trees is by traditional standards quite low. I have surveyed several low quality stands in recent months; many contain only 20 to 40 square feet of acceptable basal area per acre. These trees are surrounded by culls, low quality trees, sometimes a few good mature trees, and a second story of tolerant undesirable trees. I suggest leaving the 20 to 40 square feet of acceptable basal area and harvesting or controlling the rest. In effect, this treatment creates a sparse medium-to-good quality stand from a fully stocked low quality stand. Obviously, there are harvesting problems associated with such a procedure. First consider the advantages.

Martin Dale (1972) in his growth and yield predictions suggests that: if a 70-year-old stand growing on site 65 is cut to basal area 20 and the residual board foot volume is about 2000 feet, then the stand will produce an additional 2000 board feet in the next 10 years. So from an investment of 2000 board feet we double our yield in 10 years. But many low quality stands cut back to 20 square feet will not contain 2000 board feet, though I suspect the growth will be comparable. A new supply of logs would be produced in 10 years.

With clearcutting, some delayed action and sparse-stand retention a large acreage of low quality hardwood could be diversified readily. In such sparse stands, regeneration will begin. While its development will not be as fast as in a complete clearcut, the regeneration will probably be good. In fact, a sparse stand might encourage more oak regeneration than a traditional clearcut would. But regeneration development may depend on how the middle story and understory are handled.

So, if a stand is mainly low quality and the few good trees are to be retained, how do you get rid of the rest? The answer to this problem will vary by location, and some locations may not have an easy solution.

A general rule would be to harvest and use as much of the material as possible. If an adjacent area is to be clearcut, the harvest of the sparse stand could be lumped with the clearcut. Sometimes a firewood harvest may also be practical and useful. But many situations may call for some lopping and injection; though, if the area had been clearcut, the lopping and injection would have been performed anyway. The lopping and injection could be postponed until the final harvest in 10 years or so, but the postponement of control procedures will undoubtedly interfere with the development of regeneration.

I'm not suggesting that sparse-stand retention be used as a replacement for complete clearcutting; but it could be tested with traditional even-aged practices. The procedure would have greatest advantage where diversification was needed and where a sustained supply of logs was important during the next 10 to 20 years.

For a while into the future, low quality hardwood stands will make up a part of eastern National Forests. The management of these stands will require both an understanding of why each individual stand is low quality and an adequate appraisal of site quality. The quality of the site, multiple use needs, and existing economic conditions will dictate what is practical for a particular stand. In a given situation the best decision may be to convert to pine, regenerate naturally to hardwoods, perform an intermediate cut, or postpone action until a future date. More research and practical experience is needed to keep the costs of management in line with the potential productivity of low quality stands.

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HARDWOOD TREE PLANTING

by

Robert D. Williams

Principal Silviculturist

North Central Forest Experiment Station

Bedford, Indiana

INTRODUCTION

In Indiana, hardwoods were favored in early attempts to establish trees on abandoned farmland. On the first State forest in Indiana, hardwoods were direct seeded in the fall of both 1904 and 1905. According to the 1905 annual report of the Indiana Board of Forestry, "Seeds of white, red, bur, and chestnut oaks, American chestnut, black walnut, small and large shellbark hickories, buckeye, sugar maple, sycamore, hackberry, catalpa speciosa, red cedar, sweet gum, and black locust were secured for both field and nursery planting this fall and next spring" (Freeman 1905).

From the same report we continue, "The rodents worked havoc in all the fields bordered by woodlands, especially the parts next to the woodlands. Persons not familiar with the depredations can scarcely be made to believe the extent of such damage. There are, however, thousands of young seedlings of all the best commercial species of the oaks, besides American chestnut, black locust, Kentucky coffee tree, American ash, Texas pecan, English walnut, wild cherry, and catalpa speciosa growing in the nursery which in the course of another year or so will be large enough to begin transplanting in such places as vacancies occur in seed growth. Seeds of all kinds are also being put in storage to be used in transplanting next spring" (Freeman 1905).

At first, land managers planted hardwoods because they knew more about them than conifers. But many of the hardwood plantations failed because of insufficient knowledge of site requirements, poor planting stock, lack of rodent control, inappropriate planting methods, and inadequate control of competing vegetation.

We now know that hardwood plantations are more difficult to establish than conifer plantations. So why plant hardwoods? Some good reasons are:

- To control or modify species composition.
- To prepare for future intensification of hardwood silviculture.
- To realize the benefits from tree improvement work.
- To prevent shortages.
- To estimate with some precision the costs for raw material in the future.
- To obtain adequate stocking of preferred species in a reasonable time.

From 75 years' experience in Indiana, here are the best recommendations, to date, for establishing hardwood plantations that have a good chance to survive and grow:

1. Select good planting sites and match the species to the site.
2. Prepare the site--in some cases plowing and disking may be necessary--and control competing vegetation for at least 2 years.
3. Carefully plant sturdy, healthy stock.
4. Control mammals such as cattle, rabbits, mice, and deer that might damage the planted trees.

Now let's look at these recommendations in more detail.

SITE SELECTION

Most hardwoods are very exacting in their site requirements. Good hardwood sites have deep, moist, well-drained soil and are generally found along streams, on lower north and east slopes, and in coves. The grower should determine the site's soil texture, soil depth, soil drainage, and general fertility before deciding which species to plant. In 1975, planting charts were published for Illinois showing species recommendations by soil site characteristics (Casey et al. 1975).

Stream bottoms, especially narrow ones, are not always good sites because they may have soils with layers of gravel or chert. These soils are usually excessively drained, droughty, and not suitable for hardwoods.

SITE PREPARATION

Adequate site preparation and at least 2 years of weed control are necessary to get hardwood plantings off to a good start. Sites may be prepared by plowing and discing, by chemicals, or by a combination of the two methods. The choice will depend upon topography, accessibility, kind of soil, density and composition of existing cover, and the cost of the various methods.

Each tree species has its own herbicide tolerance at various stages of growth; this tolerance is modified by the texture, organic content, and moisture of the soil (Williams and Krajicek 1976). For black walnut, one good method is to spray strips with glyphosate in the fall to kill existing vegetation and then apply simazine the following spring either before or after planting.

If an old field planting site is too poor to support the hardwood species desired, the site may be improved by planting a short rotation crop such as pine or locust for fence posts (Carmean et al. 1976).

Fertilization has seldom improved survival or growth and is too expensive to apply at planting time and carry at compound interest until harvest (Phares 1969). At 8-percent interest, a \$1 investment in fertilizer would have to increase production value \$46 to break even after a 50-year rotation. It is best to choose a site that is fertile enough to support the species to be planted (Phares 1969).

PLANTING

Planting Stock

Although hardwoods may be established by direct seeding most plantations are established by a more consistent method--planting nursery-grown seedlings.

Direct seeding has advantages: (1) it leads to the development of a natural root system which is especially important for taprooted species such as black walnut and the oaks, (2) it eliminates planting injuries, and (3) it's inexpensive. The main disadvantage is the uncertainty of establishment, caused by rodent pilferage of seed and poor germination of apparently good seed. These difficulties may be overcome to some extent by planting germinated seed in the spring after other food is available for rodents. Direct-seeded walnut and oaks may be further protected by using the tin can method or by covering the seedspots with cow manure (Williams and Funk 1979). Even so, most tree planters prefer to plant nursery-grown seedlings.

Seedling quality is difficult to define. Seedling grades based on diameter measured 1 inch above the root collar were published by Limstrom (1963). To find out if there was more to quality than seedling size, we collected walnut seed in five states and sowed it at nurseries in Indiana, Tennessee, and Georgia (Rink et al. 1981).^{1/} Now, seven years after the seedlings were outplanted, we have concluded that seed source and planting site have a great effect on seedling performance. To provide good plantable hardwood seedlings, nurserymen should cull the damaged seedlings and 10 percent of their smallest seedlings for each species. Acceptable minimum size for each species would vary by the nursery producing the seedlings. Large seedlings are needed for some plantings. For example, paper companies planting sweetgum and cottonwood in southern riverbottoms, where weeds are to be controlled by machine cultivation, need big seedlings so the operator can see the seedlings. Small oak seedlings have little potential for rapid shoot growth (Johnson 1979). Large seedlings are required to provide the necessary carbohydrate reserves for initiating adequate root, shoot, and leaf area development.

Bey (1980) has shown that black walnut seedlings from seed collected up to 150 miles south of the planting site will grow faster than seedlings from seed collected locally. But for other species, local seed sources should be used until research shows that other seed sources provide better survival or growth.

^{1/}Rink, George, D. T. Funk, R. D. Williams, T. E. Russell, and W. Lemmien. 1981. The effects of nursery environment and provenance on 5- and 7-year survival and growth of black walnut. Unpublished manuscript on file at Carbondale, Illinois.

Other factors that affect seedling quality are:

1. Seed quality.
2. Seedling physiological condition when planted.
 - a. Lifting date for overwinter storage.
 - b. Storage methods--temperature, packing method, species.

Prolonging seed storage requires continued research. Choice of species available for planting is often governed by the seed available for sowing. Often seed is not available from preferred sources of black walnut, white oak, or white ash. So the nurseryman needs reliable long-term storage methods for the popular species.

Nurserymen have usually lifted seedlings in the fall for overwinter storage after leaf fall, after the first frost, after a hard killing frost, or after a certain number of frosts. A standard, quantifiable measure of cold hardiness, such as Ferguson et al. (1975) developed for conifers in the West, would be very helpful. We have tried instruments that measure electrical properties of the seedling stem tissue to determine when seedlings are sufficiently hardened-off for lifting (Rietveld and Williams 1978, 1979). But all methods tried have problems, and it seems questionable whether a simple, reliable instrumental method can be developed to determine a safe lifting time.

In the meantime, we have concluded that it is safe to lift walnut for overwinter storage 1 month after seedlings lose their leaves (Rietveld and Williams 1981).

Root regeneration potential (RRP) of fall-lifted and stored black walnut seedlings has been correlated with lifting date, root starch content, amount of chilling, days to bud burst, and total shoot elongation (Rietveld and Williams 1981). RRP is a good measure of physiological seedling quality but it's laborious and impossible to measure before planting time. Webb and von Althen (1980) have reported that shoot xylem water potential is correlated with RRP of hardwood seedlings at the time of removal from storage. It appears promising as a rapid measure of physiological seedling quality.

Fall-lifted and stored black walnut seedlings must be chilled at least 3,100 hours at 3°C before growth will resume. This long chilling requirement is the reason RRP is not a convenient measure of physiological seedling quality. Under greenhouse conditions, root growth is strongly related to shoot growth, so seedlings with rapidly elongating shoots can also be expected to have expanding root systems. We found that seedlings lifted in early fall had reduced vigor after overwinter storage. Although seedlings lifted earlier than November received more total chilling in storage than seedlings lifted later, their RRP when planted in the spring was much lower. The seedlings lacked vigor because they were not sufficiently developed and cold-hardened to withstand lifting and cold storage.

Root starch concentration is an important, easily measured characteristic of seedling quality (Wargo 1975). The concentration of root starch in black walnut seedlings at time of planting is correlated with field survival and growth (Rietveld et al. 1981). It would be desirable to routinely measure root starch concentration at lifting time and after storage to refine growing and storage methods and to establish grading standards.

Most root growth of sugar maple occurs in the spring, soon after the soil thaws, and then activity decreases during shoot extension and the drier summer months. Additional root growth occurs from September to early December. Sugar maple produced new white roots while heeled-in outdoors and the soil temperature remained below 5°C. This occurred 6 to 8 weeks before budbreak. Thus, by the time sugar maple seedlings are planted in the spring, they might already have produced new roots in the seedbed or heeling-in bed. This loss of essential new roots at time of lifting and planting may interfere with seedling development, forcing emphasis on root growth when the seedling is programmed for shoot growth.

Planting of container-grown stock is another method being tried to improve survival and growth. The objective of containerization is to plant seedlings with intact, undisturbed root systems to minimize transplant shock. Containerization arrests the development of the taproot and stimulates the formation of lateral roots by "air pruning" roots that emerge in an air space provided beneath the open bottom container. The result is a compact fibrous root or "plug" that contains many root tips from which new roots may be regenerated.

Spacing in hardwood plantations should be wide enough to allow for early cultural practices but close enough to allow for crop tree selection. Because tree growth is correlated with effective crown area, a tree with a large crown will grow faster in diameter than a small-crowned tree. Tree crowns should never be allowed to touch.

Mycorrhizae

Like most foresters involved in tree planting, we believe that the presence of mycorrhizae improves the survival and growth of planted trees. Mycorrhizal roots increase the effective absorptive capacity of planted trees. Different hardwood species form symbiotic relationships with different mycorrhizal species. Some hardwoods, such as black walnut, yellow poplar, maple, sycamore, ash, and sweetgum, have endomycorrhizae; others, such as the oaks, beech, alder, and hickories, have ectomycorrhizae. We need to find the best mycorrhiza for each species and possibly for different planting sites.

Although the mycorrhizal research for hardwood planting is not as far advanced as that of conifers, the successes of the conifer work are encouraging to those interested in planting hardwoods.

Planting Techniques

Optimum planting time will vary by latitude and winter temperatures. Fall planting is effective and recommended where frost-heaving is not a problem. Where frost-heaving is possible, trees should be planted in the spring before any new growth occurs.

Some common planting rules are:

1. Make the planting hole deep enough to receive all of the root.
2. Do not tangle or twist the fibrous roots.
3. Pack the soil firmly around seedling roots.
4. Do not plant when the soil is too wet.
5. Do not plant when there is snow on the ground. Melting snow in the planting hole leaves an air space.
6. Plant seedlings in an upright position.

Some planting implements have unique requirements:

1. Planting bar--make the hole wide enough and deep enough. Make sure the hole is closed around the seedling from top to bottom.
2. Auger--if an auger is used in wet heavy soil, the walls of the hole may become "plastered" and not allow the roots to penetrate outside the augered hole. Soil must be tamped around the seedling as the hole is filled.
3. Planting machine--special planters that do not "ride over" the planted seedlings are required. Get seedling at proper depth to prevent L-shaped roots. Workers should follow a planting machine to straighten and tamp soil around seedlings.

Interplanting

Black walnut trees grow faster when interplanted with nitrogen-fixing trees and shrubs (Clark and Williams 1979). Interplanting may increase growth rate of other species too. Some other advantages are:

1. Interplanting avoids monoculture.
2. Interplanted trees "train" the crop trees and may be removed at any time to allow the crop trees to develop.
3. Interplanted trees may be harvested early in the rotation, thus reducing establishment costs that must be carried.

Two potential disadvantages are:

1. The interplanted trees may not be compatible with the crop tree. For example, yellow poplar grows too fast and overtops planted black walnut.
2. An interplanted tree may spread too easily. Autumn-olive increases the growth of black walnut but birds spread the seed widely.

MAMMAL CONTROL

Fences will keep livestock out, but not deer. Planters in Michigan claim that "Hinder",^{2/} a new repellent, has prevented browse damage to their plantations. We are using Hinder with a sticker-spreader in a new walnut planting this year but so far the deer and rabbits have ignored our efforts.

It's easier to reduce damage by field mice by simply controlling the vegetation around the planted trees.

CONCLUSION

Hardwood planting is more popular now than ever. In the Northeastern Area, 25 percent of the seedlings produced in State nurseries are hardwoods (Casey 1981).^{3/} And in the Southeastern Area, 10 million hardwood seedlings were planted last year (Lantz 1977). Black locust was the most popular species, followed by sycamore, cottonwood, eucalyptus, sweetgum, yellow poplar, and ash.

Every State in the Northeastern and Southeastern State and Private Forestry Areas has tree improvement foresters on staff or has access to a geneticist at the State university. Nine of the 13 States in the SE Area belong to hardwood tree improvement cooperatives.

^{2/}Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.

^{3/}Casey, Lloyd. 1981. Personal communication. State and Private Forestry in Broomall, Pennsylvania.

Hardwood planting has experienced ups and downs since the turn of the century. However, as we learn more about how to match species to sites, how to take advantage of mycorrhizal relationships, how to assess and quantify planting stock quality, and how to interplant nitrogen-fixing species to boost growth, tree growers will become more confident and may plant even more hardwoods.

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1 TENDING YOUNG NORTHERN HARDWOOD STANDS

2 (Stocking Levels)

3 by Gayne G. Erdmann and Richard M. Godman^{1/}

4 ^{1/}Research Foresters, North Central Forest Experiment Station, USDA For.
5 Serv., Marquette, MI.

6 INTRODUCTION

7 There are 10 million acres of northern hardwood forests in the Lake States.
8 Ninety percent of these forests are in predominantly pole-size second-growth
9 stands under 80 years of age. Most of these stands originated after commercial
10 clearcutting or heavy partial cutting of old growth stands and became
11 established under essentially shelterwood conditions. Consequently, they tend
12 to be even-aged with a scattering of older residual trees. Most second-growth
13 stands contain a mixture of species with extreme differences in tolerance.

14 Sugar maple (Acer saccharum Marsh.) is the most abundant species on
15 well-drained sites. It is the major component of the Sugar Maple Type (27),
16 Sugar-Beech-Yellow Birch Type (25), and the Sugar Maple-Basswood Type (26) in
17 the Lake States (Eyre 1980).

18 Red maple (Acer rubrum L.) is the second most important northern hardwood
19 species in the Upper Peninsula of Michigan in terms of growing stock volume.
20 The types in which it occurs--the Red Maple Type (108) and the Black
21 Ash-American Elm-Red Maple Type (39)--are expanding faster than others due to
22 natural plant succession. Red maple grows in almost pure stands on moist soils,
23 along swamp borders, and ridgetops, and in mixed stands on dry sandy upland
24 soils.

1 Yellow birch (Betula alleghaniensis Britton), our most valuable
2 northern hardwood species, occurs singly or in small pure groups with other
3 species. It is a major component of the Hemlock-Yellow Birch Type (24) and
4 the Sugar Maple-Beech-Yellow Birch Type (25) in the Lake States. Yellow
5 birch in decreasing in both growing stock volume and quality. Overcutting
6 and slow growth in unmanaged stands have caused serious sawtimber shortages
7 and uncertainty about future supplies.

8 A major problem facing land managers today is how to bring these
9 second-growth stands under management. They can be managed either under
10 all-aged (uneven-aged) or even-aged silviculture.

11 ALL-AGE SILVICULTURE

12 The structure and stocking recommended by Eyre and Zillgitt (1953) for
13 sustained growth and yield of sugar maple has been verified in a replicated
14 study by Crow and others (1981). Their results in old growth stands
15 suggest an average annual net basal area growth of about 2 sq ft/acre/year
16 and about 66 cu ft/acre/year for all trees 4.6 inches d.b.h. and larger
17 under optimum conditions, and between 260 and 270 net board feet/year for
18 saw log-size trees after the first 5 years' adjustment period.

19 Results of a cutting method study in Wisconsin indicate that
20 40-year-old second growth stands on good sites ($SI_{50}=65$) can be converted
21 to uneven-aged stands with desirable structure and stocking after 3
22 selection cuts at 10-year intervals.

23 Results from this study suggest that yields averaging over 300 board
24 feet per acre per year are possible under uneven-aged management. Over the
25 15-year study period average annual net Scribner board-foot growth was
26 significantly greater (almost 100 bd ft/acre/year more) on the 90 and 75 sq
27 ft of residual basal area selection cuttings than the 60 sq ft treatment.

1 Diameter growth rates varies by species. Basswood and white ash trees
2 are usually in the upper crown classes and grow faster than sugar maple.
3 Yellow birch is normally the slowest growing hardwood species in
4 uneven-aged stand. In well managed stands growth rates of over 2.0 inches
5 in 10 years can be maintained on saw log-sized sugar maple trees after the
6 low-vigor overstory trees are harvested (fig. 1). This compares to about
7 1.0 inches in 10 years for unmanaged stands.

8 Figure 1.--Relation of mean annual d.b.h. growth of pole- and saw log-sized
9 trees to beginning basal area per acre (all trees 4.6 inches d.b.h. and
10 larger, site index 65 at age 50 for sugar maple).

11 Figure 2 shows that annual net basal area growth for all trees 4.6
12 inches d.b.h. and larger in second-growth stands exceeds 3 square feet per
13 acre per year between 20 and 70 square feet of residual basal area (Erdmann
14 and Oberg 1973). Ingrowth becomes more important at lower residual stand
15 densities. Most of the ingrowth (87 percent) is sugar maple. Mortality is
16 not an important factor in managed stands.

17 Figure 2.--Relation of periodic annual gross and net basal area growth,
18 survivor growth, ingrowth, and mortality to beginning basal area per acre
19 (all trees 4.6 inches d.b.h. and larger, site index 65 at age 50 for sugar
20 maple).

1 Net cubic-foot volume growth and cordwood volume growth also did not
2 vary greatly within a wide range of residual stand densities (Figs. 3 and
3 4). This agrees with previous work on stand basal area and cubic foot
4 volume growth by Spurr 1952, Moller 1954, and Jacobs 1969.

5 Figure 3.--Relation of periodic annual gross and net cubic-feet volume
6 growth to beginning basal area per acre (all trees 4.6 inches d.b.h. and
7 larger, site index 65 at age 50 for sugar maple).

8 Figure 4.--Relation of annual net cordwood production in pulpwood and
9 saw log-sized trees to beginning area per acre (all trees 4.6 inches d.b.h.
10 and larger, site index 65 at age 50 for sugar maple).

11 For best growth and quality development, researchers from both the
12 Lake States and the northeast recommend leaving a residual stand containing
13 between 70 and 85 square feet per acre in trees 5 inches d.b.h. and larger
14 (Eyre and Zillgitt 1953, Arbogast 1957, Jacobs 1969, Leak et al. 1969).

1 Our data from 45 to 60-year-old second-growth stands indicates that at
2 least 50 square feet of basal area in saw log trees (9.6 inches d.b.h. and
3 larger) with not more than 60 square feet of pole trees (4.6 to 9.5 inches
4 d.b.h.) are required to yield 300 board feet (net Scribner) per acre
5 annually. Figure 5 shows the relation of periodic annual Scribner net
6 board-foot growth (Z) to beginning basal area in pole-sized trees (X) and
7 beginning basal area in saw log-sized trees (Y). This model indicates that
8 we as managers have great flexibility early in management for stimulating
9 individual tree growth rates to obtain the desired structure. This
10 structure can be attained faster by crown releasing 53 crop trees in
11 precommercial and commercial thinning operations. Stem quality is not
12 adversely affected as long as crowns close and lower branches die before
13 the next scheduled thinning. Tree quality improves with increasing stand
14 density (Godman and Books 1971) and with increasing site quality. Yields
15 of 3,000 board feet per acre can be harvested at 10-year intervals once the
16 desired structure is attained.

17 Figure 5.--Relation of periodic annual Scribner net board-foot growth (Z)
18 to beginning basal area of all trees 4.6 to 9.5 inches d.b.h. (X) and
19 beginning basal area of all trees 9.6 inches d.b.h. and larger (Y).

1 The first cut in second-growth stands generally is an improvement cut
2 which thins out the overstocked pole-size classes. From this stage of
3 stand development we can go to either uneven-aged or even-aged management
4 for sugar maple stands. We already have about 50 years of research and
5 experience in developing a usable uneven-age system of management for sugar
6 maple in the Lake States. From this research, sound uneven-aged management
7 guides have been prepared for tolerant hardwoods (Eyre and Zillgitt 1953,
8 Arbogast 1957, and Tubbs 1977). As a result, we are very comfortable with
9 the selection system for producing high quality yields of sugar maple
10 saw logs, but it is not well suited to producing high yields of less
11 tolerant species such as yellow birch, red maple, basswood (Tilia americana
12 L.) and white ash (Fraxinus americana L.). On the other hand, the
13 shelterwood method of regeneration cutting is a more reliable way to
14 regenerate the less tolerant species than the clearcutting and seed tree
15 methods.

16 EVEN-AGE SILVICULTURE

17 Cleanings

18 Cleanings, to improve the species composition of the final stand,
19 normally have not been carried out in northern hardwood stands due to the
20 long term nature of the investment. However, without early cultural
21 treatment, untended stands within 10 to 20 years usually contain about the
22 same proportion of yellow birch as the original stand, regardless of the
23 cutting method or site preparation treatment previously used.

1 Although yellow birch seedling survival, top, growth, and root
2 development for the first 2 or 3 years is best under partial shade on moist
3 sites (Godman and Krefting 1960), they cannot compete successfully with
4 advance regeneration, grass sod cover, and other herbaceous competition.
5 Sugar maple regeneration offers the stiffest competition in the sugar
6 maple-beech-yellow birch type while red maple sprouts are the most serious
7 problem on wetter sites. After about 5 years, yellow birch requires
8 overhead light, adequate crown expansion space, soil moisture, and
9 nutrients to compete with many of its faster growing associates. Logan
10 (1970) reported that the "photosynthetic apparatus" of 4-year-old seedlings
11 is poorly adapted to shade. Photosynthetic rates for seedlings grown in 13
12 percent of full sunlight are only 54 to 70 percent of those grown in full
13 sunlight and their dry weights are 66 percent lower.

14 Crop tree cleanings in a 7-year-old seedling stand in Upper Michigan
15 have demonstrated the benefits of early release (Erdmann et al. 1981).
16 Birches cleaned to a 2.4 m (8-foot) radius exhibited the best stem, crown,
17 and branch characteristics without corrective pruning. Over a 9-year
18 period they averaged 5.5 cm (2.1 inches) diameter growth and 7.2 m (23.6
19 feet) in height which was 2.1 cm (0.8 inches) greater in diameter and 0.5 m
20 (1.6 feet) taller than the controls. Trees cleaned more radically than
21 2.4 m (8 feet) need to be correctively pruned to correct forking and
22 eliminate large branches. To maintain this rapid growth trees should be
23 crown released about 6 to 7 years after cleaning.

24 Hannah (1974a) also suggests that yellow birch crop trees (1/2 to 1 inch
25 d.b.h.) should be released to increase height growth and diameter growth.
26 A Lake States study in similar size trees showed an average improvement of
27 11 percent in height growth for cleaned over uncleared trees after 9 years
28 (Erdmann et al. 1981).

1 Birches can be pruned to 50 percent of their height without reducing
2 growth (Skilling 1959). Pruning should be done on small fast-growing trees
3 to limit discoloration to a small core and keep decay organisms from
4 entering wounds. Wound closure in 5.1 to 7.9 cm (2.0 to 3.9 inches) yellow
5 birch is related to wound size and to the tree's diameter growth rate (Skilling
6 1959, Solomon and Blum 1977). Branches up to 5.1 cm (2.0 inches) in diameter
7 can be pruned flush without causing lumber defects. Most wounds up to 5.1
8 cm (2.0 inches) will close within 7 years.

9 No economic analysis was made in our cleaning study, but LaBonte and
10 Nash (1978) reported that the present value of a 24-year-old white birch
11 stand with twice as many cleaned and weeded crop trees as we are
12 recommending more than paid for the early investment.

13 Cleaning other northern hardwood species during the seedling and
14 sapling stages is still questionable. Growth rates of sugar maple can be
15 stimulated but it has to be released more lightly than yellow birch. A
16 1.8 m (6-foot) thinning radius seems best for sugar maple seedlings and
17 saplings.

18 As a general rule cleanings should not be considered in seedling
19 stands with less than 5,000 stems per acre or in small sapling stands with
20 fewer than 1,000 stems per acre.

21 Sprout origin red maple, basswood, and red oak stands can benefit from
22 early cleaning. Multiple clumps should be thinned to the one or two best
23 stems. Select to leave only sprouts with low unions. Favor seedling
24 origin stems and seedling sprouts over large stump sprouts.

1 Tending Trees from Saplings Size to Maturity

2 Crop tree release studies in yellow birch saplings (Godman and Marquis
3 1969, Hannah 1974a, Erdmann et al. 1975a, Hannah 1978), poles (Erdmann and
4 Peterson 1972), and small saw logs (Erdmann et al. 1975b) in the Lake
5 States and the northeast have shown that trees from 16 to 65 years of age
6 respond well to release (Table 1). Growth rates, however, gradually fall
7 off as trees become older.

8 The objectives in crown release are to: (1) improve or at least
9 maintain species composition, (2) increase d.b.h. growth, (3) improve
10 quality, and (4) shorten veneer and saw log rotations.

11 The emphasis is on freeing crowns to grow rather than on thinning from
12 below as is done in later stages of even-age management. The crowns of
13 selected crop trees are allowed to expand by cutting main canopy trees
14 whose crowns restrict growth.

15 In pole-size stands we generally try to free about 75 to 100 trees per
16 acre if striving for even-age management; 53 trees for uneven-age
17 management. In even-age management our final goal is to produce 75
18 veneer-quality 18-inch diameter crop trees per acre that fully utilize the
19 site at rotation age.

Table 1.--Average 10-year diameter growth rates for yellow birch crop
trees of three different size classes by crown release treatments
in the Lake States

Crown Release	Diameter growth per decade		
	16-year-old Saplings	40-year-old Poles	65-year-old Saw logs
	<u>Cm (Inches)</u>	<u>Cm (Inches)</u>	<u>Cm (Inches)</u>
Control	4.8 (1.9)	3.0 (1.2)	2.8 (1.1)
1-tree ^{1/}	--	--	3.6 (1.4)
2-tree ^{2/}	--	--	4.1 (1.6)
1.5 m (5-foot) ^{3/}	7.5 (2.7)	5.3 (2.1)	4.1 (1.6)
3.0 m (10-foot) ^{3/}	7.9 (3.1)	5.6 (2.2)	--
4.6 m (15 foot) ^{3/}	9.1 (3.6)	6.6 (2.6)	--

^{1/}The single most important crown competitor removed.

^{2/}Two most important crown competitors removed.

^{3/}All trees whose crowns were within the specified distance of the crop tree's crown perimeter were removed.

1 With crown release, yellow birch can maintain itself in a favorable
2 growing position and grow rapidly throughout its life. The greatest
3 response is in the sapling stage where growth rates can be increased up to
4 over 7.6 cm (3 inches) per decade by completely releasing dominant and
5 codominant crop tree crowns from all trees whose crowns are within 1.8 to 2.4 m
6 (6 to 8 feet) (Table 1). Results from a 16-year-old sapling study in Upper
7 Michigan indicate that even earlier treatments are required to increase the
8 proportion of yellow birch trees in final stands. Yellow birch generally
9 completes about 90 percent of seasonal growth in about 60 days in the
10 northeast and the Lake States (Kienholz 1941); growth is greater in the
11 open than under a dense canopy (Jacobs 1965). Shoot growth of yellow birch
12 is considered indeterminate (Marks 1975) and partly dependent upon current
13 photosynthate (Kozlowski and Clausen 1966). The shoot elongation period
14 for heavily released (1.5 m (5-feet) radius) saplings can be extended up to
15 30 days by making more light and moisture available to the saplings (Hannah
16 1974a). Experiments of Wang and Perry (1958) show that photoperiod exerts
17 the primary control over the continuation of shoot elongation and onset of
18 dormancy.

19 Generally, about 90 percent of the total radial increment for yellow
20 birch takes place from June to August (Clark and Baxter 1958). The
21 cessation of radial growth occurs about August 10 in Upper Michigan
22 (Gilbert 1965). Growth initiation is later and cessation is earlier in
23 suppressed trees than dominant and codominant trees (Winget and Kozlowski
24 1965).

1 Advance sugar maple growth, aspen, pin cherry, paper birch, and red
2 maple sprouts are the most aggressive competitors of yellow birch in the
3 Lake States and northeast sapling stands. Removal of competing vegetation
4 around crop trees increases the amount of water available to the saplings
5 at lower tensions when compared to unreleased birches (Hannah 1974b).
6 Release may have as much effect on root development and its subsequent
7 effect of growth rates as it has on reducing crown competition for
8 sunlight.

9 Sapling- and pole-size yellow birch trees prune themselves well as
10 long as crowns are allowed to close within 7 or 8 years after release.

11 Diameter growth rates of pole-size yellow birches 11.7 to 24.1 cm (4.6
12 to 9.5 inches) d.b.h. can be increased up to 78 percent by providing 1.8 to
13 2.4 m (6 to 8 feet) of growing space between crop tree crowns and
14 neighboring tree crowns (Godman and Marquis 1969, Erdmann and Peterson
15 1972). The increase in diameter growth after release is also related to
16 foliage density; trees with the largest and thickest crowns always grow
17 best. Dominant and codominant crop trees with well-developed crowns
18 respond best to release. Strong pole-size intermediates also respond to
19 release, but it is doubtful that they can grow fast enough to be part of
20 the final even-aged crop. Complete crown release provides adequate crown
21 and root expansion space for optimizing growth rate and quality development
22 in yellow birch. In practice no more than 247 well-spaced (5.5 m x 5.5 m)
23 crop trees per hectare (100 per acre) are released to produce 185 (45.7
24 cm) final harvest trees per hectare (75 per acre). Crop tree crowns are
25 normally freed only on three sides because adjacent tree crowns are often
26 left to correct a small fork. In yellow birch the number of live limbs
27 generally increases as residual stand density decreases, particularly in
28 the second log (Godman and Marquis 1969). Epicormic sprouting increases
29 with intensity of release (Erdmann and Peterson 1972).

1 Sprouting is usually more profuse just beneath the live crown than
2 further down the stem. In trees pole size and larger, sprouting is
3 significantly greater on second logs than butt logs. Epicormic sprouting
4 is not a serious problem in managed stands where periodic thinnings follow
5 crown closure and lower branch mortality.

6 Diameter growth rates of saw log-sized trees can also be increased by
7 about 45 percent by either removing two important crown competitors or by
8 providing 1.5 m (5-feet) of crown expansion space around crop trees. In
9 saw log stands diameter growth response to release gradually builds up over
10 about a 3-year period.

11 Results of three yellow birch fertilizer studies in a small saw
12 log-size stand in northeastern Wisconsin and two pole-size stands in Upper
13 Michigan are not promising (Erdmann et al. 1975b; Stone 1977). No positive
14 diameter growth responses to varying amounts and combinations of N, P, and
15 K broadcast fertilizer applications have occurred within 3 years of
16 treatment. Rates tested include: N at 112 kg/ha (100 lb/acre), elemental
17 nitrogen; NP each at 112 kg/ha, P_2O_5 ; NK each at 112 kg/ha, K_2O ; NPK each
18 at 112 kg/ha, and N at 336 kg/ha (300 lb/acre) plus PK each at 112 kg/ha.

1 Research indicates that the annual production of quality birch
2 products in the Lake States could be greatly increased through intensive
3 culture of natural stands. The most promising trees for future grade
4 improvement should be left after thinning or crown release. Yellow birch
5 trees are financially mature at 55.9 cm (22 inches) d.b.h. or about 45.7 cm
6 (18 inches) where surface defects limit improvement to top grades (Leak et
7 al. 1968). If crown released even-aged trees will maintain the rates of
8 growth we have experienced, it will take 87 years to produce a 45.7-cm
9 (18-inch)-diameter tree. This is 60 years less than it would take without
10 crown release.

11 STOCKING GUIDES TO USE

12 A residual even-aged stocking guide based on average stand diameter,
13 number of trees per acre, and acceptable range of basal areas for best
14 growth and quality development of yellow birch is presented in table 2.
15 This stocking guide is based on measurements of growth and quality
16 development of individual trees in three birch studies now in progress.

Table 2.--Tentative residual even-age stocking guide for
pole- and saw log-size yellow birch trees
growing on good sites (site index 60+)^{1/}

<u>Average^{2/}</u> <u>stand</u> <u>D.B.H.</u>	<u>Trees</u>	<u>Average</u> <u>spacing</u>	<u>Residual</u> <u>basal area</u> <u>per acre</u>
<u>Inches</u>	<u>Number</u>	<u>Feet</u>	<u>Square feet</u>
4	521-625	9	45-55
5	365-437	10	50-60
6	290-340	12	57-67
7	235-273	13	63-73
8	200-229	14	70-80
9	180-202	15	79-89
10	156-174	16	85-95
11	138-153	17	91-101
12	125-138	18	98-108
13	111-122	19	102-112
14	98-108	21	105-115
15	90-98	22	110-120
16	80-87	23	112-122
17	77-83	23	121-131
18	72-78	24	128-138

^{1/}Figures are based on measurements of growth and quality development of individual trees in several birch studies in progress.

^{2/}Average d.b.h. of all trees 4.6 inches and larger except for the 4.0-inch class which includes all trees 0.6 inches and larger.

1 Other even-aged stocking guides have been developed for mixed northern
2 hardwood stands in the Lake States (Tubbs 1977) and the Northeast (Solomon
3 and Leak 1969, Leak et al. 1969). Separate guides were developed for three
4 different northern hardwood species groups in the Lake States (Tubbs 1977).
5 They are for typical northern hardwood stands containing mixtures of
6 wide-crowned species such as sugar maple, yellow birch, white ash, red
7 maple and red oak (Quercus rubra L.) and for those containing 20 percent or
8 more of either basswood or hemlock because of large differences in crown
9 diameter-stem diameter ratios. These stocking guides are based upon the
10 number of trees and basal areas per acre for stands by 2-inch average stand
11 diameter classes. These guides apply to all trees 4.6 inches d.b.h. and
12 larger and allow basal area stocking to increase with increases in average
13 stand diameter. Figure 6 is for typical northern hardwoods. The Lake
14 States guides, unlike the Northeast guide, do not have an "A" curve
15 representing 100 percent or full stocking, a single "B" curve representing
16 minimum stocking for full site utilization, or a "C" curve representing the
17 minimum stocking required for a stand to reach full site utilization within
18 a 10 year period on medium sites. The Lake States guides do, however, have
19 three "B" curves which represent average, maximum, and minimum residual
20 stocking levels based on actual residual stand diameter levels. The
21 average curve represents the best compromise between growth and quality
22 development.

23 Figure 6.--Stocking levels for northern hardwood stands containing less
24 than 20 percent conifers of basswood by basal area, and number of trees
25 per acre for specified diameter classes.

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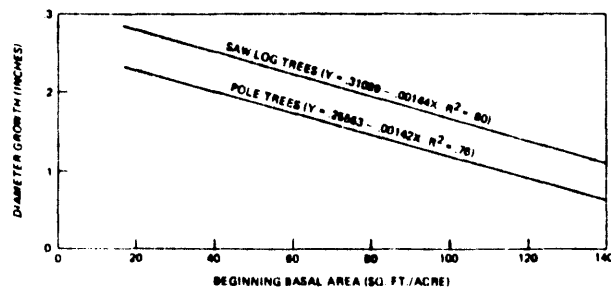


Figure 1.--Relation of mean annual d.b.h. growth of pole- and saw-log-sized trees to beginning basal area per acre (all trees 4.6 inches d.b.h. and larger, site index 65 at age 50 for sugar maple).

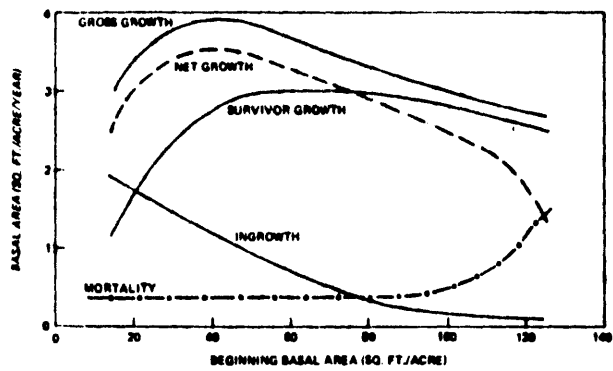


Figure 2.--Relation of periodic annual gross and net basal area growth, survivor growth, ingrowth, and mortality to beginning basal area per acre (all trees 4.6 inches d.b.h. and larger, site index 65 at age 50 for sugar maple).

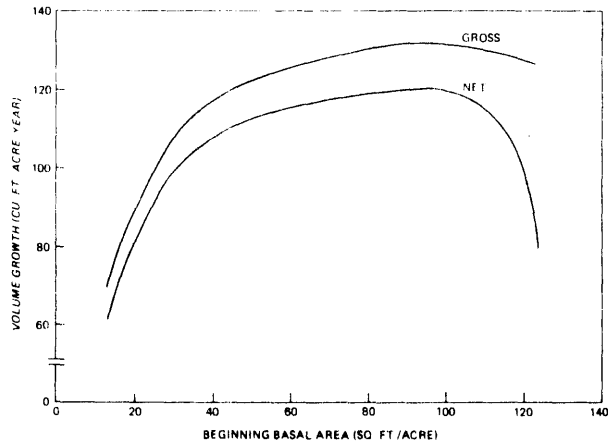


Figure 3.--Relation of periodic annual gross and net cubic-foot volume growth to beginning basal area per acre (all trees 4.6 inches d.b.h. and larger, site index 65 at age 50 for sugar maple).

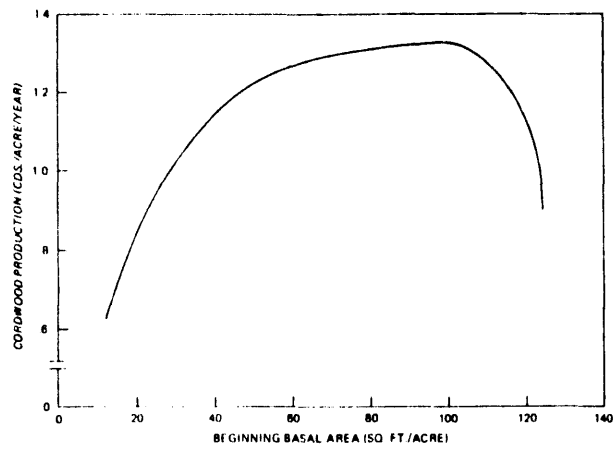


Figure 4.--Relation of annual net cordwood production in pulpwood and saw-log-sized trees to beginning basal area per acre (all trees 4.6 inches d.b.h. and larger, site index 65 at age 50 for sugar maple).

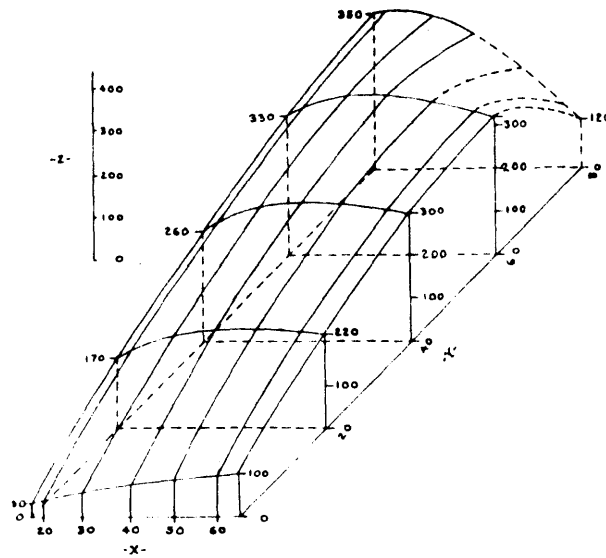


Figure 5.--Relation of periodic annual Scribner net board-foot growth (Z) to beginning basal area of all trees 4.6 to 9.5 inches d.b.h. (X) and beginning basal area of all trees 9.6 inches d.b.h. and larger (Y).

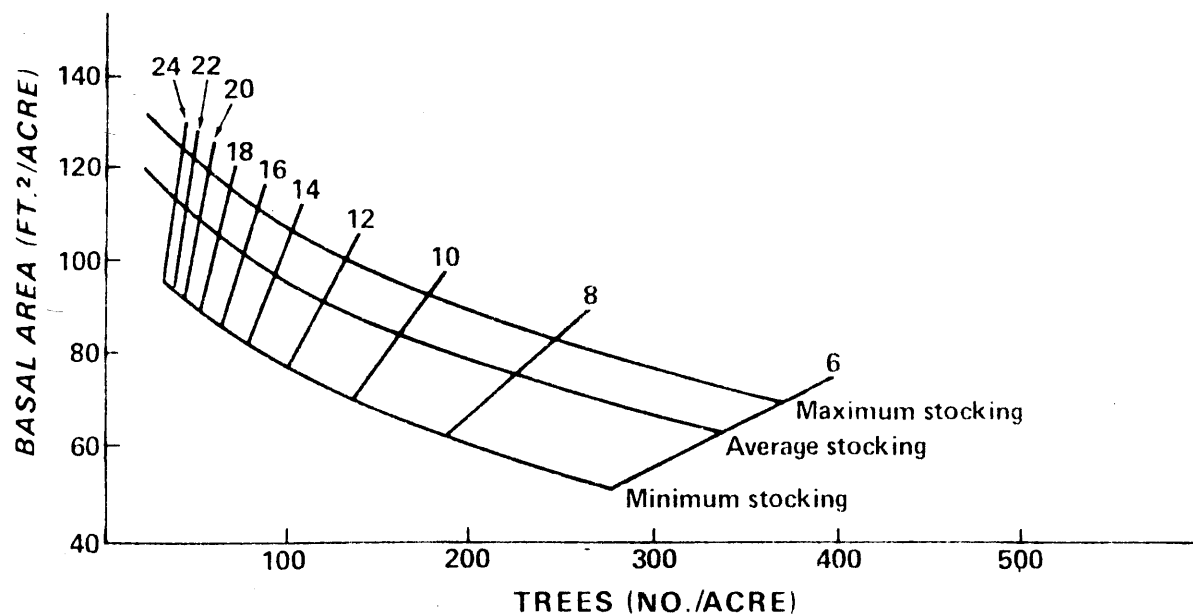


Figure 6.—Stocking levels for northern hardwood stands containing less than 20 percent conifers or basswood by basal area, and number of trees per acre for specified diameter classes.

PRODUCTION OF QUALITY HARDWOODS

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R. M. Godman and G. G. Erdmann

ABSTRACT

The primary emphasis for managing northern hardwoods on medium and better sites should be for producing sustained yields of high-grade veneer and sawlogs rather than just faster growth or higher yields of low quality products. Good quality hardwoods can be grown under even-aged or uneven-aged management. Either method is suitable for growing sugar maple, but the uneven-aged methods seems best suited for developing greater merchantable heights and higher-quality yields in upper logs of tolerant species. Even-age systems of silviculture encourage greater proportions and yields of less tolerant species such as yellow birch, white ash, and basswood.

The most important objective in managing hardwood types of the eastern United States is the production of high grade veneer and sawlogs. Almost without exception these products are remanufactured into items of much higher value and special uses. The demands for quality hardwood lumber has eliminated most of the older and larger stands. With the change from old growth to a greater dependency on second-growth some difficult problems have developed in growing and developing high grade materials.

The cull and defect in old growth stands brought under management become minimal after the 3rd cyclic cut. After that the major causes of volume, grade, and value loss are eliminated and emphasis can be placed on intermediate cuttings to increase the growth rate and merchantable height. Management normally concentrates growth on sawlog-size trees while removing the poorer trees in the smaller size classes. Consequently, the proportion of grade 2 and better trees increases steadily.

Research in hardwood management in the Lake States over the last 30 years has pointed out the difficulty of developing good quality second-growth stands. Hardwoods can be regenerated and managed under either the even-aged or uneven-aged systems but the latter generally produces better quality boles. Thirty years' experience in second-growth have enabled us to recognize what affects tree quality. Economic evaluation of growth and quality show that quality improvements add the most to individual tree value. Hardwood species are unique in that any cutting in the stand affects quality through changes in stand composition, stem form, clearness of the bole, merchantable height, insect and disease problems, climatic effects, and growth. The role that management, especially even-aged management, exerts on these factors will be described.

Bole Quality

Stand Establishment and Composition

Good bole quality depends more on the species of tree established in the stand than on measures taken after regeneration is established. Basswood and white ash, for example, develop long clear boles at an early age, and grow more rapidly in diameter than other associated species. Their site index typically ranges from 5-15 feet greater on the same soils than other hardwoods and they often grow in denser stands with higher basal areas. Pure stands of tolerant sugar maple grow more slowly, are shorter in height, and subject to greater deformities and stem changes than other associated species. Regeneration of basswood is usually dependent upon sprout growth; reliable methods of obtaining trees of seedling origin have not been developed. The seeding frequency of white ash is unpredictable because male flowers often abort before pollination. Other species have critical seedbed germination temperatures, and susceptibility to surface soil drying that require specific techniques to achieve desirable species mixtures.

Merchantable Height

After regeneration is established the most important factor affecting tree quality is repeated forking in opposite-branched species, especially sugar maple. Forking begins in the seedling stage and continues throughout the life of the tree. Almost all forking in sugar maple is caused by bud miners destroying the terminal bud. This usually results in the terminal shoot dying back to the first pair of axillary buds which causes a forked terminal. Bud loss may occur as frequently as every 3-5 years causing multiple forking along the central stem. Almost all dominant and codominant trees have forks in even-aged systems. These forks reduce potential log height and increase the risk of loss through breakage as the fork members

become larger and heavier. Callous formation in forks tends to split fork members and subjects them to breakage from wind and snow loads. Forks can be corrected to some extent in even-aged management by maintaining the surrounding stand and crown dense enough. Forks in young stands are merely temporary; in later stages they often become permanent because crown and growing space increase. In one study it was estimated that less than 6 percent of the trees would yield 2 logs. Forking is seldom a problem in uneven-aged management because shading continually controls fork development until the trees attain maximum height for the region and site.

Epicormic Sprouting

Stand density to control forking often adversely affects clear bole development by stimulating epicormic sprouting. Dormant buds are produced in abundance by most hardwood species but do not develop under high stand densities and overhead shading. When the crown is partly lost, or heavy cutting occurs, these buds break dormancy and often grow into limbs that reduce grade of the logs. Epicormic sprouting occurs most frequently following the initial cut in high density, even-aged stands because of reduced crown size. Once the crown size and vigor has increased, heavier thinnings can be made without further sprouting although the risk of forking at the current height may be increased. The fact that epicormic sprouting is controlled through crown size is illustrated in shelterwood cuttings where vigorous full-crowned dominant and codominant trees are left and no epicormics develop. Apparently growth regulators produced in and translocated from the growing terminals control the dormant buds to prevent epicormic sprouting and bole degrade.

Branch Defects

Branch-related defects cause most of the degrade on the merchantable portion of the stem. The number of these defects vary by species, species' tolerance, rate of growth, type of management and frequency of the cutting cycle. Sugar maple, a very tolerant species, usually has more limb-related defects in all log positions than other species. The number and frequency become fewer in yellow birch, red maple, white ash and basswood in managed stands. Stand density usually influences limb-related defects; more live limbs persist longer under low density stands and at high log position on the bole. So high density should be used early to reduce defect numbers.

Once the limbs have died, the rate of defect healing is correlated with the rate of diameter growth. Even moderate-size dead limbs heal relatively well at recommended management levels. Although the time required for complete healing varies, it is generally as long as it takes the bole to grow in radius the same amount as the diameter of the dead branch. In terms of tree diameter this usually means twice the branch diameter. A good estimate of the rate of diameter growth can be made by judging the size and density of the crown and the amount of growing space around the perimeter of the crown.

Large limbs and correcting fork members (over 2.5 inches in diameter) cause the most defect, discoloration, and decay in all species. Part of the loss is attributable to bark inclusion, higher moisture contents for a greater distance in the bole, and receptivity to infection from various diseases. Maintaining near optimum stand densities to enhance mortality of smaller limbs while providing adequate stocking for moderate growth tends to minimize most defects that might occur from larger limbs.

Insects

Bud miners that cause forking have the most impact on quality; the sugar maple borer is the next most damaging insect. It often partially girdles the bole and may cause breakage or large wounds susceptible to decay. Maintaining good tree vigor is the best way to reduce borer damage. Although other insects such as the maple callous borer, bronze birch borer, and cambium miners reduce growth and value, these insects occur less frequently and usually do not affect entire stands.

Diseases

Nectria and Eutypella cankers are generally the only serious disease problems in managed stands. Most cull in old growth stands developed largely from lack of management and could be eliminated during the first three cyclic cuts. In second-growth stands, Nectria and Eutypella cankers tend to be more common and possibly/affiliated with the silvicultural system.^{are}

Nectria is reported to be increased by shelterwood cutting, presumably because large block-type cuttings favor infection during the regeneration stage. The oldest shelterwood cuttings in the Lake States have a greater incidence of Eutypella than observed in other cuttings. Whether the incidence had been reduced in the previous stand, thus lowering the probability of infection, or whether the silvicultural system is the major factor remains to be determined. While the shelterwood method has been consistently successful in regenerating even-aged hardwoods, it currently appears that either using one of the shelterwood methods to increase species diversity or changing the configuration from a block cutting will be desirable to lower the incidence of these diseases.

Climatic Factors

Climatic conditions also appear to cause disease-like problems in even-aged stands. On certain topographic positions, in certain years, even-aged sugar maple becomes susceptible to winter sunscald. This occurs when the stems are from 1-3 inches in diameter and most often in February or March on bright, sunny days that warm the south side of the bole above snowline. At sunset the rapid cooling causes the cells to rupture and die. In many cases the lower 8 feet of the bole decays and continues as an open catface. In dense stands few trees completely heal, some heal only to the point of appearing as a simple frost crack. Sometimes the maple callous borer may kill the cambium of sun-scalded trees but most often decay begins after injury and resulting slow growth.

In the northern portion of the range of sugar maple, saplings and poles show numerous 1- to 3-inch vertical cracks, called annual maple "cankers", even though a disease has not been identified. Long-term records show they heal in 8 to 12 years but new ones occur on all sides of the bole. Preliminary data show this type of degrade is most common in even-aged stands, possibly resulting from tension in the wood caused by changes in air temperature. Large changes in stem diameter, for example, were found to occur in dense hardwoods simply due to cold air temperatures. In one study, periodic growth could be underestimated by nearly 50 percent in several hardwoods using the measurements taken on the coldest day. On some trees the 5 full years of diameter growth was lost in shrinkage so temperature may cause both annual maple canker and winter sunscale. Little evidence is available that the climatic problems are as common in uneven-aged stands.

Animals and Birds

The feeding of the yellow-bellied sapsucker can seriously injure or kill several species -- especially yellow birch. The sapsucker prefers the open stand conditions and can kill a tree within 2 years. Losses, however, are minimal in mixed stands when they are maintained at recommended stocking levels. Few other animals cause serious degrade; those that do are usually localized.

Management Recommendations

For tolerant hardwoods the uneven-aged method generally is best; merchantable heights, diameters, product grades, and values are usually greater. However, only a few hardwood species can be regenerated and grown under the all-size structure.

Even-aged management can be applied to all hardwood species. However, growing high quality boles under this method is more difficult. Merchantable lengths may be shorter -- although butt log quality will be high. Commensurate with even-aged concepts, most trees will probably be harvested at smaller sizes.

To achieve these grade and quality objectives specific guides are now available for managing hardwood stands under either the even-aged or uneven-aged systems. Guides for uneven-aged management use a single basal area stocking by tree diameter classes. The only new concept under this system is the stress on stocking in each of the three sawtimber diameter classes rather than simply lumping them into a single sawtimber diameter class as commonly practiced since the basal area guides were published in 1953. The single sawtimber diameter class grouping has resulted in a modified form of even-aged cutting that increases the number of cycle cuts to achieve a regulated stand as well as postponing the cutting of 100 percent of growth at each cyclic cut once structure is attained.

Even-aged management guides, for the various species groups, are designed for the best compromise between growth and quality. For species showing poor quality, managers should favor the upper limits recommended for the early cyclic cuts until a good crown and adequate stem size and merchantable height has been attained. Then the lower limits can be considered. In even-aged management few stands will be marked to the same residual basal area because of initial differences in average stand diameter. All recommendations are based on changes in tree size. In application, the most difficult problem is recognizing the within-stand variation in an area being marked and choosing the correct residual basal area density. Generally, all recommended densities shown by the various curves approximate a residual crown cover of about 80 percent for even-aged management.

The recommendations for management under either system should result in the best quality development under the circumstances. We are still fine-tuning these systems with the goal of the highest dollar yields over time commensurate with maintaining site quality.

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BIOLOGICAL DIVERSITY AND ITS USE IN SILVICULTURE^{1/}

Stephen G. Boyce^{2/}

Abstract --Operational techniques are an effective and an efficient way to use biological diversity to meet multiple-use objectives as described by the National Forest Management Act of 1976.

Additional keywords: Multiple use, diversity index, decision and control, timber, DYNAST.

^{1/}Presented at the annual Silviculture Workshop, U.S. Forest Service, Roanoke, Va. June 1-5, 1981.

^{2/}Chief Forest Ecologist, USDA Forest Service, Northeastern Forest Experiment Station, Hamden, Conn. and Visiting Lecturer in Forestry, School of Forestry and Environmental Studies, Yale University, New Haven, Conn.

INTRODUCTION

Diversity is being different. Biological diversity means differences in elements such as genes, amino acids, flowers, species, and communities of plants and animals. Meaningful information about diversity is usually expressed as the distribution of items, e.g. individuals, among different classes of an element, e.g. species. This paper is concerned with biological diversity and its use in silviculture.

The National Forest Management Act of 1976 (90 stat. 2949; 16 USC 1600) raises specific concern with diversity of tree species and diversity of communities of plants and animals.

The phrase "biological diversity" and the word "diversity" are not found in standard forestry references and handbooks, such as Ford-Robertson (1971) and Forbes (1955), but the concept of differences among classes of an element is well known in forestry. It is used in silviculture, forest measurements, land management, planning, wildlife management, and in forest insect and disease management. These are managerial uses of diversity to provide human benefits.

Many biologists use diversity in a functional rather than a managerial way. The functional approach is to search for an understanding of the functioning of forest communities, rather than directing the forests to provide human benefits. The functional approach leads to the computation of many multifaceted diversity indices (Pielou 1977; Hutchinson 1978; May 1976; Southwood 1978; Whittaker 1972). These indices are useful to some biologists but are not especially useful for land management planning, silviculture, wildlife management, and other managerial aspects of forestry.

The chore posed by the NFMA is to include diversity of forest communities and tree species in the managerial processes of forestry. This presentation describes how operational techniques (Bridgman 1927) can integrate information about diversity into land management plans. I will describe how operational techniques make it possible to develop land management plans to meet multiple-use objectives as required by NFMA.

DIVERSITY IN THE NATIONAL FOREST MANAGEMENT ACT

Diversity is not defined in the NFMA. The Committee of Scientists appointed by the Secretary of Agriculture published this definition:

"the number of different plant and animal species and each species' abundance, and the distribution and abundance of different natural plant and animal communities within the area covered by a land and resources management plan" (Federal Register 44(88) page 26584, May 4, 1979).

This definition is based on how diversity is measured. One counts the items, e.g. individuals or forests stands, and determines the distribution--the abundance-- among the classes, e.g. the species communities. The result is information about differences which is diversity. Why was this kind of information considered important for a section in the NFMA? An answer may be found in the concerns expressed by constituencies to the Congress. A summary of this information is given in the legislative history of the Act, (U.S. Senate, 1979).

The inclusion of a section on diversity in the NFMA reflects a deep-seated ethic among many constituencies to live in harmony with nature. This ethic includes providing a livelihood for diverse forms of plants and animals and maintaining diverse natural communities of plants and animals. Fulfillment of this concern requires that a forest consist of different forest types. Forest types, such as hardwood types and pine types, are defined by diversity of tree species. The signals from constituents to the Congress focused on perceptions of a decline in the diversity of forest types and a decline in the potential livelihood of some plants and animals that might result from the conversion of eastern hardwood types to pine types. This concern was explained by Senator Bumpers of Arkansas:

"The issue of type conversion is an exceedingly important one, especially for eastern forests. I have received numerous complaints on this issue from constituents in my state and I understand other Senators have had little experience.

"The basic issue is the extent to which the Forest Service should clear an area of its existing mixture of tree species and replace it with a different set of species. In Arkansas, this process has involved the systematic removal of thousands of acres of mixed hardwood stands and their replacement by stands that are predominantly pine.

"Unfortunately, both this policy and the means to implement it have been highly controversial. Large hardwood areas have been clearcut and extensive aerial spraying of herbicides has been employed to remove these species. Testimony in our hearings corroborated complaints I have received from hunters and other wildlife enthusiasts in Arkansas, that the largely pine forest that is replanted does not support the quantity nor the diversity of wildlife sustained by the previous forest type. There is also a general aesthetic loss and, in my state, a specific loss of the impressive fall color display of the hardwoods so important to our tourist industry and our citizens in general.

"[The section on diversity] of this bill would discourage the Forest Service from tree species or type conversion schemes in the future." (from page 403 U.S. Senate 1979).

There is a definite link in the history of the act between information about biological diversity and the conversion of hardwood forests to pine forests. The concern about forest type conversion led to a section on diversity in an early draft of the NFMA.

"(B) provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives." (from page 259, U.S. Senate 1979).

The intent of the section on diversity was explained in the Committee Considerations.

"Consideration was given to guidelines which would be applicable to all resources, such as: to insure consideration of the economic and environmental aspects of various systems of renewable resource management; to provide for diversity of plant and animal communities based on the suitability and capability of the land; to recognize the requirements necessary to coordinate the uses on areas identified as special provisions to protect soil, water, aesthetic and wildlife resources where conditions are critical for tree regeneration or where the land is sensitive to the impact of timber harvest. The Committee also adopted a provision that the guidelines specify how the expertise of affected State agencies, such as wildlife

conservation agencies, will be obtained as a part of the technical base for the preparation of land management plans.

"The requirement in S.3091 that the guidelines provide for diversity of plant and animal communities does not preclude conversion of timber stands from one type to another. However, the Committee is aware of the widespread public concern over conversion of eastern hardwood forests to pines. No conversion should be permitted unless it would be consistent with multiple use management and it is provided for in a land management plan developed with full public participation and review." (from page 316, U.S. Senate 1979).

There was no intent to stop conversion of hardwood types to pine types. Yet the deep concern for living in harmony with nature, for providing a livelihood for many kinds of plants and animals, was expressed in the provision for a diversity of plant and animal communities and of tree species associated with pine and hardwood forest types.

In the final version of NFMA modifications were made in the section on diversity:

"(B) provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet overall multiple-use objectives, and within the multiple-use objectives of a land management plan adopted pursuant to this section, provide where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan." (from pages 796-797, U. S. Senate 1979).

The Joint Explanation Statement of the Committee on Conference explained the changes. The modifications incorporated the essential purpose of an earlier House amendment which required preserving a diversity of tree species and forest types similar to that existing at the time of harvest. Also, the intent of the Conference was that the provisions for diversity would govern the resource plan as well as the land management plan when developed separately (from page 755, U.S. Senate 1979).

Some of the items to be noted from this summary of the act's history are:

- (1) The word "diversity" seems to be used in the dictionary sense of difference;
- (2) A primary concern of constituencies is to maintain different kinds of natural communities of plants and animals and different species of trees that are associated with different types of forests;
- (3) The forests are to be manipulated and directed to provide biologically possible combinations of benefits including providing a livelihood for a diversity of plants and animals; and
- (4) Diversity is to be related to multiple-use objectives..

Diversity of tree species and communities of plants and animals is a consequence of the transformations of a forest from state to state. The transformations may be either natural or directed by silviculture. What is needed to implement the diversity section of NFMA is a way to relate information about diversity and multiple benefits to projections of states of forest organization. The projections should describe multiple benefits and diversity of forest types and communities expected from alternative modes of silviculture. The projections are parts of alternative plans and are a source of information for decisions and for controlling the forest.

The scientific approach to integrating projections of multiple benefits and diversity is to first develop an operational definition for the diversity concept. Its purpose is to reduce information about diversity to human perceptions of actual happenings and provide information for validating actual experiences by repetition of the operations that are used to define the diversity concept.

An operational definition for the diversity concept is given in the next section.

AN OPERATIONAL DEFINITION

When the NFMA was passed in 1976, no operational definition was used for biological diversity, and there was no precedent for using information about diversity for land management planning. In his book, Ecological Methods, Southwood (1978) reports little use for the multifaceted diversity indices described by Pielou (1977), Hutchinson (1978), May (1976) and Whittaker (1972). Southwood (1978) presents a summary of many of the methods for computing a single diversity index; he examines the significance of the index values for increasing our understanding of the structure and functioning of communities of plants and animals, and finds that the diversity indices provide little or no additional information beyond that derived from using the original classification of items, e.g. individuals, among different classes of an element, e.g. species.

Boyce and Cost (1978) used techniques from physics (Bridgman 1927) to develop an operational definition. This definition and the associated criteria provide the basis for different people to repeat observations and measurements and thus provide scientific credibility for management decisions. Theory derived from experiment and research is operationally integrated into practice; technology for management planning is improved (Boyce 1978). The technique found so useful in physics is to apply the theoretical concepts by using criteria for identity, measurement and meaningfulness of elements for a specific, planned operation.

The operational definition of the diversity of renewable resources is: the meaningful differences in the elements of biological communities (Boyce and Cost 1978).

The operational criteria are:

- a. Identify which elements of the community are being considered (e.g., tree species, bird species forest types, stand conditions, age classes, junction with other communities).
- b. Specify measurements or characteristics which evaluate or distinguish elements (e.g., differences between species, measurements for classes of a continuum).
- c. Describe how the differences between elements are meaningful for management decisions (e.g., stand condition classes and the livelihood for a plant or animal, sizes of trees and the potential for wood products).

The criteria may at first appear unnecessary and pedantic, but the explicit specification of identity, measurement, and meaningfulness for the elements of diversity for each land management plan is the basis for effective communication among all interested parties, for repeat observations, and for scientific credibility in the land management plans. Explicit statement of the criteria avoids elusive definitions for diversity.

Southwood (1978, p. 429), in his guide to the analysis of diversity emphasizes the importance of examining the form and the meaningfulness of the data. He considers these steps an operational approach especially important now that computerized data collection and analysis tempt investigators to compute diversity indices without knowing the operational criteria. Indices without operational criteria can become "black boxes" that are difficult to use in different situations, are difficult for different people to reconstruct, and may lack scientific credibility.

Two Components of Diversity

Two features of diversity are to be made explicit. First, it is important to define the classes of elements of diversity. The elements of primary interest for the NFMA are tree species and plant and animal communities. Taxonomic texts define species and ecologic concepts can define communities. Specifications for classes of these elements are taken or modified from taxonomic treatments and from published descriptions of forest types and habitats. Any set of classes for any element, such as tree species, communities, soils, site index, and yield values, should have explicit operational criteria.

The second feature of diversity is distribution. It is important to know how the items are distributed among the classes according to some kind of community structure. Structure of communities may be indicated by ranking the classes. For example, species are often ranked by the abundance of individuals; diameter classes are ranked from the smallest to the largest; habitat classes are ranked by kinds of dominant species, stand ages, and stand areas.

One of the most informative ways to communicate information about diversity is to use a simple table. Table 1 displays the distribution of items, e.g. forest types, for one or more elements, e.g. forest areas. Diversity, e.g. differences, is apparent from observations of the table and quantitative values for difference, if desired, can be computed from the data. Tables of this kind are simple, effective ways to convey information about diversity of tree species and forest communities over time and space.

Boyce and Cost (1978) illustrate the computation of the Shannon diversity index for the data in table 1. It turns out that the Shannon index communicates very little information that is useful for managerial purposes (Boyce and Cost 1978).

A simple graphic method is often effective for communicating diversity. A common technique is to array the items, e.g. forest types, in order of abundance and plot the distributions (fig. 1). The curves display the fact of differences -- diversity -- although the forest types (classes) may be ordered differently for the different areas and elements. There are many variations of the graphic method. (Southwood 1978, May 1976, Pielou 1977).

Tables communicate the most information about diversity; graphs and charts convey less information; and diversity indices, especially the confounded form (Pielou 1977), display little meaningful information for silviculture and management planning.

Operationally, the intent of each table, chart, and graph should be to convey information about the distribution of items among defined classes of an element. The displays should communicate the meaningful differences within and among the elements. To meet NFMA requirements it is important to integrate information about diversity of forest communities and tree species with multiple benefits. And there should be a way to integrate information about diversity into land management plans.

The techniques described in the next section are used to project, for alternative modes of silviculture, the transformations of forests from state to state, to relate to these transforming states of organization the biologically possible combinations of benefits, and to display diversity in communities of plants and animals and forest types.

Table 1.--Diversity of forest types found on Pisgah and Nantahala National Forests and the Mountain Region Survey in North Carolina (in percent).

Forest types	Forest areas		
	Pisgah National Forest	Nantahala National Forest	Mountain Region Survey
White pine-hemlock	2.4	--	3.4
Spruce-fir	1.2	--	0.3
Loblolly pine	--	1.7	0.4
Shortleaf pine	--	--	0.6
Virginia pine	1.5	--	5.3
Pitch pine	7.1	1.2	1.4
Oak-pine	4.8	7.7	8.7
Oak-hickory	74.5	63.4	69.5
Chestnut oak	7.7	18.5	4.5
Elm-ash-cottonwood	--	--	0.2
Maple-beech-birch	2.8	7.5	5.7

From Boyce and Cost (1978). For operational definitions see Cost (1975).

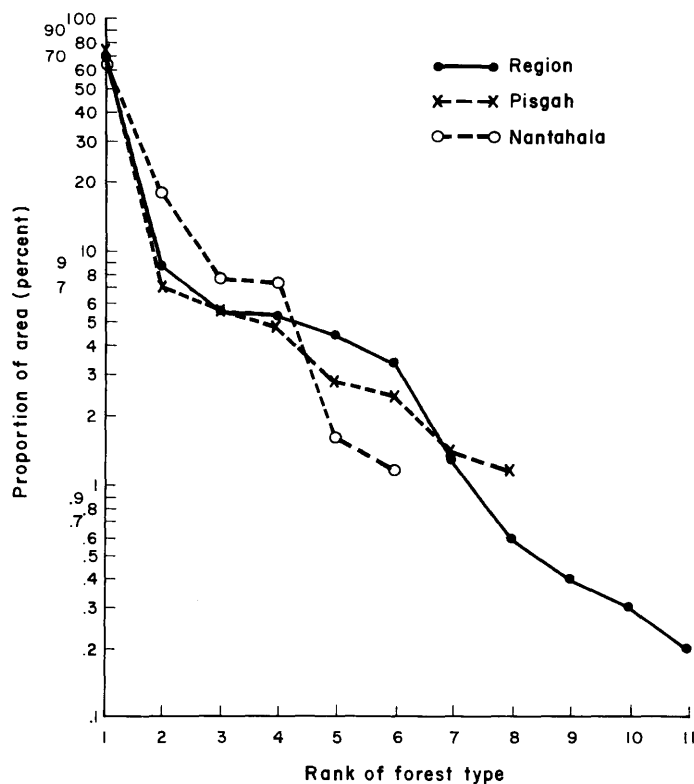


Figure 1. Example of a chart for displaying displaying diversity. The distribution of items (forest types) is plotted by rank for three areas. (Data are from table 1, definitions are from Cost 1975).

Diversity in Land Management Planning

Diversity results from the states of forest organization. The state of organization of a forest is defined by the proportional distribution of stands by age classes, area classes, and forest types. Changes in the distribution of these stand classes are meaningful for the production of timber, wildlife habitats, scenic values, streamflow and other benefits. Diversity of communities and tree species is determined by the distribution of these stand classes. For each planning area, operational criteria are specified for stands by age, area, and type classes (Boyce 1977). Type classes are defined by the diversity of tree species.

Projecting transformations of stand classes (fig. 2) is the common denominator for multiple benefits, diversity relationships, and management plans (Boyce 1977). It permits us to express potential timber yields, present net values, potential streamflow, scenic values, and the livelihood of plants and animals in relation to states of forest organization. The transformations from state to state can be directed by silviculture, and a relatively simple simulation model, DYNAST (Boyce 1977), can project relative relationships that show the results anticipated from each mode of silviculture.

DYNAST is a system dynamics model (Forrester 1961) that can simulate the ecosystem dynamics for any forest that can be described in terms of spatial and temporal changes in the age and area classes of stands by forest types (Boyce 1977). These three variables, age, area, and forest type, are the important elements that determine the biological diversity of forest communities and the diversity of trees.

Indices for benefits are related, independently of each other, to transformations in the state of forest organization. Each disciplinary area independently develops algorithms for the benefit that interest it. For example, timber, game, and nongame managers translate information from their disciplines without preconceptions about preferences and trade-offs before they put the algorithms into the DYNAST simulation models. The interrelationships among the benefits are revealed by the tables and displays produced by the simulations.

Consider the use of yield tables in land management planning. Yield tables are translations of biological relationships into a structure for forest management decisions. These tables and other yield functions have value for projecting the relative differences in timber potentials expected from alternative investments in silviculture. The projections are determined by the dynamic distribution of stands by age classes (fig. 2). All benefits, including diversity, can be related to transformations in the states of forest organization (Boyce 1977).

Functional information about diversity and the potential livelihood for plants and animals can be translated into a structure, such as yield tables, that can be used in land management planning. One example illustrates the use of knowledge about diversity for a nontimber benefit.

On the Nantahala National Forest, Coyle (in press) identified 134 kinds of spiders in four stands. One stand was a mature timber habitat; the other three were seedling habitats 1 to 5 years old. Some species of spiders lived in both kinds of habitats, some only in the mature-timber stand, and some only in one or more of the seedling stands (table 2). From Coyle's description, I translated the biological information into a forest management structure (Boyce 1980).

The translation mathematically relates the biological information to the proportional distribution of age classes in the stands. The potential livelihood for spiders is scaled from zero to one. A loss of either all seedlings or all mature timber would threaten the livelihood of some species of spiders. This information integrates the potential livelihood of spiders with other multiple benefits and makes it possible to project alternative land management plans on these integrated benefits. This technique can be used for any operationally defined groups, guilds, or communities of plants and animals, and for forest types.

One plot (fig. 3) made by the DYNAST simulation program illustrates how to project for one alternative plan the potential production of timber in relation to the potential livelihood of spiders and an estimate of net present values. These potentials and all other forest benefits vary over time with changes in the age classes in stands. The diversity of age classes for this example is displayed in figure 2. This kind of information about diversity is important for decisions to control the state of organization of forests.

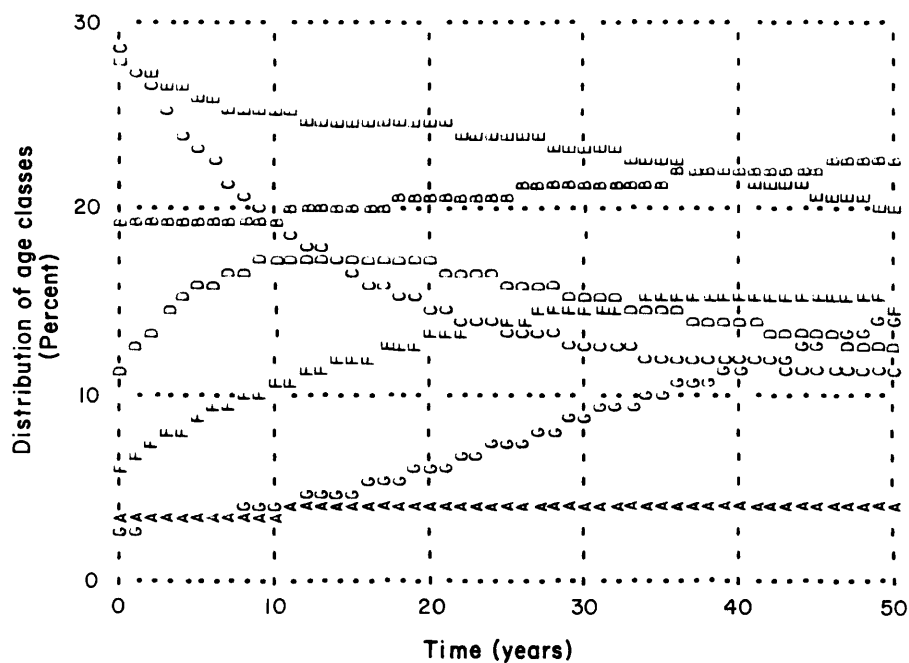


Figure 2. An example of diversity of forest communities by age classes displayed by a DYNAST simulation for one mode of silvi-culture. A = seedling habitats, B = sapling habitats, C = 6-inch pole habitats, D = 8-inch pole habitats, E = 10-inch pole habitats, F = mature timber habitats, G = old growth habitats. (Boyce 1977).

Table 2.--Numbers of species of spiders in a mature timber stand and in three seedling stands in the southern Appalachians.

Ecological category	Species found in mature stand only	Species found in mature stand and in one or more seedling stands	Species found in one or more seedling stands only	Total
Sedentary litter spiders	4	16	18	38
Hunting spiders	4	16	39	59
Aerial web builders	12	10	15	37
Total	20	42	72	134

From Coyle (in press).

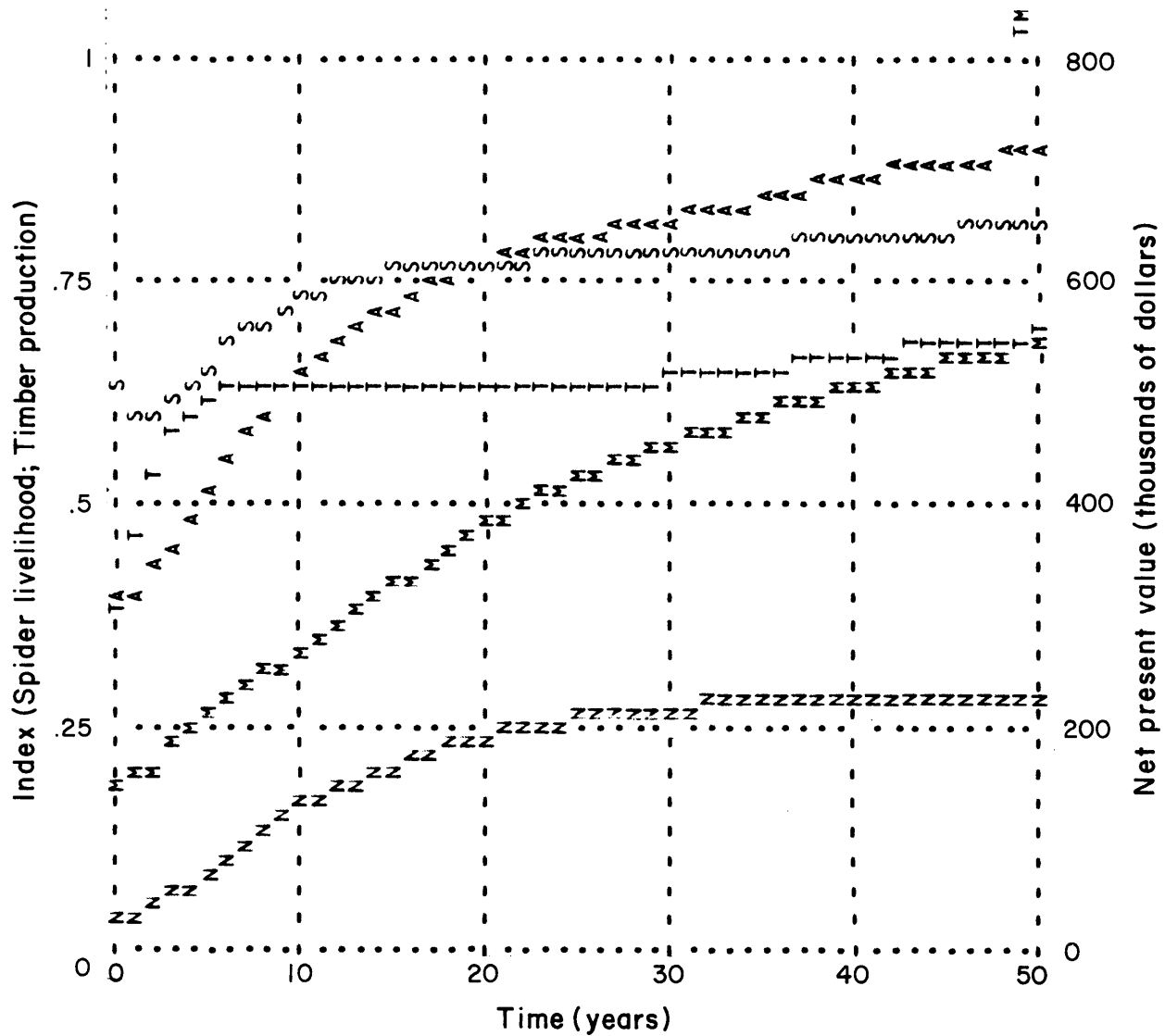


Figure 3. An example of diversity of animals integrated with other benefits by a DYNAST simulation for one mode of silviculture. N = estimate of net present value, M = spiders found only in mature stands, S = spiders found only in seedling stands, A = spiders found in both mature and seedling stands, T = potential timber production.

DECISION AND CONTROL

Complexity is the primary factor that limits the use of biological information for management planning. Complexity, resulting from many variables changing simultaneously, limits the use of utility functions and marginal values to formulate a single goal. Needed are techniques that integrate large amounts of quantitative and subjective information and reduce complexity in the decision and control processes.

The translation process, illustrated by the spider example, greatly reduces the number of variables. For example, instead of displaying the diversity of 134 species of spiders, only the diversity for three groups of spiders needs to be displayed for decisions. And, instead of attempting to display the diversity of many species of trees, forest types defined by the distribution of tree species can be used. Communities of plants and animals are displayed as the distribution of classes of stands (fig. 2) which are operationally defined by forest type, age, and area. Each display is for one of a number of alternative modes of silviculture which are parts of land management plans. The DYNAST model constrains the displays to represent biologically possible combinations of benefits.

The structure for an integrated decision and control system is illustrated in figure 4. The simulation model, DYNAST (Boyce 1977), projects alternative combinations of benefits from different modes of silviculture. The simulation may include the results of optimization analyses from the land, labor, and market inputs. After the choice of an alternative, the implementation of silviculture moves the forest toward a desired state of organization. This is a single goal toward which activities of all disciplinary areas can be directed. Inventories, monitorings, and research provide information for continually adjusting the model to conform with the reality of the forest. Adjustments for changes in social, economic, and political forces are made in the decision loop by people.

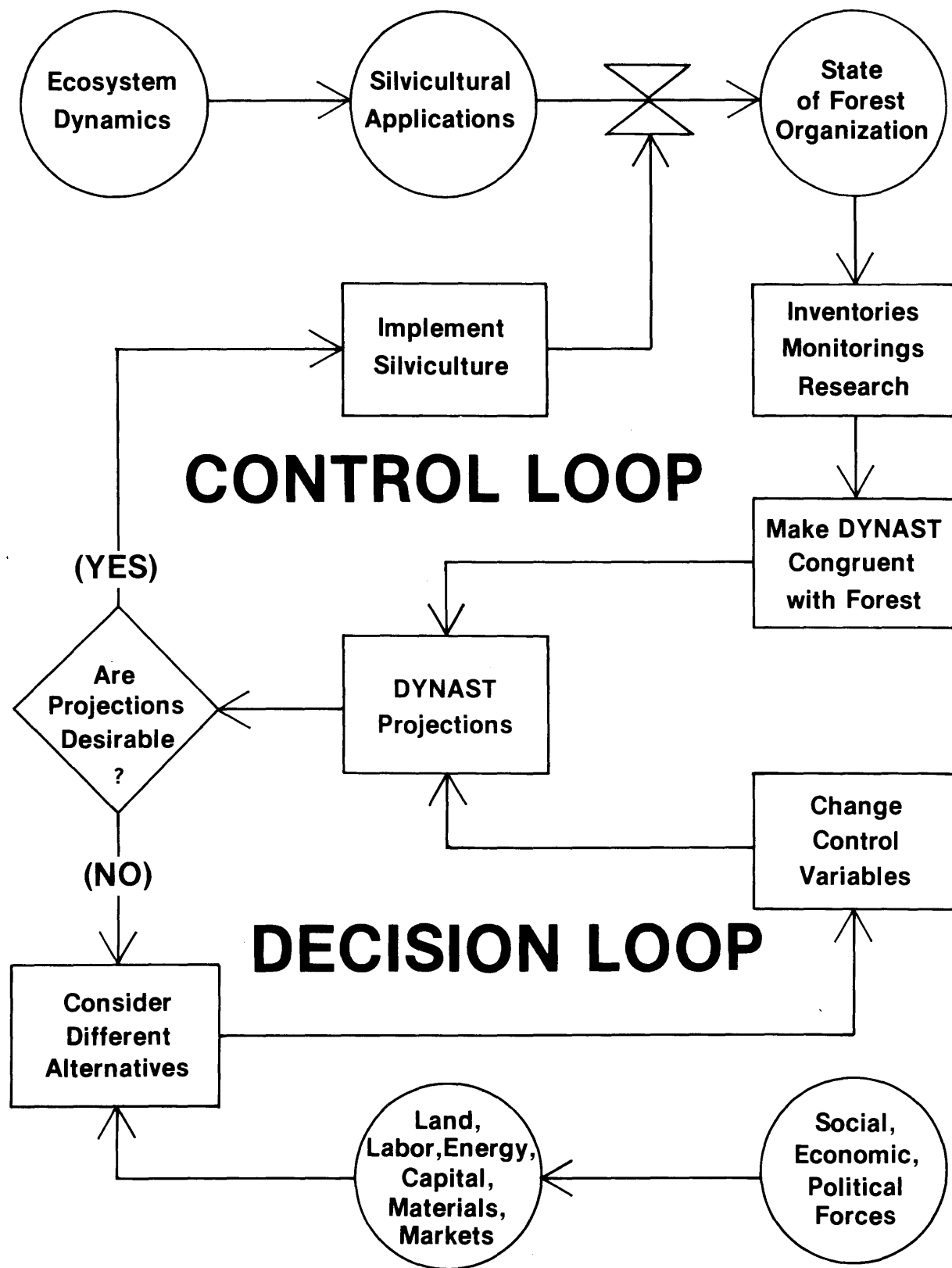


Figure 4. Structure of the decision and control system for integrating biological and managerial information.

THE IMPORTANT POINTS

An operational definition for biological diversity makes it possible for different people to repeat observations and measurements and thus give scientific credibility to management decisions.

Information about diversity can be conveyed by tables, charts, and graphs that display the relative distribution of items among operationally defined classes.

Simulation methods such as DYNAST can integrate information about diversity and multiple benefits. These integrations are useful for developing, analyzing, and choosing among alternative land management plans.

The DYNAST simulations are valuable primarily as media for communicating explicit information -- the biologically possible combinations of benefits, including diversity of forest communities and forest types, integrated and projected for alternative modes of silviculture.

When a combination of benefits -- one of the DYNAST projections -- is chosen it identifies a single goal for silviculture to direct the transformations of the forest toward the desired state of organization that provides the desired biologically possible combination of benefits, including diversity. Actions of all disciplinary areas of management can be integrated and directed toward this single goal.

Decisions are made by people responding with insights and experience to the use of management resources and to changes in social, economic and political forces. The options for choice, the DYNAST simulations, are kept congruent with the real forest by information from inventories, monitorings, and research.

This operational technique can be used to identify land management plans that satisfy the intent of the NFMA and the desires expressed by constituencies to the Congress to live in harmony with nature.

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PROBLEMS ASSOCIATED WITH EARLY HARDWOOD MANAGEMENT IN THE APPALACHIANS 1/

By: PAUL A. SHRAUDER

BACKGROUND

ALL AGED MANAGEMENT OF HARDWOODS PRACTICED IN THE APPALACHIANS
UNTIL VERY EARLY "SIXTIES".

FORESTERS ASSUMED THAT --

1. TREES OF ALL AGES COULD BE GROWN IN ONE STAND.
2. CUT TREES SELECTIVELY AS THEY BECAME MATURE.
3. REMAINING TREES SEED IN YOUNGER TREES AND PROVIDE
FUTURE GROWING STOCK.
4. CUTTING TREES, THEREFORE, COULD BE CONTINUED
INDEFINITELY IN A GIVEN AREA.
5. ANSWER TO OUR TIMBER MANAGEMENT PROBLEM (SO WE THOUGHT).

IN REALITY

DID NOT WORK THIS WAY.

- DESIRABLE SPECIES OF TREES FAILED TO RESEED THEMSELVES
OR GROW PROPERLY UNDER LARGER TREES. AFFECTED WERE DESIRABLE
INTOLERANT TREE SPECIES BOTH HIGH QUALITY TIMBER AND WILDLIFE
VALUE TREES. OAKS WERE AMONG THESE INTOLERANTS.
- SELECTIVE CUTTING LEFT MOSTLY SMALLER DIAMETERED TREES
AND/OR DEFECTIVE TREES DUE TO MARKETS. THIS, IN REALITY,
WAS AN ECONOMIC SELECTON.

1/ REMARKS PREPARED FOR NATIONAL SILVICULTURE WORKSHOP
ROANOKE, VA - JUNE 1-5, 1981

- CONCERN ESPECIALLY FOR SQUIRREL AND TURKEY WHICH REQUIRE MAST AND MORE MATURE FOREST WAS EXPRESSED.
- NECESSARY MARKETS FOR BOTH PULPWOOD AND LOW QUALITY SAWTIMBER TREES WERE NOT AVAILABLE WHERE NEEDED.
- FOREST^{lys} AND WILDLIFE BIOLOGISTS MET AND EXPRESSED CONCERN OVER THE NEW MANAGEMENT MEASURES, DISCUSS THEIR CONCERNS, PROBLEMS, MANAGEMENT NEEDS AND RECOMMEND DIRECTION.
- RESEARCH BEING CONDUCTED ON EVEN-AGED MANAGEMENT INCLUDE EFFORTS BY BEN ROACH IN THE MIDWEST. FORESTERS RECONSIDERED THEIR APPROACH.
- FIRST EVEN-AGED MANAGEMENT STRIP CLEARCUTS WERE MADE ABOUT 1958 ON THE JEFFERSON IN PATTERSON CREEK DRAINAGE BY RANGER VAN ALSTINE, NEW CASTLE DISTRICT.
- STARTED EVEN-AGED MANAGEMENT BASED ON BEN ROACH'S WORK IN 1963-64 ON THE JEFFERSON. STILL A PART OF R-7.
- HAD STRONG TIMBER-WILDLIFE COORDINATION GUIDELINES IN 1964. SEE FOREST SUPPLEMENT.
EXAMPLES - DISPERSE PERCENTAGES OF VARYING CONDITION CLASSES OVER A UNIT AREA.
 - MAX. SIZE CLEARCUT - 60 ACRES.
 - PROTECT SPRING SEEPS. NO CUTTING WITHIN 50 YARDS.
 - SPACE ALL REGENERATION CUTS.

- R-7 ABOLISHED IN 1965. JEFFERSON AND DANIEL BOONE (KENTUCKY) TO R-8 WITH THE MONONGAHELA IN WEST VIRGINIA GOING TO R-9.
- BEEN ON EVEN-AGED MANAGEMENT SINCE.

WITH THIS LOCAL BACKGROUND

- RESULTS OF CURRENT RESEARCH ON HARDWOOD STANDS FOLLOW.

MANAGING CENTRAL APPALACHIAN HARDWOOD STANDS¹

H. Clay Smith²

Abstract--Central Appalachian hardwood stands are extremely variable and complex. Stands contain a variety of tree age classes and species with different growth rates and silvical characteristics. Management practices for immature and saw-log-size stands are discussed.

STAND CHARACTERISTICS

The central Appalachian hardwood region contains almost 23 million acres of forest land, characterized by steep topography and a wide range of site conditions. Frost-free days range from 120 to 240 and annual precipitation ranges from 40 to 80 inches. Growing conditions for the most part are excellent.

There are an abundance and variety of tree species with different growth patterns and silvical characteristics. It is common to find 20 to 25 different commercial hardwood species within a few acres. Past logging, fire, agriculture, and natural disturbances are largely responsible for the current stands in the central Appalachian region. From about 1890 to 1920, the central Appalachians were heavily logged. Hairy skidders (horses and mules), railroads, crosscut saws, and manpower were the logging equipment. Most of the logging practices were forms of high-grading or commercial clearcutting. Fires were common. Both conifers and hardwoods were harvested, including spruce, hemlock, pine, and selected hardwoods such as yellow-poplar, American chestnut, and several oaks (Steer 1948). Conifers were largely replaced by hardwoods and often the residual stands were dominated by maples, oaks, and hickories.

Unmanaged central Appalachian hardwood stands have at least three tree-age classes; old residual trees that were not cut during the early logging (many of these trees are presently about 150 years old), second-growth trees that were established as a result of the logging, and trees that were established after the death of the American chestnut in the 1930s and 40s. Even-age harvesting became a major practice in the 1960s, and the resulting oldest even-aged stands are presently about 20 years of age. Partial cuttings throughout the central Appalachians have also produced additional age classes.

¹Presented at the annual Silviculture Workshop, USDA Forest Service, Roanoke, Va. June 1-5, 1981.

²Project Leader, 1103 TM project, Northeastern Forest Experiment Station, Timber and Watershed Laboratory, Parsons, W. Va.

Generally, the most significant influence on current stand structure occurred during the logging era. Thus, second-growth stands 60 to 90 years old dominate the present forest with some younger even-aged stands less than 20 years old. Many of these stands are fully stocked, immature, and in need of improvement.

Recent forest survey data reveal that only about 30 percent of the commercial hardwood forest volume is of high quality (log grades 1 and 2); about one-third of the trees 5.0 inches dbh and larger are rough and rotten, yet many wood-using industries depend on Appalachian stands for high-value sawlog and veneer products.

Stands differ in tree age classes, sites, topography, species composition, quality, and growth. Tree size is certainly not an indication of tree age (Gibbs 1963); this sometimes leads to confusion, as the relationship between number of trees and dbh class can show a reverse J-shaped curve for even-aged stands. This is especially likely when tolerant and intolerant species occupy the overstory.

MANAGEMENT PRACTICES

Mature sawlog-size stands

In preparing to manage sawlog-size central Appalachian hardwood stands for timber production, foresters have few choices when entering the stand. The forester can recommend that a new stand be established by an even-age or uneven-age regeneration method. If an even-age method is used, one can expect more species variety and a higher ratio of available intolerant to tolerant species than with an uneven-age practice. However, foresters have questions and concerns about a complete clearcut or a commercial-type clearcut (Marquis 1981), and at present there are few guidelines. We know that tree species existing under the canopy of a stand to be clearcut are tolerant to shade. Some future intolerant or more valuable species will probably be eliminated if these trees remain. However, future thinnings or harvest cuts may be made more commercial by the growth response of these tolerant species. Tolerant to intermediate species that are generally known to respond include sugar maple, white oak, beech, and red oak. I am sure there are other species.

If an uneven-age regeneration method or some type of partial cut is used to establish a new stand, the available tolerant species will dominate the new stand. Foresters need to know what tolerant species occupy the site and their value--monetary or otherwise. The commercially desirable tolerant species include sugar maple, white oak, and red maple. However, striped maple and dogwood may be in the understory and silvicultural treatments to minimize their influence in new stands are costly.

Another approach is to delay committing the stands to any management system. That is, use an intermediate or improvement cut. For intermediate cuts, old residuals, defective trees, and trees of undesirable species can be cut with no concern for establishing regeneration. Some of the variation within the stand is reduced. The quality of the residual stand will be

improved, growth response is attained on the better trees, and decisions concerning the forest management system can be made more realistically in 20 or 30 years.

Regeneration establishment and development

In central Appalachian hardwood stands, natural regeneration will occur after any kind of harvest cutting. For example, after clearcutting there are usually 10,000 to 20,000 intolerant and tolerant tree stems more than 1 foot tall established on each acre within a few years. With so many stems available, commercial species are nearly always established in new stands. In fact, I have not seen any regeneration failures in the central Appalachians, but there are areas where natural regeneration is limited by such factors as undesirable regeneration, intensive browsing, compact soil, excessive moisture, or ^{possibly} allelopathic substances produced by vegetation.

There are few regeneration failures in the central Appalachians, but the interpretation of failure depends on how one defines success. For example, if a forester regenerates a mixed hardwood stand with the expectation of establishing oaks, the forester may be disappointed with a stand of yellow-poplar and black cherry. This might be considered a failure because yellow-poplar trees do not produce very good acorns or oak lumber. Another example would be clearcutting a yellow-poplar, black cherry, basswood, and red oak mixed stand with the intention of regenerating a similar stand, but instead producing a sugar maple or possibly a pure black locust stand. What is success to one forester could be failure to another.

Thus, foresters are finding a need to be more species-specific when regenerating new stands. Our project has recently started research to develop regeneration guidelines for predicting, establishing, and controlling species composition in restocking of central Appalachian hardwood stands. The significance of the problem is emphasized by the fact that oaks, particularly red oak, are not readily abundant in newly regenerated hardwood stands on good oak sites, even where there were a number of red oak trees before the regeneration cut.

Growth and yield

Though some yield table information for central Appalachian hardwood stands is available (Schnur 1937, Beck and Della-Bianca 1972), additional information for central Appalachian hardwoods is needed.

Trimble (1975) compiled individual tree growth information for dominant and codominant hardwood trees 15 to 20 inches in diameter. The average annual dbh growth for yellow-poplar and red oak was approximately 0.23 inches. White ash and black cherry trees each averaged 0.20 inches dbh growth per year. For the more tolerant species such as red maple and sugar maple, the annual dbh growth averaged 0.20 inches while beech averaged 0.12 inches. Generally, data from the Fernow Experimental Forest at Parsons, W. Va. indicate that tolerant species have slower growth rates, less value, and less total volume per tree in each dbh class than intolerant species (Table 1). This is significant when considering the changes in species composition that results from different management systems.

Table 1.--Average volume per tree and dbh growth rates for several intolerant and tolerant hardwood species (Trimble 1975).

Species	Volume per tree ^{a/}	Average annual dbh growth ^{b/}
	<u>fbm</u>	<u>Inches</u>
INTOLERANT		
Yellow-poplar	662	0.23
Red oak	527	.23
White ash	597	.20
Black cherry	573	.20
TOLERANT		
Sugar maple	541	.20
Red maple	538	.20
Beech	455	.12

^{a/} Average volume for 24-inch dbh tree to 8-inch top. International 1/4-inch rule using local volume tables for oak site index 70 on the Fernow Experimental Forest.

^{b/} Dominant and codominant, 15 to 20 inches dbh; intolerants 50 to 60 years old, tolerants at least 120 to 130 years old.

CULTURAL PRACTICES

Thinning immature stands

Foresters are interested in knowing answers to such questions as when to thin young stands; how feasible is a precommercial thinning; what is the optimum percentage of basal area to remove for a particular objective; what is the economic return from thinning; what are the benefits of cutting or only killing trees? It is difficult for foresters to thin central Appalachian hardwood stands because there is no general stocking guide applicable to all of them. There are three or four stocking guides that could be used, including Gingrich (1967; upland oaks), Leak et al. (1969; northern hardwoods), Beck and Della-Bianca (1972; yellow-poplar), and Roach (1977; Allegheny hardwoods). In the past, perhaps the most-used guide throughout the area has been the one for upland oaks. We are cooperating with Marquis's research project at Warren, Pa., to verify or modify the Allegheny hardwood guide for use in certain central Appalachian hardwood stands.

Crop tree release in young stands

Crop tree release is one treatment used in even-aged stands to stimulate dbh and height growth, eliminate unwanted species, and to some degree manipulate species composition. Considerable information has been published recently on crop tree release in young hardwood stands. Generally, researchers are uncertain or recommend no release at this time for many central Appalachian hardwood tree species (Trimble 1972, Della-Bianca 1975, Smith 1977). In some cases, results can be interpreted as positive for certain species and growth parameters (Trimble 1974, Boyette and Brenneman 1978).

On the Fernow and the Monongahela National Forest, we have been releasing crop trees of seedling and sprout origin at various intervals after clearcutting. Presently, information is available on trees released 7 years after clearcutting when the codominant trees averaged about 15 feet tall. Also, trees of seedling origin have been released 10 years after clearcutting and trees of sprout origin have been released 8 and 12 years after clearcutting.

The 7-year release was done by cutting all trees in a 5-foot radius around each crop tree, releasing the trees to a dominant crown class position. In the 8-, 10-, and 12-year release, all trees competing with the crowns of the crop trees were removed--a complete release. In all instances, the released trees were compared to other crop trees not released for height growth, dbh growth, clear bole length, change in crown class, and potential as crop trees at each remeasurement period.

Codominant crop trees 15 feet tall. On the basis of the crop tree release techniques we have used, we cannot recommend early release of yellow-poplar, black cherry, sugar maple, or red oak crop trees of seedling origin in young stands 7 years after clearcutting (codominant crop trees about 15 feet tall). Occasionally, there is a trend toward increased dbh growth, but other factors, such as crown class regression and changes in crop tree status in later years, tend to negate this trend.

Codominant crop trees 25 feet tall or taller. However, our results have been quite different for codominant stems of sprout and seedling origin about 25 feet tall or taller.

In West Virginia, we selected dominant and codominant crop trees from 7- and 12-year-old yellow-poplar, basswood, red maple, black cherry, and red oak stump sprout clumps. Tree heights and dbh at the time of release averaged approximately 25 feet and 2.9 inches for 7-year-old dominant and codominant sprout stems. For the 12-year-old sprout stems, height and dbh averaged 37 feet and 4.1 inches. For all species and age classes, there were 237 control trees and 224 release trees. Sprout clumps were thinned to the best one or two stems per clump. These were completely released to a free-to-grow crown position.

The 5-year results for both 7- and 12-year-old sprouts indicated that height growth was not affected by release, but dbh growth of the thinned stems was increased to about 1.5 times that of the control stems. For 7-year-old sprouts of yellow-poplar, basswood, and red maple, 5-year results indicated that dbh growth was significantly greater for the thinned than for

the control stems. The periodic growth differences of the thinned stems were about 0.8 inch higher than those of the control stems for each of the three species studied.

For the 12-year-old sprouts, 5-year results indicated that the dbh growth for the thinned yellow-poplar, red maple, and red oak sprouts was significantly greater than that of the unthinned stems. Five-year periodic dbh growth response of the thinned sprouts averaged 0.6, 0.7, and 0.2 inch, respectively, for these three species. Black cherry thinned sprouts were 0.4 inch larger than the control stems, but this difference was not significant.

Codominant crop trees 25 feet tall or taller. In another study recently completed on the Fernow Experimental Forest, crop trees of seedling origin 25 feet tall or taller responded positively to release. Codominant yellow-poplar, black cherry, and sweet birch trees of seedling origin on good oak sites (SI 70) and black cherry and sweet birch on fair oak sites (SI 60) were released. The study trees were in stands that had been completely clearcut 10 years previously. The response categories were grouped by two height classes at the time of release--25.0 to 32.9 feet tall and 33.0 to 39.9 feet tall. All trees were released to a free-to-grow crown position.

Five-year results indicated no differences in height growth between the released trees and the control trees for either of the two height categories or site classes. However, the released trees produced a significantly greater growth in dbh for all species and height categories except sweet birch and black cherry over 33 feet tall on the fair sites and sweet birch under 33 feet on good sites.

On the good sites, the 5-year dbh growth response for released yellow-poplar and black cherry trees under 33 feet tall increased about 0.3 and 0.4 inch more than the control trees. Also, the dbh growth of sweet birch was 0.2 inch greater for the released trees than for the control trees, but this difference was not significant. For trees over 33 feet tall, a similar positive 5-year growth response in dbh of 0.3 to 0.5 inch was observed for released yellow-poplar and black cherry trees.

On the fair sites, 5-year dbh growth of sweet birch and black cherry under 33 feet tall was 0.2 and 0.3 inch greater than that of the control trees. However, for trees greater than 33 feet, no significant difference in 5-year dbh growth response was found.

Thus, in this study some trees of seedling origin 25 feet tall or taller responded significantly in dbh growth. In all cases, the released trees produced more dbh growth than the control trees, though the response differences were not always significant. Also, the regression of crown classes for the released or control crop trees was not a problem.

Seedling versus sprout origin stems

Stems of sprout origin are quite numerous where even-age cutting practices are applied to stands about 40 to 60 years of age. If foresters were asked to choose between stump sprouts and stems of seedling origin, most

would select seedling-origin stems for we have been taught that decay is a serious problem with sprout-origin stems. However, within the last few years I have changed my attitude toward decay in sprout-origin stems.

One major concern has been the possibility of sprout-origin stems rotting from the decay of the parent stumps. Wood tissue from 7- and 12-year-old stump sprouts on the Fernow was cultured. The sprouts were primarily basswood, and in several cases the original stumps were almost completely rotted. Pathologists from the Forest Service Laboratory in Delaware, Ohio, could not isolate any rot organisms in the wood tissue of the cut basswood sprout stumps. Also, Beck (1977) reported that yellow-poplar stump sprouts thinned to one sprout at 6 years of age had no apparent butt rot from the parent stump during the 18-year evaluation period.

Recent developments have raised questions about the sprout-rot-decay concept (Lamson 1976). Fire protection is much improved, reducing the potential for wounding and subsequent decay. High-origin sprouts are not as common since better logging practices have lowered stump height. Also, the compartmentalization of wounds and decay is better understood (Shigo 1974).

Often considerable money is spent on cultural practices to reduce the number of sprout-origin stems. In several 50-55 year ^{old second growth} stands on the Fernow Experimental Forest where cut stumps and small stems have been treated with herbicides, the newly regenerated stands average 15 to 20 percent sprout-origin stems. Where no herbicides are used, about 40 to 50 percent of the stems are expected to be stump sprouts (Smith 1981).

Height and dbh growth data were recorded and summarized for yellow-poplar, black cherry, and red oak trees on the Fernow and the Monongahela National Forest, 250 trees per species per origin class (Table 2). After 12 years, sprout-origin stems were considerably larger and taller than seedling-origin stems. How long the height and dbh differences between these origin classes will continue is unknown.

Grapevines--Young to Mature Stands

Grapevines can be a major problem in managing good quality central Appalachian hardwood sites with even-age cutting practices. These vines are intolerant and can cause considerable damage to hardwood stems (Trimble and Tryon 1979). Grapevines degrade saplings and pole-size trees by bending and uprooting them and break the crown branches. Trees can be killed.

Reproduction establishment and development in central Appalachian even-aged stands can be excellent, but a few hundred unnoticed grapevines per acre can soon preclude the production of quality hardwood timber. In my opinion, grapevines, and to a degree Dutchman's pipe, are becoming a major problem where even-age cutting practices are used (Smith 1979). Though grapevines are important to wildlife and recreation, their rampant growth must be controlled if producing quality timber is a forest objective. Overstory shade and herbicides are effective in killing germinating seedlings or sprouts from cut grapevine stumps. However, grapevines layer and sprout prolifically if cut. In full sun the vines will grow 15 to 20 feet per year. Also, grapevine seed remains viable in the soil for many years (Wendel 1981) and will often germinate after an even-age cutting.

Table 2.--Height and dbh growth of dominant-codominant trees of seedling versus sprout origin in 12-year-old clearcuts on good central Appalachian oak sites.

Species	Dbh		Height	
	Seedling	Sprout	Seedling	Sprout
	-----inches-----		-----feet-----	
Yellow-poplar	2.5	4.7	24	40
Black cherry	2.7	4.4	26	43
Red oak	1.8	3.0	23	31

Many central Appalachian stands contains small arborvita-like clumps of grapevines. These areas will not produce timber products for many, many years and should probably remain in grapevines because even herbicides may be only a temporary control measure; vines will regrow from stored seed and vine layering. Foresters interested in producing quality timber cannot ignore a grapevine problem; it will continue and multiply. Grapevines should be controlled in young stands before they do serious stem damage and after a dense overstory canopy has developed, when the forester can easily work in the stand. In my opinion, the various interest groups should be able to work out a suitable compromise for grapevine management.

SUMMARY

In managing central Appalachian hardwood stands, foresters need to be aware of the complexity and variation present in each stand. Often there are a multitude of commercial species with different growth rates and in different diameter classes at approximately the same age in the same stand. Site index quality must be readily recognized, but steep topography and site conditions complicate management and harvesting decisions.

In the central Appalachians, reproduction can usually be established readily by any regeneration method. Problems occur when foresters want to regenerate and develop future stands of certain species. Stand growth and yield information is needed for these hardwood stands. Some stocking guides are used for certain forest types, and while others may be applicable, particularly the Allegheny hardwood stocking guide, researchers need to verify or modify potential guides before recommending them.

Though recommendations for releasing crop trees have been uncertain, recent studies of trees of seedling and sprout origin indicate that trees at least 25 feet tall at time of release will respond in dbh growth. The treatment technique used completely released crop trees to a free-to-grow crown class position.

In my opinion, more management consideration should be given to stump sprouts. Young sprout stems can be nearly twice as large as stems of seedling origin. How long the height and dbh growth difference will continue is unknown; however, trees of stump-sprout origin cannot be overlooked in managing central Appalachian hardwood stands.

Vines, particularly grapevines, are becoming a major problem in regenerating even-aged stands on good sites. They can destroy hardwood quality in young saplings and pole-size trees. Methods to reduce the number of grapevines are available. One thing is certain, if grapevines are present in stands before an even-age harvest cut, they will be a problem in the future stand.

There are many concerns in management of central Appalachian hardwood stands that we have not addressed in this paper. In the future, management of Appalachian hardwood stands could become an economic issue: that is, manage stands to grow the highest value species such as black walnut, black cherry, or white ash, or not at all. Perhaps presently marginal sites will not be considered for timber management unless stands can be established that include pines to increase the stand value. Currently economic concerns in government are a major public issue. Foresters in all disciplines may need to revise their objectives to maximize site productivity or lose their management opportunities to an alternative that offers a higher return.

No doubt managing central Appalachian hardwood stands will become even more complex as we managers become more aware of what is needed to attain specific objectives. Combining various disciplines to satisfy landowners' objectives adds even greater complications. Foresters must maintain an awareness of management situations and be certain that any management practices they select relate to existing stands and are attainable in reality. We must continue to improve management techniques. Being aware of how a given stand was established, what prescription alternatives are available, and what the owners' objectives are can lead to a management decision that is satisfactory to all concerned.

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ORIGIN, DEVELOPMENT AND MANAGEMENT OF MIXED HARDWOOD STANDS—
SOUTHERN APPALACHIANS

by

D. E. Beck
Southeastern Forest Experiment Station
Asheville, North Carolina

Geographic Setting

The southern Appalachians are the mountain mass extending from southwestern Virginia into northern Georgia. They are bounded on the east by the Blue Ridge chain and on the west by the Unaka Mountains (which include the Great Smokies); a series of more or less transverse chains and intermountain valleys connect the two (Fig. 1). Bedrock in the Blue Ridge is primarily granite, usually highly metamorphosed; in the Unakas sedimentary rocks, more or less metamorphosed, are predominant. Elevations range from about 1,500 to more than 6,600 feet. Rainfall averages from 40 inches in some interior valleys to more than 100 inches in the southwestern mountains. Rainfall during the growing season is usually about one half the annual total. Growing season ranges from 150 to 200 days depending on elevation. In short, climate for tree growth is excellent and the region is heavily forested.

Species Distribution

There are more than 140 tree species in the region, and mixed stands are very much the rule. Ten or more species may form the dominant canopy on areas of less than $\frac{1}{4}$ acre. Species mixtures are, however, not simply haphazard arrangements. Species distributions and their mixtures are controlled by a complex of environmental factors that are largely reflected in moisture and elevational gradients (Fig. 2).

The most mesic sites—the coves and lower protected slopes—contain complex mixtures including yellow-poplar, northern red oak, birch, ash, and cucumber at lower and middle elevations with sugar maple, basswood, and buckeye at higher elevations up to 5,000 feet (Davis 1930, Whittaker 1956). As sites become progressively drier, passing from protected to open slopes to upper slopes and ridges, composition becomes progressively dominated by mixtures of oaks, including white, black, chestnut, and scarlet. The most xeric upper slopes and ridges are dominated by pine. At elevations above 5,000 feet red spruce and Fraser fir dominate along with representatives of the northern hardwood group. Most of my remarks deal with coves and moist slopes.

Historical Factors

A third factor, past treatment, has played a major role in shaping the stands we see today on the National Forests of the southern Appalachians. A number of historic events that can be bracketed by definite time periods have strongly influenced stand structure, condition, and, to some extent, species composition. The region was first impacted by white men in the early 1800's as settlers cleared land, cut timber for local use and introduced grazing and frequent fire in the surrounding forests (Nesbitt 1941). Heavy logging with export of lumber occurred from about 1880 to the early 1930's (Frothingham 1931). The earliest logging was very selective; only the best and largest individuals of preferred species such as yellow-poplar, walnut, ash and cherry were cut. The diameter limit was progressively lowered and more of the species taken; by 1930 all species over 10 to 12 inches d.b.h. were being utilized, with the exception of larger culls that were left standing. Many stands were cutover several times. Throughout this period, fire was a constant companion of logging (Frothingham

1931). During the latter stages of the period, chestnut blight eliminated American chestnut and did its part to shape current stands.

From the time of first acquisition by the Forest Service until about 1960 management was characterized by protection and selection. Fire and grazing were progressively excluded. Timber harvests were by single-tree selection--often amounting to diameter-limit cutting--and were accompanied by elimination of large culls and some less-desirable species. Starting in the early 1960's regeneration harvests became primarily clearcutting with control of residual, non-merchantable trees. The stands we see today are products of various combinations of these past treatments.

Stand Structure

Stands vary from very sparse and laden with culls to heavily stocked with large, high-quality trees. Stands that occupied old fields, areas logged cleanly, and areas logged and severely burned are often very even-aged. Stands with multiple-age classes reflect a succession of heavy partial cuts. Most stands have at least two age classes; stands of very old, scattered culls interspersed with relatively even-aged poles and small sawtimber are very common. Many stands have three or more distinct age classes. In multiple-aged stands, most trees have endured some suppression during their lifetime.

A good example of a multiple-aged stand that shows a series of historical events going back to the earliest settlement in 1810 is shown in Tables 1 and 2 (Beck 1980). As in even-aged stands, we find a considerable range in height and diameter reflecting differences in species growth rates and competitive positions. But this stand is far from even-aged. In fact, the oldest trees trace their origin to wood clearing following the original land grant and the

youngest to a timber harvest in 1954--events separated by 145 years. Trees less than 27 years old, which make up 30 percent of the dominant stand, originated as stump sprouts after the 1954 diameter-limit cut that removed all trees over 12 inches d.b.h. Another 53 percent consists of yellow-poplar and red maple 60 to 90 years old that trace their origin to events between 1900 and 1920--possibly one or more high-gradings. These trees were mostly subdominant saplings and poles at the time of the last cut. The remaining 17 percent are oaks and hickories well over 100 years old. Evidence suggests that when they originated between 1810 and 1900 repeated high-grading, grazing, and burning occurred. Most of the stands on the National Forests of the southern Appalachians show some variation of that history in their rings. Today's manager of National Forest land has to deal with a complex variety of species, ages, sizes, and conditions. Except for the handful of even-aged stands regenerated since 1960, the youngest age class is usually 60 or more years old.

The challenge is to regenerate the species we want and to manage the trees that are present for many years (perhaps 60+), given current harvest rates. We are not exactly overwhelmed with hard research data for such stands, but our best evidence suggests that neither job is hopeless.

Management of Multiple-Age Stands

As for management, we are finding growth response to thinning across a wide range of species, ages, and tree conditions and very respectable growth rates on trees of relatively advanced age. Yellow-poplar and northern red oak in even-aged stands over 70 years old have doubled their radial growth rates following heavy thinning (Beck and Della-Bianca 1971). Trees of a number of species have shown

the ability to respond to release even after very extended periods of suppression (Table 2). This means that we can concentrate growth on better-quality trees of desired species through a combination of thinning, sanitation-salvation, TSI, or what have you. This is not to say that sparse cull-laden stands can be turned into fully stocked, high-quality stands. But the potential for management is better than we may have thought up to now.

Regeneration

Reproductive potential of southern Appalachian mixed hardwood stands is very strong. In most cases the potential new stand is constantly in place in the form of seeds, seedlings, seedling-sprouts, and potential stump and root sprouts. The regeneration effort consists mainly of the orderly removal of the mature stand and treatment of residual culls and nonmerchantable understory trees. During the years of protection from fire and grazing, understories have developed that contain mostly tolerant, nontimber species, 400 to 600 trees per acre 1 to 5 inches d.b.h., and 12 to 15 square feet of basal area. Treatment of understory trees is the key and, of course, the costly part of regeneration. By treating understories with herbicides or lopping individual stems, we have successfully regenerated mixed stands with a wide variety of harvest cuts. In some cases, overstory was removed in one cut on areas of $\frac{1}{4}$ acre or more, and on other areas the overstory was removed in two or more partial cuts extending over 12 years (McGee 1967 and 1975, McGee and Hooper 1970 and 1975). Our experience to date shows that most components of mixed stands are able to hold their own. The well-known exceptions are oak species on the better quality sites. Table 3 shows a typical example of stand development on a good site after clearcutting with lopping. A mature stand that contained nearly 50 percent oak

species has been converted to one at 16 years of age that contains less than 5 percent oaks--and those in relatively poor competitive position. The challenge, then, is to devise methods that will control species composition and in particular encourage oak species on good sites.

The key seems to lie in strong, advance reproduction. But our research and the historical evidence suggest that it will not be accomplished by simply manipulating the overstory prior to the final harvest cut (Loftis 1979). It appears that understory treatment, perhaps rather intensive and repeated, will be required. Table 3 shows the kind of stand many managers would like to achieve; it was obtained by clearcutting (McGee 1972). The higher quality, lower slope is dominated by yellow-poplar but has good components of red oak; the intermediate quality, middle slope is a complex mixture of the mesic as well as submesic species; the upper slope of lower quality is predominately oak. The key seems to be that the original stand contained 80 oaks per acre in understory trees 2 to 6 inches d.b.h. and an additional 4,800 oaks per acre less than 2.0 inches d.b.h. Prior to harvest in 1931 the stand had been periodically high-graded, burned, and grazed (Jemison 1946).

Management of Even-aged Stands

Management of the new, even-aged stands now being created will become increasingly important as time goes on. What to do with the relatively few seedling-sapling stands started since about 1965 has already provoked more controversy than any other facet of mixed stand management. Our best evidence suggests that one-time precommercial thinnings or cleanings are marginal operations at best (Della-Bianca 1975a, Downs 1946, Della-Bianca 1975b). We can demonstrate growth response on released crop trees. But the primary

objective of altering species composition has not been conclusively demonstrated. It appears that if substantial change in species composition is possible at all it will require expensive, repeated operations.

Our data on growth of pole and sawtimber stands and their response to management is very preliminary, but opportunities for management appear to be very good. Of course, a major objective is to increase tree size at rotation. In Figure 3 curve A shows average diameter by age for the whole stand, and curve B shows average diameter of the 25 largest trees per acre for a large number of undisturbed, mixed, even-aged stands. By judicious thinning it should be possible to obtain an average stand diameter equal to curve B as a minimum. Curve C is based on a 20-percent increase in diameter growth of even the largest trees after thinning and is close to the maximum possible for mixed stands. On rotations of 100 years, it should be possible to increase average stand diameter by 25 to 50 percent over unthinned stands. Most species in mixed stands in the southern Appalachians have proven to be responsive to additional growing space, allowing for redistribution of growth to trees of desired species and quality.

Perhaps the greatest challenge in mixed stands will be in projecting growth and yield. Growth rate differences by species are dramatic. We are finding diameter growth rates that range from 0.5 inches in 5 years for hickory to 1.5 inches for yellow-poplar growing in the same stand. It seems quite clear that the stand-level projectors that have proven useful for single-species stands--yellow-poplar, for example--will be inadequate for mixed stands. Perhaps an additional variable that describes species composition will work. But it seems more likely that adequate growth projections will require projection of

individual tree development by species or species groups. Growth and yield projections will probably be more of a challenge to research than to management. But more detailed information on individual trees will be required, and different approaches to examining stands and prescribing treatments may be needed.

Regeneration and management of mixed stands in the southern Appalachians does present a challenge. Standardized, cookbook solutions are probably not going to work, particularly on the great variety of existing multiple-aged stands of many species. But prescriptions on a stand-by-stand basis using the knowledge we already have of individual species growth and regeneration characteristics provide good opportunities for achieving the National Forest goal of growing large, high-quality timber.

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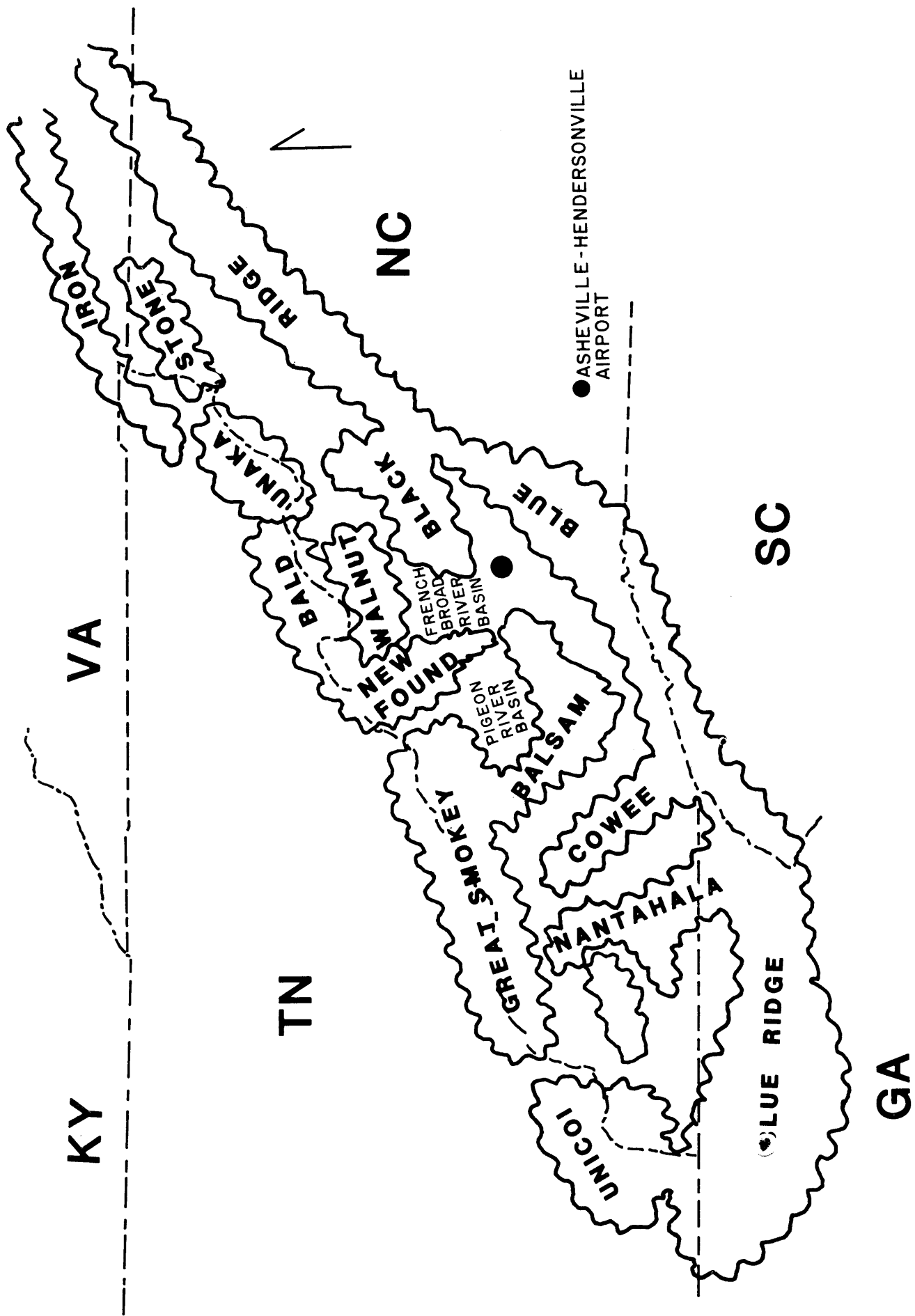


Figure 1.---Southern Appalachians

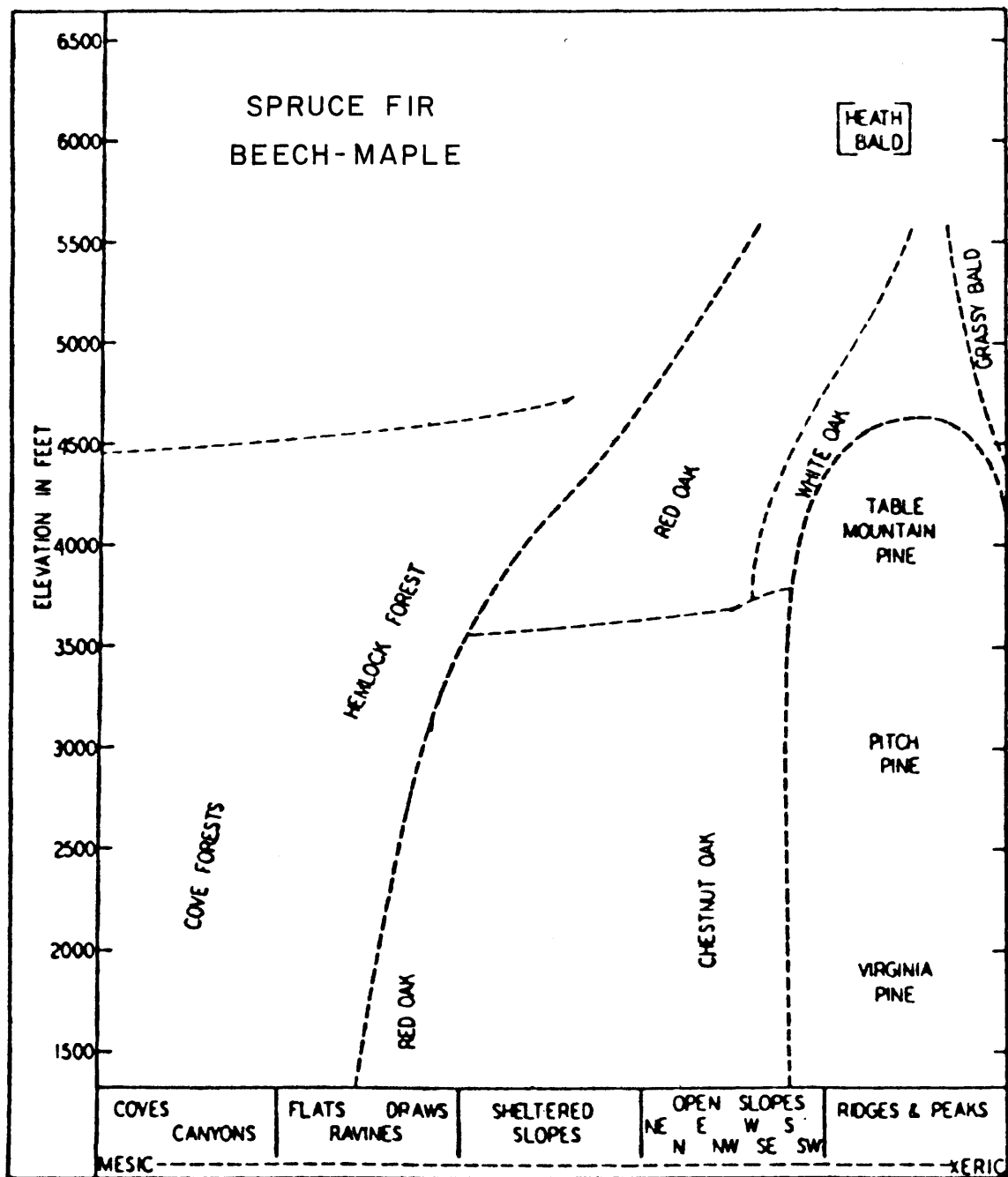


Figure 2.--Vegetation pattern--southern Appalachians
(adapted from Whittaker 1956).

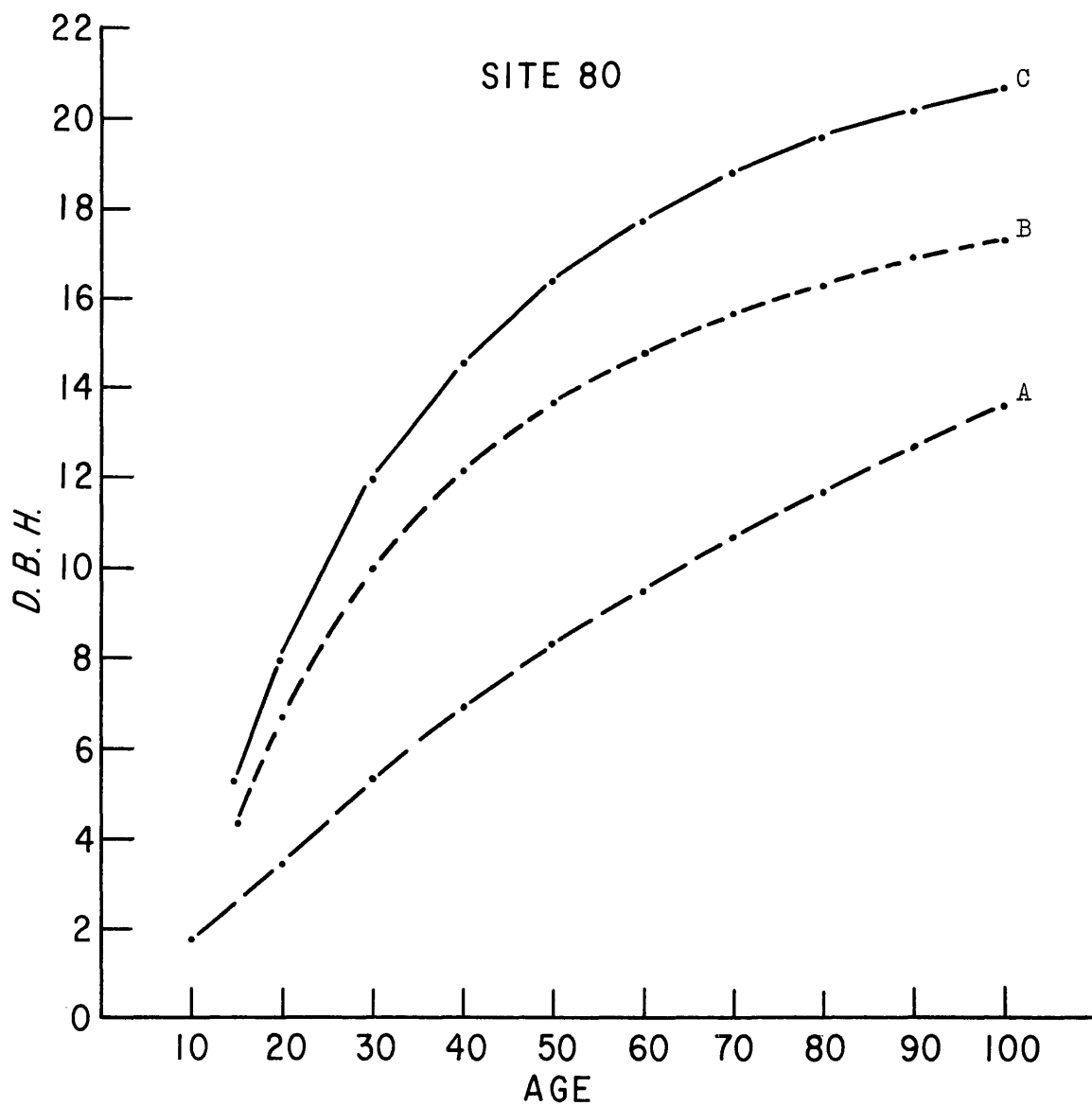


Figure 3.--Mean stand diameter for (A) undisturbed stands vs. potential mean diameters for thinned stands (B)(C).

Table 1.--Size distribution of multiple-aged stand.

SPECIES	HEIGHT		DBH	
	MEAN	RANGE	MEAN	RANGE
OAK	92	(83 - 102)	16.7	(13.5 - 22.2)
HICKORY	87	(74 - 113)	11.0	(7.9 - 19.4)
R. MAPLE	85	(66 - 110)	13.0	(7.6 - 22.0)
Y. POPLAR	92	(66 - 122)	12.9	(5.8 - 22.0)

Table 2.--Age structure of multiple-aged stand.

AGE CLASS	YP	LOC	RM	OAK	HICKORY	ALL
27	21	3	--	--	--	24
31 - 40	--	--	--	--	--	--
41 - 50	--	--	--	--	--	--
51 - 60	--	--	--	--	--	--
61 - 70	10	--	5	--	--	15
71 - 80	9	--	4	2	1	16
81 - 90	5	--	6	--	1	12
91 - 100	--	--	--	1	2	3
101 - 110	--	--	--	2	1	3
111 - 120	--	--	--	3	1	4
121 - 130	--	--	--	--	1	1
131 - 140	--	--	--	--	--	--
141 - 150	--	--	--	1	--	1
151 - 160	--	--	--	--	1	1
161 - 170	--	--	--	1	--	1

Table 3.—Response to release of subdominant trees.

Species	Age and size at release						Five-year diameter growth			
	Age		DBH		Height		Before release		After release	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Oaks	85	(49-137)	99	(4-12)	68	(48-85)	.5	(.2-1.0)	1.6	(.9-2.5)
Hickory	79	(46-127)	62	(4-12)	55	(37-94)	.3	(.1- .6)	1.0	(.2-1.2)
R. Maple	47	(18- 62)	60	(2-13)	47	(23-65)	.4	(.1-1.2)	1.5	(.6-2.5)
Y. Poplar	44	(33- 58)	65	(2-11)	57	(16-92)	.6	(.2-1.5)	1.8	(.3-3.0)

Table 4.--Species composition (trees $\geq 5.0''$) forty years after clearcutting.

SPECIES	LOWER SLOPE SI=80		MIDDLE SLOPE SI=75		UPPER SLOPE SI=60	
	NUMBER	%	NUMBER	%	NUMBER	%
YELLOW-POPLAR	40	43	19	11	5	3
S. BIRCH	32	34	13	7	-	-
LOCUST	-	-	23	13	44	21
N. RED OAK	13	14	19	11	7	3
W. OAK	-	-	-	-	23	11
CH. OAK	6	7	75	42	59	29
BL. OAK	-	-	6	3	11	5
SC. OAK	-	-	14	8	32	15
HICKORY	-	-	-	-	5	3
R. MAPLE	-	-	5	2	-	-
MISC.	2	2	6	3	21	10
TOTAL	93	100	180	100	207	100

EVEN-AGE DEVELOPMENT AND MANAGEMENT
OF MIXED HARDWOOD STANDS: ALLEGHENY HARDWOODS¹

David A. Marquis²

Abstract--Most Allegheny hardwood stands contain at least two different age classes as a result of the sequence of cuttings that led to their formation. The mixture of species with widely different growth rates and tolerance levels adds to the complexity of present stand structure. Some modifications of traditional even-age silvicultural techniques seem desirable to provide for more efficient management of these mixed hardwood stands.

¹Presented at the annual Silviculture Workshop, USDA Forest Service, Roanoke, Va. June 1-5, 1981.

²Principal research silviculturist, USDA Forest Service, Northeastern Forest Experiment Station, Warren, Pa.

INTRODUCTION

Because most of our eastern hardwood forests originated after commercial clearcutting around the turn of the century, we tend to think of them as even-aged stands. Although this is partially correct, it is also a great oversimplification that probably has muddled our thinking about appropriate stand management and regeneration practices.

Actually, our present stands are not completely even-aged. The process by which these stands were created did not resemble clearcutting nearly as much as it resembled a sequence of shelterwood or diameter-limit cuttings. If we look closely at these stands, we find that their age arrangement is complex and that regeneration did not always originate in one fell swoop.

In this paper, I examine the sequence of cuttings that led to the formation of present cherry-maple on Allegheny hardwood stands, trace the development of the resulting stand structures and age arrangements, and mention a few of the implications for silvicultural practices.

GENERAL HISTORY OF FOREST CUTTING

The original forests of the Allegheny Plateau in northwestern Pennsylvania were primarily hemlock-beech and beech-maple associations with some smaller amounts of pine-oak-chestnut in the larger stream valleys (Hough and Forbes 1943). The original stands were uncut until about 1800, when some lumbering began for white pine adjacent to streams. From about 1850 to 1890, white pine, hemlock, and fine hardwood sawlogs were cut throughout the region; these partial cuts were restricted to the larger and better trees because of markets limited to these products, and lack of economical transportation to move large volumes of timber from the upland areas. After about 1890, logging railroads and huge band sawmills became practical. These technological advances, coupled with development of markets for small products such as pulpwood and chemical wood, provided the incentive for clearcutting over extensive areas. Between 1890 and 1930, nearly the entire Allegheny Plateau of northwestern Pennsylvania was cutover (Marquis 1975; Westveld 1949).

Because the chemical wood plants prevalent on the Plateau at that time utilized trees of all species and sizes down to 2 or 3 inches in diameter, the railroad-era clearcuts were very complete. This gave rise to second growth hardwood stands that are as truly even-aged as those resulting from any commercial logging operation.

Within this general pattern of cutting, there was great variation from place to place. The number of partial cuts made in any individual stand during the 1850-1890 period ranged from none to several; their severity ranged from light to heavy. Some of these cuts were made for a single product--first for white pine, later for hemlock, still later for fine hardwoods. In many stands, there were two separate cuts 10 to 20 years apart for hemlock.

In other stands, some combination of these products may have been taken in a single entry. Each of these partial cuts was followed by a surge of regeneration with species composition and density determined by the seed sources present, residual overstory density, and other factors.

After logging railroads were built, it was common to cut for multiple products. Sawlog cuts after this time generally removed all species of sawtimber-size trees, and chemical wood or pulpwood was often removed at the same time, or shortly after. However, some stands never received a chemical wood clearcut. Other stands, especially those that had been clearcut early, were clearcut a second time for chemical wood only.

Chemical Wood Clearcuts

The chemical wood clearcuts determined present stand condition, and the practices involved need to be understood. The chemical wood industry was very well developed on the Allegheny Plateau of northern Pennsylvania and southern New York. These industries produced charcoal, acetic acid, acetate of lime, wood alcohol, and similar products through the destructive distillation of wood. Because they could utilize nearly all species and sizes of trees, vast acreages on the Plateau were almost completely clearcut. Nevertheless, even the chemical wood clearcuts left scattered residual trees from the old stand. On the basis of a dozen stands on which we have records, residuals typically ranged from 2 to 8 inches in dbh and numbered from 50 to 400 stems per acre and represented 2 to 10 square feet of basal area. These residuals had an important impact on the new stand that developed.

Stands that were clearcut for sawtimber, but that never received a chemical wood clearcut, are even more heavily influenced by the residuals from the older stand. In these instances, residuals may have accounted for 20 to 50 square feet of basal area after cutting, and such stands are really multi-aged, even though they are commonly lumped with and treated like even-aged stands.

CLASSIFICATION OF STANDS BASED ON CUTTING HISTORY

Most Allegheny hardwood stands can be grouped into a few major categories on the basis of past cutting history.³ Stand condition before the final cut and the type of final cut chiefly determine present stand condition (fig. 1). Origin and probable cutting history can be determined by following the arrows backwards in figure 1. There are several possible routes for most present stand types, and this indicates several possible sequences of past cutting that could have led to a single present type. Of course, there are gradations between and among these categories, especially in the number, size,

³Marquis, David A. 1981. The effect of past cutting history on the structure, species composition, and development of present-day Allegheny hardwood forests. In preparation.

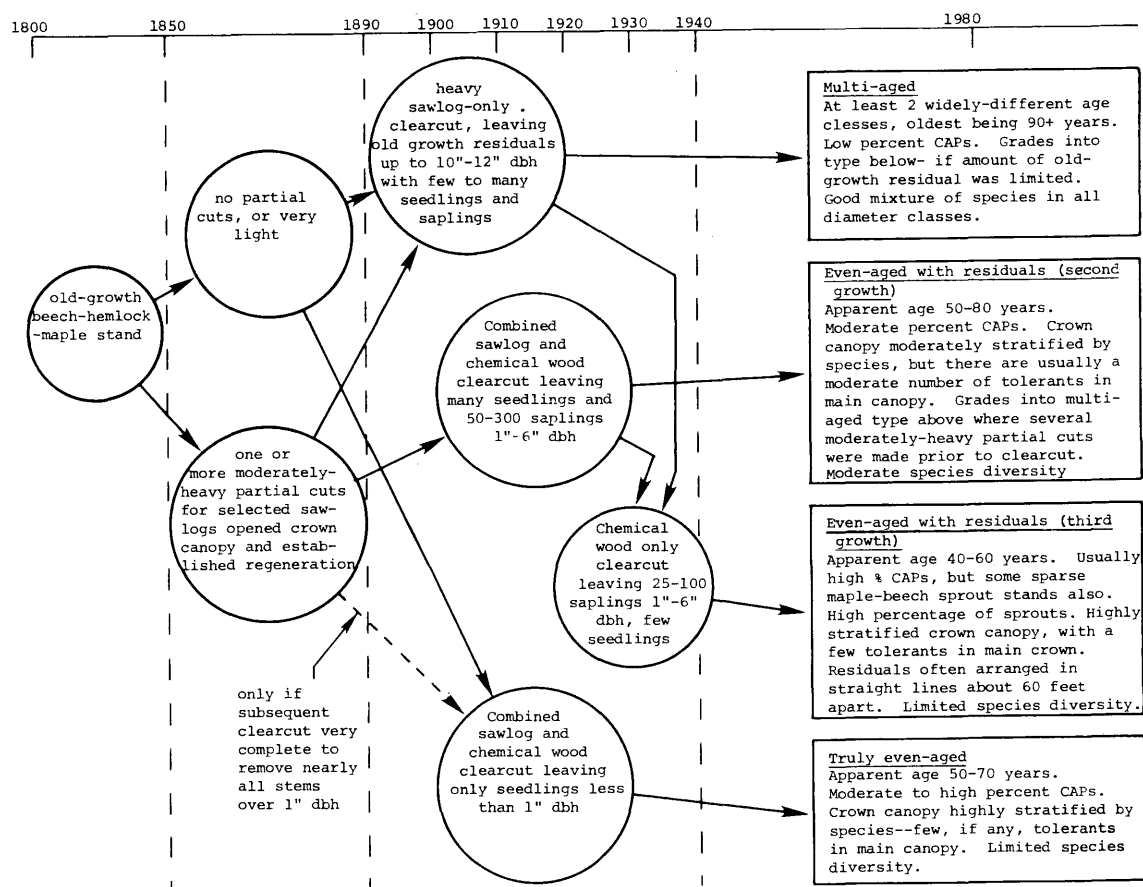


Figure 1.--Effect of past cutting practices on present Allegheny hardwood stand conditions.

and species of residual trees left after the final cut. Nevertheless, this classification provides a convenient basis for discussion during the examination of some actual stand records.

STAND DEVELOPMENT IN NOMINALLY EVEN-AGED STANDS

Evidence of a stand's past history and present age arrangement is often preserved in its diameter distribution. But one must look carefully because diameter distributions can be misleading.

Truly Even-aged Stands

Table 1 provides data on a 35-year-old truly even-aged Allegheny hardwood stand. The final cut that led to the present stand was a combined sawlog-chemical wood clearcut in an old-growth stand. Immediately after the chemical wood cut, all residual trees 0.5 inch in dbh and larger were cut down as part

Table 1.--Number of trees per acre in a truly even-aged (35 years) Allegheny hardwood stand that was completely clearcut of all trees 0.5 inch in dbh and larger.

Dbh	Sugar maple	Beech	Black cherry	Yellow-poplar	Red maple	Birch	Striped maple	Total
1	1,198	340	0			2	2	1,542
2	416	56	4			0	2	478
3	134	4	38			2	4	182
4	54		48		4	4	6	116
5	14		58	4	2			78
6	8		50	4	2			64
7			60	4				64
8			48	2				50
9			22	2				20
10			10					10
11			2					2
12			2					2
Total	1,824	400	342	16	8	8	14	2,612

Total basal area: 115 ft²/acre
Percent cherry, yellow-poplar: 68
Quadratic stand diameter: 2.8 inches
Cherry, yellow-poplar diameter: 6.4 inches
Effective age: 24 years

of a study on the Kane Experimental Forest. This stand was a special case; the experimental removal of all residuals created a truly even-aged stand.

When the total number of trees in this stand is plotted over diameter class, the diameter distribution for the stand forms an inverse J-shaped curve. This type of diameter distribution is traditionally associated with all-aged stands. Even-aged stands are assumed to follow a bell-shaped or normal curve (Smith 1962; Meyer and others 1961; Meyer and Stevenson 1943; Baker 1934). This apparent discrepancy in diameter distribution has led to many erroneous conclusions about the age arrangement and proper management of northern hardwood forests. Some have assumed that because a stand exhibits a typical all-age diameter distribution it must be all-aged. Nothing is further from the truth, as illustrated by this strictly even-aged stand.

Actually, most natural even-aged stands exhibit the inverse-J diameter distribution if tolerant or moderately tolerant species are present, especially when the stands are young. This fact has been reported many times (Hough 1932; Wilson 1953; Marquis 1967; Roach 1977; Oliver 1980) but is still not widely appreciated.

The reason for the inverse-J distribution in even-aged stands is that tolerant species such as sugar maple and beech are capable of surviving for many years without making much growth when they are crowded or overtopped. In dense young stands, a few stems emerge into dominant crown positions and grow rapidly. Other stems are overtopped but survive; this leaves a large number of trees in the small diameter classes.

When the stand contains a mixture of species of widely different tolerances and growth rates, the diameter distribution is stratified by species groups. The intolerants jump ahead of the other species and capture the dominant crown positions and larger diameters. Those intolerants that don't maintain dominance quickly die and are absent from the smaller size classes. The tolerants survive in the lower crown layers and smaller sizes and create a highly stratified, even-aged mixture as described by Smith (1972). Even-aged Allegheny hardwoods contain black cherry in the dominant position, sugar maple and beech in the suppressed crown position, and red maple and other species, if present, in an intermediate strata between the two extremes (fig. 2). The diameter distribution of the intolerant cherry does form a bell-shaped curve, even though the stand as a whole does not.

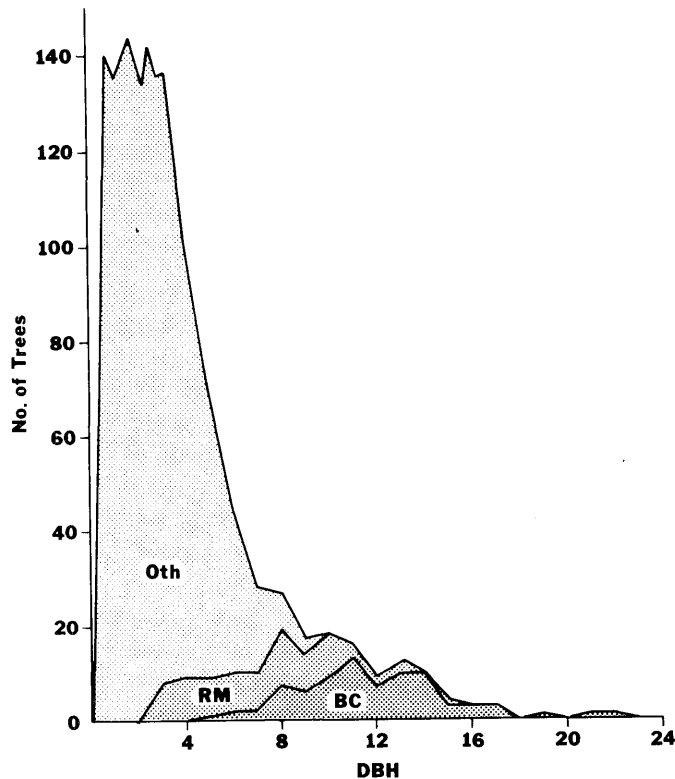
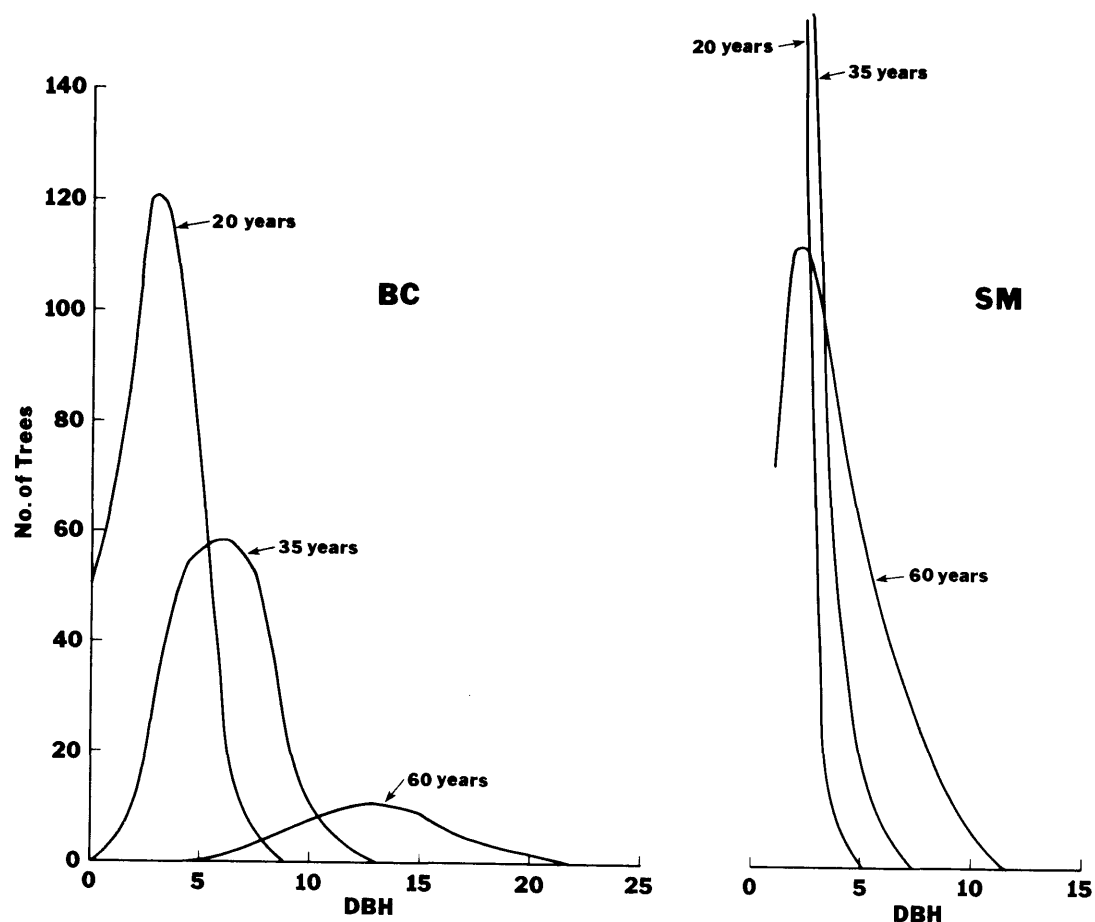


Figure 2.--Diameter distribution, which shows stratification by size class, for a 60-year-old even-aged (with residuals) Allegheny hardwood stand.

Diameter distributions for black cherry and sugar maple at 20, 35, and 60 years of age in truly even-aged stands are shown in figure 3. The distribution for black cherry is a bell-shaped curve that becomes increasingly flatter as the stand matures. The distribution for sugar maple is a very steep inverse-J curve with the largest sugar maple much smaller than the

Figure 3.--Diameter distribution for black cherry and sugar maple in truly even-aged stand.



largest black cherry at the same age. For example, at age 35, the largest black cherry are 13 inches in dbh, whereas the largest sugar maple are only 7 inches in dbh. A very heavily skewed bell-shaped curve begins to develop even for sugar maple if the stand remains fully stocked for many years. These curve forms and relative sizes are typical of stratified, even-aged stands.

Even-aged with Residuals

The effect of leaving a small number of residual trees at the final chemical wood clearcut is shown in table 2 and figure 4. The general form of the diameter distributions for black cherry and sugar maple remains the same--bell-shaped for cherry and inverse-J for maple. But the maple have much larger diameters that cause the tail of the inverse-J curve to extend much farther than would be expected in a truly even-aged stand. The trees in this extended tail are the residual stems of a distinctly older age class. The residual tolerants have a place in the main crown canopy, and their diameters are approximately the same as those of the larger black cherry.

Table 2.--Number of trees per acre for an even-aged stand (35 years) with residuals.

Dbh	Sugar maple ^{a/}	Beech ^{a/}	Black cherry	Red maple	Other	All species
1	328	56	0	0	0	384
2	168	16	0	0	0	184
3	52	4	4	0	0	60
4	32	20 ^{a/}	0	0	0	52
5	28 ^{a/}	4 ^{a/}	4	0	0	36
6	24 ^{a/}	8 ^{a/}	4	0	4	40
7	16 ^{a/}	0	8	0	4	28
8	12 ^{a/}	4 ^{a/}	4	4		24
9	12 ^{a/}	8 ^{a/}	8	0		32
10	8 ^{a/}	0	12	0		20
11	4 ^{a/}	0	0	0		4
12	4 ^{a/}	8 ^{a/}	12	4		28
13	0		8	0		8
14	4 ^{a/}		0	0		4
15			4	4		8
Total	692	128	68	16	4	912

Total basal area: 113 ft²/acre

Percent cherry: 32

Quadratic stand diameter: 4.8 inches

Cherry diameter: 10.0 inches

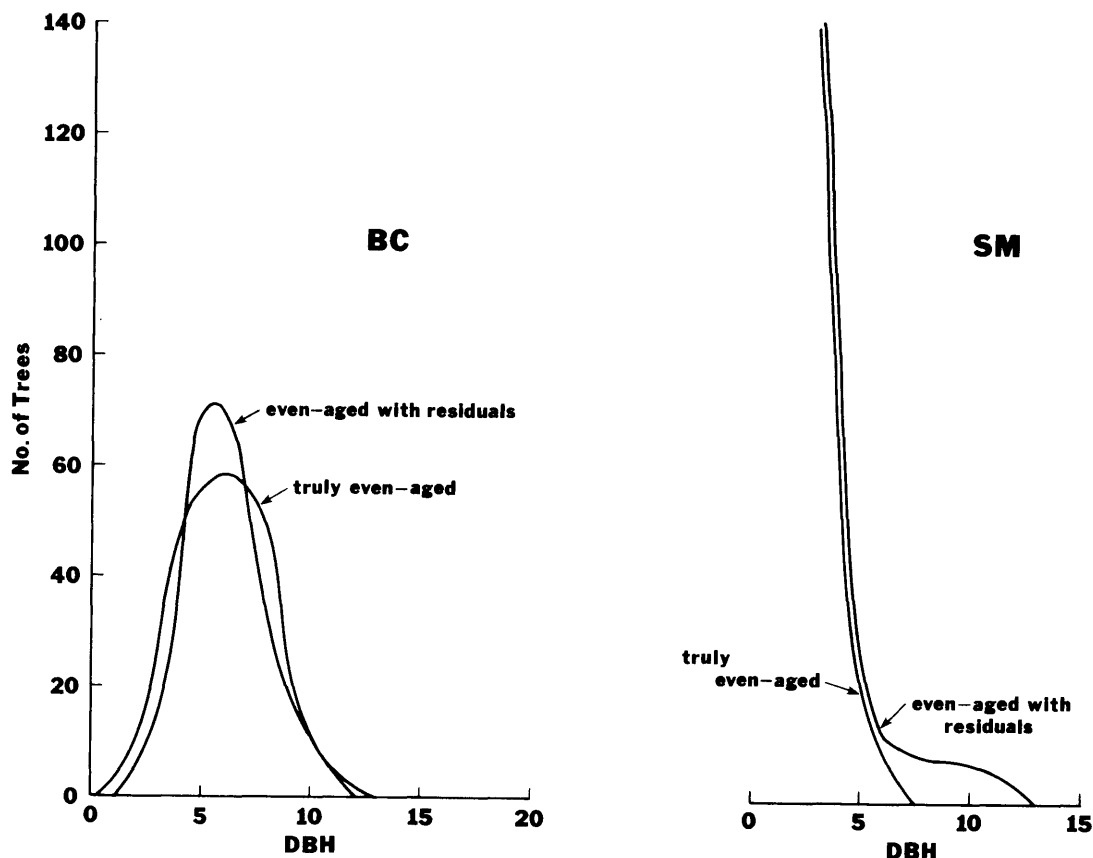
Effective age: 46 years

^{a/} Some or all of trees shown are residuals of an older age class.

Although the slight difference in the diameter distribution of sugar maple in the two stands may appear inconsequential, the residual trees have had a major impact on stand development. In this example, the relatively small number of residuals left after chemical wood cutting (180 stems per acre 1.5 inches in dbh and larger represent 10 square feet of basal area) constitute about 47 square feet or 41 percent of the total stand basal area at 35 years of age. Retention of residuals yields:

- a lower proportion of black cherry (35 versus 65 percent of the basal area) and correspondingly higher proportions of sugar maple and beech;
- a larger stand diameter (4.4 inches versus 2.8);
- faster stand development (effective age of 42 years versus 24 years, as indicated by yield data for Allegheny hardwoods); and
- tolerant species in the main crown canopy (34 square feet of sugar maple and beech in trees 6.5 inches and larger, versus none).

Figure 4.--Diameter distributions for black cherry and sugar maple in two 35-year-old stands, one truly even-aged, and one even-aged with residuals (second-growth).



These comparative data are based on an early experiment in a stand that received a combined sawlog-chemical wood cut, and then had all residual stems 0.5 inch in dbh and larger chopped down on some plots (Marquis 1981a).

Examination of numerous other stands that were clearcut for chemical wood and known to contain small residual trees has revealed consistently the same pattern shown in figure 4. Where sugar maple and beech are present in the main crown canopy in diameters comparable to the largest black cherry, the sugar maple and beech are invariably residual stems of an older age. They are in the main crown layer because they received a head start on the faster growing intolerants. Truly even-aged stands that result from complete clearcutting do not contain sugar maple and beech in the dominant crown canopy if numerous intolerants regenerated at the same time.

Multi-aged Stands

In multi-aged stands, diameter distributions for both black cherry and sugar maple differ from those in even-aged stands. As an example, the stand described in table 3 and plotted in figure 5 received a partial cut for

Table 3.--Number of trees per acre for multi-aged Allegheny hardwood stand.

Dbh	Sugar maple	Beech ^{a/}	Black cherry	Red maple	Yellow-poplar	Others ^{a/}	All species
1	7	66 ^{a/}				38 ^{a/}	111
2	6	25 ^{a/}				18 ^{a/}	49
3	14	10 ^{a/}				3 ^{a/}	27
4	17	6					23
5	16	5					21
6	19	3					22
7	14	3		1			18
8	12	3		1		1	17
9	13	1				1	15
10	10	1					11
11	10	2		1			13
12	8	1	1	2			12
13	9	0	1	1	1		12
14	4	1	1	2	1		9
15	2		1	1	2		6
16	2		1	1	1		5
17	1		1	1	2		5
18			1		2		3
19		1	1		2		4
20			2		3		5
21			2		1		3
22			1		1		2
23			1		1		2
24			2		1		3
Total	164	128	16	11	18	61	398

Total basal area: 149 ft²/acre

Percent cherry, yellow-poplar: 45

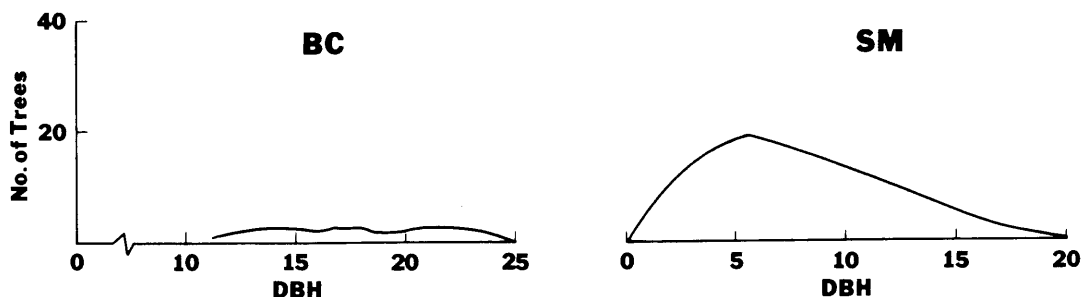
Quadratic stand diameter: 8.3 inches

Cherry, yellow-poplar diameter: 18.9 inches

Effective age: 76 years

^{a/} Some or all trees shown are new age class that developed after the salvage of ice-damaged trees 40 years ago.

Figure 5.--Diameter distributions for black cherry and sugar maple in a multi-aged stand that resulted from sawlog-only cutting.



hemlock sawlogs in 1888, and another cut for hardwood sawlogs in 1900. There may have been other cuts before the hemlock cut of 1888, but these have not been documented. The stand was never cut for chemical wood, so it never received a clearcut, although the hardwood sawlog cut was quite heavy. A surge of reproduction developed after each of the two cuts, and this reproduction together with some residuals from the original stand provides at least three distinct age classes.

The black cherry diameter distribution is broad and irregular. This is typical of older stands with a low percentage of cherry. If there are several closely spaced age classes of cherry, the curve may show several peaks, especially if the last cutting was recent.

The sugar maple distribution in a multi-aged stand such as this example, which has had no significant cutting since 1900, may depart drastically from the inverse-J form. The intermingling of three or more age classes plus death of the very small maples in this older stand produces a nearly bell-shaped curve. In stands where the last cutting was more recent, the bell-shaped curve will be more heavily skewed toward the small diameters, and the tail of the curve at the larger diameters may have a distinct hump (fig. 6). In other stands, especially older ones, the sugar maple distribution may be flat, much like the cherry curve.

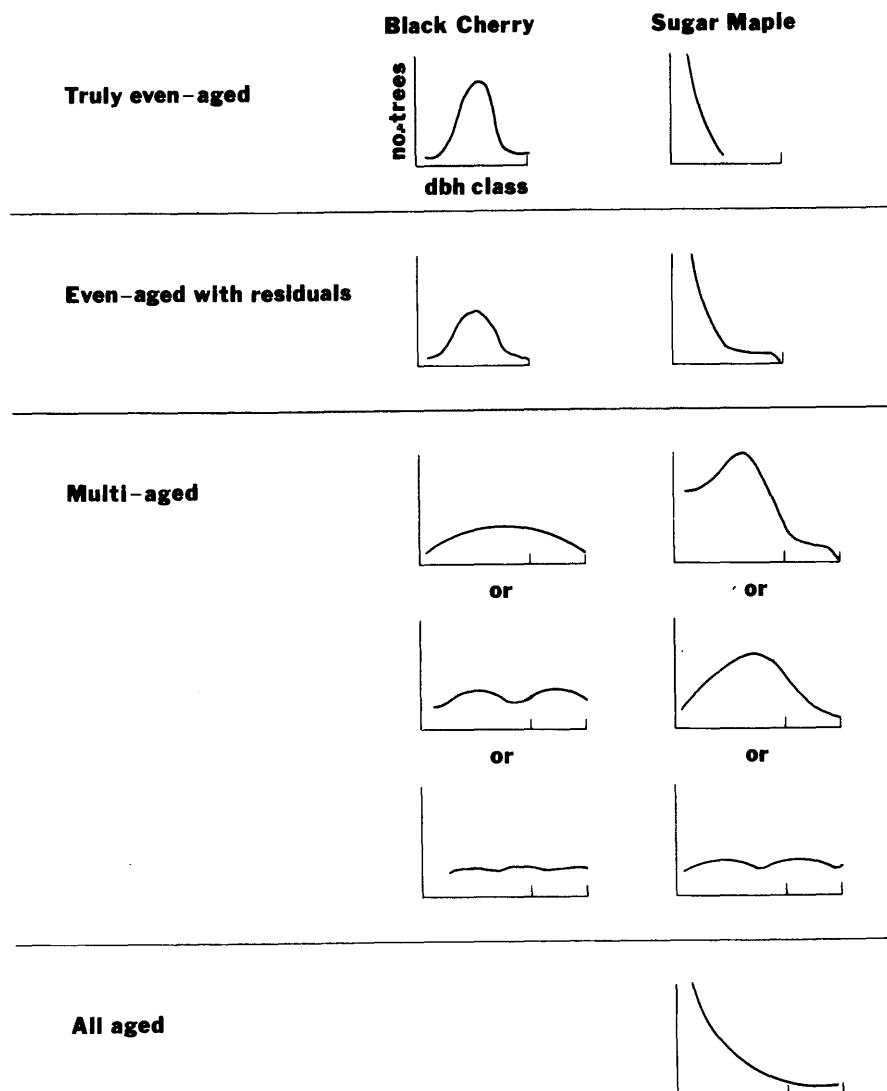


Figure 6.--Characteristic diameter distributions for black cherry and sugar maple in stands of different origin and age arrangement.

The patterns described above for multi-aged stands apply only to so-called second-growth stands that resulted from heavy cutting (but not chemical wood clearcutting) in the 1890-1930 era and were then left undisturbed. If such stands were disturbed more recently, they would contain a much younger age class of tolerant species that would have reestablished the inverse-J diameter distribution, which represents a truly all-aged structure.

Characteristic diameter distributions for black cherry and sugar maple for each of the several age arrangements described above are shown in figure 6.

SILVICULTURAL IMPLICATIONS

Truly even-aged stands of Allegheny hardwoods are highly stratified by species. Slower growing tolerant species are relegated to the understory and smaller diameters. This makes management by traditional even-age silviculture techniques difficult. Fortunately, there are relatively few truly even-aged stands today, except for research plots. Nearly all present-day second-growth stands contain several different age classes.

Thinnings in truly even-aged stands are complicated because even-age thinning theories are based on the assumption that the stand has a bell-shaped diameter distribution. Thinning should occur from below to favor the larger, better quality stems; increase average stand diameter; and reduce the time required for the stand to reach maturity.

But with the large number of small stems present when the stand has an inverse-J curve, it is not clear how to thin. Thinning to remove the bottom end of the diameter distribution would entail cutting many saplings and small poles noncommercially. The growth response among the dominants and codominants tends to be small for such understory thinnings. But, if you try to reduce density to an appropriate level without treating the small trees, you gut the main stand, reduce the percentage of intolerants, decrease stand diameter and extend the rotation, and provide enough growing space so that the tolerant saplings survive indefinitely.

In time and without thinning (50-60 years), the tolerant saplings eventually die or grow into pulpwood size so the stand can be thinned commercially. But this delays the start of density control well beyond the time when maximum response can be expected from the primary crop trees.

Furthermore, the several species do not mature at the same time in truly even-aged mixed species stands. Cherry matures in 80 to 90 years, whereas sugar maple matures in 150 to 180 years. The maple will be pulpwood and small sawtimber size when the cherry matures. If the entire stand is clearcut when cherry is mature, the maple is sacrificed when its value is very low but increasing at a maximum rate. However, if the cherry is harvested and the maple is held an additional 30 to 80 years, the cherry seed source is eliminated and regeneration to intolerants is more difficult at the end of the maple rotation.

Stands that are not truly even-aged (those that contain a representation of older tolerants) are easier to manage. The residual tolerants are about the same size as the intolerants and can be brought to maturity at the same time. Furthermore, stands that contain residuals develop at a faster rate--saplings represent a small proportion of the stand, average diameter is greater, and so on. Such stands can receive a commercial thinning at a considerably earlier age than a truly even-aged stand.

We need to reexamine some of our traditional even-age silvicultural maxims, and modify them to facilitate management of these mixed-hardwood stands. Techniques and theories developed for pure, even-aged intolerants just don't always work well in mixed hardwoods.

The current practice of complete clearcutting--removal of all stems down to about 2 inches in dbh--is creating a third forest of truly even-aged stands that may be difficult to manage. If the species in the mixture differ widely in growth and tolerance, it may be more efficient to purposely encourage the perpetuation of several age classes. The retention of carefully selected tolerant residuals at the time of harvest cutting is one technique that looks promising in Allegheny hardwoods (Marquis 1981b).

More elaborate schemes that provide for two rotations of cherry during the same time that a single rotation of maple is grown are also possible. We have one such two-age scheme now under study in Allegheny hardwoods.

Thinning and rotation-length strategies for stands with inverse-J structures and mixed species also need to be reconsidered. Preliminary studies using computer stand growth projection techniques have shown that maximum value yields of Allegheny hardwoods are obtained only if the cutting is prescribed to fit the species composition and structure of each stand. Longer rotations than those currently in use appear desirable in some stands.

In summary, mixed hardwood stands are complex in structure, age arrangement, and composition. Over the past 10 years or so, we've learned a considerable amount about the natural development of these stands. Improvements in silviculture and management efficiency in the future will depend on the imaginative use of this knowledge to develop techniques tailored more specifically to the characteristics of these mixed hardwood forests.

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HARDWOOD TREE IMPROVEMENT

James L. McConnell
Regional Geneticist
USDA, Forest Service, Region 8

In the South and Eastern United States, the uncertainty of the future use and importance of hardwoods has caused problems to the planners of tree improvement programs. What is the future of Southern and Eastern Hardwoods? Does it lay in the production of high quality wood for the production of high priced furniture and veneer, or will it be in the area of high per unit production of wood for energy? Another important aspect of hardwood tree improvement is the production of high mast bearing and fruitful trees for wildlife benefits. Even another is the importance of hardwoods able to withstand the rigors of the urban environment. These are some of the problems faced by our tree improvement specialists. As with many programs, you just can't have everything in one nice, little package.

Compared to pine tree improvement programs, hardwood tree improvement is more complex, probably more costly and certainly more varied. The results may also be more rewarding.

In the time and space allowed, I can do little more than give you a summary of the different programs here in this part of the country. I will be discussing both the Forest Service's Region 8 and Region 9 programs, and also a little of the North Carolina State University Cooperative Hardwood Tree Improvement Program.

First, Region 9. It is comprised of the following states: Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, Wisconsin.

1. The average annual cut on the Region 9 National Forests is about 500 MMBF, 70% hardwood.
2. The average annual regeneration (all methods) in Region 9 National Forests is about 50,000 acres, with 70% in hardwoods.
3. The average number of hardwood trees planted at the present time in Region 9 is about 500m trees representing 8-12 species, or 5% of the total number of trees planted.

4. The Region has three zones for tree improvement:
 - a. Lake States 7 N. F. 3 States
 - b. Central States 3 N. F. 4 States
 - c. Eastern States 4 N. F. 4 States
5. The following lists indicate by zone (States) the species priority by level of program intensity. The species priorities were determined by consideration of the following factors:
 - a. Acres of commercial forest land by timber type.
 - b. Genetic variation within the species.
 - c. Potential plantability of the species.
 - d. Current research programs.
 - e. Estimated economic gain.
 - f. Consideration of development programs being conducted by other units.

6. The following is a summary of the superior tree selections for hardwoods, by ZONES/STATE, that are in the National Forest Programs. (NOTE: Not all selections are on National Forest land/or made by National Forest.)

<u>SPECIES</u>	<u>LAKE STATES</u>	<u>CENTRAL STATES</u>	<u>EASTERN STATES</u>
RED MAPLE			32
SUGAR MAPLE	51		75
YELLOW BIRCH	134		112
PAPER BIRCH	94		58
WHITE ASH	1		108
GREEN ASH		77	
BLACK WALNUT		312	
TULIP POPLAR		115	28
EASTERN COTTONWOOD	1	88	8
POPLAR HYBRIDS	7		
BLACK CHERRY	68	1	152
WHITE OAK		36	
SCARLET OAK		20	
N. RED OAK	62	3	22
BLACK OAK		20	
BASSWOOD	78	1	5
<u>TOTAL</u>	496	673	600
1769			

7. The following is a summary of the acres of evaluation plantings and/or seed orchards, by zone, by species, for hardwoods:

SPECIES	LAKE STATES		CENTRAL STATES		EASTERN STATES	
	#Sites	Total-Acres	#Sites	Total-Acres	#Sites	Total-Acres
TULIP POPLAR			12	15	4	5
BLACK WALNUT			7	46	3	7
BLACK CHERRY	1	5			21	39
PAPER BIRCH					1	1
YELLOW BIRCH					22	30
WHITE ASH					2	3
COTTONWOOD			2	8		
GREEN ASH			1	6		
WHITE OAK			2	2		
N. RED OAK			1	1		
SUGAR MAPLE					3	9
POPULUS	1	27				
TOTAL						
SITES	83	2	25		56	
ACRES	204	32		78		94

8. The Region has been working with Alex Shigo, NEFES, the past few years in evaluating the possibilities of screening superior tree selections for improvement in decay resistance using a Shigometer. Researchers have indicated "a reduction of cull by...even 2% in crop trees would make any amount of effort economically viable." They feel this procedure still needs a little more research but could be very valuable, particularly in evaluation plantations.
9. Here are some general comments on hardwood tree improvement as viewed by John Murphy, Regional Geneticist. "Most projections indicate that, in the future, the demand for hardwood will be increasing and the land base will be decreasing. Some people speculate as to what form the demand will be (i.e., fiber, quality lumber, etc.)."

In any event, John believes it is safe to say that there will be a market for any increase in volume, quality and reduction in rotation length that an improvement program can produce. The hinge to an improvement program is the long-term economic considerations and the development of methods that can utilize the improved material (planting or seeding practices).

Tree Improvement programs for hardwood species have basically been adaptations of coniferous programs, which are developed with large, intensive, planting programs. The present volume of hardwood plantings and the lack of fundamental planting and maintenance procedures may require much different approaches than have been used to date.

Region 9's improvement programs may have to concentrate on improvement by rapid generation turnover. Producing and testing F_2 seed of perhaps twice the improvement of F_1 seed. Thus, perhaps making F_2 economically plantable where F_1 or lower level seed was not economically plantable.

The big tree improvement effort in the South has been in the pine program. Hardwoods have not been neglected, however.

Region 8 is comprised of: Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, Puerto Rico, South Carolina, Tennessee, Texas, Virgin Islands, Virginia.

1. The Fiscal Year 80 annual cut on the Region 8 National Forests was 1,298 MMBF, of which 12% was hardwood. On the average, the total annual cut may vary, but the percent of hardwoods cut remains in the 11-13% range.
2. In Fiscal Year 80, Region 8 planted a total of 55,868 acres, 1.1% of which were hardwoods (includes 250 acres of mahogany in Puerto Rico).
3. Besides mahogany, the species being planted in Region 8 are: sawtooth oak, water oak, white oak, laurel oak, nuttall oak, walnut, green ash and baldcypress.
4. The Region has five tree improvement zones for hardwood tree selection:

<u>ZONE</u>	<u>NATIONAL FORESTS</u>
Arkansas	Ouachita and Ozark
Kentucky	Daniel Boone
Northern Appalachian	George Washington, Jefferson (less Holston and Clinch Districts)
Central Appalachian	Pisgah North of Asheville, Cherokee North of Little Tennessee River, and the Clinch and Holston Districts of the Jefferson
Southern Appalachian	Nantahala, Chattahoochee, Cherokee South of Little Tennessee River, Pisgah South of Asheville, and Andrew Pickens District, Sumter.

The remainder of the Region is divided into the following geographic areas. No selections will be made in these areas at the present time.

<u>AREAS</u>	<u>NATIONAL FORESTS</u>
North Alabama - Mississippi	Talladega, Bankhead, Holly Springs, Tombigbee, Bienville, and St. Francis
West Gulf	Sabine, Angelina, Sam Houston, Davy Crockett, Kisatchie, Homochitto, and DeSoto
East Gulf	Conecuh, Apalachicola, Osceola, and Ocala
Delta	Delta
Piedmont	Oconee, Sumter (excluding Andrew Pickens), Uwharrie
East Coast	Francis Marion and Croatan.

5. Initial priority is given to the selection and preservation of 30 superior trees in each of six species within the geographic zones listed previously -

Black Oak	All geographic zones
White Oak	All geographic zones
Northern Red Oak	All geographic zones
Chestnut Oak	All geographic zones, except Arkansas
Yellow Poplar	All geographic zones, except Arkansas
Black Cherry	Northern, Central, and Southern Appalachian

6. Tree Selection Status (Number of Trees)

<u>Species</u>	<u>Zone</u>	<u>Locator</u>	<u>Goal</u>	<u>Selected to Date</u>
Black Oak	ARK.	F.S.	30	37
White Oak	ARK.	F.S.	30	34
N. Red Oak	ARK.	F.S.	30	48
Black Oak	KY.	F.S.	30	40
White Oak	KY.	F.S.	30	37
N. Red Oak	KY.	F.S.	30	30
Chestnut Oak	KY.	F.S.	30	36
Yellow Poplar	KY.	F.S.	30	41
Black Oak	N. APP.	F.S.	30	35
White Oak	N. APP.	F.S.	30	29
N. Red Oak	N. APP.	F.S.	30	37
Chestnut Oak	N. APP.	F.S.	30	34
Yellow Poplar	N. APP.	F.S.	30	32
Black Cherry	N. APP.	F.S.	30	25
Black Oak	C. APP.	F.S.	30	28
White Oak	C. APP.	F.S.	30	24
N. Red Oak	C. APP.	F.S.	30	39
Chestnut Oak	C. APP.	F.S.	30	30
Yellow Poplar	C. APP.	F.S.	30	29
Black Cherry	C. APP.	F.S.	30	34
Black Oak	S. APP.	F.S.	30	38
White Oak	S. APP.	F.S.	30	38
N. Red Oak	S. APP.	F.S.	30	32
Chestnut Oak	S. APP.	F.S.	30	31
Yellow Poplar	S. APP.	F.S.	30	42
Black Cherry	S. APP.	F.S.	30	34

Total Hardwood Selections 894 Trees

7. Region 8 has no hardwood evaluation planting. The Region is going to take over a couple of Northern Red Oak plantings established by TVA in 1973 and one Yellow Poplar planting established in 1974. Hopefully, these areas can be converted to seeding seed orchards or seed collection stands.

8. The overall policy and objective of the Region 8 Hardwood Tree Improvement Program is:

- A. Limit initial phase of Hardwood Tree Improvement Program to superior tree selection of silviculturally important species within recognized geographic sources, the preservation of these selections in clone banks, progeny testing and genetic worth of the selections, and development of hardwood stand conversion methods.
- B. Cooperate with the States, other Federal agencies, universities and private industry in exchange of hardwood clones, tree improvement information in propagation techniques, selection criteria, stand conversion methods, and silvicultural use of clonal material.

Also active in the East is the North Carolina State University Cooperative Tree Improvement and Hardwood Research Program. The Hardwood Cooperative is composed of 18 states and forest industries. Members of the co-op plant about 3,400,000 hardwood seedlings on approximately 6,700 acres annually. They claim a 10% improvement in yield will be initially obtained from genetically improved material and, after the orchards are rogued of the poor genotypes, this figure will be about 20%.

The Cooperative is making tree selections in the following species:

Sycamore	Black Oak
Sweetgum	Chestnut Oak
Yellow Poplar	Willow Oak
Red Maple	Scarlet Oak
European Black Alder	Swamp Black Gum
Northern Red Oak	White Oak
Black Cherry	Sugar Maple
Tupelo	Southern Red Oak
Green Ash	White Ash
Black Walnut	Basswood
Cherrybark Oak	Water Oak

Research in hardwood genetics and tree improvement is a subject all-unto-itself, and I have no intention of going into it here. Let me just say, all four Forest Research Stations in the East and South have projects placing major emphasis on the important Northern and Southern hardwood species. Both the Region 8 and Region 9 Tree Improvement Programs have important ties with the hardwood research projects.

Before hardwood genetics and tree improvement can move ahead much further, however, several of the problems of simply dealing in general with the hardwood resource must be solved.

Natural Regeneration

- Obtaining the desired species and stocking.
- Silvicultural practices to shorten the rotation.

Artificial Regeneration

- How to plant hardwoods.
- Proper seed sources.
- What is the role of exotics?
- Fertilization, mycorrhiza, site preparation,
and hardwood nursery practices.

Hardwood markets must improve.

Hardwoods must be considered an important component of stand, not simply a weed.

The better hardwood lands are hard to manage - too wet, too steep, tied down for recreation, aesthetics, wilderness, etc.

Better utilization, especially in low quality stands.

ESTIMATING TIMBER STAND VALUES:

A GUIDE TO TREATMENT¹

Paul S. DeBald²

INTRODUCTION

First I describe how silviculture and economics fit into the overall timber management process. Then, I highlight in detail the importance of stand values in guiding stand treatment. Finally, I outline a few ways to blend silviculture and economics.

I emphasize that silviculture and economics are not two separate things. Each is an important part of the other; they should not and cannot be separated.

BACKGROUND

Management Process

The management process can be viewed in many ways. Experts in the field of management propose various methods to describe the process and its many components. But I like things simple. I view the management process as a three-part system that is open and permeable and functions as part of a supra system (fig. 1).

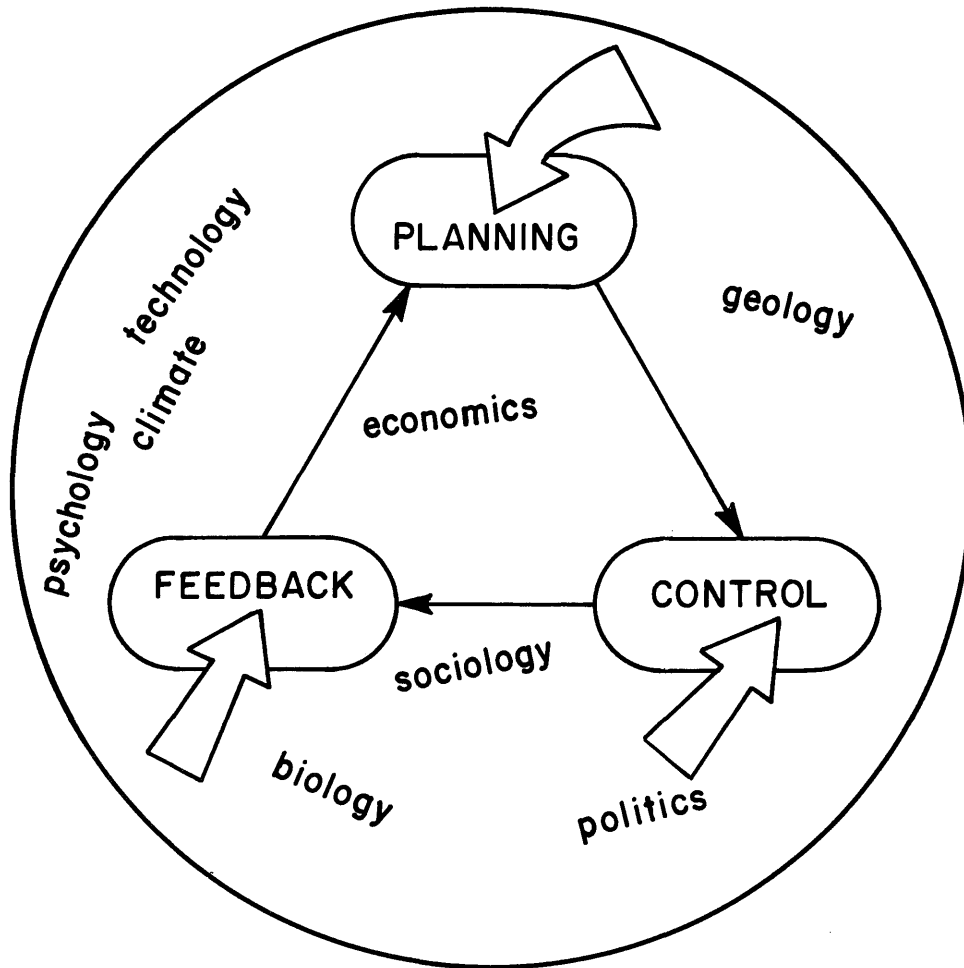
By supra system, I mean the real world full of factors that affect the management process: climatic, geologic, biologic, economic, political, social, psychological, technological, organizational, and so on. These factors constantly interact and change. They affect the management process in different ways, to different degrees, and at different times.

By open and permeable system, I mean that the management process does have some effect on the supra system. But most of the permeability goes the other way: the supra system has many great effects on the management process, and I will describe some of them.

¹Presented at the National Silviculture Workshop, USDA Forest Service, Roanoke, Va. June 1-5, 1981.

²Research forester, USDA Forest Service, Northeastern Forest Experiment Station, Delaware, Ohio.

Figure 1.--The management process.



Management planning

The three elements of our simple management model are interrelated, but I want to look mainly at the planning function. It has three sequential parts:

1. Prescription is the identification of potentially desirable changes in current operations.
2. Design is the detailed description of the inputs needed, the processes used, and the outputs expected in carrying out the change.
3. Evaluation is the assessment of the desirability of the contemplated change (Marty 1978).

Desirability tests

I have used the word *desirable* a couple of times. What is a desirable change?

Let's face it, not all changes are desirable. In order for a change to be desirable, it must meet a number of tests, and the important ones are:

Feasibility.--For a change to be feasible, we must know how to accomplish it and must have available the people, time, things, and money needed to make the change. Many suggested changes fail one or more of these tests.

Productivity.--The change must help the organization to achieve its objectives more fully. Some changes are counter productive. Other changes promise so small an increase in goal attainment that they aren't worth pursuing.

Acceptability.--The proposed change must be acceptable to all those who influence the decision process, both inside and outside the organization. The supra system that I mentioned earlier is often extremely important in deciding which changes are desirable (Marty 1978).

Flexibility.--Some changes result in irreversible situations--the felling of a tree. Many changes result in temporary situations that through feedback provide for subsequent planning and control--a cleaning in a previously unmanaged stand. By keeping many options open for as long as we can, we lessen the risks imposed by changes in our organization's supra system.

Effectiveness.--The change must create additional output or satisfaction at a reasonable cost. Some changes, even though they are feasible, productive, acceptable, and flexible, may cost far more than they are worth.

Economic effectiveness

There are a number of ways to estimate economic effectiveness. Classic examples are net present worth, internal rate of return, and benefit-cost analysis. Each approach is different mathematically, but each uses the following procedure:

1. Describes the contemplated action
2. Defines its economic costs
3. Predicts its physical effects
4. Defines the economic benefits
5. Compares the economic costs with the economic benefits.

The procedure shows why we cannot separate silviculture from economics: every silvicultural action has its cost; every effect has its benefit. In reality, the sign on either may be reversed.

The definition of costs and benefits provides estimates of the relative values of possible alternatives. Ideally, these estimates will 1) express both benefits and costs in comparable units, and 2) express values for all alternatives in comparable units (Sinden and Worrell 1979). And, where planning and decisionmaking are separate functions handled by separate individuals, the estimates will express values in units that are comparable to all of the individuals involved.

Money is the conventional unit for defining costs and benefits. It usually meets the above requirements. But any index that meets those requirements will do. For some actions, units of time may be more meaningful than units of money--setting rotation ages and timing cash flows, for example. For other actions, an index of relative values is all that may be needed. Uncertainties of future markets may preclude the prediction of expected stumpage prices. Wildlife studies in a particular area may indicate that beech trees are two or three times more valuable than oaks.

The important thing is to be able to define both costs and benefits. We cannot test economic effectiveness without them. As professionals, we need to know we are doing the best we can with what we have. And as civil servants in today's questioning world, we need to be able to prove it.

HIGHLIGHTING STAND VALUES

To keep things simple, I will use mostly dollar values. I sense that the USDA Forest Service has adequate local cost information that is continually being improved. I will focus on the value of timber itself. But even with these restrictions, things still are not simple.

Eastern Hardwoods Are Diverse

Eastern hardwoods are many and diverse. Each tree is unique. Each stand is a unique aggregate of individual trees. The site that each stand occupies is also unique. Thus, the management of eastern hardwoods provides many strong challenges. One of those challenges is the estimating of stand values.

Species diversity

Each species has its own package of characteristics as to strength, workability, appearance, appeal, and so on. Dollar rates in the market place attest to this and tend to differentiate relative values among species. Thus, flat-rate, woods-run, lump-sum stumpage prices will not always do for management planning. This is especially true when comparing alternative management activities in eastern hardwoods. We need to consider their diversity, both as trees and as products.

Take lumber, for example. At a given time and in a given area, one is sure to find some big differences in lumber prices from one species to another. The size of the actual differences will, of course, vary over time as markets change. But, in the course of our work with quality-index values, we have found that the relative lumber prices among species tend to hold fairly well over some rather lengthy time periods--even 10 years or more.

There are exceptions, though. One that comes quickly to mind is the big jump in hard maple prices in the 60's, when the bowling craze was sweeping Japan. A rule of thumb remains, however: the lumber value of a

particular species is likely to hold its position relative to other species. It's a good rule to keep in mind when carrying out silvicultural operations that involve manipulating species composition or scheduling the harvest of an even-aged stand.

Size diversity

The quality-index values provide a handy way to differentiate relative values for individual trees. They are also useful for comparing tree value by size, within species. Figure 2 shows differences in tree values both by species and by diameters within species for trees with similar height and grade characteristics.

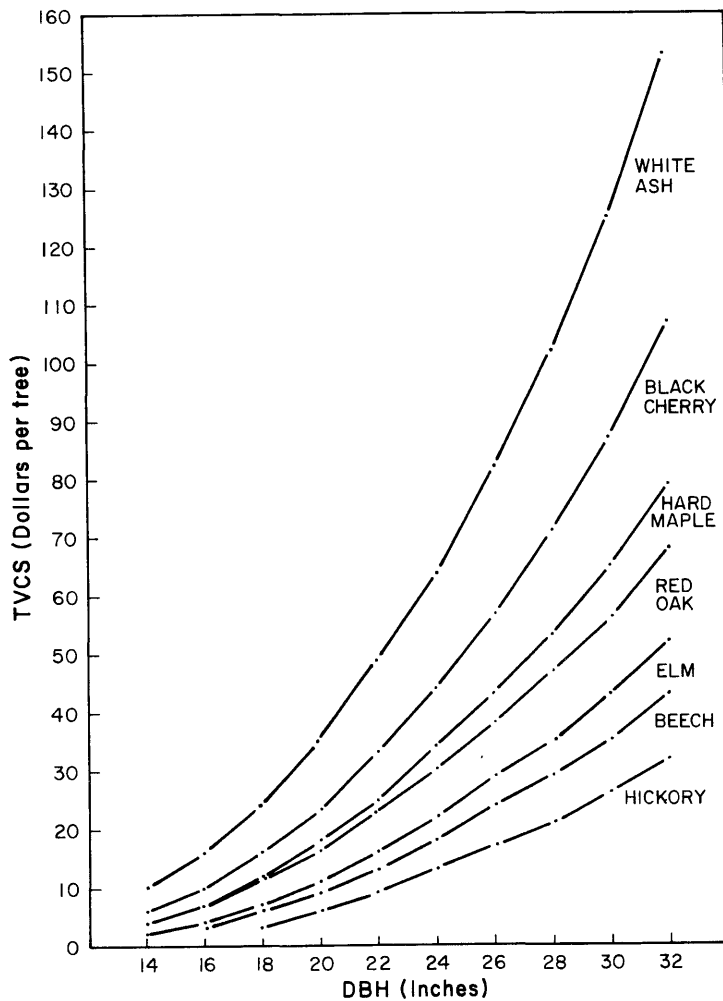


Figure 2.--Tree value conversion standards for 2-log trees with grade 2 butt-logs, selected species.

The dollar values are in tree value conversion standards (TVCS) that represent a tree's worth in dollars, based on the quantity and quality of its expected yield of 4/4 (1-inch) lumber and regional average conversion costs. They are standards, not in the sense that they are fixed and absolute values, but in the sense that they are criteria for gaging tree value within a given framework of circumstances (Mendel et al. 1976).

Value standards can be applied to timber inventories the same as volume standards are. The mechanics are simple: use either TVCS tables that are comparable to volume tables or TVCS equations that are comparable to volume equations. Such applications add a new dimension to inventory work by allowing stock tables, per-acre estimates, stand summaries, and so on to be expressed in dollars as well as in board feet.

TVCS summaries make inventories more meaningful by reflecting timber quality as well as timber quantity. They can be obtained by including value-standard calculations with the usual volume calculations. The other ingredients--species, dbh, merchantable height, and butt-log grade--are often included in most field tallies.

Quality diversity

TVCS are also useful to show the importance of timber quality in the estimation of timber values. Figure 3 shows the relative value differences in trees within the same butt-log grade. The increased value through increased size reflects the aim of concentrating growth on selected crop trees. But note, especially, the large differences in tree values from one butt-log grade to another. This points to the even greater importance of concentrating growth on those crop trees that are likely to improve in grade over time.

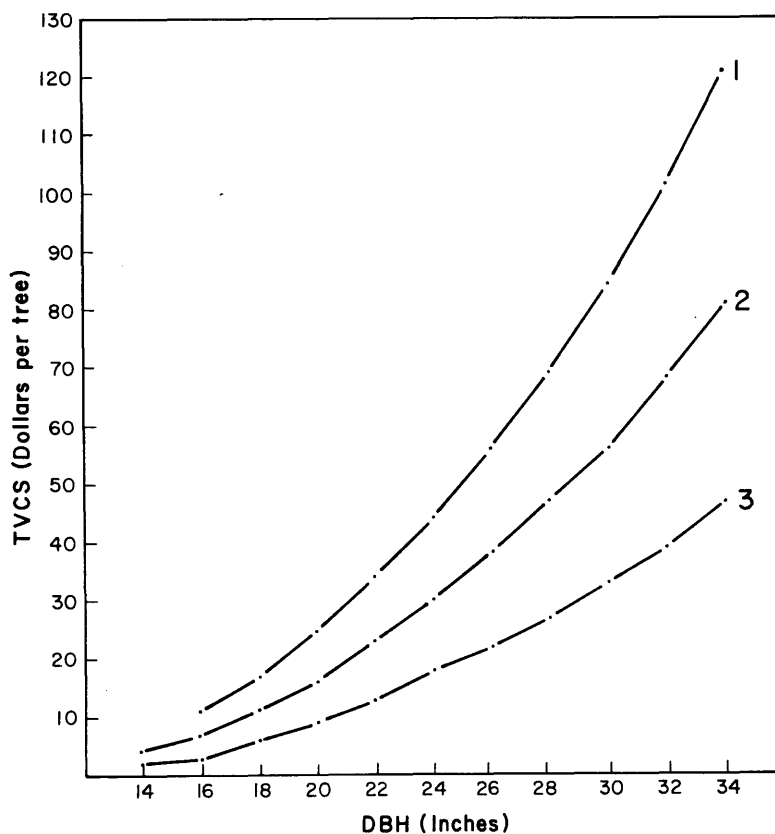


Figure 3.--Tree value conversion standards for 2-log red oaks, by butt-log grade.

Forest managers do, of course, employ this kind of thinking. TVCS can help assign relative values to your expectations, not only for individual trees, but also for timber stands, by aggregating the values of the individual trees in the stands. So, you can use them in making value projections for stands and in evaluating timber management alternatives. You can also use them to calculate rates of value increase and to determine financial maturity diameters.

TVCS were developed for most of the important eastern hardwoods a few years ago and published in a series of papers called SETs--Stand Evaluation Tools. One of the papers outlines an individual tree approach to making stand evaluations (DeBald and Mendel 1976). This paper lists pointers on estimating tree development patterns in individual sawtimber trees and the pointers are useful in making on-the-ground projections for individual trees in a stand.

Product diversity

We have been talking strictly in terms of timber values for lumber. What about other products? What about multiple products? Eastern hardwoods are diverse in product potential too.

Figure 4 depicts a hierarchy of relative product values, along with a general woods-run volume distribution that is typical of many eastern hardwood stands. Although the actual values will vary from one stand to another because of species and size mix, logging chance, market conditions, and so on, the value relationships among products are often impressive.

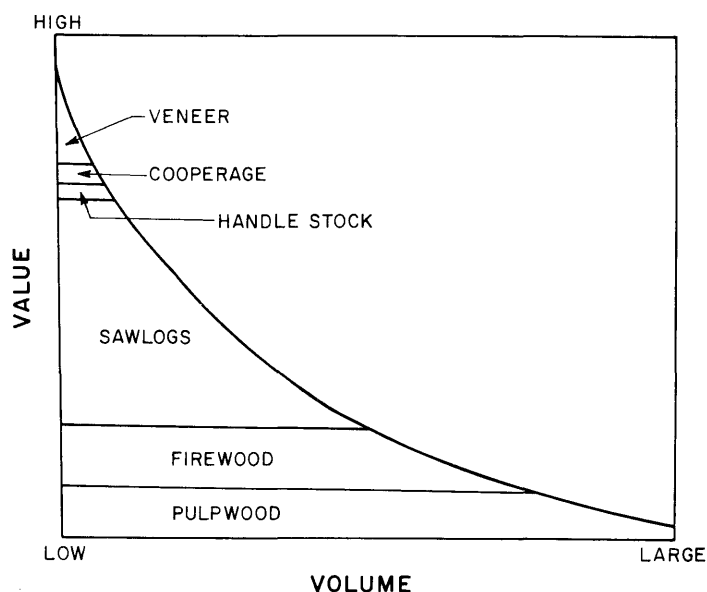
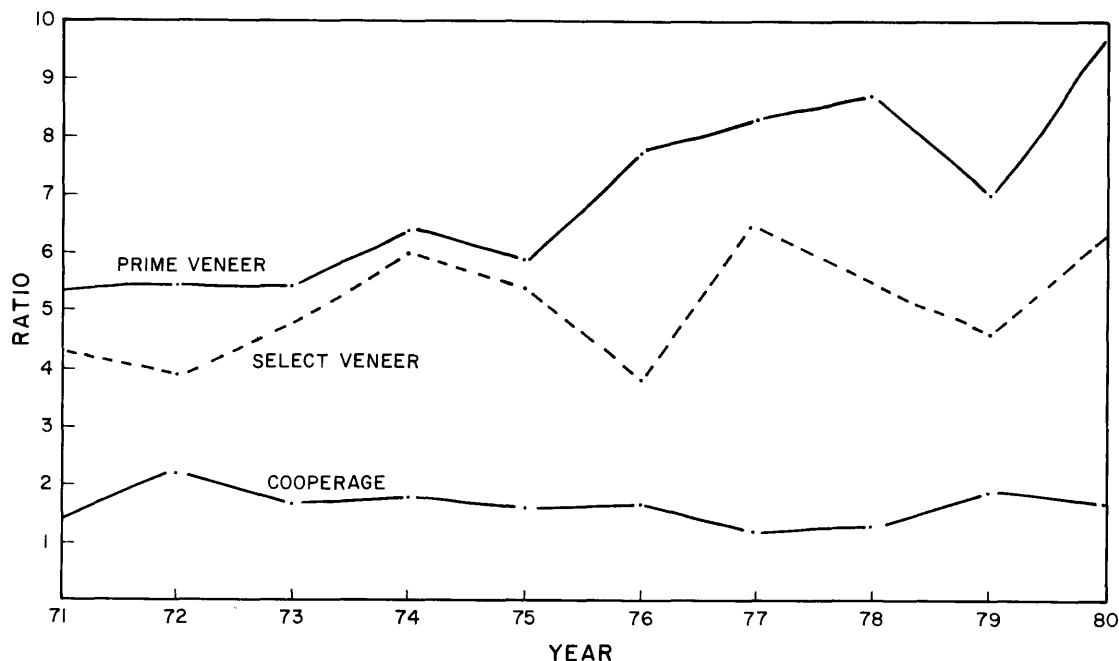


Figure 4.--Typical value/volume hierarchy, eastern hardwoods.

White oak stumpage prices in Ohio during the past 10 years provide some good examples (fig. 5). Stumpage prices paid for cooperage in Ohio have averaged, rather steadily, 1-1/2 times those paid for sawlogs. Prices paid during that period for white oak veneer are even more impressive. The ratio of select-veneer stumpage to sawlog stumpage averaged 5:1, within a tight range between 4:1 and 6:1. Similar ratios for prime-veneer stumpage in Ohio have averaged 7:1, but ranged widely between 5:1 and 10:1. Whereas the ratios for cooperage and select-grade veneer show level trends over the period, the ratio for prime-grade veneer has nearly doubled.

Figure 5.--Stumpage-price ratios: Ohio white oak, 1971-80.



Product-value ratios will, of course, vary from one area to another and change from time to time. So, they should be developed and monitored locally. The important thing is to recognize the product diversity in eastern hardwoods, along with their biological diversity, and to incorporate product values into management planning. High-quality, high-value trees are few in number. Producing more of them is a major aim in hardwood silviculture. Ability to define their benefits in terms of higher-valued products, where appropriate, can often help to justify the cost of producing them.

BLENDING SILVICULTURE AND ECONOMICS

There are many ways to blend silviculture and economics. Forest managers have used many of them in developing the art and science of silviculture. I will outline a few methods that I like and am familiar with. They fall into three general areas--the tree values themselves, the trees or stands to be valued, and the employment of tree values.

Tree Values

I am partial to the use of TVCS. They do, however, have a shortcoming in that they apply only to lumber products. Here is how to get around that:

Use flat rates per cord for pulpwood and fuelwood, where quality is of little importance. These, along with TVCS for sawtimber, cover most of the timber in most stands in most areas. Where veneer or cooperage markets are, or may be, available, use stumpage value ratios similar to the ones I described for Ohio.

Breakdowns of stumpage values by species and log grades work well, too. But their use requires either the grading of individual logs in a tree or the estimation of average volume/grade distributions by species in a given area--TVCS require only butt-log grades and have volume/grade distributions already built in.

Unfortunately, information on tree grade often is not included in data collected during stand inventories, or in data developed from yield tables or stand growth simulators (Ernst and Marquis 1979). To overcome this problem, Ernst and Marquis describe a method for estimating tree-grade distributions by dbh and species. Their work, based largely on timber sale cruise data from the Allegheny National Forest, provides such estimates for typical cherry-maple stands on the Allegheny Plateau. Similar studies could provide empirical tree-grade distributions for other areas in the east.

Trees to be valued

Stands of trees that are already of commercial size do not usually present many grading problems. As the old saying goes, "most trees tend to grade themselves." The projection of tree quality, though, is a bit tougher. It can be done either by proportioning, as Ernst and Marquis suggest, or by making on-the-ground estimates of quality development in individual trees, based on careful examination of existing external features and a feel for diameter-growth patterns. With either method, the diameter-size qualifications for the various grades are often helpful in projecting tree quality, especially in poletimber-size trees.

The tough job is guessing what might happen in extremely young stands over long periods of time. For now, we will need to do just that--guess. But making professional judgments is usually better than doing nothing. Meanwhile, a multidiscipline group at our Delaware Lab is conducting a series of studies that is aimed at a quality classification system for young trees that predicts future products in young trees, and tracks quality development over time. Martin Dale, Bob Brisbin, and Dave Sonderman are the principals in this work. Initial results from the studies are promising (Sonderman and Brisbin 1978, Sonderman 1979). I especially like the team's courage in publishing their early results. We need more of that kind of courage, particularly in long-range studies.

Employment of tree values

My favorite example of blending silviculture and economics was fashioned on the Fernow Experimental Forest. I refer to "A Procedure for Selection Marking in Hardwoods," by Dick Trimble, Joe Mendel, and Dick Kennell (1974). The paper describes a procedure for combining silvicultural considerations with financial maturity guidelines into a tree-marking system. The silvicultural considerations keep the system from becoming a strict diameter-limit cut. The financial maturity guidelines aim at the principal of maximum net return. The combination provides for a well-stocked residual stand which contains, consistent with sound silviculture, the greatest possible value in trees that are growing at or above the owner's alternative rate of return.

Another good example of blending silviculture and economics was developed by Bill Leak (1980), "Rapid Economic Analysis of Northern Hardwood Stand Improvement Options." I like it because it is an on-the-ground approach for projecting volumes and values by product and for determining rates of return. And it can be worked with a hand-held calculator.

Most of the other management planning systems that I know about require the use of computers. My favorite among them is called TIMPIS (Timber Inventory and Management Planning Information System). It was developed in a cooperative agreement between the Northeastern Forest Experiment Station and Purdue University, and John Moser was the principal investigator. TIMPIS was designed, primarily, for use by service foresters. Its purpose is to reduce their computational drudgery and, at the same time, provide the information that small-woodland owners need to make their management choices. TIMPIS is a package of flexible subroutines and can be tailored to the specific needs of individual users. It provides, among other things, estimates of stand values based on individual-tree projections. It gives the user a number of tree-value options: overall stumpage price, stumpage by species, stumpage by species and log grade, and TVCS.

We are currently engaged in a technology transfer effort to begin the use of TIMPIS by service forestry organizations in a number of states. The system's use, though, is not limited to small woodlands. Because it allows for stratification, TIMPIS can be used in management planning for medium and large timber holdings. It can, in addition, be used in research applications.

SUMMARY

The planning of stand treatments, an integral part of the timber management process, is affected by both the realities and the visions of the changing world around us. Such planning must meet a number of important tests: feasibility, productivity, acceptability, flexibility, and effectiveness. The test of effectiveness usually requires the estimation of timber stand values in order to define the economic benefits of the physical effects expected to result from the contemplated actions. This, in turn, allows for the comparison of economic benefits to economic costs.

Money is the conventional unit for defining costs and benefits. In eastern hardwoods, because they are so diverse, the money units that are used in stand valuations should consider differences in species, timber size, timber quality, and product potential. Stumpage values by species and log grade should be the minimum consideration.

We have a number of timber inventory and management planning tools to choose from, depending on individual needs and individual circumstances. Use whichever ones you feel comfortable with. But in doing so, be sure to use tree values that reflect the diversity in our great eastern hardwoods.

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SOME DIEBACK AND DECLINE DISEASES
OF NORTHEASTERN FOREST TREES:
FOREST MANAGEMENT CONSIDERATIONS^{1/}

David R. Houston^{2/}

Abstract--Several important dieback and decline diseases of northeastern forest trees are discussed with respect to their forest management relationships of cause, effect, and possible amelioration.

Additional keywords: Maple decline, oak decline, beech bark disease.

^{1/}Presented at the Annual Silviculture Workshop, U.S. Forest Service, Roanoke, VA. June 1-5, 1981.

^{2/}Principal Plant Pathologist, USDA Forest Service, Northeastern Forest Experiment Station, Forest Insect and Disease Laboratory, Hamden, CT.

INTRODUCTION

Diebacks and declines are complex tree diseases of major significance in many forest regions. Diebacks and declines differ from diseases caused by primary pathogens in that an environmental stress is required to predispose trees to attack by secondary organisms that cannot lethally attack healthy trees (Houston 1967, 1973, 1974).

The stress factor(s) can be abiotic, e.g., extremes of moisture or heat, or biotic, e.g., insect defoliation or scale or aphid attack, or combinations of these. In the absence of such stresses the organisms of secondary action, often ubiquitous in the ecosystem, occupy various niches ranging from saprophyte to weak pathogen. The organisms of secondary action deliver the coup de grace to trees that, in the absence of their attack, would recover following abatement of the stress.

A conceptual framework for the diebacks and declines (Houston 1981) can be expressed by a series of equations:

Healthy tree + stress => Altered tree (dieback begins)

Altered tree + more stress => Tree altered further
(dieback continues)

Altered tree + organisms of secondary action => Tree
invaded (tree declines, dies)

It is probable that every tree species sometime, somewhere, has suffered from a dieback and decline disease. Indeed, several of our most important Northeastern hardwood tree species or species groups have been or are now seriously affected by dieback and decline.

Among the most notorious diebacks and declines are birch dieback, ash dieback, maple declines, oak decline, and beech bark disease. I will discuss the latter three of these diseases from the standpoint of (A) how past forestry practices may have set the stage for their development, and (B) how they have influenced forest management. Finally, (C) I will speculate about how silviculture might be used to reduce the impact of these problems in the future. Let me begin by indicating that we have almost no solid information on (A) and (C) and precious little on (B). What I will present, therefore, are concepts based on our observations and studies on cause-effect relationships made over the past 20 years.

CASE I: Maple Decline

Background: We recognize several dieback-declines of sugar maple. The most conspicuous is the decline of roadside trees attributable primarily to the cumulative toxic effects of winter road salt, and to the effects of water shortages associated with the disturbed roadside environment. But maples growing in sugarbushes and forests have their share of decline problems as well.

The most thoroughly investigated forest maple decline occurred in northeastern Wisconsin in the mid to late 1950's. A series of intensive studies on this problem, then termed maple blight, revealed for the first time some of the cause-effect relationships of a biotically initiated dieback-decline disease.

In brief, maple blight was initiated by a complex of defoliating insects, including several species of leafrollers and the maple webworm, that severely defoliated sugar maple for up to 3 successive years. Mortality of defoliated trees, associated in many cases with attacks of roots and root collars by Armillaria mellea, the shoestring root rot fungus (Houston and Kuntz 1964), was extreme in localized pockets scattered over 10,000 acres. Recent research has confirmed this relationship between defoliation and Armillaria (Wargo and Houston 1974), and has also clarified its biochemical basis (Wargo 1972). In addition, twigs of trees weakened by defoliation may be invaded and killed by weakly pathogenic fungi such as Steganosporum ovatum (Wargo and Houston 1974).

Thus, maple decline in the forest can be expressed by the equations:

Healthy maple trees + defoliation => Altered trees
(root food reserves reduced, dieback begun)

Altered tree + defoliation => Trees altered further
(food reserves depleted, decline continues)

Altered tree + S. ovatum and A. mellea => Altered
trees invaded (trees decline, die)

A. Forest management vs. maple blight

This particular decline was confined almost exclusively to forests owned and managed by the then Goodman Division, Calumet and Hecla, Inc. Abutting forests of other ownerships were affected little if at all. For several decades before 1958, Goodman forests had been managed intensively and selectively logged--usually on a single tree basis. This was reputedly the longest period of such management by any Lake States concern. In essence, this management consisted of systematic removal of high quality yellow birch, sugar maple, and ash; together with the selection pressure exerted by an extremely high deer population, it fostered a relentless shift toward purity of sugar maple.

Observations suggested that the initial outbreaks probably began where an earlier blowdown had released a dense understory of sugar maple saplings, and in a stand opened up a few years earlier by an exceptionally heavy cut.

Studies revealed that maple blight was more severe in some stands than in others and that, before the maple blight, stands where the disease occurred differed in composition and structure from nearby undiseased stands (Geise et al. 1964). Within the blight area itself, differences in disease incidence and severity were related to stand features:

1. Only 22% of the sugar maple had symptoms in stands with highest basal area (170 ft²) compared to 70% of the maples in stands with low basal area (60 ft²) (Skillings 1964).
2. The proportion of blighted maples increased as the numbers of trees per acre (of all species) decreased, and as the relative proportion of sugar maple increased (Geise et al. 1964, Skillings 1964).
3. Although all size classes were affected, the disease was most severe in stands with highest relative numbers of sugar maple trees and saplings. Overmature trees and suppressed trees were most vulnerable (Geise et al. 1964).

B. Maple decline vs. forest management

For several years following the onset of the disease, forest management plans were severely altered. Special crews and trucks were employed to mark and salvage dead and dying timber--a task made difficult by the scattered location of the pockets of dead trees. Long term effects, while not yet documented, could be expected to include increased defect (stain and decay) associated with dead branch stubs and sunscald wounds in severely opened stands. Although changes in species composition probably will not be significant except in areas of high tree mortality, the relatively higher mortality of saplings may produce a skewed stocking distribution in the near future. Large areas with severe mortality may revert to an earlier successional status.

CASE II: Oak Declines

Background: While similar in many respects to maple decline, oak declines are considerably more complex as there are more hosts, more initiating stress factors, and more important organisms of secondary action. Oak declines are not new to the forests of eastern North America; indeed, oak has frequently exhibited decline on a massive scale. In all of the occurrences studied, trees were stressed initially by one or more adverse environmental factors--drought, frost or defoliation--and then mortally attacked by root fungi and borers.

In the northeastern U.S., occurrences of oak decline have followed severe outbreaks of defoliating insects (Hepting 1970, Staley 1965). Some of the most serious situations in recent years have been associated with severe defoliations by gypsy moths in the mid-1950's, mid-1960's and early to mid-1970's--periods characterized also as times of water shortage.

The gypsy moth was introduced to Massachusetts in 1869 for use in laboratory studies. It escaped, found a favorable and abundant supply of food and habitat, and has caused severe defoliation ever since. In recent years, it has spread rapidly westward and southward into ever more extensive oak-hickory forests supporting ever greater numbers of highly preferred hosts.

Biochemical changes triggered by the defoliation-refoliation process render trees susceptible to girdling attacks by Agrilus bilineatus, the twolined chestnut borer, above ground and by the shoestring fungus below. Both of these organisms are common inhabitants of the forest, where they colonize weakened and dying branches, or dying and dead roots, respectively.

The oak decline system can be described by the equations:

Healthy oaks + gypsy moth defoliation => Altered trees
(root food reserves reduced, dieback begins)

Altered oaks + defoliation => Oaks altered further
(root reserves depleted, other biochemical changes, dieback continues)

Altered oaks + A. bilineatus and A. mellea =>
Invaded oaks (cambial zones invaded, trees decline and die)

A. Management (disturbance) vs. gypsy-moth-triggered oak decline

Site strongly influences where gypsy moth defoliation will occur. In New England, where gypsy moths and forests have interacted for over a century, some forests have been defoliated many times (susceptible); some only rarely (resistant) (Bess et al. 1947, Houston and Valentine 1977, Valentine and Houston 1979).

Susceptible forests characteristically grow on dry sites such as rocky ridges or deep sands. In many cases, they have been disturbed--sometimes frequently--by fires, wind, and snow or ice storms. The trees in these forests, mainly dry-site oaks, are highly favored as food by gypsy moths, are slow growing, small and scrubby, and possess abundant refuges for the insect such as bark flaps, deep bark fissures, and holes or wounds.

Resistant forests characteristically grow on relatively undisturbed sites where moisture is not limiting. They usually are well stocked, and often contain mixtures of preferred and nonpreferred species. Trees on these sites have good growth rates and relatively few structural refuges.

People have often disturbed forests in ways that indirectly influence their susceptibility to gypsy moth defoliation, and in turn to oak decline. Repeated heavy logging and frequent fires in New England in the early 1900's rendered many formerly resistant forests susceptible to the insect (Bess et al. 1947, Campbell and Sloan 1977). These disturbances effectively checked the forest's biotic development and sometimes set it back to an earlier and less stable stage. From around 1930 until quite recently a lessening of such disturbances allowed many forests to develop to stages more resistant to the gypsy moth. However, recent "reurbanization" of some New England forests, especially for housing developments, has again increased their susceptibility. It appears that the actions of people affect forested backyards as the forces of nature affect forests on adverse sites. Opening up forests to make lawns, raking up leaf litter, and keeping pets help to discourage natural predators of gypsy moth; and walls, woodpiles, and objects in the backyard-forest ecotone provide the insect with a host of suitable refuges (Campbell et al. 1976).

While most of our actions, by altering stand composition and structure, serve to favor the initiating stress agent--gypsy moth--some undoubtedly influence the mortality-causing agents of secondary action as well. Large numbers of crown branches injured or weakened in logging encourage buildup of the twolined chestnut borer; and the stump/root-system food bases created by repeated logging insure that the shoestring fungus will be vigorous and abundant. Thus, silvicultural practices, especially those that necessitate frequent disturbances of a forest, may foster the important opportunistic organisms of secondary action. This almost guarantees that significant numbers of trees will be invaded and possibly killed if they are

predisposed by extrinsic stress factors. The fact that we concentrate forest management on resistant better sites may be another reason why relatively more trees may succumb to oak decline on these sites than on poor, susceptible sites.

B. Oak decline vs. forest management

There is little documentation on how oak decline has affected forest management. There have been cases where, in order to salvage dead and dying trees, harvest schedules for particular areas have been advanced, and those for other areas postponed. The long-run effects are difficult to assess. Tree mortality resulting from oak decline can materially alter the course of forest succession. In moderately moist northern New England, the development of hardwood forests following agriculture or disturbance by heavy logging or fire often begins with stands rich in such shortlived pioneers as grey or white birch and aspen. Later, these species are succeeded, first by early-stage, longer-lived oaks and eventually by more shade-tolerant species such as red oak, sugar maple, beech, and hemlock. Most oaks in these forests are relatively transient, and their dominance of the site is usually short.

Moderately heavy defoliation of these forests by gypsy moths often serves to accomplish in a short time what succession would do eventually, especially if forest development is well advanced. Preferential defoliation of early stage species tends to reduce their relative abundance, leaving forests richer in species characteristic of more successional mature forests. Severe, repeated defoliation, however, can result in considerable tree mortality, even among species that are generally less favored by the gypsy moth.

In southern New England, oaks tend to be more numerous and to dominate the forest for longer periods. In such stands heavy tree mortality can drastically set back forest development to earlier stages.

Evidence is increasing that for oaks to regenerate, the overstory and understory canopy densities must be carefully regulated. In shelterwood cuts, the first cut should not remove more than 40% of the overstory stocking, nor should it create large holes in the canopy overstory (Gingrich 1967). This crown canopy density is required to maximize the survival and competitive advantage of the advanced oak reproduction, and to discourage the rapid development of other species in the understory. Obviously, the death of groups of large overstory canopy oaks will wreak havoc with recommended shelterwood regeneration systems.

Oak decline promises to be of greater consequence as the eastern oak resource assumes greater importance in the years to come. While research now underway to determine how to better utilize the huge Appalachian resource of low-grade trees will undoubtedly increase the value of these forests, it will also make it imperative that forest management consider oak decline.

CASE III: Beech Bark Disease

Background: Beech bark disease, a major dieback-decline disease of American beech, begins when bark is attacked by the beech scale, Cryptococcus fagisuga, and culminates when bark altered by this attack is invaded and killed by the fungi of the genus Nectria (Ehrlich 1934). The framework of beech bark disease can be expressed as:

Healthy beech trees + beech scale => Beech trees
with altered bark

Altered beech bark + Nectria spp. => Beech bark invaded
(trees girdled, die)

The scale was introduced to Nova Scotia about 1890. The first reported outbreak of beech bark disease occurred around Halifax in 1920, and by 1932 it occurred throughout the mature beech areas of the Maritime Provinces and in local areas of eastern and south-central Maine. Since then, the insect has spread through New England and New York, and recently was found as far south as the Maryland border in the eastern half of Pennsylvania. Tree mortality is now high in the central and western Adirondack Mountain region (the epidemic killing front); and defect is extreme on old residual trees and in young thicket stands, primarily of root sprout origin, in long-affected forests of the Maritimes, Maine, and parts of New Hampshire and Vermont (the endemic aftermath zone).

A. Forest management vs. beech bark disease

Beech has long been regarded as a "weed", or at best a species less desirable than its northern hardwood associates, sugar maple and yellow birch. This is due in part to its poor seasoning characteristics and in part to its dense clumps of root sprouts which deter seedling regeneration by its more esteemed colleagues. Beech does have some important virtues: It is a favorite of woodturners and users of small dimension dense hardwoods; of hardwood pulpers and, of course, of woodburners. And it often is the sole mast producer in the northern hardwood country. In much of Europe, beech (with similar properties) is the primary hardwood--and is used extensively for flooring.

A long history of discriminatory highgrading coupled with beech's production of copious root sprouts not favored by deer has resulted in many forests that are overly rich in large, mature to overmature beech trees with many beech sprout clumps in their understories. Such forests are the most susceptible to beech bark disease.

B. Beech bark disease vs. forest management

Beech bark disease severely affects forest management. In pure or nearly pure beech stands, all large beech trees may be killed, while in stands with small amounts of beech the trees may be injured slightly or not at all. In recent surveys in Vermont, New Hampshire, and Maine, beech bark disease had killed about 60% of the large trees in those plots where the disease had occurred. Overall, about 30% of the large beech had been killed, another 17% were dying, and many of the survivors were injured so severely that they have little hope of providing quality material (Houston and O'Brien 1981).

High tree mortality usually triggers salvage operations to reduce losses. Dead or damaged beech trees are rapidly attacked by insects and decay fungi and wood quality is markedly reduced in 2-3 years after bark is killed. When large areas are affected, salvage can be a major operation and managers can be forced into continually trying to catch up to the disease.

Opening the stand by mortality or salvage cutting often has resulted in the release and development of dense beech thickets of root-sprout origin. Some aftermath stands have many more beech stems after the disease than before (Houston 1975, Filip, 1978).

In aftermath stands management problems caused by beech bark disease differ from those in the killing front. Trees rarely are killed outright in aftermath forests. Instead, they are rendered highly defective by the interactions of the now-endemic populations of beech scale, Nectria, and another scale, Xylococcus betulae. The cankers continuously produced by this complex render trees unsuitable for high-value uses--and lower their value even for some low-quality uses such as pulp. And dense beech thickets can preclude the easy conversion to more desirable species. In the following section two specific examples are given of how beech bark disease has affected forest management.

1. The Bartlett Experimental Forest Example

A long term uneven-age management study was begun in 1952 in the Bartlett Experimental Forest in New Hampshire (Filip 1978). Beech bark disease entered the picture during the early years of the study. The following stand treatments were employed:

- a. A 100% tally was made in 1952 (before the first cut) and in 1976 (after the second cut).
- b. Harvest cuts were made in 1952 and 1975 of timber marked under the single-tree selection system using a 20-25 year cutting cycle. In both harvest operations, beech severely weakened by beech bark disease was salvaged. Sugar maple and other species were favored over beech because of the disease.
- c. TSI treatments were made in 1956 and 1953 to release sugar maple saplings overtopped by beech thickets and to kill culls of all species.

Results

a. Effects on species composition and volume. Beech remained a strong component of the stand--accounting for 53% of stand volume in both inventories. However, actual volume of beech decreased by 339 ft³ per acre. The proportion of sugar maple and hemlock increased while some species, yellow birch and paper birch especially, decreased.

b. Hardwood quality--sawtimber of beech vs. other hardwoods. Beech was degraded significantly by the disease--and salvage of this species and TSI operations upgraded the general butt-log quality of the stand. The actual volume of beech in Grades 1 and 2 decreased by 49 ft³ per acre compared to an increase of 93 ft³ for other species. The proportion of "local use" poor-quality logs increased by 25% in beech and decreased by 2% for other hardwoods.

c. Stand structure after beech bark disease vs. stand structure dictated by the management guide. While the residual basal area in 1976 was nearly that desired, a 33% shortfall occurred in numbers of trees 18" dbh and larger. This was primarily the consequence of salvaging severely weakened beech.

2. The Finch, Pryne Example

Forest management practices on lands of Finch, Pryne and Co., Inc. in the eastern and central Adirondacks have been severely affected by beech bark disease (Olmsted 1979). Beech comprises some 3,375,000 tons of pulpwood plus about 62,000,000 bd. ft. of logs on company forests. The disease entered the Adirondacks in the late 1950's to early 1960's. By 1965 it had resulted in sufficient damage and mortality to cause Finch Pryne to alter their normal management practices.

Initially, management focused on the softwood component of the forest--and harvesting of hardwood was primarily highgrading designed to encourage softwoods. With time, as hardwoods assumed greater importance, highgrading was replaced by systems employing stem selection in 3 or 4-cut shelterwood harvests. Normally, up to 20% of the merchantable volume was removed at 7 to 10-year intervals.

By 1965, the epidemic development of beech scale in some stands necessitated sanitation cutting. At first, only heavily infested trees were removed; but when it was learned that trees with even minor infestations often died before the next harvest, it was decided to remove all infested beech trees and enough of other species to make up the desired volume. The current policy, in stands with 50% or more in beech, is to cut all merchantable beech 8" dbh and over and any other trees that will not survive to the next cut. In stands with only a small amount of beech, the shelterwood harvest system is used--with care to remove as many of the diseased trees as possible.

C. Silviculture and its potential for reducing or preventing dieback and decline diseases

I am sometimes asked the question, "How can forest management, aside from salvaging dead or dying trees, reduce the impact of diseases that might or might not occur sometime in the future, whose initiating factors are difficult--perhaps impossible--to predict or influence, and whose mortality-causing agents are ubiquitous in normal healthy ecosystems"?

I usually respond to that question in terms that are surprisingly optimistic, as there have been very few attempts, even in research, at silviculture operations to prevent diebacks and declines.

1. Regulating Species Composition

Beech bark disease and maple blight are situations where reduced diversity, both of species within a stand and of age and size classes within a species, is associated with increased stand susceptibility and vulnerability. This is largely because the initiating biotic stress agents in these diseases are host-specific. And the forests most resistant to gypsy moth are those with diverse composition on mesic sites. Therefore, silvicultural operations designed to enhance species and age class diversity would seem important to reduce the impacts of these diseases (Tables 1-3).

TABLE 1.--Silvicultural operations to reduce occurrence and impacts of maple decline arranged according to the "framework" of the disease.

Healthy host trees	+	Stress	+	2nd action organisms	=	Dieback-decline
		(Insect defoliators)		(<i>Armillaria mellea</i>)		(Dead & dying trees)
1. TSI - favor best, vigorous trees, and remove vulnerable overmature trees.		1. Maintain species diversity to reduce impact of host-specific defoliators.		1. Use systems that invade forest the least to reduce stump food base availability.		1. Salvage as soon as possible.
2. Maintain a) species and b) stand diversity. a) avoid highgrading (single tree sel.) b) use group selection cuts or shelterwood systems to encourage mixed ages of non-suppressed trees.		2. Monitor forest to determine buildup and areas affected.				
3. Spray defoliators if necessary and feasible to protect high value stands.						

TABLE 2.--Silvicultural operations to reduce occurrence and impacts of oak declines arranged according to the "framework" of the disease.

Healthy host trees	+	Stress	+	2nd action organisms	=	Dieback-decline
		(Gypsy moth)		(<i>Agrilus bilineatus</i>) (<i>Armillaria mellea</i>)		(Dead & dying trees)
1. Encourage stand and species diversity. Where feasible, favor less-preferred species.		1. Spray insect initiators when necessary and feasible.		1. TSI to reduce numbers of weakened, poor vigor trees and trees with dying branches (brood wood for beetles).		1. Salvage as soon as possible.
2. Remove suppressed or weakened trees in TSI.		2. TSI to remove insect refuges.		2. Avoid silvicultural systems that disturb forests repeatedly (cuts) in order to reduce stump food bases.		2. Remove dead and dying hazard trees from roads, camp sites, etc.
3. Remove trees with defect in TSI to reduce insect refuges.		(Adverse environmental factors)				
		3. Match species to site				
		- convert drought sites to conifer				
		- avoid frost pockets				
		- avoid waterlogged soils.				

TABLE 3.--Silvicultural operations to reduce occurrence and impacts of beech bark disease arranged according to the "framework" of the disease.

Healthy host trees	+	Stress	+	2nd action organisms	=	Dieback-decline
		(<u>Cryptococcus fagisuga</u>)		(<u>Nectria coccinea</u> var. <u>faginata</u>)		(Dead & dying trees) (Live trees w/bark killed)
1. Reduce proportion of beech in overstory.	1. Monitor buildup of insect in order to schedule TSI and salvage of heavily infested trees.		1. Monitor forest; schedule TSI and salvage when <u>Nectria</u> appears.		1. Salvage as soon as possible especially trees that pose hazards to people or property.	
2. Encourage regeneration of other spp. a) group selection b) shelterwood (2 cut) with prior herbiciding of understory and control of high deer populations.	2. Salvage heavily infested trees when feasible. 3. Leave "resistant trees".		2. Salvage or fell trees with heavy <u>Nectria</u> fruiting. 3. Leave trees free of <u>Nectria</u> .		2. Remove dead and dying trees in TSI and salvage. 3. Remove small defective diseased trees in fuel wood cuts when feasible.	
3. Discriminate against large, overmature trees.						
4. Leave trees with smoothest bark.						
5. Leave "resistant trees" and their sprout clumps.						

2. Regulating Stand Density

In the case of maple blight, density seemed to be important; stands with low densities were the most severely affected. However, species diversity was also important as the low-density stands affected were those with high proportions of sugar maple trees and saplings. Practices designed to maintain full stocking until shelterwood cuts are made would seem appropriate (Table 1).

In the case of beech bark disease, several trials have been conducted to determine whether insect buildup or disease development could be slowed or halted by regulating stand density.

a. In a study begun in 1952 on the Bartlett Experimental Forest in New Hampshire, from 20 to 50% of the basal area was removed in different areas of a stand (Crosby and Bjorkbom 1958). Little or no beech was cut. At the outset, 1/3 of the beech were heavily infested, the rest lightly so, and no Nectria was found.

After 4 years, treatments had little effect on the amount of scale present on the heavily infested trees, but heavy thinning appeared to cause a slight reduction on lightly infested trees, especially on trees under 9 inches dbh. Medium and light cuts had no effect on scale abundance. Nectria developed on 80% of the trees originally heavily infested, and although fewer trees in the heavily cut areas became infected, moderate and light cuts had no effect on the fungus. The heavy cuts required to produce effects on scale or Nectria probably are not justified because of the adverse effects on the residual trees.

b. In England, an 8-year-long study was conducted in two beech plantations 32-37 years old (Parker 1980). Three thinning regimens, light, medium, and heavy, were employed where approximately 30-33, 45-62, and 60-67% of the stems were removed, respectively. After 8 years, scale populations increased regardless of the thinning level--progressing from an initial low level to a generally moderate level. Proportionately more trees died of beech bark disease in the unthinned and lightly thinned plots than in plots moderately and heavily thinned.

c. Neither of these studies, nor others like them, were designed to maintain tree densities (basal areas) at a more-or-less constant level. In a study begun recently in France in 150 to 180-year-old beech plantations, thinning will be repeated every 5 years or so to maintain stand densities at prescribed levels.

3. Timber Stand Improvement

In the three diseases discussed here large overmature trees are especially susceptible to stress and to attack by secondary action organisms--and in the oak and maple declines, suppressed understory trees are especially vulnerable as well. Timber stand improvement operations to remove cull trees, and silvicultural practices to reduce the proportion of trees in suppressed categories would be of value in maintaining more resistant stands. Theoretically, the removal in TSI operations of trees bearing large numbers of structural refuges for gypsy moths would tend to increase the resistance of the stands to this insect; discrimination against beech trees infested with beech scale, and the favoring of "clean" trees should help increase the proportions of resistant stems (Tables 1-3).

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MANAGING RED ALDER
IN THE
CONIFEROUS FORESTS OF THE PACIFIC NORTHWEST ^{1/}

The forests of the Pacific Northwest are characterized by vast expanses of conifers. Yet much of the area, especially in the wet coastal environment, is stocked with red alder (Alnus rubra Bong.). At present, about 3.4 million acres are occupied by this species, mostly on private land. On the National Forests, red alder is now growing on about 140 thousand acres (Developed from Atterbury, 1978). In Oregon alone, the commercial volume of red alder has been estimated at almost 9 billion board feet (Overholser, 1977), while in Washington state, the 1965 inventory was about 12 billion board feet (Little, 1978).

The role of red alder in forest succession has sometimes been misunderstood. Early observers suggested that the alder acted as a nurse crop for development of Douglas-fir (Pseudotsuga menzeisii (Mirb.) Franco), but recent studies indicated that Douglas-firs suppressed in early stages of stand development did not persist (Newton et al., 1968). Common successors to pure stands of red alder in the Oregon Coast Range often include various brush species. Ultimately the more tolerant conifers, such as western hemlock (Tsuga heterophylla), western redcedar (Thuja plicata) or Sitka spruce (Picea sitchensis) may occupy the site (Franklin and Pechanec, 1968).

Our past management of red alder has often been focused on one objective: converting to stands of Douglas-fir wherever possible. This made good economic sense at the time. Empirical data indicated that we could grow substantially greater volumes of useable wood with conifers than with alder after about twenty years (Atterbury, 1978). It seemed reasonable to emulate the vast Douglas-fir forests, with their tremendous volumes of quality wood. Thus we found traditionally that our forestry education, silvicultural practices, logging systems, milling and marketing were derived from Douglas-fir forestry.

The picture has been changing during recent years, a reflection of new markets, ecological knowledge, and management emphasis. Where earlier demand for alder was limited to small and relatively inefficient mills, we are now seeing expanded use in the furniture industry. The foreign demand has increased. Use as fuelwood has also expanded, and the potentials for energy production are being explored.

^{1/}By Walter H. Knapp, Silviculturist, Pacific Northwest Region, USDA Forest Service, Portland, OR. Presented at National Silviculture Conference, Roanoke, VA. June 1981.

The silviculturist in the Pacific Northwest now needs to consider the attributes of red alder as a potential crop on many sites. Some of the most prominent factors to evaluate include:

1. Nitrogen fixation. Red alder fixes atmospheric nitrogen, which is potentially available for enhancing plant growth on nitrogen-deficient sites (Miller and Murray, 1978).

2. Disease mitigation. Red alder is not susceptible to laminated root rot. Crop rotations could potentially reduce the levels of stand infections of root decay fungi in conifer stands (Nelson et al., 1978).

3. Ecosystem diversity. Adding an additional tree species to the stand can act as an ecological buffer, increase the amount of edge, and consequently provide benefits for many kinds of wildlife.

4. Biomass production. Because of its nitrogen-fixing capability, red alder could potentially be managed for biomass production with less danger of nutrient depletion. Of course, the effects of total utilization on other nutrients would also need evaluation.

5. Regeneration ease. Red alder produces large amounts of seed at frequent intervals. Stand establishment is relatively easy compared with many conifers, and juvenile growth is rapid (Kenady, 1978).

6. Economic value. Present stands have positive economic value -- They will pay their way out of the woods in most cases. But stumpage is only a fraction of Douglas-fir value at present. Future stands are expected to somewhat close the gap, but it seems reasonable to predict that the conifers will command a stumpage premium for many decades. The point here is that alder will have value, and will be in demand in the wood markets of the future.

Red alder can't be grown everywhere in the Pacific Northwest. Furthermore, it probably should not be a primary crop on most of those lands where it can be raised. We see that alder provides an important silvicultural option which needs to be considered in our management. Our challenge is to identify the conditions where we should grow alder, refine the silvicultural techniques which apply to the species, and use these approaches as a part of balanced management in the Northwest.

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MANAGING RED ALDER ON THE SIUSLAW NATIONAL FOREST 1/

The Siuslaw National Forest is located in the Oregon Coast Range, southwest of Portland, Oregon. The National Forest extends from Coos Bay north to Tillamook along the Oregon coastline. The Forest extends inland approximately 12 airline miles.

The management of red alder (*Alnus rubra*) is being evaluated on the Siuslaw National Forest as part of the total Forest planning effort. Prescriptions are being prepared specifying that red alder be grown in conjunction with conifers for the objectives of providing wildlife habitat and visual variety. An additional prescription is being prepared which specifies growing red alder in the riparian ecosystem. If approved, these prescriptions will be implemented when the Forest Plan goes into effect in 1983.

Presently, red alder is managed in conjunction with conifers in plantations of the Siuslaw National Forest as part of intensive timber management. This management direction is based on an analysis completed on the Siuslaw in 1980.^{2/} Today, I want to discuss this analysis with you and show how the results are to be applied.

The management of red alder in combination with Douglas-fir (*Pseudotsuga menziesii*) was evaluated for a particular soil type. This soil type, which will be referred to in this paper as Mapping Unit 41, was reported to be low in nitrogen. It is the predominant soil type on 83,613 acres, or approximately 15% of the commercial forest land base, on the Siuslaw.

Physical Conditions

1. Location. Mapping Unit 41 occurs on three Ranger Districts, Alsea, Waldport, and Mapleton. A fourth District, Hebo, does not have this particular mapping unit.

2. Topography. The elevation range is from 100 feet to approximately 2,000 feet. The slopes range from 50 to 90% and occur on all aspects.

3. Climate. Average annual precipitation ranges from 80 to 120 inches. Snow contributes only a small part to this total, and it is not generally persistent. The average annual temperature is 48°F to 50°F with frost-free periods ranging from 160 to 180 days (Corliss 1973).

1/ By Thomas C. Turpin, Silviculturist, Siuslaw National Forest, Pacific Northwest Region, USDA Forest Service, Corvallis, Oregon. Presented at National Silviculture Conference, Roanoke, Va., June 1981.

2/ Thomas C. Turpin, "Silvicultural Prescription, Mapping Unit 41, Siuslaw National Forest," February 1980. Submitted to Region 6 Silviculturist Certification Panel.

4. Soils. The soils of Mapping Unit 41 correspond to the following Soil Conservation Service description. They are in the Bohannon-Slickrock Association, Bohannon Series. The phase is Bohannon gravelly loam, dissected, 50 to 90% slopes. These are well-drained soils developed in colluvial materials derived from arkosic sandstone. They have a duff layer of 0 - 1/2-inch. The A1 horizon is very strongly acid, with 20% pebbles. The permeability is moderate, runoff is very rapid, and erosion hazard is very high. Available water-holding capacity is 3 to 4 inches. The effective rooting depth generally ranges from 20 to 40 inches (Corliss 1973).

Soil analysis results indicated the following:

	pH	P ppm	K ppm	Ca Meq/100g	Mg MEQ/100g	CEC Meq/100g	OM %	M ppm
Plantations	5.7	19	340	6.9	3.0	28.8	5.8	30.64
Natural Stands	5.5	6.7	283	3.7	2.2	30.0	6.5	31.02

This is based on 15 samples from eight stands on Mapping Unit 41 (the nitrogen percent was determined using the Waring-Bremner test as described by Shumway and Atkinson (1977)).

Biological Conditions

1. Site Index. The average Douglas-fir site index (100-year base) is 162. This site index was determined from timber inventory plots that occur on Mapping Unit 41.

2. Plant Community Type. The area is within the Tsuga heterophylla Zone. Dominant coniferous species is Douglas-fir. However, there are considerable amounts of western hemlock and western redcedar. The dominant hardwood species is red alder. The dominant plant species in the understory are salal, vine maple, sword fern, and dwarf Oregon-grape.

3. Condition of Stands and Damaging Agents.

Diseases. The principal disease problem, Phellinus weirii, is the most significant disease of coastal Douglas-fir. It occurs in patches up to one acre or more in size.

Plantations. All plantations are satisfactorily stocked and in satisfactory condition. However, Phellinus weirii is present in all the plantations observed on Mapping Unit 41. The Phellinus weirii occurrence was more noticeable in plantations that have had all red alder removed from the stand.

4. Animal Populations

Big game. The big game population is low on this mapping unit. These areas are not ideal for big game species, such as black-tailed deer and Roosevelt elk because of steep slopes and lack of favorable browse.

Mountain beaver. Mountain beaver population is low due to a lack of favorable habitat.

Rabbit and hare - The populations are low.

Treatment Alternatives

Based upon the results of the soil analysis, this mapping unit was found to be low in nitrogen. Coupled with the findings of Shumway and Atkinson (1977) who reported that significant growth response to fertilizer was found when the ammonium production of the soil was below 36mg/g, three alternatives for silvicultural treatment were analyzed. These alternatives, which measured the biological potential, were:

1. Pure Douglas-fir, no fertilization. This is present management which includes clearcutting, broadcast burning, planting 400 Douglas-fir seedlings per acre, stocking surveys, animal control (10% of area), release (50% of area), pre-commercial thinning and release at age 10, commercial thinning at ages 28, 38, 48, 58, 68, and final harvest at age 85.

2. Pure Douglas-fir with the addition of artificial fertilizer. This alternative is the same as alternative 1, except for the addition of 200 lbs. per acre of nitrogen as urea after each commercial thinning.

3. Mixed Stand (Douglas-fir and alder). This alternative includes clearcutting, broadcast burning, planting 360 Douglas-fir seedlings per acre, stocking surveys, animal control (10% of area), release (50% of area), precommercial thinning and release at age 10. At the time of precommercial thinning 40 red alder per acre will be left on an approximate spacing of 33 feet. Commercial thinning will occur at ages 28, 38, 48, 58, 68, with final harvest at age 85. Upon the second commercial thinning, age 38, the red alder (tree age 33) will be harvested from the stand.

A display of the alternatives is as follows:

<u>Treatments Prescribed</u>	<u>Alternative 1</u>	<u>Alternative 2</u>	<u>Alternative 3</u>
Regeneration Harvest	Clearcut	Clearcut	Clearcut
Site Prep. (Year 1)	Broadcast burn	Broadcast burn	Broadcast burn
Planting (Year 1)	400 Seedlings/Ac.	400 Seedlings/Ac.	360 Seedlings/Ac.
Stocking Survey (Year 2)	First-year survival check.	First-year survival check.	First-year survival check.
Animal Control (Year 2)	If needed	If needed	If needed
Stocking Survey (Year 4)	Third-year survival check, vegetative competition check.	Third-year survival check, vegetative competition check.	Third-year survival check, vegetative competition check.
Release (Year 4)	If needed.	If needed.	If needed.

Display of Alternatives (Continued)

<u>Treatments Prescribed</u>	<u>Alternative 1</u>	<u>Alternative 2</u>	<u>Alternative 3</u>
Stand Examination (Year 9)	Determine pre-commercial thinning and release needs.	Determine pre-commercial thinning and release needs.	Determine pre-commercial thinning and release needs.
Precommercial Thinning & Release (Year 10)	Leave pure conifer stands; 350 trees/acre.	Leave pure conifer stands; 350 trees/acre.	Leave pure conifer stands; 350 trees/acre.
Commercial Thinning (Year 28)	Reduce to recommended stocking level, leaving 210 conifer/acre	Reduce to recommended stocking level, leaving 210 conifer/acre	Reduce to recommended stocking level, leaving 40 red alder and 170 conifer/acre
Fertilization (Year 28)	No fertilizer	Fertilize with 200 pounds/acre of nitrogen as urea after commercial thinning	No fertilizer
Commercial Thinning (Year 38)	Reduce to recommended stocking level, leaving 136 conifer/acre	Reduce to recommended stocking level, leaving 131 conifer/acre	Remove the 40 red alder/acre and reduce stocking level to 131 conifer/acre
Fertilization (Year 38)	No fertilization	Fertilize with 200 pounds/acre of nitrogen as urea after commercial thinning	No fertilization
Commercial Thinnings (Years 48, 58, 68)	Maintain stocking levels between recommended and maximum	Maintain stocking levels between recommended and maximum	Maintain stocking levels between recommended and maximum
Fertilization (Years 48, 58, 68)	No fertilization	Fertilize with 200 pounds/acre of nitrogen as urea after each comm. thinning	No fertilization
Regeneration Harvest (Year 85)	Clearcut	Clearcut	Clearcut

The following assumptions were utilized in conducting the analysis of the alternatives:

1. The final harvest on existing stands will be done by the clearcut regeneration method.
2. The slash treatment after harvest is part of the next rotation.
3. Alder will occur naturally in the plantations.
4. Natural regeneration of red alder cannot be relied upon after commercial thinning because the logging method to be used will not prepare a seedbed for red alder. In addition, alder does not often resprout when over 10 years of age. (Personal communication with John Gordon, Oregon State University.)
5. Based upon a very conservative estimate, one alder tree growing in a dominant or co-dominant position will produce 1 pound of available nitrogen per acre per year. (Carpenter et al. 1979, and personal communication with Dave Perry, Oregon State University.)
6. Nitrogen buildup obtained in a 33-year rotation of alder will provide enough nitrogen for the remaining years of the Douglas-fir rotation.
7. Red alder not only changes atmospheric nitrogen into a form that can be used by other plants, it also benefits the soil (Bergstrom 1979).
8. For the purpose of this prescription, it is assumed that the current relative values (costs and revenues) of wood products and treatments (including fertilizer) will remain unchanged. However, a significant change in these relative values would necessitate re-evaluation of the alternatives.

Analysis of Alternatives

Yield projections were developed for each alternative using the Douglas-fir Managed Yield Simulator (Reukema and Bruce 1977).

The yields for Alternative 2 were based upon a 10.3 percent growth adjustment. This adjustment was derived from the Regional Forest Nutrition Research Project^{3/} based on plots falling within the geographical area of the Siuslaw National Forest and having an average site index of 162.^{4/}

^{3/} Miller, Richard E., 1979. Unpublished data from Regional Forest Nutrition Research Project on file at College of Forest Resources, University of Washington, Seattle, Washington.

^{4/} This is a conservative growth adjustment because no account is made of the increase in fertilizer response when the fertilizer is applied to a thinned stand.

The yields for the red alder (Alternative 3) were calculated outside of the simulator, then the DFIT analysis for Alternative 2 was reduced by 40 trees per acre at age 38, and the red alder volume yield was inserted. Yield projection for red alder was based upon the following research data: Chamber (1974), Williamson (1967), Newton (1967), Smith (1977), and Miller and Murray (1971).

Present net worth was calculated at a 4% investment rate.

In addition to volume projections and economic analyses, the alternatives were evaluated for long-term productivity, and disease and insect resistance. The results of this analysis are tabulated below.

<u>Evaluation Criteria</u>	<u>Alternative 1</u>	<u>Alternative 2</u>	<u>Alternative 3</u>
Fiber Production**	84 MBF	92 MBF	93 MBF (Includes 90 D-fir, 2.7 alder)
Present Net Worth* (4%)	\$974	\$1,072	\$1,050
Cost of Production***	\$596	\$654	\$592
Long-Term Productivity	Site deterioration expected.	Nitrogen depletion minimized by fertilizer addition.	In addition to supplying nitrogen, alder will improve soil properties by adding organic matter, lowering bulk density, & enhancing moisture & nutrient retention.
Disease & Insects	Monoculture. Highly susceptible to insects and disease.	Monoculture, same as Alternative 1.	Species mix, possible resistance to root rot

* On a per-acre basis.

** Volume projections assume 100% stocking per acre.

***Discounted costs for total rotation @ 4% interest.

Selection of Alternative

Based upon this analysis, Alternative 3 is the selected alternative.

This alternative provides for the best long-term productivity, gives the highest fiber production, has the lowest cost of production, and offers the best protection against disease and insects.

The economic analysis showed Alternative 3 to be ranked second in present net worth. However, it is felt that the above-stated benefits outweigh this economic consideration.

Need for Research

In the development of this analysis, it became very evident that I was working on the verge of the unknown. I have identified several areas where additional research would be helpful in making sound management decisions. Some of these areas are as follows:

1. What is the extent and possible impact of Phellinus weirii on the Siuslaw National Forest?
2. Is there a correlation between soil type and Phellinus weirii occurrence?
3. What are appropriate species, from a management perspective, for planting in Phellinus weirii pockets?
4. What is the effect of fire upon the soils in Mapping Unit 41?
5. How do we manage red alder in a mixed condition with conifer? (Many studies have been discussed, but very few actual examples exist).
6. What is the benefit of red alder to wildlife?
7. What can be gained from a genetics program for red alder?

Conclusion

The management of red alder in the coniferous forests of the Pacific Northwest has not been considered a viable management alternative until recently. This analysis provided a basis upon which to make management decisions involving the role of red alder in the Siuslaw National Forest.

As a result of this analysis, the following direction has been taken:

1. In the development of the Forest Plan, management of red alder is being incorporated into the development of prescriptions for future management.
2. The Districts on the Siuslaw National Forest have been instructed to begin immediate implementation of Alternative 3 of this analysis on Mapping Unit 41 and other soil types low in nitrogen.
3. It has been recognized that the other major soil types need to be analyzed to determine the role of red alder.

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Managing Northern Hardwoods
to Meet
Visual Resource Objectives

by Warren R. Bacon

Managing the Northern Hardwoods for visual enjoyment of the public can be an exciting and rewarding challenge for silviculturists and landscape architects. Much has already been done; (i.e. the work in USDA Handbook 559 of Dr. David Marquis) much is left to be accomplished.

Developing silviculture prescriptions to achieve visual resource goals involves establishing "visual quality objectives" (VQO) and the "desired character" to be created and/or maintained under an adopted VQO. Visual Quality Objectives are established through use of the Visual Management System (VMS) USDA Handbook 462 inventory and the Forest Land Management Planning process. The VMS prioritizes National Forest lands as to the importance of esthetics based on the inherent physical and biological diversity of the land (variety class) and the degree of public concern and exposure for those same lands (sensitivity levels). The VMS also provides a method for determining a recommended visual quality objective based on the inventory. The inventory and often the recommended VQO are used in the land management planning process to provide an adopted VQO which is in concert with other resource goals and objectives for the area.

Determining the "desired visual character" for the future will also likely be part of the land management planning process. The desired character is the appearance of the landscape to be created and/or maintained over time. The desired character description may set goals for featured species; scale of stand structure; tree diameters bark characteristics; textural patterns; and contrasting tree species, shrubs, and ground covers.

Establishing the desired character should explore the potential in visual diversity and natural appearance but at the same time be within the biological potential.

Much of emphasis of the Timber Chapter, USDA Handbook 559, is centered around six different silvicultural processes which illustrate how to incorporate criteria for desired visual character with silvicultural systems to meet visual quality objectives. Following is a narrative example of one of these processes entitled "Maintain a Mixture of Tolerant and Intolerant Species in Northern Hardwoods." It is adapted from the slide tape training module developed by the U.S. Forest Service and Professor Wayne G. Flusty of the Department of Landscape Architecture, University of Wisconsin Extension. It is best read in conjunction with the Timber Chapter USDA Handbook 559 and viewing the slide tape.

Northern hardwood forests occur throughout the north and eastern United States, from the Lake States across the northern Appalachians and into New England.

The climax northern hardwood forest is dominated by shade tolerant species including American beech, sugar maple, and eastern hemlock.

Around the turn of the century, a considerable amount of logging took place in the climax northern hardwood stands and resulted in stands with a variety of species. This included a mixture of size classes because of the differing growth rates and tolerance levels of the species.

Many of these areas have developed into 60 to 80 year old, even-aged timber stands.

The biological and species diversity of northern hardwoods allows considerable treatment flexibility We can manage for intolerant species, through even-aged methods of regeneration or we can manage by uneven-aged management. The choice depends on the land management objective and specific resource needs.

Development of desired visual character descriptions provides the foundation to formulate management prescriptions. The potential of this phase of landscape management should not be left to chance or visual mitigation considerations.

Some of the landscape features and desired character that can be achieved through management are as follows:

Fall color provides one of the most widely recognized visual characteristics. Specific color patterns can sometimes be introduced.

Studies suggest that perceptions of scenic quality may be influenced by landforms. Steep landforms provide opportunities for a variety of viewing distances, while flat areas offer primarily foreground views except when associated with larger water bodies.

Water in steeper terrain is generally related to streams and rivers. In the more level terrain, water features of lakes, ponds, meadows, swamps, bogs, rivers, and streams are typically found. These water features make a significant contribution to the visual resource.

The landscape character is often viewed as a mosaic of vegetative situations. This provides visual diversity in form, line, color, and texture.

Areas can be managed for large tree character, with a park-like understory. The appeal of this visual situation has been identified in numerous research studies.

Attractive flowering shrubs and wildflowers should be considered with the desired character of hardwoods.

Cultural effects (log cabins, split rail fences, etc.) in or near the hardwoods can also provide desirable visual character.

Research findings show that forest viewers perceive differences in the attractiveness of stands on the basis of certain spatial qualities.

Pleasant forest openings can be introduced to create a visually diverse landscape and in many situations benefit other resources requiring such openings.

There are two different landscape management approaches to managing openings: long-term and short-term. Short-term management of openings is generally related to reducing the harshness of size, shape, and edge of harvest units. Forest openings under short-term management are allowed to regenerate quickly. This type of management is typically associated with the Visual Quality Objective of Modification and Maximum Modification. An exception would be creating small short-term openings to introduce an intolerant species for desired visual character in VQO's of Retention and Partial Retention.

In situations where openings are introduced and maintained, the need should be established as part of the desired visual character description. Long-term management of openings will generally apply to the visual quality objectives of Retention and Partial Retention. Early tree regeneration is discouraged.

Long-term management spaces in Northern Hardwoods can be further defined as canopied or open landscapes. The criteria for management differs.

In canopied landscapes the desired visual character description needs to address stand density, height of canopy, and viewing distance.

In developing open landscapes the objective is to create and hold the same spatial feeling as a bog, lake, or marsh. This requires early and specific management criteria, in addition to edge, scale, shape, and dispersement requirements. The type of vegetation on the "floor" of the open landscape and duration of the opening must be clearly developed in the prescription.

The striking visual contrasts between seasons also needs to be considered. To establish and maintain some of these many desired visual characteristics will require landscape management considerations starting with land management planning and continuing through project level activities.

A midlevel stage of planning that may be used in this process is termed corridor viewshed planning. A corridor viewshed is defined as the total landscape seen or potentially seen from all or a logical part of a travel route, use area, or water body. The purpose of corridor viewshed planning is to provide the management direction for retaining or creating the desired forest character in an attractive sequential arrangement over time and space.

Corridor viewshed planning, in a broad form, may take place as part of land management planning or at a time when interim visual quality objectives are established. Corridor viewshed planning should occur in more detail as an action plan subsequent to land management planning.

Northern hardwood cordidor viewshed planning should identify:

- existing and potential visual character appropriate with the selected Visual Quality Objective
- biological opportunities and constraints
- associated-resource objectives

Interdisciplinary activity in all three steps will set corridor viewshed direction within biological potential.

Corridor viewshed direction should also establish the description, amount, scale, and disbursement of the desired visual character. Featured tree species, number and target diameters for each species, contrasting species variety, desired bark characteristics, shrubs and ground covers, seasonal color, enframed views, and long-term space management needs are examples of desired visual character.

The visual goals stated in the Northern Hardwoods section of the Timber Chapter can be used to establish some of the visual direction for viewshed planning.

Visual Goal I--an unbroken forest with large trees 18-30 inches in diameter, and a mixture of smaller sized trees can be achieved through uneven-aged cutting methods.

This will provide the desired large tree appearance with long-term visual space management of a canopied landscape in the foreground.

Even-aged cutting methods will be used to achieve Visual Goal IIA. This will initially create a strong edge, with a well defined space in the forest. The introduction of intolerant species will provide a diversity of forms, colors, and textures to the landscape. The scale and distribution of openings needs to be carefully studied to meet visual objectives.

Visual Goal IIB is a modification of the previous visual goal. This goal suggests creating stands of intolerant species primarily for their desired visual character, but at a much smaller scale

than Goal IIA. Even-aged cutting methods will again be used. This goal is different than IIA in that specific intolerant species are favored for visual needs, rather than just introducing some diversity with intolerant species.

Visual goals can be used with site-specific desired visual character, landscape design techniques, and biological data to write silvicultural prescriptions.

Many treatment strategies are available due to the biologic diversity among the many species. Some examples of the special northern hardwood treatments listed in the Timber Chapter are illustrated below.

The "esthetic" shelterwood concept will require three entries and will conceal most of the visual disturbance associated with a recent harvest cut.

This concept will encourage the more tolerant species to develop and visually dominate the stand.

The "esthetic" shelterwood may be handled as follows: At year 0, or the present time, a seed cut would be made that reduces canopy stocking to a level sufficient to encourage the establishment of natural seedling regeneration.

At year 10, or when appropriate make the first of two removal harvests. Remove approximately one-half of the overstory. Moderately fast seedling growth can be expected, while retaining adequate canopy density to meet selected landscape design criteria.

The final overstory removal can be made at age 20 to 25, or when the regeneration reaches the desired height. At this time an option is available to leave three to five or more upper canopy trees per acre. This will create additional visual diversity and provide some large tree character.

"Two-age" management is another treatment concept and can be applied to an even-aged, 50-year-old stand. The intent is to avoid complete overstory removal while permitting intolerant species maintenance. When established it will involve the maintenance of two distinct age classes in all areas at all times.

The two-age appearance is obtained by entering and harvesting about one-half of a 50-year-old stand. The open canopy will enable intolerant tree species to regenerate.

After 50 years growth the two age classes will be 50 and 100 years old. At this time the 100-year-old trees can be harvested and the 50-year-old trees thinned. Again for visual and wildlife purposes, three to five, or more, 100-year-old trees can be left per acre.

Single tree selection can provide the desired visual character of a continuous large tree appearance and long-term canopied space management. Studies have shown that mixed hardwood stands managed under the selection system are more attractive than unmanaged stands of the same forest type.

Some additional stand management conditions which have visual implications are the density of tree stocking and stand structure related to tree size. For example, the goal of maximum timber production may only establish 18- by 24-inch diameter trees, while the desired visual character may set the tree size at 18 by 30 inches or greater.

National Forest Landscape Management, Volume 1, The Landscape Design Training Module and Timber Chapter, review some of the more widely used landscape design techniques. Several techniques which are suggested in the northern hardwood treatment guides need to be reviewed. They are roadside openings, spacings of roadside openings, and the concept of inclusions.

Roadside openings are a landscape design technique related to the width of the opening, measured along the edge of the road.

This technique does not necessarily limit the depth or length of the outer edges of the opening, nor does it mean the width of the roadside opening should not be varied. Variety can be created by varying the width of openings.

Spacing of openings is a landscape design technique that is determined by measuring the minimum distance between openings along the edge of the road.

The distances should be varied to create variety, relate to the landscape features, and meet selected visual quality objectives.

The visual impact of clearcut, group selection, and openings created after the final harvest of a shelterwood sequence can be softened considerably by a variety of landscape design techniques. These include: (1) retention of some islands of residual trees in the openings; (2) progressive cutting from the back toward the observer; (3) selection of size, shape and orientation of openings; and (4) feathering of edge.

In the timber chapter a number of silvicultural treatments are illustrated for northern hardwoods. These treatment guides are not intended to be fixed requirements.

The treatment guides are keyed to some of the desired visual characteristics provided by the three visual goals.

Within each visual goal, distance zones of foreground, middleground, background are shown for the various treatments.

The full array of visual quality objectives are also included under each goal and distance zone.

The guides also suggest silvicultural treatments for each of the distance zones, visual quality objectives and visual goals.

These guides provide users a variety of information which is intended to stimulate site-related creativity, rather than rigid treatment compliance.

The following narrative illustrates how the guides can be used to initially select different treatments for the same visual objective. In the illustration the visual objective is Retention.

Visual Goal I suggests single tree selection or group selection.

Visual Goal II suggests treatments of clearcutting are acceptable, but only for reasons of enhancement; the esthetic shelterwood is acceptable as is two-age management cutting or thinning.

The six treatments suggested for foreground Retention are all acceptable but each provides different visual character.

The development of criteria for desired visual character must start with the adopted Visual Quality Objective from the land management plan. In this example (Figure A) the Visual Quality Objective for the foreground is Retention. The Sensitivity Level is I and the Variety Class is B.

The inventory and analysis of specific, on-site, visual characteristics must be mapped. This would include not only the existing visual character, but the potential or desired visual character. In some situations the existing character may also be the desired character.

The variety class B rating indicates that a high diversity does not exist. Vegetation pattern is one of the four landscape features rated and is usually the only one to be manipulated. By improving vegetative diversity and variety, it may be possible, over time, to move this area to a higher scenic rating of Variety Class A.

After the visual inventory and analysis, the desired visual character is defined (Figure B). Note that some situations exist, such as large tree character, and will need to be maintained. Other desired character may be introduced. Also, Species are not designated at this time; only the visual intent, such as color or bark contrasting species, or conifers in a hardwood stand. It is at this point in the process that other resource objectives must also be included.

Biological data is needed to determine both the biological opportunities and limitations of the site. The data gathered through the compartment examination or stand examination process will provide the information needed to evaluate

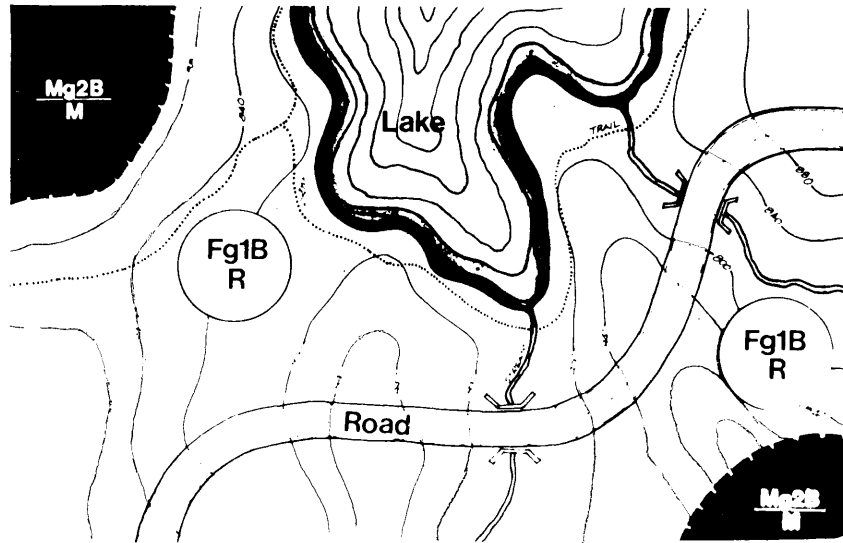


Fig. A

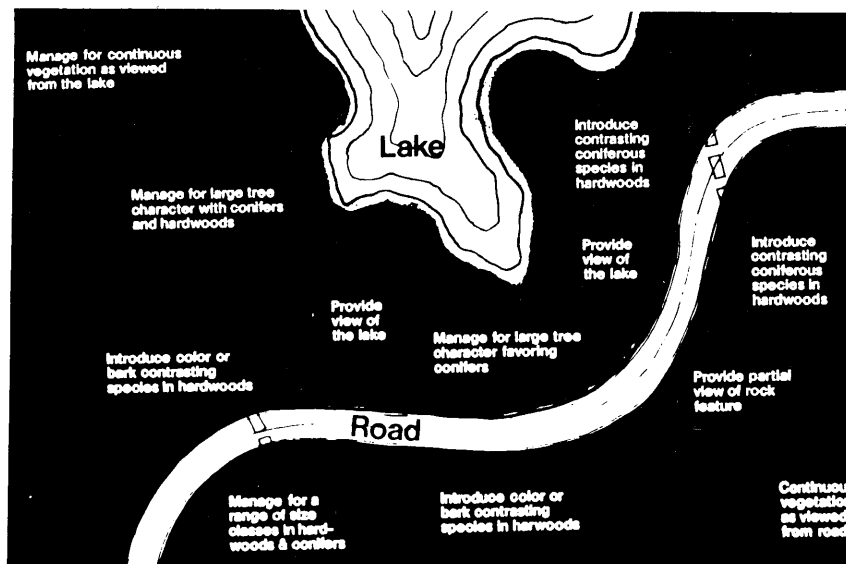


Fig. B

present stand structure, ecological trends, and biologic potential. For example, in Figure C, Stand I might represent a 100-year-old stand with a distribution of diameter classes and include conifers in the poor drainage situations.

Stands 2 and 3 (in Figure D) could represent better drained sites that include a range of hardwoods such as sugar and red maple, yellow birch, beech and other species.

The visual units, which do not necessarily follow biological boundaries, are joined with the biological units of the stand inventory map. This overlay process develops

Management Response Units (Figure E). It is at this point in the process that the desired visual character is tested with possible biological options and present stand situations. Can the site satisfy the desired visual character needs? What about the existing stand? Does it need to be modified or replaced? Possibly the desired visual character needs to be adjusted for biological reasons. These adjusted units are used to write silvicultural prescriptions which meet land management objectives.

Silvicultural prescriptions are written for each response unit, with treatments that meet the desired character and are biologically feasible. The letters "A" through "E" are used in this example to provide viewers a common reference for each response unit.

Response Units A-1, A-2, and A-3 can be treated through single tree selection to meet the desired character. Because all three response units occur in the same stand, they currently have the same visual character. The following illustrations will show how to create three different visual conditions from

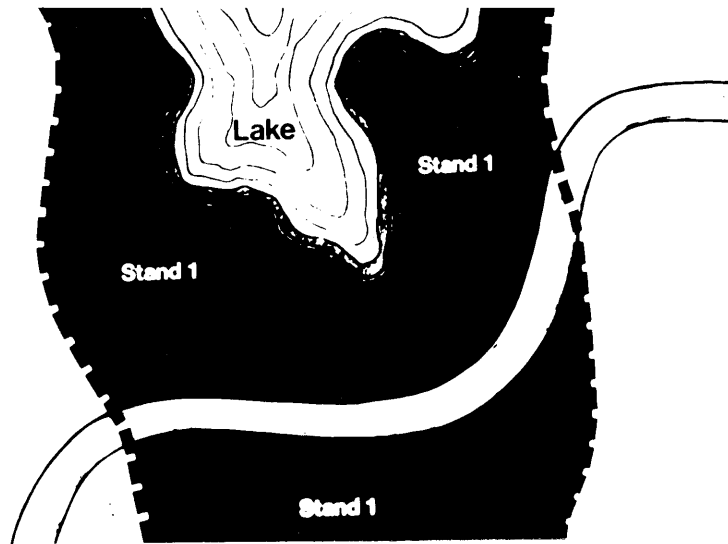


Fig. C



Fig. D

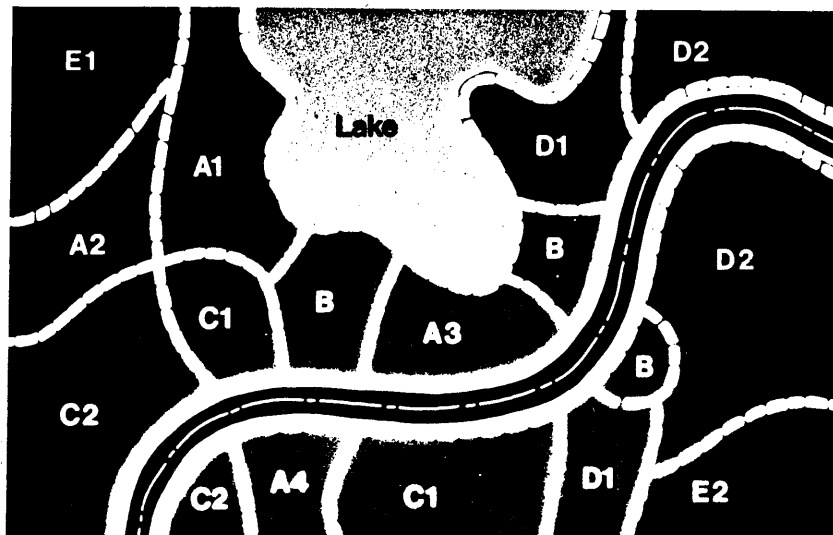


Fig. E

the same stand. In response Unit A-1, the desired character is to maintain the large tree character of yellow birch and hemlock. This can be accomplished by cutting mostly from the smaller diameter classes.

Response Unit A-2 presently has the same visual characteristics as Unit A-1. The desired character in response Unit A-2, is to favor the large tree character of the stand's hardwood component and provide visual change from Unit A-1. This can be accomplished by not emphasizing the conifers. The silvicultural prescription could be to remove most of the hemlock component and small diameter yellow birch and maple.

Response Unit A-3, also in stand 1, will be managed to maintain a range of size classes and mixture of hardwoods and conifers. The silvicultural prescription in this response unit will include cutting in all diameter classes and from both the hardwood and conifer component to meet the desired character. There will be fewer large trees in Unit A-3 than A-1 or A-2. Extended rotations will be used for A-1, A-2, and A-3 with potential tree diameters ranging from 18 inch to 30 inch.

In Response Unit B, also in stand 1, the desired character is to open and maintain views to the lake and rock feature. This can be done by cutting underneath. The size of the cutting units will be controlled by the area needed to provide the view. The silvicultural treatment prescription will include rather heavy cutting from the lower crown classes leaving the upper and larger crown classes to provide large tree character and allow views of the lake and rock feature. Removal of the lower limbs or residual trees may also be necessary to open the view.

In Response Unit C-1 and C-2, the desired character is to provide color and texture contrasts in bark and foliage. In C-1, which is in Stand 1, the possible species which could accomplish this are: yellow birch, red maple, aspen, and conifers. The silviculture treatment could call for management by a series of small group selection cuttings.

Response Unit C-2 has the same desired character but because it is part of Stand 2 has white birch as a component. The existing visual character meets the desired character. The white birch could be maintained by small group selection treatments.

The desired character in response units D-1 and D-2 is to provide a mosaic of hardwoods with some conifers for contrasting textures, forms and colors This might include balsam fir, or some spruce species, for conical and short rotation codominant vegetation with hemlock or white pine for long-term future dominant vegetation. The moist site conditions in D-1 should dictate species such as spruce, hemlock, balsam fir, yellow birch and red maple.

Response Unit D-2, which is a slightly drier site, would include white pine, red pine, and sugar maple.

The silvicultural treatments could be small group selection or shelterwood, with possibly some conifer planting.

In Response Unit E-1, which is subject to intensive views of a long duration, from the lake and trail, the desired character is to maintain the appearance of continuous crown texture and color. Species selection is not important.

This would allow small group selection, single tree removal or esthetic shelter-wood cutting. Unit E-2, which has the same desired character, but is viewed from the road for a short duration, could be treated similar to Unit E-1 but with the added option of small well designed removal cuts.

These illustrations have shown how the criteria for desired visual character are related to Visual Quality Objectives, viewshed planning, and silvicultural treatments.

In summary, this has illustrated the wide flexibility within northern hardwood management to achieve many of the desired visual characteristics and landscape design techniques.

Both the biological situation and desired visual character need to be understood and related.

The appropriate team members are needed to develop a corridor viewshed planning process.

The desired visual character and landscape design techniques were used with the visual goals stated in the timber chapter and the desired visual character was documented with landscape design techniques and used to write silvicultural prescriptions for the corridor viewshed.

All steps are necessary to manage the corridor viewshed as an attractive multi-resource area of the forest.

WILDLIFE AND ENDANGERED SPECIES

Arnold F. Schulz ^{1/}

The physical realm of Mother Earth is composed of three major categories — animal, vegetable, and mineral. These three are very much inter-related and in a major way, each is basic to the other two. A change in one causes a reaction in the other two. The reaction can be positive or negative.

Forest managers historically have been primarily concerned with the production and management of timber. Guided by economic principles, they were basically oriented to tree production on a sustained basis. There is also a long history of exploitive logging where little or no attempts were made to establish or influence a new crop of trees.

Times have changed on public lands, and there is evidence of some broadening of management emphasis on private lands. The economic principles of board foot production, while still valid, must also relate to the demands of other forest resource products. New laws have required management emphasis modification to protect and benefit wildlife, water quality, soil productivity, scenery, and vegetation.

OBJECTIVE

Many of the previous papers of this workshop deal with hardwood silviculture and emphasize the management and regeneration of hardwood stands. The objective of this paper is to express ways in which wildlife habitat management can be coordinated with silvicultural prescriptions to benefit both the timber and wildlife resources.

THE RESOURCE PICTURE

A. Timber

About 37 percent of the Eastern United States is covered by forest lands (Hamilton and Oswald 1980).

^{1/} Arnold F. Schulz is the Forest Wildlife Biologist on the Monongahela National Forest, Elkins, W. Va. This paper prepared for the National Silviculture Workshop, Roanoke, Va., June 1-3, 1981.

<u>Section</u>	<u>Total Land and Water</u>	<u>Forest Land</u>
Northeast	138,491,800 Acres	83,147,100 Acres
Northcentral	329,363,300	79,224,500
Southeast	157,008,200	91,005,800
Southcentral	<u>398,821,300</u>	<u>128,030,200</u>
Totals	1,023,684,600 Acres	381,407,600 Acres

Since all forest land is included in the preceding total, a separation of evergreen and hardwood acreages is desirable. (Hamilton and Oswald 1980.)

<u>Section</u>	<u>Hardwoods</u>	<u>Evergreens</u>
Northeast	61,734,900 Acres	21,412,200 Acres
Northcentral	65,060,700	14,163,800
Southeast	55,686,700	35,319,100
Southcentral	<u>98,031,400</u>	<u>29,998,800</u>
Totals	280,513,700 Acres	100,893,900 Acres

In the East, National Forest land constitutes only 6 percent of the total forest land. However, this acreage is significant because of the many goods, services, and supplies provided. By section, National Forest land (Hamilton and Oswald 1980) is distributed as follows:

<u>Section</u>	<u>National Forest Land</u>
Northeast	2,477,600 Acres
Northcentral	8,861,300
Southeast	5,294,600
Southcentral	<u>6,953,900</u>
Totals	23,587,400 Acres

B. Wildlife

Historically, state wildlife agencies emphasized management of game animals because their principal source of funding came from the hunter and fishermen licenses. Non-game wildlife often benefitted, both directly and indirectly, through the many facets of game management. Recently, emphasis has been given to management of

all vertebrate species through passage of non-game legislation in a number of states, the Multiple Use and Sustained Yield Act (Public Law 86-517), the Endangered Species Act (Public Law 93-205), the Forest and Rangeland Renewable Resources Planning Act (Public Law 93-378), the National Forest Management Act of 1976 (Public Law 94-588), and the Environmental Protection Act (Public Law 91-190). Over 1100 different wildlife species occur in Eastern forest and range lands (Schweitzer, et al. 1980).

<u>Vertebrates</u>	<u>Number of Species by Section</u>			
	<u>Northeast</u>	<u>Northcentral</u>	<u>Southeast</u>	<u>Southcentral</u>
Amphibians	49	56	85	85
Birds	344	325	336	384
Fish	208	262	505	351
Mammals	81	98	95	109
Reptiles	<u>48</u>	<u>74</u>	<u>47</u>	<u>112</u>
Total number of Species	730	815	1118	1041

The list of Federal threatened and endangered species for the East (Schweitzer, et al. 1980) includes:

	<u>Number of Species by Section</u>			
	<u>Northeast</u>	<u>Northcentral</u>	<u>Southeast</u>	<u>Southcentral</u>
Amphibians	0	0	1	3
Birds	3	4	9	10
Fish	4	3	4	14
Mammals	4	4	7	7
Reptiles	<u>0</u>	<u>0</u>	<u>5</u>	<u>2</u>
Total Species	11	11	26	36

Some of the above animals occur on National Forest land in the East. Since species names were not included, overlap between sections is possible. National Forests contain a number of additional species which may be scarce, have a very limited range, have special habitat requirements, or that are very sensitive to habitat disturbances. These are classed as Sensitive Species (Schweitzer, et al. 1980) on National Forest lands and number as follows:

<u>Vertebrate</u>	<u>Number of Species by Section</u>			
	<u>Northeast</u>	<u>Northcentral</u>	<u>Southeast</u>	<u>Southcentral</u>
Amphibians	7	8	49	45
Birds	109	112	212	180
Fish	41	32	206	220
Mammals	25	26	46	68
Reptiles	<u>4</u>	<u>14</u>	<u>53</u>	<u>34</u>
Total Species	186	192	566	547

C. Use and Demand

Both timber and wildlife project large demands for the future. Hardwood timber nationally showed a use of 6.5 billion board feet in 1976. Projections for the year 2030 show a demand of three levels (Hair 1980).

Low Level	-	13,990,000,000 b.f., a 115% increase
Medium Level	-	15,980,000,000 b.f., a 146% increase
High Level	-	17,890,000,000 b.f., a 175% increase

Wildlife use and demand has been projected in the 1980 RPA assessment (Schweitzer, et al. 1980).

	<u>Percent Demand Increase by Section to 2030</u>			
	<u>Northeast</u>	<u>Northcentral</u>	<u>Southeast</u>	<u>Southcentral</u>
Freshwater				
Fishing	76%	87%	106%	87%
Waterfowl				
Hunting	47%	67%	85%	67%
Big Game Hunting	41%	45%	63%	45%
Small Game				
Hunting	15%	22%	32%	22%

Nature study has been projected to increase nationwide by 31% to 147% in the year 2030 (Kaiser 1980).

Preceding data indicate a significant increase in both wildlife and timber demand by the year 2030. Additional data in the assessment show a steady trend in human population increase and a loss of forest land and wildlife habitat to development, encroachment, and corresponding land use patterns.

D. Management of Ecosystems

An ecosystem is a biological assemblage generally having relatively similar vegetation and wildlife species. Biologists and others have described a number of different classifications of ecosystems, based on potential natural vegetation, forest types, present vegetation types, life zones, biomes, ecoregions, biogeographical regions, and others. Since plant and animal distributions do not always coincide, single units of classification are unworkable (Smith, 1974; page 535).

However, some animals characteristically occur in certain vegetative types, facilitating hierarchical classification into ecosystems. Of major importance to this paper is that animal diversity is related to vegetative diversity within or between ecosystems. For this reason ecosystem integrity is important for maintaining certain species of wildlife. Silvicultural systems that change or remove forest types and ecosystems, have the potential of severely impacting one or more animal species. Examples which could create this condition by silvicultural treatments could include converting hardwoods to evergreens, discriminating against certain tree species, removing an entire age class over a large area, changing forest types and species composition, removal of certain understory plants, planting herbaceous openings to trees, removing tree shade from cold water streams, and other treatments incorporated without biological inventory, objectives, and coordination. With over 1100 wildlife species present in the East, it is difficult for the forest manager to account for each animal's needs in the land-use planning process. Thomas, et al (1979) adapted a life form classification developed by Antti Haapanen to group specific combinations of habitat requirements for animal reproduction and feeding. This will enable the forest manager to evaluate the response of wildlife to habitat much more readily than if each species were considered individually. Steps are underway nationally to computerize each species of wildlife's habitat preferences, foods, reproduction, and similar biological information which will facilitate management by creating, protecting, or enhancing these life forms where they occur or can be produced. Following is the life form system (Thomas, et al. 1979).

Life Form	Reproduces	Feeds	Examples
1.	In water	In water	bullfrogs, hellbender
2.	In water	On the ground, in bushes, and/or in trees	tree frogs, toads, tiger salamander

Life Form	Reproduces	Feeds	Examples
3.	On the ground around water	On the ground, and in bushes, trees, and water	northern water snake, mallard ducks, water shrew
4.	In cliffs, caves, rimrock, and/or talus	On the ground or in the air	raven, Virginia big-eared bat, woodrat
5.	On the ground without specific water, cliff, rimrock, and/or talus	On the ground	killdeer, meadowlark, savannah sparrow, horned lark, deer, turkey
6.	On the ground	In bushes, trees, or in the air	night hawk, Nashville warbler
7.	In bushes	On the ground, on water, or in the air	towhee, alder flycatcher
8.	In bushes	In trees, bushes, or in the air	cardinal, indigo bunting
9.	Primarily in deciduous trees	In trees, bushes, or in the air	northern oriole, cedar waxwing
10.	Primarily in conifers	In trees, bushes, or in the air	purple finch, golden-crowned kinglet
11.	In conifers or deciduous trees	In tree, in bushes, on the ground, or in the air	mourning dove, red squirrel
12.	On very thick branches	On the ground or in water	greathorned owl, blue heron
13.	In own hole excavated in a tree	In trees, in bushes, on the ground, or in the air	common flicker, pileated woodpecker

Life Form	Reproduces	Feeds	Examples
14.	In a hole made by another species, or a natural hole	On the ground, in water, or in the air	wood duck, southern flying squirrel
15.	In a burrow underground	On the ground or under it	woodchuck, short-tailed shrew
16.	In a burrow underground	In the air or in the water	muskrat, chipmunk, bank swallow, river otter, kingfisher

Additional study is needed to classify the Eastern vertebrate species (over 1100 species) by life form occurrence. The effects of a proposed silvicultural action could then be partially evaluated by comparing the number of species adversely affected to the number benefitted. The size, condition, location, and juxtaposition of the life form and amount to be treated would also be applicable to a silvicultural decision. The effect on the critical habitat of threatened and endangered species must also be considered.

Hardwood timber in the Eastern United States has been divided into major forest types (Hamilton and Oswald 1980). Forest land and resource planning in the East should consider these as ecosystems and incorporate management actions that are compatible to the capabilities, objectives, and integrity of these divisions. These hardwood ecosystems include:

- Oak - pine
- Oak - hickory
- Oak - gum - cypress
- Elm - ash - cottonwood
- Maple - beech - birch
- Aspen - birch

While the management of coniferous ecosystems has not been a part of this interspersed, diversity and extent are important to wildlife in the East.

COORDINATING WILDLIFE HABITAT NEEDS WITH SILVICULTURE

Commercial timber harvests have the potential of improving forest wildlife habitat at levels much greater, and less expensive than managing with wildlife funding alone. Thomas (1979) expressed the concept by stating:

"Wildlife habitat management in forests requires manipulation of tree cover (Trippensee 1948), but this is usually too expensive solely for wildlife purposes. Forest management practices undertaken to enhance wood production, however, cause dramatic changes in wildlife habitat. If correctly planned and executed, timber management practices are potentially the most practical way to achieve wildlife habitat goals."

There are three options the forest manager can use to achieve wildlife objectives in relation to silvicultural treatments -- manage for wildlife species richness, manage for featured wildlife species, or a combination of the two. Hall and Thomas (1979) put it very succinctly by stating:

"The process of simultaneously achieving wildlife and wood production goals is based on manipulation of several variables: (1) scheduling of silvicultural treatments, (2) arrangements of stands in time and space, (3) stand condition, (4) size of treatment area, and (5) land-type."

Each area of the East will likely have its own emphasis -- to feature game species, species richness, species of special interest or concern, endangered or threatened species, or to increase a species or group of species. In addition to protecting and enhancing the foregoing life forms and ecosystems, several specific coordination measures are suggested.

Manage for habitat diversity to assure wildlife species richness:

A. Utilize even-aged management systems in order to:

- (1) Balance age classes.
- (2) Facilitate establishment of shade intolerant tree and shrub species.
- (3) Create brushy areas for food and cover.
- (4) Create or enhance "edge" by treating stands to change timber type or age class.

- (5) Provide greater control over tree species mixtures in future stand.
- (6) Provide for increased habitat interspersion.
- (7) Longer rotations will maintain a greater percentage of the area in mast production. Shorter rotations will provide greater browse capability.
- (8) Longer rotations will increase potential for dens or tree cavities. Shorter rotations will decrease potential for dens and tree cavities.

B. Utilize all-aged management system in order to:

- (1) Maintain an almost continuous canopy over a large area.
- (2) Provide constant mast supplies on continuous acreages.
- (3) Retain den trees on continuous acreages.
- (4) Maintain shade cover over cold water streams.
- (5) Provide an ecosystem of the more shade tolerant tree and shrub species, with less variety of mast.
- (6) Create a greater woody understory density in treated stands.
- (7) Produce less variety of wildlife species over larger acreages.

C. Other coordination measures suggested through silvicultural treatments:

- (1) Regeneration cuts between 10 and 40 acres in size will cover the home range of most herbivore vertebrates.
- (2) Retain den and mast trees in clumps of 8-12 trees in clearcuts at the rate of 1 clump per 3 to 4 acres.
- (3) Create permanent herbaceous openings by seeding log landings and roads.
- (4) A generous portion of the winter range of the wild turkey should be relatively free of woody understory. Maintain a "B" level stocking (Roach and Gingrich 1968) when thinning continuous canopy hardwood stands.

- (5) Thinning operations which open the canopy by 50% to 75% can favor songbirds.
- (6) Plant patches of evergreen cover in extensive hardwoods. Size of patches should be from 1/2 to 2 acres. Establish one patch per 10 to 15 acres of hardwoods.
- (7) Favor mast producing trees and shrubs in silvicultural treatments.
- (8) In converting hardwoods to conifers, leave clumps or strips of hardwoods to provide diversity. Favor mast and/or den trees as leave clumps.
- (9) Protect and enhance dense, low understory evergreen cover where such cover is scarce.
- (10) Retain wild grape, serviceberry, dogwood, greenbrier, and other mast producing shrubs and vines.
- (11) Utilize prescribed burning as a management tool to favor wildlife where feasible and environmentally acceptable.
- (12) Clearcut strips or patches of hardwoods adjacent to conifer stands to provide edge and diversity.
- (13) Protect water quality by maintaining riparian habitats.
- (14) Retain snags for wildlife.
- (15) Establish wildlife waterholes in drier areas. Road building or logging equipment may be leased or contracted for this operation.
- (16) Close roads to public vehicular travel to protect those wildlife species which require isolation from frequent human contact -- such as black bear, wild turkey, cougar, bobcat, eagles, and species requiring specialized nesting sites.
- (17) Leave dead and down logs and large branches for wildlife cover and as a source of insects used as food by other animals.
- (18) Stands of old growth timber should be retained where this type of ecosystem is needed by animals that require such environment. Percentages desired range from 5% to 10% of an area. Old growth, discussed here, are trees left one or two cutting cycles beyond the rotation age rather than the economic rotation age.

SUMMARY

There are more than 381 million acres of forest land in the eastern United States. Of this, over 280 million acres are classed as hardwoods. In 1976, six and one-half billion board feet of hardwoods were harvested. Predictions for the year 2030 show increased demands for hardwood lumber of between 115% and 175%.

Over 1100 wildlife species live in eastern forest ecosystems. Hunting and fishing are expected to increase over 1977 levels by 15% to 85% by the year 2030, and nature study by a 31% to 147% (nationally) increase.

Silvicultural treatments can benefit or adversely affect wildlife habitat. Since 1960, a number of state and federal laws have been passed to encourage or require the consideration and coordination of wildlife and other natural resources in the management of forest lands. More information on the biology and habitat needs of wildlife is being published each year. Biologists strongly support the use of silvicultural treatments to enhance habitat diversity and maintenance of ecosystem integrity. In addition to use of ecosystem management, the classification of wildlife habitat by life forms will assist the land manager in making decisions. Adjustments in forest management for the welfare of wildlife have impacts on wood production. These are some of the tradeoffs that will need to be considered.

There are three options available to achieve wildlife objectives in relation to silvicultural treatments: Manage for species richness, manage for featured wildlife species, or a combination of the two.

Achieving wildlife and wood production goals concurrently is based on the manipulation of several variables: (1) scheduling of silvicultural treatments, (2) arrangements of stands in time and space, (3) stand condition, (4) size of treatment areas, and (5) land-type. If correctly planned and executed, timber management practices are potentially the most practical way to achieve forest wildlife habitat goals. Wildlife biologists and foresters must work together if the system of forest land management is to achieve all resource objectives.

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APPENDIX MATERIAL

1981 National Silviculture Workshop

Monongahela National Forest

Field Itinerary

June 3-4

Stop Schedule

June 3

12:30 Leave Roanoke
3:00 White Sulphur - Coffee Stop
3:30 Leave
4:00 stop 1
4:30 Leave
5:30 Snow Shoe

June 4

7:30 Leave Snowshoe
8:00 Stop 2
8:30 Leave
9:00 Stop 3 and 4
9:45 Leave
10:15 Stop 5, 6, and 7
11:15 Leave
11:45 Stop 8
12:00 Leave
12:15 Lunch
1:00 Leave
1:30 Stop 9
2:00 Leave
2:05 Stop 10 (from bus)
2:10 Leave
2:45 Stop 11
3:45 Leave
4:45 Snowshoe

Stop #1 Coles Run

Acres - 25

Year of Origin - 1972

Cultural Treatments - Site Preparation, 1972

Site Index - 40 to 70 (Northern Red Oak)

Regeneration - Natural, Fully Stocked

Discussion: This clear cut unit will be managed as two stands. The dryer south facing slope will be managed for yellow pine pulp and white pine sawlogs on a 60 to 70 year rotation. The north facing slope will be managed for mixed hardwood sawlogs on a 110-130 year rotation.

Stop #2 Blasted Bridge

Acres - 28

Year of Origin - 1966

Cultural Treatments - Site Preparation - 1966

Croptree Release - 1975

Regeneration - Natural, Fully Stocked

Site Index - 80 (Northern Red Oak)

Discussion: The old stand^{ed} contained a high percentage of defective beech left by the logging in the early 1900s. Regeneration consists of species in all tolerance ratings and 14 commercial species are represented.

A research study done in conjunction with the croptree release in 1975 showed that Black Cherry responded with accelerated diameter growth but reduced height growth.

The results of a stocking survey made in 1981 indicated the following species distribution:

<u>Species</u>	<u>No/Acre</u>
Black Cherry	400
Birch	270
Beech	150
Maple	130
Other Commercial	90
Non Commercial	<u>100</u>
Total	1140

Stop #3 Scenic Highway - CC.1

Acres - 50

Year of Origin - 1969

Cultural Treatments - Site Preparation, 1969

Regeneration - Natural, Fully Stocked

Site Index - 65 (Sugar Maple)

Discussion: Several non commercial species on the forest can present regeneration problems. These species are striped maple, mountain maple, and fire cherry. The maples become established prior to the regeneration cut and can be controlled prior to cutting. Fire cherry regenerates from seed after the cut but is usually not dense enough to preclude regeneration of commercial species. This stop demonstrates an abundance of these species. However, there are sufficient commercial species in the dominant and codominant crown classes to insure a new crop.

The results of a stocking survey made in 1981 indicated the following species distribution:

<u>Species</u>	<u>No/Acre</u>
Sugar Maple	750
Birch	210
Beech	100
Other Commercial	40
Non Commercial	<u>250</u>
Total	1350

Stop #4 Scenic Highway - CC-2

Acres - 53

Year of Origin - 1970

Cultural Treatments - Site Preparation - 1970

Regeneration - Natural, Fully Stocked

Site Index - 65 (Sugar Maple)

Discussion: The results of a stocking survey made in 1981 indicated the following species distribution:

<u>Species</u>	<u>No/Acre</u>
Maple	310
Beech	230
Black Cherry	110
Other Commercial	50
Non Commercial	<u>590</u>
Total	1290

Stop #5 Lower Williams Thinning

Acres - 29

Year of Origin - 1919

Site Index - 94 (Black Cherry)

Average Basal Area 1978 - 150 sq. ft. (To 1" DBH)

Treatments - Commercially Thinned, 1962

Present Species mix:

<u>Species</u>	<u>Basal Area (Sq. ft.)</u>
Sugar Maple	48
White Ash	44
Black Cherry	26
Red Maple	12
Misc. Commercial	<u>20</u>
Total	150

Stop #6 Lower Williams Sale

Acres - 48

Year of Origin - 1970

Cultural Treatments - Site Preparation, 1970

Site Index - 91 (Black Cherry)

Regeneration - Natural, Fully Stocked

Discussion: The results of a stocking survey made in 1971 and 1981 indicated the following species distribution.

YEAR 1971

<u>Species</u>	<u>No./A</u>
Sugar Maple	4690
Beech	737
Birch	402
Basswood	201
Black Cherry	201
Red Maple	134
Misc. Commercial	<u>335</u>
Total	6700

YEAR 1981

<u>Species</u>	<u>No./A</u>
Maples	300
White Ash	190
Birch	100
Black Cherry	100
Other Commercial	100
Non Commercial	<u>300</u>
Total	1090

Stop #7 Road Curve Sale

This stand was heavily cut around 1912 creating a 2-age stand. Many trees in the older age class had extensive rot and were declining in vigor. The stand was commercially cut in 1977. Marking concentrated on removing older high risk trees and thinning the second growth component to desired densities. Marking was cautious in order to retain the old age appearance. Felling damage was heavy in some areas.

Stop #8 Upper Williams Overlook -

This overlook provides a view into concentrated clearcuts of 5 sales cut between 1964-1970. Over 15 MMBF was harvested.

The Big Spruce Sale immediately across the hollow had 6 clear cuts totaling 312 acres and ranged in size from 34 to 87 acres.

Areas of concentrated regeneration cutting were instrumental in initiating the Monongahela Court Case. These concentrations occurred in areas with a well developed transportation system and good markets.

Stop #9 Goose and Pheasant Sale

This stand was part of a larger sale cut between 1968 and 1970. The stand was mature northern hardwood with abundant advanced regeneration. Average basal area in merchantable trees was 60 square feet and defect averaged 20%.

New Stand Data:

Acres - 14
 Year of Origin - 1969
 Site Index - 85 (Black Cherry)
 Regeneration - Natural, Fully Stocked
 Treatments - Site Preparation, 1970

A stocking survey in 1971 indicated a seedling density of over 5000 commercial stems per acre. The new stand will contain less beech and more black cherry than the old stand.

The results of a stocking survey in 1981 indicated the following Species distribution:

<u>Species</u>	<u>No./Acre</u>
Black Cherry	330
Cucumber	270
Maples	190
Birch	80
Beech	70
Non Commercial	<u>40</u>
Total	980

Stop #10 Lake Road Y.P.

Year of Origin - 1916

Cultural Treatments - Precommercial Thinning 1963

Site Index - 100 (Yellow Poplar)

Discussion: This stand is typical of the yellow poplar type. This type grows on the best sites, is easy to regenerate when a seed source is present, is relatively easy to manage and is highly productive. Average stand volume exceeds 20,000 bd. ft./ave.

